# EXPLORING THE ROLE OF FISCAL POLICY IN ENVIRONMENTAL SUSTAINABILITY OF PAKISTAN

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# Exploring the Role of Fiscal Policy in Environmental Sustainability of Pakistan

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Candidate of **Master of Philosophy** at the National University of Modern Languages do hereby declare that the thesis **Exploring the role of Fiscal Policy in Environmental Sustainability of Pakistan** submitted by me in partial fulfillment of MPhil degree, is my original work, and has not been submitted or published earlier. I also solemnly declare that it shall not, in future, be submitted by me for obtaining any other degree from this or any other university or institution.

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# ABSTRACT

Environmental sustainability is one of the main concerns in recent decades. Environmental degradation affects human health which ultimately affects productivity and thereby economic growth. Keeping in the view of Environmental sustainability the aim of this study is to construct Environmental sustainability index that focuses on the air, land and water indicators. Many factors affect Environmental sustainability and among those Fiscal policy is one of the main factors. Thus study aims to investigate how fiscal policy affects environmental sustainability in the long run and short run. We have taken the time series data in the context of Pakistan from 1974 to 2020. For the estimation of symmetric and asymmetric effects, we apply the Autoregressive Distributed Lag method (ARDL) and Non-linear Autoregressive Distributed Lag Method (NARDL) techniques. According to the Autoregressive Distributed Lag method results in our findings show that the developmental expenditures have a negative, but the subsidies have a positive impact on environmental sustainability in the long run while in the short run, both have a negative impact. The Non-linear Autoregressive Distributed Lag Method result shows that in the long run, subsidies have a positive impact on positive and negative shocks whereas, in the short run, subsidies have a negative impact on positive shocks and a positive effect on negative shocks. While in the asymmetric relationship subsidy have a positive effect on both positive and negative shocks. The study suggests that government should reduce the subsidies on energy consumption products and give subsidies to those industries which use environmental friendly techniques. Environmental restrictions to reduce pollution must be properly implemented through effective monitoring.



**Keywords:** Environmental sustainability, Fiscal policy, ARDL, NARDL.

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Dedicated to my Mother

&

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# CHAPTER 1

# INTRODUCTION

The previous few centuries have shown an ongoing association between economic development and climate change (Zhou et al. 2022). There has been tremendous academic progress in the previous few decades on the factors that ensure environmental protection. Many of these studies have warned of the deteriorating effects of global warmings, such as rising temperatures and regional and global weather anomalies (Grimm et al. 2008). To a large extent, scientists and environmentalists agree that rising levels of atmospheric carbon dioxide (CO2) emissions are one of the most serious environmental hazards (Malik et al. 2016). Historically, global economies on the road to social and economic progress have also confronted the difficult problem of lowering environmental pollution caused by growing energy use, income, urbanization, and population. Social and economic aspects that promote development have major environmental consequences (Al-mulali et al. 2012). According to Georgantopoulos (2012), governments often struggle to adequately manage the primary sources of climate change, notably energy-led emissions, although energy consumption is essential to supporting socioeconomic progress and quality of life.

The considerable challenge which is facing in the 21$^{st}$ century is to ensure a sustainable environment for human well-being. The 2030 Agenda of Sustainable Development, generally known as the Sustainable Development Goals (SDGs), are the precursor to the Millennium Development Goals (MDGs), and the historic climate change agreement in Paris are two essential international agreements to provide this sustainable future. Both development goals agreed to strike a balance between scientifically essential and politically feasible approaches to achieving long-term development (Oluwaseun, 2020).

Achieving economic and environmental sustainability is not possible without challenges. The Sustainable Development Goals can be achieved through sustainability pillars, which are Environmental protection to create a clean and healthy environment; we need to sustain ecosystems, air quality, integrity, and the sustainability of our resources. Economic development is to ensure a reasonable degree of economic well-being now without harming future generations' ability to obtain the same financial rewards. And social development to ensuring access to essential resources to provide a high degree of social fulfilment, which including lowering poverty and hunger, and enhancing educational and healthcare quality, while enhancing drainage and quality of water.

When all of the goals are solid, the planet's and human society's requirements are met in a way that ensures their survival. Environmental sustainability is the first layer of the three pillars, as social and economic sustainability is ultimately based on a clean and healthy environment.

The two fundamental challenges that developing economies confront today are economic growth with a sustainable environment (Abbass et al. 2022). The pressing challenges which are facing by developing countries, in the context of economic expansion are environmental sustainability. As a result, environmental protection necessitates a concerted effort on the part of fiscal policy to exacerbate and modify tactics (Jalil and Feridun, 2011). Pakistan is also in a developing stage to enhance their economic growth and also faces many challenges, for example, inappropriate infrastructure, health issues, environmental degradation and poverty. To address demographic and economic concerns, Pakistan is one of the developing nations that use traditional technology and energy sources, which has caused to rise in greenhouse gases and other dangerous pollutants in the air (Abid et al. 2022). As a developing economy, it must provide natural resources to meet its economic and social demands, and its economic structure has severe environmental consequences (Faisal, 2017). However, in comparison to industrialized countries and emerging countries are now contributing little to Greenhouse gas emissions. Therefore, if they keep following the conventional business cycle, the long-run environmental consequences would be severe (Hynes and Wang, 2012). Pakistan, like other developing countries, must create policies to protect its economical, socio, and environment concerns.

Many of the budgetary adjustments required to improve sustainable natural resource use as well as protection of the environment would be appropriate policies even in the absence of such particular considerations. This is because many of the most harmful provisions result from distortions implemented for non-environmental purposes. After all, the same policy objective can be attained through less detrimental means. To assist farmers, some countries have zero-rated fertilizers and pesticides under VAT. As an alternative, the standard rate of VAT may be imposed on these commodities, reducing the possibility of false refund claims and generating additional income, which could then be used to fund investments that assist small farmers, such as those to improve rural transportation networks. In such circumstances, environmental considerations are frequently just second in the policy debate, with revenue and standard efficiency issues taking precedence. Nonetheless, the massive environmental benefits of such measures can be enormous (Gupta et al. 2002). A great fiscal policy may lead to environmental sustainability in any country (Mahmood et al. 2022). Environmental quality is indeed rising as a result of fiscal policy in most of the world's largest carbon-emitting nations, including the USA, China, and India. As a consequence, twin strategies are crucial in developing countries, including Pakistan (Sana et al. 2020).

The systematic roles of fiscal policy instruments are to promote long-term economic growth and development through a well-designed spending and taxation structure (Hemming et al. 2002). Subsidies from the government are significant fiscal instruments for reallocating resources and promoting economic and social growth (Frye and Shleifer, 1997). They have also been shown to have a crucial influence on the financial activities and service responsibilities of publicly traded corporations (Luo et al. 2019). In contrast, subsidies which are given by the government seem to be more likely to flow to enterprises that pay more taxes and produce larger common good (Tang and Luo, 2007).

The replacement and consumption of government incentives are overall powerful motivators for the adoption of environmentally friendly technologies. Firms can make various pricing decisions under different subsidy programmes, and consumers can change their buying habits as a result (Mitra and Webster, 2008; Zhang et al. 2014). Substitute incentives encourage new environmentally friendly product consumption as well as the recovery of low energy-efficient products, whereas consumption subsidies can encourage both replacement and first-time buyers of new brand products. In terms of social welfare, higher subsidy spending can help consumers while adding to the government's financial burden (Li et al. 2018). Subsidies shift resources to less productive uses, and a rise in any subsidy reduces the economy's marginal product of emissions, resulting in an emissions decrease. In contrast, subsidies tend to shift resources to businesses that produce greater emissions. Subsidies thus raise pollution emissions if resources are directed to an industry with high enough emissions intensity to offset the reduction in emissions generated by a lower overall marginal product of emissions (Kelly, 2009).

## 1.1 Objectives of the Study

The focus of this research is to check the symmetric and asymmetric impact of Development expenditure and current subsidies on Environmental Sustainability. As a result, the following are the study's specific and broad objectives:

- To construct the index of environmental sustainability by considering the air, water and land indicators.
- To check the impact of fiscal instruments on environmental sustainability in the long run and short run.
- To examine the asymmetric effect of fiscal instruments on Environmental sustainability.

## 1.2 Research Questions

The following are the study's research queries:

i. Do current subsidies affect Environmental sustainability?

ii. Does development expenditure affect Environmental sustainability?

## 1.3 Significance of the Study

The cost of economic progress in terms of environmental deterioration is suffered primarily by underdeveloped nations due to a lack of capital and finance. Developing countries have environmental issues because they need economic growth through industrialization while lack of physical capital and financial resources doesn't allow developing countries to move towards advanced and environmentally friendly production techniques. One of the most crucial aims of Sustainable Development Goals is to attain Environmental sustainability. This study has novel contribution to the literature by constructing the index of Environmental sustainability. In addition, this study examines the asymmetric effects of independent variables on Environmental sustainability in Pakistan, which would help us understand the effect of positive and negative shocks on fiscal instruments. This study can assist academic staff, experts, and policymakers in incorporating research findings to design policies that may lead to a sustainable environment because sustainable growth is impossible without a sustainable environment.

## 1.4 Organization of the Study

This chapter aims to introduce the study, its objectives and its significance of the study. Chapter 2 reviews of literature and the literature gap, chapter 3 explains in detail of methodology, theoretical background, estimation techniques and diagnostic model and description of variables. Chapter 4 focuses on the construction of the environmental sustainability index. Results and discussion are explained in chapter 5 and chapter 6 are based on the conclusion of the research and policy recommendations as well as a future gap of the study. Towards the end of the research, the references are mentioned.

# CHAPTER 2

# LITERATURE REVIEW

The basic aim of the study is to highlight the pertinent aspect of environmental sustainability and the implication of fiscal policies on environmental sustainability. So the chapter on literature review explains the previous studies which are related to our research with their methodology and their findings. It also provides the appropriate content regarding the research and also talks about the research gap of the study. Section 2.1 defines environmental sustainability and then the environmental sustainability index in detail. Section 2.2 explains the relationship between fiscal policy and environmental sustainability. Then 2.3 sections explain the government expenditure impact on environmental sustainability. Section 2.4 provides the impact of development expenditure on environmental sustainability in detail with their findings. The next section which is 2.5 examines the effects of subsidies on environmental sustainability. After that, the relationship between control variables which are trade and urbanization with environmental sustainability is explained in detail. At the end of this chapter, the research gap exists.

## 2.1 Environmental Sustainability

Initially, it was believed that sustainable development referred to both social, economic along with environmental development. Since the concept of "three essential pillars" was established, it has gradually come to be recognized and accepted that socio-economic sustainability has sample benefits attached to it and it has its unique advantages, which is a very distinct, crucial and pertinent element for the economic and sociological growth of humans as well as the progress and development of humans at the governmental and state level (Moldan et al. 2012). The word environmental sustainability was originated and first used by scientists and representatives from the World Bank who initially coined and invented the term "Environmentally Responsible Development" (World Bank 1992). Following then, the phrase "environmentally sustainable development" was utilized (Serageldin et al. 1995). As a result, environmental sustainability emerged as an important concept that has assumed enough importance in our current security milieu. According to Goodland (1995), Environmental sustainability is very important to ensure the safety and security of humanity and focuses on improving the standard of human living and welfare through securing the means of production which is used mostly for daily life demands as well as ensuring the human waste drains are still not exceeded.

### 2.1.1 Index of Environmental Sustainability

Since the 1992 Rio Earth Summit, the concept of developmental sustainability has also been recognized as an essential objective. Several scientists and experts have worked to construct measuring techniques to assess sustainable development. After that in 2002, Environmental Sustainability Index (ESI) is a significant step in this direction. The Columbia and Yale Universities and World Economic Forum established the composite index of environmental sustainability index (ESI), in which data is assembled at a national scale to determine a nation's success in maintaining a habitable and sustainable environment for humans. By 2002, the Environmental sustainability index has been used in 142 countries. However, it is yet to be determined if it can be implemented at the provincial scale. Cui et al., (2004), attempted to use ESI to assess Shandong's long-term development in China. They selected 22 indicators and 43 variables, and the results indicated that Shandong's ESI was 49, demonstrating that Shandong seems far from being in a condition of sustainability.

The purpose of measurement of sustainability seems to be to transfer environmental decision-making towards even further scientific, statistical, and analytical foundations. The

Environmental Sustainability Index has become one of the biggest tremendous works to lay the framework for measuring sustainability. Babcicky (2013) investigates the reliability and validity of the whole composite index and also comes up with new information about the development of forthcoming indicators construction in addition to enhancing the discipline of sustainability measurement. The environmental sustainability index design confirmed that it is opposite to Pressure-State-Response (PSR) model, and then a principal components analysis was conducted to identify the index's latent structure. Furthermore, the ESI's performance is examined in cross-national regression models. Based on the index's structure as well as the weighted mechanism, their findings reveal an insufficiency of stability with the model of well-established PSR, as well as a probable bias against economically developed nations. A revised evaluation of each country's sustainability yielded the Equalized ESI, by establishing a re-weighted index. The Equalized ESI increases the rich-country bias while improving the quality index assessment. In other words, the Equalized ESI reveals the original ESI's flaws. They demonstrate that using the environmental sustainability index as an index of sustainability has significant conceptual flaws and issues of validity.

According to Blanc et al., (2008), composite indicators are made up of indexes which are applied to evaluate countries' performance in a particular area of policymaking. However, most are plagued by empirical issues. Several sets are utilized to demonstrate various difficulties concerning environmental sustainability indexes. The most serious flaws are due to a deficient conceptual approach and an absence of a common unit of collection. The majority of the researchers and environmentalists assess environmental conditions directly, while some rely on proxies like pressure and other factors especially those used as response parameters. Often they also use a parameter that is a mixture of both proxies. Furthermore, there was another composite index, which was created for sustainable development and was created as a result of the EU project EPSILON. Its purpose is to assess regional sustainability in Europe to inform policy choices that would advance regional sustainability. Indicators are given using a cogent framework based on the "driving force-pressure-state-impact-response" technique, including the innovative weighting project that uses data from a disability-adjusted life year evaluation of the influence on human health (DALYs). The outcomes are compared to those achieved with an even more typical aggregated strategy based on equally weighted as well as several normalization strategies.

Jha and Murthy (2003) provide a critical assessment of the ESI approach. It is stated that ESI's representation of environmental degradation and sustainability contains conceptual flaws. The selection of variables, as well as the statistical approach used to compile the index, is also determined to be deficient. They suggest an alternative methodology based on Principal Components Analysis, arguing that it is superior to the ESI methodology. Given the likelihood of the employment of aggregate environmental indices in forthcoming environment protection, the critique offered is significant. While Siche et al., (2008) compare environmental sustainability indicators of major countries which are ecological footprint and environmental sustainability index these are most commonly used, with two energy levels (energy sustainability index and renewability). They are obtaining all the attraction among scientists and government authorities. Despite efforts to develop an indicator that appropriately captures a region's sustainability, the findings of their study indicate that there is currently no fully satisfactory measure. They feel that they are most of them could further be upgraded; however, the outcomes indicate a probability of achieving a single higher indicator of sustainability by combining the ecological footprint with the renewability energy index.

According to Shruti et al., (2020), there seems to be a considerable agreement that initiatives launched as part of India's Smart Cities Mission (SCM) must be applied to create techniques for Environmentally Sustainable Smart Cities (ESSC). Whereas advanced nations have already focused on Urban Mobility and are still focusing on Smart Sustainable Cities, the situation among underdeveloped nations is quite dissimilar. An SCM standard appears to focus a greater emphasis on economic and social growth, as well as governance concerns, throughout their modern version, by utilising contemporary information and communication technologies (ICT). Environmental indicators which are 24 (including 11 from present standards) were authorized after even a two-stage screening procedure to ensure the environmental sustainability of certain mega infrastructure projects. These metrics might be used to assess how environmentally sustainable smart cities are and how they work and how things work inside them. They claim that the city's environmental sustainability has been divided into five categories based on how well the city ranks on Smart City Environmental Sustainability Index (SCESI). These categories of SCESI are Excellent, Good, Fair, Poor, or Critically Low. With the use of all these indicators, a preliminary framework has also been developed to arrive at the Smart City Environmental Sustainability Index (SCESI), which ranges from 0 to 100. Five Indian cities currently under construction under SCM (Varanasi, Patna, Delhi, Bhubaneswar and Allahabad) have just been examined using this approach. According to the research, two cities that are Patna and Varanasi fall in the poor category of the SCESI with the results of SCESI = 20-40, while three cities that are Delhi, Allahabad, and Bhubaneswar fall in the Fair category with the final results of SCESI = 40-60 range of environmental sustainability. The developed Smart City Environmental Sustainability Index may be utilized as a screening and diagnostic tool for management and planning initiatives about the human environment.

## 2.2 Fiscal Policy and Environmental Sustainability

One of the basic objectives of fiscal policy in advanced as well as emerging economic growth is to strike the right balance between environmental protection and economic growth (Ullah et al. 2021). According to López et al., (2011), governments usually increase government spending to boost the economy during economic recessions. While fiscal spending increases may be ephemeral, the spending composition is regularly adjusted in favour of social programmes and other public goods, which may continue for a long time. They evaluate the environmental consequences of fiscal spending patterns.

There is a considerable amount of literature that examines its effect on environmental sustainability. Some studies examined the influence of financial regulation on environmental protection by using models. Ullah et al., (2021) have used an asymmetrical technique to investigate the asymmetry impacts of macroeconomic policies (monetary and fiscal policy) on environmental pollution in Pakistan. The methodology used by the researchers is known as Nonlinear Auto-regressive Distributed Lag (NARDL). The research findings show that both positive and negative fiscal policy shocks have a statistically significant decreasing impact on environmental degradation in Pakistan over the long term, but both have a large expanding influence on carbon emissions in the short run. Even so, both positive and negative macroeconomic factors increase short-term carbon dioxide emissions, whereas positive macroeconomic factors reduce long-term carbon dioxide emissions. Mughal et al., (2021) used the NARDL approach to the panel data and time series dataset with the basic aim to examine long and short-term estimations at the national and provincial scales, to evaluate the impact of monetary and fiscal policies on environmental protection in ASEAN member states. The long-term conclusion shows that contractionary monetary policy reduces carbon dioxide emissions, whereas expansionary monetary policy increases airborne gas emissions, according to an ASEAN (Association of

South East Asian Nations) regional analysis. The long-run coefficient demonstrates that the fiscal growth of ASEAN lowers CO2 emissions. Carbon dioxide emissions are significantly and favourably impacted by expansionary fiscal and monetary policy in the medium term, but they are hardly affected by contractionary macroeconomic measures (fiscal and monetary policy). The analysis of the long-run coefficient demonstrates that the economic growth and development of ASEAN states lessen the emission of Carbon Dioxide CO2. Carbon dioxide emissions are significantly and favourably impacted by the expansionary fiscal and monetary policies that are mostly focused on attaining medium-term objectives, but they are hardly affected by contractionary macroeconomic policies and measures (fiscal and monetary policy).

Katircioglu and Katircioglu (2018) examine the impact of fiscal policy factors on the quantity of carbon dioxide emissions in Turkey in addition to GDP and energy consumption. The results show that Turkey's fiscal policies and carbon pollution are stable over the long term; as a result of fiscal policy, carbon dioxide emission levels tend to follow long-term trends. The effects of fiscal policy on carbon dioxide emissions are negative, indicating that stronger fiscal policies lead to lower levels of carbon dioxide emissions. This demonstrates that Turkey's financial measures in the energy business are successful in terms of environmental effects.

According to Chan (2020), the effects of macroeconomic policies on the environment, as well as their interactions with climate policies, remain understudied in the extant literature. Their research study aims at making a comparison between the impact of carbon pricing and traditional macroeconomic instruments like monetary and fiscal policy on lowering air hazard. He demonstrates how interest rates, government expenditure, and carbon tax rates should fluctuate over time to maintain current levels of carbon emissions. To prove his idea he used an environmental dynamic stochastic general equilibrium (E-

DSGE) model. They discover that (1) while all of the aforementioned strategies have, although they both have the potential to reduce carbon emissions, their fundamental implementations are not always the same. All monetary, fiscal, and carbon tax measures reduce abatement efforts, income taxes, and total levels of prices. (2) With the help of total factor productivity (TFP) shocks fueling economic booms, the fiscal policy seems to be the only method to restrict emissions while improving the affordability of households in terms of goods and services. (3) Carbon taxes must support the monetary system rather than respond to fiscal policy when it comes to the interaction between environmental and economic policies.

Fiscal policy, which includes government spending, revenue, and taxation, is the crucial factor of the demands sector in any country of their economy (Halkos and Paizanos, 2013). While on the other side, fiscal strategies, taxation, and spending of government have all been directly and indirectly related to economic growth, agriculture, industries, and services productivity levels, overall energy usage, and protection of the environment. Fiscal policy instruments affect the environment in a variety of ways. Any economy's budget deficit boosts accumulation and gross capital formation, commerce activity, and demand for the consumption of energy (Dongyan 2009; Balcilar et al. 2016). Government incorporates the green fiscal policy to address environmental concerns (Khan et al. 2022).

There are some studies which show the influence of governmental expenditure on a sustainable environment. Halkos and Paizanos (2013) calculated the direct as well as indirect environmental consequences of government expenditure. The mediating effect, in contrast, is regulated through the influence of government expenditures on incomes and in turn, the impact of income on pollution. Appropriate econometric methods are utilized to account for the dynamic character and probable endogeneity of the connections studied. The utilization of Sulfur Dioxide (SO2) by the government is predicted to have an adverse significant effect on per capita emissions while having no direct influence on Carbon dioxide. While the indirect impact on SO2 is negative at lower salaries but as the level of personal income increases, the impact becomes positive. It is pertinent to mention here that the throughout the analysis, the indirect impact of SO2 on atmospheric carbon dioxide is primarily negative across the analysis period. Bekhet and Lojuntin (2020) investigated the impact of government spending (GSE) on carbon dioxide emissions as a proxy for environmental quality in Malaysia. Empirical results have been provided by the researchers to establish a co-integration connection and prove that Malaysia's GDP, government spending, and carbon dioxide emissions are connected. Although government investment has not resulted in a reduction in carbon dioxide emissions, the statistics provided by the EKC support the existence of the EKC in Malaysia.

Levytska and Romanova (2020) investigated how government investment in environmental protection and other economic and social metrics affect GDP. It examines the environmental legislation that Ukraine needs to develop its environmental activities. Reduced government spending on environmental protection is causing the current crisis, which will have a detrimental impact on the implementation of environmental protection programmes. To examine the relationship and connection between various variables, the neural network model was used. Their finding of the study help to establish how much government spending on environmental protection should be reduced to boost GDP, as well as what amendments need to be made to legislation to achieve a transition to economies that ensure long-term development.

### 2.2.1 Development Expenditure and Environmental Sustainability

Development expenditure is the government's resources or investments to conduct economic development programmes that can improve the economic position and boost economic growth. Development expenditure is a long-term investment (Abdullah and

Maamor, 2010). Macroeconomic growth is being driven by long-term investments in development expenditure projects. A rise in macroeconomic growth could lead to an increase in government development expenditures, especially in the public sector, which includes social, education, and health (Usman, 2011).

Gupta et al., (1995) identified the areas of public spending policy that interact with the environment. It claims that reforming certain forms of subsidies, spending more on maintenance as well as on operation and conducting a thorough environmental evaluation of investment programs will help to improve the quality of the environment and, ultimately, lead to an economy that is moving towards "sustainable development". Cheng et al., (2021) explore that differentiated policies are essential for cities to improve their CO2 emission reduction efficiency, which is critical for climate change mitigation. Their findings reveal disparities in emissions in cities with similar socioeconomic characteristics. The carbon dioxide emission of local public spending as well as other public spending, followed mostly by the amount of local public spending and public environmental spending, had the biggest impact on emission variations between city groups had various socioeconomic conditions. The proportions of public environmental and other spending had only a minimal impact. Gupta and Barman (2015) explain that the efficiency of the private inputs including both sectors is affected by the environmental quality and public infrastructure spending. Both sectors damage the environment and benefit from public spending on pollution reduction and groundwork, and only the formal sector pays the tax. The steady-state growth equilibrium and also the second-best optimized fiscal policy both are explored. In the decentralized competitive equilibrium, the socially ideal relative size of the informal sector is lower than just its second-best optimum overall size. Through boosting public current spending in the social and public sectors and raising public revenue through taxes, Pakistan's ecological footprint will eventually be reduced over time (Zahra et al. 2022).

Health is the most crucial factor in developing human resources. Productivity will rise as a result of a healthy lifestyle. Hence, some studies show the relationship between environmental sustainability and health expenditure and also show their findings. Abdullah et al., (2016) explore how environmental quality and socioeconomic factors affect national health expenditures. They used yearly time series datasets for their research on the GDP, sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon dioxide (CO2), and health expenditure (HE) in metric tonnes per capita. They also used data on the fertility rate (FR) and mortality rate (MR) per 1,000 live births. Applying the auto-regressive distributed lag model (ARDL) allows researchers to test whether it is possible to predict both short-term and long-term effects on environmental quality. According to their research, CO2, MR, FR, NO2, and SO2 were found to have a long-term link with health spending in Malaysia, according to their research. In four global socioeconomic categories, Apergis et al., (2020) looked at the long-term correlations between the amount of pollution and how it impacts the healthcare sector and tends to analyze the associated healthcare cost. The researchers have applied the applying panel estimations framework that has taken common related effects such as cross-sectional dependence, unobserved heterogeneity, and temporal persistence into account. According to their findings, it is extremely important and necessary for all the subgroups to spend on their healthcare department/ sector. Their research results revealed that only a 1% increase in national income has elevated increased the spending on the healthcare sector manifold. According to the study, there is an overall increase of 7.2 % in spending on healthcare. Furthermore, there is a 9.3 %, 8.6 %, 6.8 %, and 2.9 % increase for low, low-middle, upper-middle, and high-income associations, respectively. In contrast, a 1% increase in carbon dioxide emissions caused a 2.5 % increase in overall health expenditures and 2.9 %, 1.2 %, 2.3 %, and 2.6 % increases for these four income groups.

On the other hand, Yazdi et al., (2014) examined how factors like income and environmental quality affect how much is spent on healthcare. They looked at the viability of applying the co-integration and (autoregressive distributed lag) ARDL techniques to evaluate the short- and long-term effects on environmental quality. They discovered a link between health spending, income, sulfur dioxide emissions, and carbon monoxide emissions. There are clear indications that both long-term and short-term implications that are caused under the influence of the factors such as income, carbon monoxide emissions, and sulfur dioxide emissions, all have statistically significant positive effects on health care spending. They found that SPM emissions had a short as well as long-term positive impact on healthcare expenses that are also statistically very important. The link between health expenditure (HE), pollution (nitrogen oxide emissions and carbon dioxide), and economic growth in Sub-Saharan African countries, according to Zaidi and Saidi (2018) for both the short-run and long-run outcomes, employed the ARDL estimate method. They also use the VECM Granger-causality test to determine the direction of causation. To begin with, the result findings of the ARDL model reveal that economic growth has a positive impact on spending in the health sector, while carbon dioxide and nitrogen oxide emissions have a long-term negative impact on the cost of healthcare. In contrast, a 1 per cent increase in carbon emissions and NOE will cause a 0.066 per cent and a 0.577 per cent drop in health expenditures, respectively. Their findings show that a 1 per cent increase in GDP per capita will raise health spending by 0.332 per cent. However, the findings of the VECM Granger causality test indicate that there is only a one-way link between per capita GDP and health expenditures. Additionally, it shows a two-way causal link between healthcare spending and CO2 emissions, as well as between CO2 emissions and GDP per capita.

The fundamental relationships between climate, expenditure on health, and economic expansion have just recently begun to be explored in the field of economics both in developing and developed countries. Here is some literature which is related to developing countries. Ghorashi and Alavi (2017) while using data from Iran, investigated the causal relationship between economic growth, carbon emissions, and healthcare spending using dynamic simultaneous equations models. Their research shows a unidirectional causal association between health spending and economic growth and a bidirectional causal relationship between economic growth and carbon emissions. In Iran, the upcoming year will be crucial for environmental conservation due to the strong bi-directional causation link between carbon emissions and economic growth. China, which is likewise in the process of development, is the subject of the second study. The environmental challenges in China become more prominent in recent years, coinciding with the country's rapid economic growth. Simultaneously, the pollution levels in China have been quickly increasing, harming the health of its citizens. In this aspect, when China's environmental quality deteriorated, public health spending soared. Hao et al., (2018) systematically examined the influence of environmental degradation on inhabitants' health spending. Based on panel data from Chinese provinces, their analysis indicated that environmental pollution (measured by soot and Sulphur dioxide emissions) will still lead to an increase in health care costs for Chinese residents, using the first-order difference generalized model of moments (GMM) method to adjust for potential endogeneity. A rise in $SO_2$ and soot emissions per capita at this stage of economic growth would result in a large increase in public health spending per capita.

Compared to other energy sources, using renewable energy helps minimize health care costs because it doesn't harm the environment (Mujtaba and Ashfaq, 2022).

Empirical findings imply that, during most of the examined timeframe, increases in education have increasingly compensated for increases in per capita $CO_2$ emissions due to economic growth which affects environmental sustainability. Furthermore, only in recent years has it been demonstrated that increasing per capita income and expanding education lower emissions. However, given the difficulty of managing income development, it might be important to investigate the prospect of expanding education to achieve environmental goals (Balaguer and Cantavella, 2018). Therefore, Li et al., (2021) highlight the relationship between higher education and environmental sustainability and examine the impact of higher education on the sustainability of the environment. The researcher has performed a controlled study by applying control variables including population, gross domestic product, electricity use, and foreign direct investment (FDI) inflows. They used cross-sectional dependence, panel unit-root, Kao co-integration tests, fully dynamic ordinary least squares, and modified ordinary least squares to analyze their data. According to their findings, higher education and foreign direct investment are important factors in reducing $CO_2$ emissions. Needy individuals in emerging economies are compelled to exploit natural resources to survive on a routine basis, and their environmental degradation is predicted to further impoverish them. Subramaniam and Masron (2020) investigate how education affects environmental and poverty-related concerns in developing nations. By using an autoregressive distributed lag (ARDL) technique; the research discovers facts about the existence of poverty-related emissions. Evidence also suggests that if education reaches a particularly high threshold level, the positive effects of poverty can be minimized. The marginal impact shows that there is a relationship between education and environmental degradation. It reveals that more education can help to reduce the likelihood of damage caused to the environment by the poor.

### 2.2.2 Subsidies and Environmental Sustainability

Subsidies to domestic players are provided by several developed and developing countries, resulting in overproduction and overexploitation of natural resources, creating a severe danger to environmental sustainability. Encouraging sustainability in the future is long overdue but also essential for greening supply chains to environmental and increasing international requirements. Industries have been forced to review their production technologies as a result of increasing consumer demand for environmentally friendly products and regulatory changes. However, determining the expense of a green economy and how to allocate it are still hard challenges (Ling et al. 2022). Chakraborty and Mukherjee (2013) describe the impact of subsidies from the government budget on the all-over environmental performance score using the panel data estimation technique. Their actual findings corroborate their theoretical assumption that subsidies contribute to the degradation of the environment, and that is particularly problematic in developing countries.

The agricultural industry of Pakistan employed more than 60% of its population. It also provides food for over 162 million people and supports the acquisition of foreign money (Afzal and Ahmad, 2009). The amount and structure of agricultural subsidies have an impact on input utilization and destruction of the environment; consequently, agricultural policy structure is significant for environmental performance (Atici, 2009). Studies on the detrimental effects of government subsidies on environmental sustainability abound and their numbers are very high. For intense, agricultural subsidies contribute to excessive input consumption and, as a result, biodiversity loss (Steenblik, 1998). According to Badiani et al., (2012), to boost agricultural output and economic growth, the Indian government offers agricultural power subsidies to the poor in rural, up to 85% of the total cost of delivery. Contrarily, those subsidies for agricultural inputs run the risk of lowering agricultural production over time and harming the environment. Farmers' use of chemical fertilizer is changing as a result of agricultural subsidies (Guo et al. 2021). Although nitrogen fertilisers are necessary for present-time farming, through use of massive quantities of mineral fertilisers in Italy over the last three decades has resulted in serious long-term consequences for the environment such as eutrophication of soils and waters, biodiversity loss, human health risks, and drinking water pollution. Regulatory instruments used to reduce and control mineral fertilizers, such as the Nitrate Directive, have had mixed results in the protection of the environment to date. At that time, Europe's Common Agricultural Policy (CAP) subsidies structure favors intensive agriculture, and national fiscal policy offers a 4% Taxation reduction on mineral fertilizers (Gazzani, 2021).

Subsidies for energy in developing nations have long been the focus of discussion in economic circles. Despite their widespread appeal of providing support to the poor. They boost the size of the deadweight loss and reduce customer welfare. However, removing a subsidy completely will make electricity costs for the poor. Finding the optimal amount of subsidy that has the least negative effects on the economy while benefiting the most consumers is therefore crucial in the context of emerging nations. Pakistan has acute energy shortages, which have compelled the government to offer significant electricity subsidies. According to Khalid and Salman (2020), the targeted subsidy plan not only reduces costs but also enhances the quality of life for the most disadvantaged members of society. Energy subsidies have raised energy consumption, which has resulted in excessive carbon dioxide ($CO_2$) emissions, potentially lowering environmental quality. This issue occurs all around the world, especially in developing nations that are going through a period of industrialization. Here are some studies which show the relationship between energy subsidies and environmental sustainability. Sasana and Aminata (2019) investigate that Economic Globalization (GE), energy subsidies (ES), renewable energy (RE), population growth (PG), Economic growth (EG), and overall usage of primary energy (PE) all had an impact on carbon dioxide emissions ($CO_2$). To examine obtained data, multiple linear regressions (multiple regression models) were estimated using the ordinary least square approach. According to their findings, total primary energy usage, subsidies on energy, economic growth, renewable energy use, and population expansion have a negative impact on $CO_2$ emissions.

According to Sasana et al., (2017) energy subsidies, energy consumption, and population increase in Indonesia affected $CO_2$ emissions. Using time series data, the analysis of multiple linear regressions was done using the ordinary least squares method. According to their results, carbon dioxide emissions in Indonesia are significantly and favourably impacted by energy subsidies, the use of fossil fuels, and population growth. Meanwhile, the use of renewable energy contributes to a decrease in the atmospheric emissions of carbon dioxide. On the other hand, Mundaca (2017) notes that reducing fuel subsidies for gasoline and diesel by about 20 cents per litre will lead to significant drops in $CO_2$ emissions, both locally and worldwide. For instance, present emissions from the use of diesel and gasoline in Iran might be cut by as much as 90% and 50%, respectively, but in Saudi Arabia, the reductions could be as much as 70% and 40%, respectively. The growing reliance on foreign energy sources has created a massive demand-supply mismatch, as evidenced by decreasing the demand for natural gas and electricity. It has sociological, economical, and environmental consequences. Several countries are moving their attention from imported to indigenous resources that are often less expensive, more environmentally friendly, as well as provide competitive (Nawaz and Alvi, 2018).

## 2.3 Control Variables and Environmental Sustainability

### 2.3.1 Trade and Environmental Sustainability

Researchers and policymakers have concentrated their efforts on determining what causes environmental deterioration as a result of various forms of environmental degradation and natural resource depletion around the world. The search for a healthy environment has become a worldwide issue affecting more than one country. Climate change is wreaking havoc on economies all around the world as a result; millions of people are suffering (Asiedu et al. 2021). To promote environmental protection, constraints on economic expansion and global commerce are necessary. Additionally, the current regime must support technical advancements that will cut emissions (Munir and Ameer, 2022).

The relationship between environmental sustainability and investment flows and trade has gotten a lot of attention recently. In recent years, FDI has been channeled more to Low developing countries and emerging nations, their exporting bundle is heavy on essential and manufactured exports. Among countries at various economic levels, Chakraborty and Mukherjee (2013) investigate the connections among the environmental performance index (EPI), investment flows and trade. While manufactured-oriented exports and inward foreign direct investment movements are adversely associated with environmental sustainability, service exports and outward FDI movements are favorably related. Their findings also show that numerous politico-economic factors (such as a liberal democratic setup and lower corruption) have a beneficial impact on a country's environmental performance. Surprisingly, the environmental performance index has a negative coefficient for low-income nations, but it has a positive value for high-income countries. Their findings back up the theory that trade and investment movements have a substantial influence on the environmental sustainability of the country. By using the fixed effect, OLS regression, and extended technique of moments; Khan et al., (2022) investigate bilateral trade, technology, and qualitative organizations in the context of environmental sustainability. Their findings show that the use of renewable energy, trade openness, and foreign direct investment have negatively affected carbon dioxide emissions, while many institutional qualitative parameters make a significant contribution to environmental sustainability; even so, this is still below the desirable level for enhancing environmental quality.

According to Boutabba (2014), there is a long-term and causal connection between the growth of the financial industry, carbon dioxide emissions, income, energy use, and trade openness. According to Dogan and Seker (2016), the EKC hypothesis is supported for the top leading renewable energy economies as expanding non-renewable energy usage increases air gas emissions while rising renewable energy consumption, trade openness, and financial development all lower carbon dioxide emissions.

To examine how increased trade liberalization results in even more serious environmental issues. How the emission of carbon dioxide (Co2) is affected by the phenomenon of trade openness is investigated by Chen et al., (2021). The panel quantile regression technique is used to fully account for the potential heterogeneity. Furthermore, their study investigates the substitute effect of energy, the economic effect, as well as the science and technology effect. Their research shows that greater trade openness significantly reduces carbon dioxide emissions, albeit the impact varies depending on the amount of airborne carbon dioxide emissions. Thus, trade openness has a positive indirect influence on $CO_2$ emissions through the economy, but it has a negative indirect impact on $CO_2$ emissions due to energy substitution and technical effects. As a result, it is crucial to use more renewable energy, reduce energy intensity, and establish policies that are appropriate for local settings to reduce carbon emissions. In the case of China, exports are typically shown to be positively associated with pollution, whereas imports are likely to have a detrimental influence on both the entire country and across regions (Fang et al. 2020).

There are some studies which used the Autoregressive Distributed Lag ARDL model to explore the relationship between trade and the environment. In Belgium, the United States, and Canada, Asiedu et al., (2021), look at how trade and economic expansion affect environmental deterioration. To give fresh evidence and policy implications, they used an autoregressive distributed lag technique. However, their research shows that trade openness has no effect on carbon emissions, but economic expansion slows down environmental deterioration over time. However, trade and carbon emissions show no meaningful relationship, but economic growth and carbon emissions have a favorable short-run tie. Pata (2019) looked at the relationship in Turkey between the environmental Kuznets curve and trade openness. The inverted U-shaped EKC hypothesis is true, and trade openness has an increasing effect on carbon dioxide emissions, according to the results of their long-run estimators. On the other hand, Turkey has not yet generated the amount of money required to cut pollution. Along with these conclusions, it was found that Turkey's slower development and output during the financial crisis of 2001 resulted in lower short- and long-term pollution. Our data demonstrate that in Turkey, scale and composition impacts surpass the effects of economic growth and trade openness.

Usman et al., (2022) explore how the use of non-renewable and renewable energy, financial development, economic growth, trade openness, and other factors affect carbon dioxide ($CO2$) emissions in Pakistan. Their long-term research indicates that although financial development and the use of renewable energy have a major positive impact on environmental quality, and economic growth, the use of non-renewable energy sources, and trade openness have a negative impact. Their research shows that, in the near term, nonrenewable energy consumption and trade openness have a considerable negative impact on environmental quality, but renewable energy sources have a positive effect. Awan et al., (2018) look into the link between GDP, foreign direct investment, trade openness, and environmental quality in the context of Pakistan. To examine the long-run and short-run relationships among predicted variables Awan et al., (2018) use an autoregressive distributed lag ARDL-bounds testing technique. They discovered a positive and robust long-term association between Pakistan's environmental degradation, trade openness, and foreign direct investment. On the other side, the environment's state is unrelated to GDP. Environmental damage as a result of trade openness and foreign direct investment must be considered by policymakers, and environmental quality should not be overlooked. Local and international groups must be subjected to government enforcement of environmental laws. As a result of the findings, it was suggested that future trade between the countries be performed. As a result of increasing trade, countries' economies will expand, promoting economic progress while reducing environmental degradation.

### 2.3.2 Urbanization and Environmental Sustainability

Pakistan's urban population has grown significantly since the beginning of civilization. The overwhelming growth of Pakistani cities threatens the environment, as well as wreaking havoc on sanitation, education, energy, and law and order. Only 17.6% of Pakistan's population lived in cities in 1951, but that number has now risen to more than 40% (Government of Pakistan, 2017). Unregulated urbanization without any of the proper information and communication technology (ICT) and transportation networks causes unwanted results, such as pollutants, mishaps, and heavy traffic. Rapid urbanization is a crucial engine of sustainable economic development (Chatti and Majeed, 2022).

Numerous empirical studies demonstrate how urbanization affects carbon dioxide ($co_2$) emissions in both underdeveloped and developed countries (Poumanyvong and Kaneko, 2010; Al-Mulali et al. 2013; Ali et al. 2017). The impacts of urbanization on carbon dioxide ($CO_2$) emissions in Pakistan are described by Ali et al. in 2019. For long-run and short-run co-integration, the auto-distributed lag model ARDL bound testing approach has been employed, and the VECM model has been used for causal analysis. The study's findings revealed a connection between the factors. Urbanization has been found to raise carbon emissions both over the long and short term. There was an immediate one-way causal relationship between urbanization and carbon emissions. Their research had policy concerns, according to the researchers. In large cities, vehicle emissions can be minimized by encouraging the use of public transit. According to their research, government support is required for urban industrial and residential sectors to adopt green technology, and a public awareness campaign to educate and train people on environmental degradation mitigation and adaptation should be launched.

Azam and Khan (2016) empirically evaluate the impact of urbanization, as well as a few other explanatory variables, on the degradation of the environment as evaluated by carbon dioxide emissions across four nations in the South Asian Association for Regional Cooperation (SAARC) region, including Pakistan, India, Bangladesh, and Sri Lanka The approach of least squares was utilized as an analytical tool for variables estimation methods after the implementation of several important as well as crucial statistical procedures. The overall influence of urbanization on the environment is varied, according to least squares analysis. In India and Bangladesh, the impact of urbanization on the environment has seemed to be significantly adverse, whereas in Sri Lanka, it is significantly positive, and in Pakistan, it is insignificantly beneficial. The study's research suggests that policymakers should develop long-term urban planning policies that can significantly reduce $CO2$ emissions and pollution. Shaheen et al., (2020) used empirical estimations of auto regressive distributed lag (ARDL) to show that power consumption and Gross domestic product are the main causes of Pakistan's toxic environment and to quantify the clear contribution per cent of each dynamic factor in Pakistan. Their goal was to investigate the effects of GDP, energy use, and urbanization on carbon dioxide emissions in Pakistan. Energy consumption and GDP have a significant impact on $CO2$ emissions in the long run, according to empirical research; however, industrialization and urbanization have negligible impacts. According to their empirical evidence, they propose that closing the economic gap among both rural and urban regions, as well as changes to energy generation and mechanical innovation will provide Pakistan with a valuable reference in its efforts to reduce carbon emissions.

Shah et al., (2020) determine the relationship between carbon dioxide emissions, energy intensity, and urbanization from 1980 to 2017 using the ideas of ecological modernization and environmental transition. They thoroughly looked at the empirical relationships between emissions, per-capita income, urbanization, imports and exports, energy consumption, trade openness, and energy intensity. The causality techniques of the Vector Error Correction Model (VECM) and Johnson co-integration are employed in the analysis. Their findings confirm the dynamic and U-shaped association between urbanization and carbon emissions, as well as the connection between per capita income and carbon emissions. Their statistical findings show a positive association between urbanization, inflation, financial development, and energy intensity, but an adverse connection between labour force participation, trade openness, and carbon emissions. In addition, the findings of causality analysis reveal that the variables in the models have a range of causal linkages. Ali et al., (2017) conduct an empirical investigation of the impacts of urbanization on carbon dioxide emissions in Singapore. They employed the autoregressive distributed lags (ARDL) approach in their research. Their main analysis shows that urbanization has a detrimental and significant impact on Singapore's carbon emissions, suggesting that it is not a hindrance to the country's efforts to improve its environment. As a result, urbanization improves the environment in the research nation by reducing carbon emissions. Their results indicate that economic expansion directly worsens environmental quality by raising carbon emissions in the nation, suggesting that economic growth has a positive and large influence on carbon emissions. Despite its high rate of urbanization in Singapore, it shows that the city is dedicated to 100 per cent of the population, and the environment is not suffering.

Using data from 1950 to 2014, Kirikkaleli and Sowah (2020) employed the wavelet coherence technique to evaluate the connection between urbanization and environmental sustainability from a global viewpoint. They investigate both short- and long-term causal relationships between urbanization and environmental sustainability in a global setting by the wavelet coherence approach. Their results show that: (i) during their research, they discovered major weaknesses in urbanization and environmental sustainability at various time and frequency ranges. (ii) For medium and long-term timeframes, there is a substantial wavelet link between urbanization and environmental sustainability; whereas the correlations are really not significant for short-term horizons, and (iii) for medium and long-term timeframes, there is a substantial wavelet link between urbanization and environmental sustainability, whereas, correlations are also not significant for short term horizons. According to their research, global urban planners and policy experts endorse advanced environmentally friendly technologies and renewable energy sources to regulate worldwide Emissions of co2 and pollution levels caused by industrialization; policy reforms to combat climate change are just as well suggested as evidence proves compact city theory.

China is seeing the highest levels of urbanization ever recorded. This has greatly improved the quality of life for residents, but it has also led to significant environmental problems in the Beijing-Tianjin-Hebei urban region (BTHUA). Liang et al., (2019) created metrics for urbanization and environmental pollution as a consequence. The following are the findings of their research. (i) From 0.157 in 2000 to 0.438 in 2015, the urbanization index rapidly increased. Environmental protection in urban agglomerations is influenced by national policies. (ii) The level of the service sector, government output, residential revenue, education levels, and Internet-based were all factors that contributed to reducing pollution. Environmental pollution has been increased by factors such as urbanization, population aggregation, economic progress, industrial growth, urban expansion, and the construction of transportation. (iii) The influence of urbanization on pollutants varied on a regular schedule, and the fluctuation period corresponded to the five-year plan of China. National law has significantly benefited coordinated urbanization and environmental conservation while having a delayed effect. Although the strength of each influence differed, the effects of demographic, economic, social, geographic, and comprehensive urbanization trends on pollution were substantially the same (iv) While urbanization improved environmental quality in the mountains, it aggravated local pollution in the lowlands and along the shore. Rapid urbanization in Africa also poses a threat to the continent's long-term prosperity.

Effiong (2016) looks into the environmental effects of urbanization in 49 African countries. The findings indicate that urbanization reduces environmental pollution when using the Stochastic Effects by Regression on Population, Affluence, and Technology (STIRPAT) framework, a recently created semi-parametric panel fixed-effects regression model, and two atmospheric air pollutants, carbon dioxide (CO2) and ambient particulate matter PM10 emissions. The conclusion is more obvious with PM10 emissions but less so with CO2 emissions, according to the semi-parametric analysis. Furthermore, there is no proof for Kuznets' inverted U-shaped curve theory linking pollution and urbanization. Thus, according to Ali et al., (2017), the issue of urbanization won't be a problem when it comes to passing legislation to stop the country's environment from getting worse. When formulating environmental mitigation strategies, authorities should place more emphasis on the nation's rate of economic growth than on urbanization since urbanization has a significant impact on rising carbon dioxide emissions.

The findings of this review demonstrate that there is a large amount of existing literature on the specific topics of investigation for this research. But some of them find the impact of fiscal policy on $CO_2$ and all these studies are conducted on panel datasets. Many researchers have found the impact of different subsides and development expenditures on the environment, but none have found the impact both in one framework. However, when taken together, it is evident that past research is expanding knowledge. The asymmetric impact of development expenditure and current subsidies on environmental sustainability is a neglected area in the literature. Therefore, this study contributes to the literature by constructing an index of environmental sustainability and assessing the role of fiscal policy, which is disaggregated into the current subsidies and development expenditure to ensure environmental sustainability in Pakistan. This study further contributes to the literature by analyzing the asymmetric effect of fiscal policy on environmental sustainability.

# CHAPTER 3

# METHODOLOGY

This chapter describes how to evaluate the impact of Development expenditure and current subsidies on environmental sustainability. Section 3.1 explains the theoretical background of the variables. Section 3.2 focuses on the econometric model of this research and estimation techniques that are ARDL and NARDL is explained in the 3.3 section which is used in this research, while the 3.4 section discusses what diagnostic test is used to check the results of ARDL and NARDL model. Data sources of each variable are discussed in section 3.5. Section 3.6 explains the description of variables. While section 3.7 is a construction of a composite index and explains how we apply the PCA on index indicators. The description of indexing variables is explained in 3.8 sections. In the last section, the data source of the indicators which are used to make an index of environmental sustainability is mentioned.

## 3.1 Theoretical Background

According to many researchers' Environmental sustainability is a major concern and many economic theories have emerged in the recent past that highlighted the need of a sustainable environment to achieve sustainable goals. In this effort to make the environment sustainable, many researchers have suggested different solutions to mitigate the environmental problems. Many economists highlighted the role of macroeconomic policies to achieve the goal of sustainable environment and stable growth. Environmental challenges such as climatic changes, habitat destruction, soil depletion, and deforestation caused by unsustainable patterns of production and consumption over the past several decades, combined with the current crisis and its social and economic aspects, have reemphasized the role of the policies. Fiscal instruments are also having a potential role to play in making the environment sustainable. Gupta et al., (1995) suggests that restructuring different subsidies, raising maintenance and operations costs, and thoroughly evaluating various aspects and impacts of the capital projects on the environment will help to improve the environment and would guide policy makers and other people working for a better and sustainable environment to devise policies and strategies accordingly. Public expenditure policy which considers the environment as an important aspect would lead to sustainable development.

One of the top priorities for policymakers is to ensure environmental sustainability with the expansion of economic growth in their home country. However, Nuroglu et al., (2018) are of the view that environmental quality declines as a nation industrialize up to a specific level. Thus, the degradation of the environment and economic growth are positively related, and after attaining a target of a certain level of growth, the relationship becomes negative (Kahuthu, 2006), especially in developing countries like Pakistan. The use of sound fiscal policy helps to achieve economic objectives as well as promote sustainability by integrating environmental and social dimensions into the economic policy (Hansen, 1990; Harris, 2001). Redirecting government expenditure toward social and public benefits is thought to minimize pollution in terms of fiscal policy approaches. But raising overall public spending without altering its makeup does not lessen pollution (López et al. 2011). On the other hand, pollution tax also enforces industries to adopt environmental-friendly production techniques (Bovenberg and DeMooij, 1997).

Following the study of Ullah et al., (2021), macroeconomic policies help to achieve the target of environmental sustainability thus environmental sustainability is the function of fiscal policy.

ES = f (fiscal policy)

Along with macroeconomic policies, urbanization also affects environmental sustainability. Increased urbanization may help accelerate environmental degradation in many economies, particularly in countries where they have less awareness and concern about the environment. People continue to migrate from rural to urban areas in search of quality pastures and social security, and urbanization is a huge social phenomenon that continues to increase daily around the world (Ali et al. 2017).

ES = f (fiscal policy, Urbanization)

Moreover, economic theories have also highlighted that environmental sustainability can be significantly influenced by trade. The impacts of trade can be seen in both upstream and downstream activities and can happen through direct or indirect pathways (Andrew, 2000). Restaurants and food service, tourism, transportation, entertainment, health care, and construction services are just a few of the major service exports that have an impact on the environment. As earnings rise as a result of trade and development, the need for environmental restrictions is likely to rise as well (Cole and Elliott, 2003). Because environmental regulations are less strict in emerging nations, businesses from those nations might be a little more inclined to invest in those polluting industries (Cole et al. 2011). Industries can exhaust the natural resources of developing nations because their exports mostly relay on mineral and agriculture products (UN, 2011). Thus, this study analyzes the impact of fiscal policy along with trade and urbanization on environmental sustainability.

ES = f (fiscal policy, Urbanization, Trade)

## 3.2 Econometric Strategy

Based on the theoretical background we have following the econometric model,

$$ES_t = \alpha_0 + \beta_1 F + \beta_3 X_t + \mu_t \quad (1)$$

Where environmental sustainability is the dependent variable, which is denoted by ES, $\alpha_0$ is the intercept of the model. F shows the fiscal instruments and X is the set of control variables and $\mu$ is the error term. This study considers development expenditures and subsidies to analyze the role of fiscal policy on environmental sustainability. X is an independent and controlled variable in the model, which includes trade and urbanization. Thus the model can be described as follows,

$$ES_t = \alpha_0 + \beta_1 Dexp_t + \beta_2 S_t + \beta_3 T_t + \beta_4 U_t + \mu_t \qquad (2)$$

In equation 2, Dexp (development expenditure) and S (subsidies) are independent variables which are disaggregated forms of fiscal policy. T is a controlled variable, which is trade. U is also a controlled variable, which is urbanization.

## 3.3 Estimation Technique

Estimation is the process of obtaining an estimate, or approximation. It helps us analyse the independent variable on the dependent variable empirically. Before applying estimation techniques, this study uses some preliminary tests.

### 3.3.1 Descriptive Statistics

Descriptive statistics are presented in the first stage of data analysis. Descriptive statistics is the quantitative definition of collecting knowledge about all the variables. Descriptive statistics are intended to synthesize a survey rather than utilize the data to think more about a population that the sample of data is considered to represent. The overview of statistics begins with reporting the number of observations for all variables included in the sample, then moves on to reporting central tendency, which consists of mean, median, mode, minimum, and maximum values, and finally reporting standard deviation, which is used as a measurement of dispersion.

### 3.3.2 Correlation Matrix

After the presentation of descriptive statistics, the next step is to examine the correlation between variables. The correlation matrix is used to investigate the degree of linear relationship among variables. It also suggests multi-co-linearity between variables in the same estimate equation. The OLS estimator does not exist in the presence of perfect multi-co-linearity. The pair wise correlation cofactor generated from a correlation matrix is useful in defining the problem of multi-co-linearity.

The primary goal/ objectives of the study are to analyze and check the symmetric and asymmetric impacts of development spending and subsidies on environmental sustainability are the goal of this research.

The objective of this research is to check the symmetric and asymmetric effects of development expenditures and subsidies on environmental sustainability. Therefore, linear ARDL and non-linear ARDL will be used. Before applying ARDL and NARDL, this study examines the order of co-integration of each of the variables.

### 3.3.3 Test for Stationary

The next step is to ensure the stationary of the variables because if a variable's data is non-stationary, all of the regression analysis findings are meaningless.

#### ***3.3.3.1 Augmented Dickey-Fuller (ADF)*****:** The basic strategy is to examine the presence of unit roots in the time series presented to assess the stationary data. The Augmented Dickey-Fuller (ADF) test, introduced by Dickey and Fuller (1979), is the most often used test for analyzing the unit root in a data set.

#### ***3.3.3.2 Phillips and Perron (PP):*** Time series analysis still makes extensive use of a set of unit root tests developed by Phillips and Perron in 1988. Serial correlation and heteroskedasticity in mistakes are addressed in various ways by the

unit root tests Phillips Perron (PP) and Augmented Dickey-Fuller (ADF). The Phillips and Perron tests ignore any serial correlation in the regression estimates, whereas the ADF tests employ parametric auto-regression to mimic the ARMA structure of the errors in the test regression.

### 3.3.4 Autoregressive Distributed Lag Method (ARDL)

The ARDL model may be used to estimate the parameters that have been integrated with various patterns, I(0), I(1), or a combination of both. The ARDL approach is inappropriate if the variable is integrated at I(2). The autoregressive distributed lag model (ARDL) co-integration approach is preferable and helpful when there is a single long-run link between the regressors and a limited number of respondents. Using the F-statistic (Wald test), the long-term relationships between the underlying variables are examined (Nkoro and Uko, 2016).

It has three advantages over all other previous and standard co-integration approaches. The first is that the Autoregressive distributed lag can be used with variables of order one, order zero, or fractionally integrated variables; not all parameters under consideration need to integrate in the same order. The second advantage is that the ARDL test is significantly more effective in circumstances with small and limited sample numbers. The final and third benefit is that the ARDL approach allows us to acquire unbiased long-run model estimations.

The model ARDL is as follows:

$$\Delta ES_t = \alpha_0 + \sum_{j=1}^{T} \theta j ES_{t-j} + \sum_{j=0}^{T} \psi j Dexp_{t-j} + \sum_{j=0}^{T} \pi j S_{t-j} + \sum_{j=0}^{T} \Omega j T_{t-j} + \sum_{j=0}^{T} £ j U_{t-j} + \varepsilon_t \quad \textbf{(3)}$$

The unrestricted form of ECM is as follows:

$$\Delta ES_t = \alpha_0 + \sum_{j=1}^{T} \theta j \Delta ES_{t-j} + \sum_{j=0}^{T} \psi j \Delta Dexp_{t-j} + \sum_{j=0}^{T} \pi j \Delta S_{t-j} + \sum_{j=0}^{T} \Omega j \Delta T_{t-j} + \sum_{j=0}^{T} £ j \Delta U_{t-j} + \lambda_1 ES_{t-1} + \lambda_2 Dexp_{t-1} + \lambda_3 S_{t-1} + \lambda_4 T_{t-1} + \lambda_5 U_{t-1} + \varepsilon_t \quad \textbf{(4)}$$

To determine whether two variables have a long-term equilibrium relationship, the standard F statistic is recommended by Pesaran et al., (2001) for the assessment of the null hypothesis which is $H_0$: $\lambda 1 = \lambda 2 = \lambda 3 = \lambda 4 = \lambda 5 = 0$ against the alternative of $H_1$: $\lambda 1 \neq 0$, $\lambda 2 \neq 0$, $\lambda 3 \neq 0$, $\lambda 4 \neq 0$ and $\eta 5 \neq 0$. If the F statistic is statistically significant, it means that the variables are expected to be co-integrated. After we've established our co-integration, we can calculate the long-run effects by normalizing coefficient estimates λ2 to λ5 on λ1. Based on differenced variables, short-run estimations are arbitrated.

The restricted form of the error correction model is given as follows:

$$\Delta ES_t = \alpha_0 + \sum_{j=1}^{T} \theta j \Delta ES_{t-j} + \sum_{j=0}^{T} \psi j \Delta Dexp_{t-j} + \sum_{j=0}^{T} \pi j \Delta S_{t-j} + \sum_{j=0}^{T} \Omega j \Delta T_{t-j} + \sum_{j=0}^{T} £ j \Delta U_{t-j} + \Pi\, ECT_{t-1} + \varepsilon_t \quad \textbf{(5)}$$

Where equation 5 shows the short-run impact of independent variables on environmental sustainability, whereas the ECT term is obtained by the given equation:

$$ECT_{t-1} = ES_{t-1} - \alpha_0 - \alpha_1 Dexp_{t-1} - \alpha_2 S_{t-1} - \alpha_3 T_{t-1} - \alpha_4 U_{t-1} \quad \textbf{(6)}$$

### 3.3.5 Non-linear Autoregressive Distributed Lag Method (Non-Linear ARDL):

In contrast to ARDL, which assumes that the potential influence of the independent variable would remain the same, NARDL's design allows for the possibility of asymmetric impacts of positive and negative variations in independent parameters on the dependent variable. Furthermore, if the effects of separate components of an explanatory variable are discovered to have the same effect, the NARDL model devolves into the conventional symmetric ARDL model. The NARDL approach also offers graphs of cumulative dynamic multipliers that are used to identify the patterns of adjustment that follow both positive and negative shocks to explanatory variables. Intriguingly, the models are basic and complete enough to allow for any asymmetry transitioning from the short run to the long run.

However, to assess the asymmetric effect non-linear ARDL will be used, and the equation is as follows.

$$\mathrm{Dexp}^{+}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{Dexp}^{+}{}_{t} = \sum_{t=1}^{T} \max(\Delta \mathrm{Dexp}^{+}{}_{t}, 0) \quad \textbf{(7)}$$

$$\mathrm{Dexp}^{-}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{Dexp}^{-}{}_{t} = \sum_{t=1}^{T} \min(\Delta \mathrm{Dexp}^{-}{}_{t}, 0) \quad \textbf{(8)}$$

$$\mathrm{S}^{+}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{S}^{+}{}_{t} = \sum_{t=1}^{T} \max(\Delta \mathrm{S}^{+}{}_{t}, 0) \quad \textbf{(9)}$$

$$\mathrm{S}^{-}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{S}^{-}{}_{t} = \sum_{t=1}^{T} \mathrm{mix}(\Delta \mathrm{S}^{-}{}_{t}, 0) \quad \textbf{(10)}$$

$$\mathrm{T}^{+}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{T}^{+}{}_{t} = \sum_{t=1}^{T} \max(\Delta \mathrm{T}^{+}{}_{t}, 0) \quad \textbf{(11)}$$

$$\mathrm{T}^{-}{}_{t} = \sum_{t=1}^{T} \Delta \mathrm{T}^{-}{}_{t} = \sum_{t=1}^{T} \mathrm{mix}(\Delta \mathrm{T}^{-}{}_{t}, 0) \quad \textbf{(12)}$$

In the following step, S (subsidy), T (trade) and Dexp (development expenditure) will be replaced with $S^{-}$ $S^{+}$ $T^{-}$ $T^{+}$ and $DE^{-}$ $DE^{+}$ variables in Eq. (13). We'll finalise the formulation of the NARDL model.

$$\Delta \mathrm{ES}_t = \alpha_0 + \sum_{j=1}^{T} \theta j \Delta \mathrm{ES}_{t-j} + \sum_{j=0}^{T} \psi j \Delta \mathrm{Dexp}^{+}{}_{t-j} + \sum_{j=0}^{T} \psi j \Delta \mathrm{Dexp}^{-}{}_{t-j} + \sum_{j=0}^{T} \pi j \Delta \mathrm{S}^{+}{}_{t-j} + \sum_{j=0}^{T} \pi j \Delta \mathrm{S}^{-}{}_{t-j} + \sum_{j=0}^{T} \lambda j \Delta \mathrm{T}^{+}{}_{t-j} + \sum_{j=0}^{T} \Omega j \Delta \mathrm{T}^{-}{}_{t-j} + \sum_{j=0}^{T} \pounds \Delta \mathrm{U}_{t-j} + \lambda_1 \mathrm{ES}_{t-1} + \lambda_2 \mathrm{Dexp}^{+}{}_{t-1} + \lambda_3 \mathrm{Dexp}^{-}{}_{t-1} + \lambda_4 \mathrm{S}^{+}{}_{t-1} + \lambda_5 \mathrm{S}^{-}{}_{t-1} + \lambda_6 \mathrm{T}^{+}{}_{t-1} + \lambda_7 \mathrm{T}^{-}{}_{t-1} + \lambda_8 \mathrm{U}_{t-1} + \varepsilon_t \quad \textbf{(13)}$$

Such models are referred regarded as asymmetric or nonlinear ARDL models because they include partial sum (positive and negative) variables in Eq. (13), whereas the earlier model (4) is a symmetric or linear ARDL model.

## 3.4 Diagnostic Tests

Performing several diagnostic tests is essential in time series analysis. Several diagnostic approaches for assessing a time series' dependence (correlation) structure have been presented in the literature. No linear function of the delayed variables can accurately represent the behaviour of the current variable if the time series is serially uncorrelated. No linear or nonlinear function of the delayed variables may adequately capture the behaviour of the current variable if the time series is a catastrophic difference sequence. There is no connection between both the present and previous variables in a serially independent time series. As a result, conducting diagnostic testing on data series demonstrates how these data may well be represented. After estimating a model, diagnostic tests can be run to analyze model residuals as well as serve as model adequacy tests (Kuan, 2008).

### 3.4.1 CUSUM and CUSUM Square Test

CUSUM tests are commonly used in regression models and statistics to determine whether a regression equation of interest has structural changes (or structural breaks). The interpretation was based on a series of a total of standardized residuals from frequent pattern sub - samples that were calculated repeatedly. A structural break happens in econometrics and statistics when the parameters of regression models change unexpectedly over time, resulting in severely biased estimations and projections as well as model unreliability (Andrews, 1993; Chu et al. 1996; Zeileis et al. 2005). The CUSUM of squares testing is recommended because it is especially effective at detecting changes in conditional variables of the model, regardless of whether the variance of the regression error is included in the set of variables shifting, particularly at the end of the sample.

### 3.4.2 Jarque-Bera Test

A data sample's ability to demonstrate the skewness and kurtosis of a normal distribution is determined by the Jarque-Bera test (Jarque and Bera, 1980). The normalcy of the error term is examined using the Jarque-Bera test. If the error term is normally distributed, the parameters are thought to be normally distributed. As a result, both the T-test and the F-test will be valid.

The Jarque-Bera test statistics are stated as follows:

JB = $\frac{n}{6}\left(S^2 + \frac{1}{4}\ (k-3)^2\right)$

Where n stands for the number of observations (or degrees of freedom), S for sample skewness, and K for sample kurtosis. Jarque-Bera (JB) test follows Chi-distribution.

### 3.4.3 Ramsey RESET Test

A statistical method for evaluating the generic linear regression model specifications is the Ramsey Regression Equation Specification Error Test (RESET). In 1968, Ramsey developed this exam. It looks at the possibility that non-linear combinations of fitted values might help to explain the response variable. The test implies that the model is mis specified and that the data generation process could be adequately described by a polynomial or other non-linear functional forms even if non-linear combinations of explanatory factors had any power to interpret the response parameters (Ramsey, 1974).

### 3.4.4 Breusch–Pagan Test

In 1979, Trevor Breusch and Adrian Pagan developed the Breusch Pagan analysis, which is used in statistics to determine if a linear regression analysis has heteroskedasticity. That is the foundation of the Breusch Pagan assessment. A chi-squared test was used. This is because the statistical test has an n2 with k degrees of freedom distribution. The null hypothesis of heteroskedasticity is accepted and homoskedasticity is rejected if the test statistic's p-value is less than a specific cutoff (for example, p=0.05).

## 3.5 Data Source of Variables

This study examines the impact of fiscal policy components on environmental sustainability in Pakistan during a period ranging from 1974 to 2020. The World Development Indicator (WDI) and the Pakistan Economic Survey are the data sources.

Table 3.1

*Data Source of Variables*

| Variables | Description of variables | Definitions | Source |
|---|---|---|---|
| ES | | We make the index of environmental sustainability using PCA | Self-constructed |
| DE | Development expenditure as % of expenditures | Development expenditure is government spending that helps economic growth by increasing productivity and the country's actual income. | ESP |
| S | Subsidy as a% of expenditures | All unrequited, nonrefundable current account transfers to commercial and public industries; and cash as well as in social security, social assistance, and employer welfare programs are examples of subsidies, financial assistance, and other welfare programmes. | ESP |
| T | Trade as a % of GDP | Trade is defined as the total volume of goods and services delivered and received expressed as a share of GDP. | WDI |
| U | Urban population as a % of the total population | According to national statistics agencies, the urban population is made up of people who live in urban regions. | WDI |

Note: ES is environmental sustainability, DE is development expenditure, S is a subsidy, T is the trade and U is urbanization.

ESP is an economic survey of Pakistan, and WDI is a world development indicator.

## 3.6 Description of Variables

A variable in research is usually a person, place, item, or phenomenon that is being evaluated in some way. Looking at what the terms themselves indicate about the variable is the simplest way to comprehend the relationship between a dependent and an independent variable.

### 3.6.1 Environmental Sustainability

Environmental sustainability is the dependent variable. This study makes the environmental sustainability index, which is explained in the next chapter.

### 3.6.2 Development Expenditure

Development expenditure is used as one of the independent variables. Development expenditure refers to government spending that helps economic growth by increasing the production and the actual income of a country. There are two types of revenue development spending: revenue development spending and capital development spending. Government spending and taxation are fiscal instruments that are both directly and indirectly related to economic growth, farming, manufacturing, and services productivity patterns, aggregated energy usage, and protection of the environment. Fiscal policy instruments affect the environment in a variety of ways. A budget deficit in any economy stimulates cumulative economic growth and accumulating, business investment, and energy demand (Dongyan, 2009; Balcilar et al. 2016)

### 3.6.3 Subsidy

The subsidy is taken as an independent variable in this study. Subsidies, financial assistance, as well as other welfare programs include all unrequited, nonrefundable current account transfers to corporate and public industries, cash as well as in-kind social security, social assistance, and employer welfare programmes. Complete update at the end of the financial period equals financial information at the beginning of the period plus flows during the period. Current subsidies data particularly include the data on energy subsidies, cash transfers and food items.

### 3.6.4 Trade

Trade is the second control variable. Most of the developing countries are open economies, so we have included trade in our model. Trade is defined as the sum of goods and services which are supplied and purchased as a percentage of GDP. As earnings rise as a result of trade and prosperity, the need for environmental restrictions is likely to rise as well (Cole and Elliott, 2003). A country's ability to specialize in the manufacture of goods and services over which it has an edge over its competitors is enabled by trade. As a result, carbon emissions are expected to determine if additional energy is required in the production chain of a sector in which a country now produces more due to its highly competitive advantage (Dogan and Turkekul, 2016).

### 3.6.5 Urban Population

The controlling factor is the urban population. According to national statistics agencies, the urban population consists of those who resided in urban areas. The indicator is determined using data from the World Bank's urbanization and population ratios as well as the United Nations' World Urbanization Prospects. Urban percentages are the proportion of the population that resides in an area that has been categorized as "urban" as a whole. They are computed by the Statistics Division of the Department of Economic and Social Affairs of the United Nations. More care should be used when analyzing urban area percentages for various nations. Each nation has a different system for designating its people as "urban" or "rural." The limits that are set determine the population of a city or metropolitan region.

## 3.7 Methodology to Construct Composite Index

Designing a composite index is a difficult process consisting of various stages that influence the outcome and validity of the findings. The primary issues with this technique are the theoretical framework chosen for data availability and the selecting of further relevant parameters, as well as their treatment to compare and combine them. It is essential to identify the following measures to address in a short period (Mazziotta and Pareto, 2012).

1. Determining the phenomena to be investigated: The concept should be expressed so that it is apparent what the composite index is measuring. This must connect to a theoretical foundation that links different sub-groups and indicators together.
2. Choosing a set of independent variables: In an idealistic situation, indicators would be chosen based on their relevance, analytical soundness, timeliness, and accessibility, among other factors. The selection stage is the outcome of a trade-off between the danger of losing information and the possibility of redundancies caused by overlapping information. A statistical technique for indicator selection entails evaluating the correlation between prospective indicators and then considering those that have the lowest correlation to prevent repetition (Salzman 2003).
3. Normalization of the individual indicators: This stage tries to bring the parameters closer together. Before any data aggregation, normalization is necessary since the indicators in a data collection frequently have different measurement units. As a result, it is necessary to standardize the indicators by converting them to pure, dimensionless numbers. Another justification for normalization is the potential that certain factors may be favorably connected with the phenomenon under study (positive "polarity"), while others may be negatively correlated with it (negative "polarity"). We would like to normalize the data so that when the normalized indicators rise, the composite index rises as well. Normalization techniques include ranking, rescaling (or min-max transformation), standardization (or z-scores), and indication (index number transformation or "distance" to a reference).

4. Adding the normalized indicators together: It is the creation of one or more composite indices by combining all of the components (mathematical functions). A variety of aggregating methods are available. The most common methods are additive techniques, which range from accumulating weighted modifications of the real parameters to adding up unit ranks in each indicator. Principal Component Analysis (Dunteman, 1989) and other multivariate techniques are frequently employed.

The definition of the phenomena and the choice of indicators, which are essential to notice, are indistinguishable from the statistical technique component; as a result, the choice of individual variables is not independent of the aggregated approach.

There is no common approach for constructing composite indexes. In each case, the application has a significant influence on the design, which includes both formal and heuristic components as well as some experience in the subject of the phenomena. Nonetheless, the benefits of composite indices are obvious, and they include one-dimensional measurement of phenomena, ease of interpretation of numerous individual indicators, and ease of data processing (e.g., ranking units and comparing their performance over time).

### 3.7.1 Frequently Used Indicators of the Environmental Sustainability Index

Table 3.2

*Indicators of Environmental Sustainability*

| S.No | Indicators | Sources |
|---|---|---|
| 1 | Energy intensity, Carbon dioxide intensity, per capita $CO_2$ emissions, $CO_2$ emissions from energy generation, and forestry change ratio | Shah et al., (2019) |
| 2 | Greenhouse gases ($CO_2$, N2o, Ch4, HFCs, PFCs, SF6), organic substances, inorganic substances, heavy metals, POPs, water quantity and soil degradation | Blanc et al., (2008) |
| 3 | Carbon dioxide emission, methane emission, water pollution and deforestation | Babcicky, (2013) |
| 4 | Crop concentration index, soil stress, nitrogen risk factor, soil reaction, soil compaction, soil salinity, surface water reaction, ground water reaction and soil fertility problem | Sabiha et al., (2016) |
| 5 | Minimize environmental stress, lessen human sensitivity, increase institutional and social capability, and practice global stewardship | Cui et al., (2004) |
| 6 | Environment system, reduce environment stress, human susceptibility, global stewardship and social and institutional capacity | Jha and Murthy, (2003) |

### 3.7.2 Principal Component Analysis (PCA)

PCA (principal component analysis) is a technique for reducing the size of a data set using statistics. Pearson and Hotelling created it in 1901 and 1933, respectively, with Jolliffe (2002) serving as the most authentic source. The principal component analysis is a computational complexity method that reduces the complexity of large datasets by reducing a large set of variables into a smaller subset that preserves the portion of the information in the larger set. Naturally, a data set's accuracy suffers when the number of parameters is reduced. Smaller data sets are easier to examine and interpret, and machine learning algorithms can interpret data more efficiently and easily without having to deal with unnecessary elements, therefore the approach to dimensionality reduction is to compromise some accuracy for simplicity. By reducing the number of related features, PCA proves to be effective without required data labelling (too many can cause over fitting).

In linear regression, PCA is beneficial in a variety of ways.

- Identifying and removing multi-co-linearity from the data.
- The input space's dimension is reduced, resulting in fewer parameters and "easier" regression.
- Concerning the previous statement, the PCA choice of base reduces the variance of the regression coefficient estimator.

Before applying PCA to extract weights, the main step is to normalize the indicators to make it is unit less because different indicators are measured in different units. Many studies used different techniques; we used the minimum and maximum transformation techniques.

Mathematically, if we have a series of n correlated indicator variables; PCA is used to generate uncorrelated components such that each component Zi is a linear combination of the indicators $Y_1$, $Y_2$ . . . . $Y_n$ is the set that the maximum variance is removed from the variables.

$$Z_1 = \alpha_{11} \left[\frac{Y_1 - \overline{Y_1}}{S_1}\right] + \alpha_{12} \left[\frac{Y_2 - \overline{Y_2}}{S_2}\right] + \ldots\ldots\ldots\ldots\ldots + \alpha_{1n} \left[\frac{Y_n - \overline{Y_n}}{S_n}\right]$$

$$Z_2 = \alpha_{21} \left[\frac{Y_1 - \overline{Y_1}}{S_1}\right] + \alpha_{22} \left[\frac{Y_2 - \overline{Y_2}}{S_2}\right] + \ldots\ldots\ldots\ldots\ldots + \alpha_{21} \left[\frac{Y_n - \overline{Y_n}}{S_n}\right]$$

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

$$Z_n = \alpha_{n1} \left[\frac{Y_1 - \overline{Y_1}}{S_1}\right] + \alpha_{n2} \left[\frac{Y_2 - \overline{Y_2}}{S_2}\right] + \ldots\ldots\ldots\ldots\ldots + \alpha_{nn} \left[\frac{Y_n - \overline{Y_n}}{S_n}\right]$$

Where α's are the weights that are assigned to the n principle component, and s is the standard deviation. Here a constraint is put on the weights that $\alpha\ \alpha \doteq 1$, that is, squared weights must sum to one. The weights for the first component $Z_1$ are chosen such that this component has the largest variance and $Z_2$ has the second large variance and so on. To find the Eigen values, PCA requires the use of a covariance matrix. As a result, an example of a covariance matrix is as follows:

$$CM = \begin{bmatrix} \alpha_{11} \left[\frac{Y_1 - \overline{Y_1}}{S_1}\right] & \cdots & \alpha_{1n} \left[\frac{Y_n - \overline{Y_n}}{S_n}\right] \\ \vdots & \ddots & \vdots \\ \alpha_{n1} \left[\frac{Y_1 - \overline{Y_1}}{S_1}\right] & \cdots & \alpha_{nn} \left[\frac{Y_n - \overline{Y_n}}{S_n}\right] \end{bmatrix}$$

The variances of the principal components are shown by the Eigen values of the matrix CM, which can be determined by solving the characteristic equation and representing the variances of the principal components. The following equation can be used to obtain the Eigen vector.

$$|\, CM - \lambda I \,| = 0$$

The principal component analysis (PCA), a linear transformation that transforms data into a new coordinate system, places the greatest variance of any projection of the data on the first coordinate, the second greatest variance on the second coordinate, and so on. The new set of variables, the principal components, is linear functions of the original variables. This is often accomplished by calculating the covariance matrix for the complete collection of data. Then, eigenvectors and Eigen values of the covariance matrix are computed, and the eigenvectors and Eigen values are organized in decreasing order of Eigen value. It is vital to keep in mind that the bias of PCA is not always suitable; depending on the application, characteristics with low variance may have a considerable predictive relevance (Sewell 2008).

## 3.8 Description of Indexing Variables

### 3.8.1 Level of Water Stress

After adjusting for environmental water needs, the ratio of total freshwater extraction as a percentage of available freshwater resources, as reported by all significant sectors, indicates the degree of water stress. The major industries, according to ISIC standards, are manufacturing, the electrical sector, services, forestry and fisheries, and agriculture. The term "water withdrawal intensity" is another name for this metric.

### 3.8.2 Fossil Fuel

Products made from coal, oil, petroleum, and natural gas all qualify as fossil fuels. The International Energy Agency gathers data about energy (IEA). The International Energy Agency (IEA) bases its statistics for economies that are not OECD members on national energy data that has been updated to match yearly questionnaires filled out by OECD member states. Data on combustible renewable and waste are frequently based on minuscule surveys or other incomplete information, providing only a basic picture of changes and making it challenging to compare them across countries. Some of these disparities are explained in the IEA reports with national notes. All types of energy are converted to oil equivalents, including primary energy and primary electricity. For turning nuclear electricity into oil equivalents, a theoretical thermal efficiency of 33% is assumed, whereas hydroelectric power conversion efficiency is considered to be 100%.

### 3.8.3 Methane (Ch4)

Human-caused methane emissions include those from agriculture and industrial methane generation. Described in CO2 equivalents using the GWP100 measure from the IPCC's Second Assessment Report, with CH4 (GWP100=21) included. The global warming potential is used to convert emissions into carbon dioxide equivalents, this enables comparison of the effective contributions of other gases. A kilogramme of methane is 21 times more effective than a kilogramme of carbon dioxide at trapping heat in the earth's atmosphere within 100 years.

### 3.8.4 Nitrous Oxide Emissions (N2O)

Combustion of fossil fuels, pesticides, forest fires, and livestock manure are the primary sources of nitrogen oxide emissions. Nitrous oxide is a potent greenhouse gas, with a 114-year atmospheric lifespan compared to 12 years for methane. Nitrous oxide has over 310 times the global temperature rise potential of carbon dioxide per kilogramme within 100 years. The global warming potential is used to convert emissions into carbon dioxide equivalents, allowing for comparison of the effective contributions of other gases.

### 3.8.5 Carbon Dioxide Emissions (CO2)

The majority of greenhouse gases connected to global warming are carbon dioxide emissions, which are mostly byproducts of energy generation and use. Cement production and fossil fuel burning account for the majority of human-produced carbon dioxide emissions. Various fossil fuels release different quantities of CO2 for the same quantity of energy: oil emits around 50% more CO2 than natural gas, while coal emits roughly twice as much. For every metric tonne of cement produced, over half a tonne of carbon dioxide is released. Carbon dioxide emissions come from the burning of fossil fuels and the production of cement, but they do not come from land use practices like deforestation. Any weight may be expressed using the kt unit of measurement (kiloton).

Elemental carbon is commonly utilized in the calculation and quantification of Carbon dioxide emissions. They were transformed to actual CO2 mass by multiplying them by 3.667.

### 3.8.6 Total Forest Area (TFA)

The forest area refers to the area of any land classified or governed as forest under any legal authority dealing with forests. Every cultivated area that may occur within a forest is listed under the heading "cultivated area."

## 3.9 Data Source of Indicators of Environmental Sustainability

The effect of fiscal policy on environmental sustainability is examined in this study. We use several measures to create the environmental sustainability index, including the amount of water stress, fossil fuel use, the total area covered by forests, methane emissions, carbon dioxide emissions, and nitrous oxide emissions. The information is gathered from the Pakistani economic survey and the global development indicators. The table below provides a description and brief meanings for each term.

Table 3.3

*Data Source of Indicators of Environmental Sustainability*

| Variables | Description of variables | Definitions | Source |
|---|---|---|---|
| WS | percentage of freshwater withdrawal to total freshwater resources | Water stress arises when the consumption of water surpasses the available supply during a specific period as well as when poor quality limits its use. | WDI |
| FF | % of total energy consumption | Fossil fuels are created when plants and animals break down. These fuels, which include carbon and hydrogen and are present in the crust of the Earth, may be burnt to produce energy. Natural gas, petroleum, and charcoal are examples of fossil fuels. | WDI |
| TFA | % of the total area | The area of any land categorised or controlled as forest under any legal law dealing with forests is referred to as forest area. Every cultivated area that could exist within such a forest is displayed under the heading "cultivated area." | ESP |
| CO2 | Kt | Burning fossil fuels and making cement both result in carbon dioxide emissions. One of them is carbon dioxide, which is created when fuels that are solid, liquid, or gas are burned as well as when gas is flared. | WDI |
| N2O | thousand metric tons of CO2 equivalent | Burning agricultural biofuels, the chemical sector, and animal husbandry all contribute to nitrous oxide emissions. | WDI |
| CH4 | Kt of co2 equivalent | Methane is the most basic hydrocarbon, with one carbon atom and four hydrogen atoms. Methane seems to be an extremely major contributor to global warming. | WDI |

NOTE: WS is the level of water stress, FF is a fossil fuel, TFA is a total forest area, CO2 is carbon dioxide emission, N2O is nitrous oxide emission and CH4 is methane emission.
WDI is the world development indicator and ESP is the economic survey of Pakistan.

# CHAPTER 4

# CONSTRUCTION OF ENVIRONMENTAL SUSTAINABILITY INDEX

This chapter explains the construction of the environmental sustainability index. Section 4.1 present the descriptive statistics of the index indicators, while section 4.2 show the pair-wise correlation between the variables which are used to make an index. Section 4.3 present the Eigen value while the last section shows the factor loading of each component and the graph of scree plot of Eigen values after applying the principle component analysis PCA.

## 4.1 Descriptive Statistics

The initial step in the analysis is to report descriptive statistics. Descriptive statistics is the branch of statistics that deals with quantifying knowledge. The number of observations of all variables contained in the sample is reported first, followed by the central tendency, which comprises mean, minimum, and maximum values, and finally the standard deviation, this is often used as a measurement of mean dispersion.

Table 4.1

*Descriptive Statistics of Indicators*

| Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| WS | 47 | 105.83 | 10.544 | 94.256 | 122.692 |
| FF | 47 | 53.387 | 8.369 | 36.522 | 62.476 |
| CH4 | 47 | 11689.324 | 3085.109 | 6324.727 | 15850 |
| N2O | 47 | 35831.662 | 15738.307 | 14308.825 | 64250 |
| CO2 | 47 | 96505.641 | 57920.648 | 21418.947 | 237246.67 |
| TFA | 47 | 4.551 | .826 | 2.6 | 5.715 |

*Note:* WS is water stress, FF is a fossil fuel, CH4 is methane, N2O is nitrous oxide emissions, CO2 is carbon dioxide emissions and TFA is total forest area.

Table 4.1 shows that the average value of water stress in Pakistan from 1974 to 2020 was 105; its minimum value is 94, while its maximum value is 122 because ineffective management is to blame for Pakistan's water challenges. Water management is difficult due to unequal access and distribution, population growth, urbanization, rising industrialization, a shortage of storage capacity, and climatic risk. The fossil fuel average value is 53, the minimum value is 36, and the maximum value is 62. The standard derivation is 8, which shows the dispersion of the mean. The minimum value of methane is 6324.727 and the maximum value is 15850, Pakistan's main source of methane emissions is agricultural output. Around 32% of all human-caused methane emissions come from livestock and cows' gastro-enteric discharges. This proportion is likely certainly much greater considering Pakistan is one of the world's top dairy producers. The average value of methane is 11689.324. Moreover, the average value of Nitrous oxide is 35831.662, its minimum value is 14308.825 and its maximum value is 64250. Pakistan's nitrous oxide emissions reached 60,950 thousand metric tons in 2018. Pakistan's nitrous oxide emissions increased by 2.58 per cent annually from 37,810 thousand metric tons to 60,950 thousand metric tons from 1999 to 2018 respectively.

The average value of carbon dioxide is 96505.641; the minimum value is 21418.947; and the maximum value is 237246.67 because natural gas is the primary source of carbon dioxide emissions in Pakistan from the burning of fossil fuels, accounting for more than 40% in 2018-19. The major contributors to CO2 emissions from gas are the power, household, and industrial sectors, followed by the fertilizer sector. The average value of the total forest area is 4.551, while the minimum value is 2.6 and the maximum value is 5.7. In Pakistan, forests and planted trees cover 4.2 million hectares or 4.8 per cent of the total land area. Compared to a global average of 1.0 hectares, Pakistan has less forest per capita at almost 0.05 hectares.

## 4.2 Pair-Wise Correlations

A pair-wise correlation matrix is a table that presents the coefficients of correlation between two variables. Each table cell displays the relationship between two variables. Data can be summarized using a correlation matrix, and it can also be used as input for more complex investigations or as a diagnostic instrument for more analysis.

Table 4.2

*Pair-Wise Correlations among the Indicator of Environmental Sustainability*

| Variables | Water stress | Fossil fuel | Methane | Nitrous oxide | Carbon dioxide | Total forest area |
|---|---|---|---|---|---|---|
| Water stress | 1.000 | | | | | |
| Fossil fuel | 0.813* | 1.000 | | | | |
| | (0.000) | | | | | |
| Methane | 0.719* | 0.719* | 1.000 | | | |
| | (0.000) | (0.000) | | | | |
| Nitrous oxide | 0.912* | 0.919* | 0.641* | 1.000 | | |
| | (0.000) | (0.000) | (0.000) | | | |
| Carbon dioxide | 0.814* | 0.990* | 0.776* | 0.919* | 1.000 | |
| | (0.000) | (0.000) | (0.000) | (0.000) | | |
| Total forest area | -0.921* | -0.854* | -0.664* | -0.884* | -0.844* | 1.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | |

*Note.* *** $p<0.01$, ** $p<0.05$, * $p<0.1$

The result indicates that methane, nitrous oxide, carbon dioxide, and fossil fuels are all significantly and positively correlated with water stress. But water stress has a significant and negative correlation with total forest area. Fossil fuel also has a significant and positive correlation with methane, nitrous oxide, and carbon dioxide. While with the total forest area, it has a significant but negative correlation. Water stress, fossil fuels, and carbon dioxide all have a considerable and strong positive correlation with nitrous oxide, although methane has a significant but weakly positive correlation. While nitrous oxide has a strong, but negative, relationship with total forest area. Whereas the total forest area exhibits a statistically significant and negative relationship with all of the factors because when the forest increases the land will be clean so the gas emissions will decrease.

## 4.3 Eigen Values

A specific set of scalar values known as Eigen values is connected to a set of linear equations, often frequently in matrix equations. Characteristic roots are used to describe the eigenvectors. After linear transformations, it is just a non-zero vector which can only be altered by its scalar factor.

Table 4.3

*Eigen Values of Components*

| Component | Eigen value | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp1 | 5.146 | 4.710 | 0.858 | 0.858 |
| Comp2 | 0.436 | 0.147 | 0.073 | 0.930 |
| Comp3 | 0.289 | 0.187 | 0.048 | 0.979 |
| Comp4 | 0.102 | 0.078 | 0.017 | 0.995 |
| Comp5 | 0.024 | 0.020 | 0.004 | 0.999 |
| Comp6 | 0.003 | -- | 0.001 | 1.000 |

Based on Kaiser Criterion, the first component is used to construct the index of environmental sustainability, the Eigen value of the first component is 5.146 and it's explaining 86 per cent variation as shown in table 4.3. According to Kaiser (1960), an Eigen value greater than 1 indicates that the component explains the variability of more than one variable.

## 4.4 Factor Loadings of Each Component

Correlation coefficients among observable variables as well as latent common factors are known as factor loadings. Factor loadings are frequently referred to as regression weights or standardized regression coefficients.

Table 4.4

*Factor Loading of each Component.*

| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Comp6 | Unexplained |
|---|---|---|---|---|---|---|---|
| Ws | 0.412 | -0.170 | -0.574 | 0.362 | 0.557 | 0.176 | 0 |
| Ff | 0.422 | -0.051 | 0.510 | -0.157 | 0.475 | -0.556 | 0 |
| Ch4 | 0.355 | 0.882 | -0.201 | 0.036 | -0.175 | -0.156 | 0 |
| N2o | 0.421 | -0.329 | 0.094 | 0.545 | -0.596 | -0.229 | 0 |
| Co2 | 0.425 | 0.074 | 0.478 | -0.052 | -0.006 | 0.763 | 0 |
| Tfa | -0.411 | 0.279 | 0.365 | 0.737 | 0.277 | 0.026 | 0 |

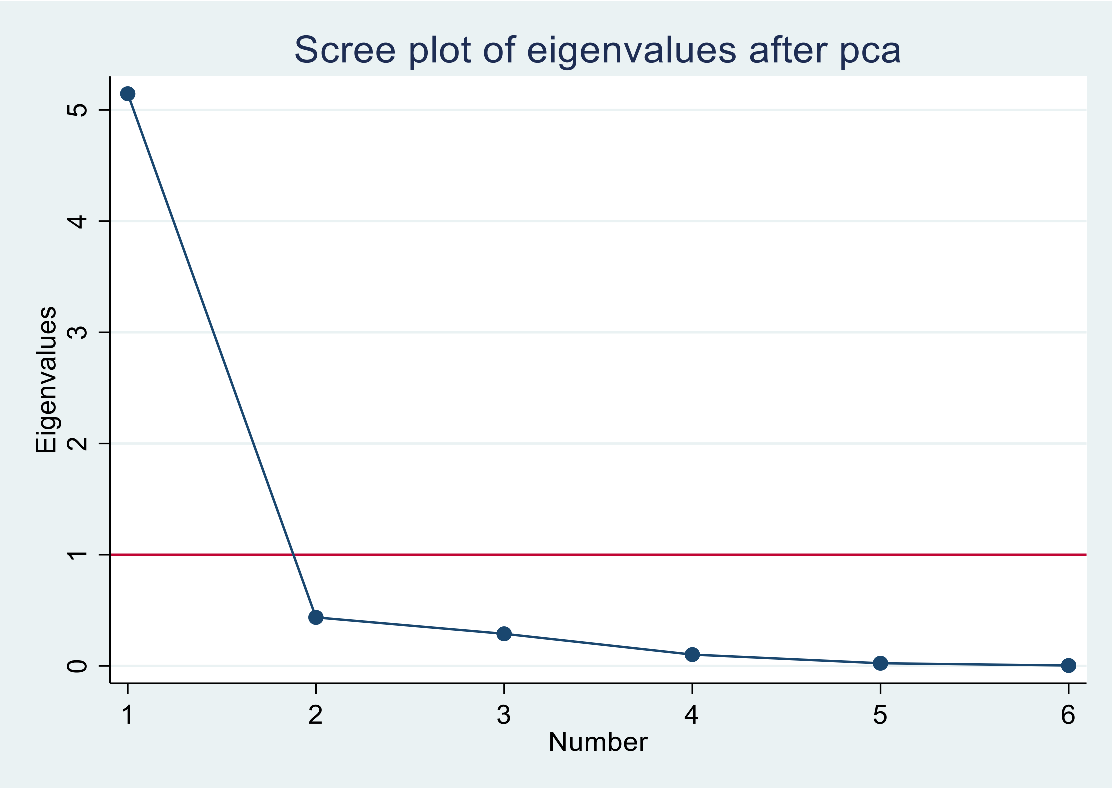
KMO= 0.6535

WS is water stress, FF is a fossil fuel, CH4 is methane, N2O is nitrous oxide, Co2 is carbon dioxide and TFA is total forest area.

The sampling adequacy is measured by KMO, which is 0.6535. It accepts values in the 0 to 1 range. The values near 0 are regarded unsuitable, whilst values close to 1 are considered suitable. The scree plot given in the below figure also confirms that we should retain only the first component.

Figure 3.1

*Scree Plot*




Thus to construct an index of environmental sustainability, the factor loadings of the first component are used to find the Weighted sum to construct an index.

# CHAPTER 5

# RESULTS AND DISCUSSION

The research findings are described in the results section of this chapter, whereas the interpretation and importance of the findings are covered in the discussion section. Section 5.1 displays the variables' descriptive statistics. The unit root test, which is present in the 5.2 Section, demonstrates that all parameters are co-integrated at both the level and the first difference. While the pair wise correlation is given in the 5.3 section. The results of the short-run and long-run ARDL models are presented in detail in Section 5.4. On the other side, the 5.5 section has a detailed description of the NARDL model's detailed results. Then, several diagnostic tests are applied to investigate model misspecification, serial correlation, heteroskedasticity, data stability, and data normality.

## 5.1 Descriptive Statistics

Descriptive statistics is a branch of statistics in which data collection is evaluated. Descriptive statistics are used to summaries a set of data. Each model's descriptive statistics are listed below:

Table 5.1

*Descriptive Statistics.*

| Variable | Obs | Mean | Std. Dev. | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| ESI | 47 | 47.167 | 69.033 | 2.17 | 99.99 | 0.4705265 | 2.04136 |
| S | 47 | 5.521 | 3.615 | 1.4 | 18.6 | 1.384879 | 5.157283 |
| De | 47 | 23.653 | 8.395 | 10.1 | 42.8 | 0.4918126 | 2.450642 |
| T | 47 | 32.126 | 3.522 | 25.306 | 38.499 | -.2947384 | 2.2536 |
| U | 47 | 32.036 | 3.206 | 26.005 | 37.165 | -.1913377 | 1.903096 |

Note: Normal Skewness: 0, Mesokurtic: Kurtosis of 3
ESI is Environmental Sustainability, S is Subsidy, De is Developmental Expenditure, T is Trade and U is Urbanization

The results start with the descriptive statistics of the dataset. The descriptive statistics with all selected parameters are presented in the above table 5.1. A statistical summary is a numerical representation of the most important aspects of data. Summarizing a sample instead of the total population also explains the number of observations. The standard deviation, minimum, and maximum values are used as indicators of inconsistency, whereas the mean is used as an indication of central tendency. To measure the normality we consider the skewness and kurtosis. Kurtosis is a measure of the peakness and flatness of the series distribution. Skewness is used to quantify the degree of asymmetry in the series.

Table 5.1 displays the total number of observations for all variables used in the model from 1974 to 2020. The environmental sustainability index has 47 observations. The minimum value of environmental sustainability is 2.17 and the maximum value is 99.99 while the standard deviation is 69.033 which shows dispersion from the average value. The value of Skewness is 0.4705265 which is normally distributed around its mean. The kurtosis value is 2.04136 which is Platykurtic (negative kurtosis) because its value is lower than 3, which shows the flatted curve. With the 5.521 average value, the minimum value of the subsidy is 1.4 and the maximum value is 18.6, which is increasing year by year. This is due to the reason that Pakistan is a developing country and there are a lot of infant industries, so the government has to give them subsidies to grow further. The standard deviation is 3.615, indicating dispersion from the average value. The skewness value is 1.384879, which shows positive skewness (long right tail). The value of kurtosis is 5.157283, which is leptokurtic (positive kurtosis) because its value is greater than 3, so it shows the peaked curve. The average value of development expenditure is 23.653. Their minimum value is 10.1 and their maximum value is 42.6, while the standard deviation is 8.395, which shows dispersion from the average value. The skewness value is 0.4918126, which shows the distribution has symmetry around its mean. The value of kurtosis is 2.450642, which is platykurtic (negative kurtosis) because its value is lower than 3, so it shows a flattened curve.

Trade and urbanization are our control variables. Trade % of GDP with 47 observations, the average value is 2.088, with a minimum value of 25.306 and a maximum value is 38.499, and the standard deviation is 38.499, which shows the dispersion from the average value. The value of skewness is -.2947384. This value shows that it is slightly skewed. The value of kurtosis is 2.2536, which is platykurtic (negative kurtosis) because its value is lower than 3, which shows the flattened curve. Urbanization has an average value of 32.03. Their minimum value is 26.005; their maximum value is 37.165. However, the value of the standard deviation is 3.206, which shows the dispersion from the average value. The skewness value is -.1913377, which indicates a skewed slightly. The kurtosis value of 1.903096 is platykurtic (negative kurtosis) because it is less than 3, indicating a flattened curve.

## 5.2 Unit Root Test

The following step is to make sure that all the variables are stationary because if a variable's data is non-stationary, all regression analysis results will be spurious. Unit root tests are always performed before the regression analysis to verify the stationary of the variables. The Phillips Perron (PP) and Augmented Dickey-Fuller (ADF) tests are performed in this investigation to determine whether the variables were stationary.

Table 5.2

*Unit Root Tests*

| **Variables** | **Level** | | **Difference** | | **Decision** |
|---|---|---|---|---|---|
| | **ADF** | **PP** | **ADF** | **PP** | |
| | -1.829 | -1.336 | -6.242 | -6.262 | |
| ESI | 0.108 | 0.126 | 0.0000 | 0.0000 | I(1) |
| | -3.324 | -3.228 | -9.082 | -10.105 | |
| S | 0.0139 | 0.0184 | 0.0000 | 0.0000 | I(0) |
| | -1.571 | -1.459 | -7.163 | -7.223 | |
| DE | 0.4982 | 0.5538 | 0.0000 | 0.0000 | I(1) |
| | -2.310 | -2.369 | -6.654 | -6.661 | |
| T | 0.1688 | 0.1506 | 0.0000 | 0.0000 | I(1) |
| | -8.421 | -5.008 | -2.051 | -2.075 | |
| U | 0.0000 | 0.0000 | 0.0000 | 0.0000 | I(0) |

Environmental sustainability, development expenditure and trade are stationary at the first difference, according to the results of the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests, which both have p-values above 0.05. Subsidy and urbanization population are stationary at the level because their p-value is less than 0.05.

## 5.3 Pair-Wise Correlations

After the checking stationery of the parameters, the following step is to analyze the pair wise correlation among the variables.

Table 5.3

*Pair Wise Correlations*

| Variables | ESI | S | DE | T | U |
|---|---|---|---|---|---|
| **ESI** | 1.000 | | | | |
| **S** | 0.164 | 1.000 | | | |
| | (0.271) | | | | |
| **DE** | 0.796* | 0.298* | 1.000 | | |
| | (0.000) | (0.042) | | | |
| **T** | 0.195 | -0.089 | 0.051 | 1.000 | |
| | (0.189) | (0.552) | (0.735) | | |
| **U** | -0.991* | -0.164 | -0.770* | -0.251 | 1.000 |
| | (0.000) | (0.272) | (0.000) | (0.089) | |

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: ESI is environmental sustainability index, S is a subsidy, DE is development expenditure, T is a trade and U is urbanization

The above table shows that the environmental sustainability index has an insignificant linear relationship with subsidies and trade, which might be due to the existence of a non-linear link between the variables. While with the developmental expenditure ESI has a significant and positive correlation. ESI is statistically significant but negative correlation with urbanization. Development expenditure has a significant correlation with subsidy because when the government gave more spend on subsidies the development expenditure will reduce. Development expenditure has negative and significant relation, due to the increase in urbanization, the expenditure of developmental projects could not be fulfilled. With trade, it has insignificant and positive co-relation of development expenditure. Subsidies have insignificant and negative co-relation with trade because when the government gave subsidies on food items the export will reduce automatically. Subsidies also have insignificant and negative co-relation with urbanization.

Trade has also an insignificant and negative co-relation with urbanization because urbanization causes a decline the exports while imports will increase.

## 5.4 Auto Regressive Distributed Lag Model (ARDL)

The ARDL co-integration technique is superior in dealing with parameters that are integrated at various orders, I (0), I(1), or a combination of the two. This is because it is strong since there is only one long-run relation among the independent variables in a small sample size. The F-statistic is used to evaluate the long-term relationship between the underlying variables (Wald test). In this method, the series long-run relationship is considered as being formed if the F-statistic value is higher than the critical value. The main benefit of this technique is that it can locate many co-integrating vectors.

Table 5.4

*Co-integration Test Statistics*

| Test statistics | Value |
|---|---|
| F_PSS | 7.999 |
| T | -6.128 |

Table 5.5

*Critical Values*

| | Critical values | |
|---|---|---|
| Level of sig | I(0) | I(1) |
| 1% | 3.740 | 5.060 |
| 5% | 2.860 | 4.010 |
| 10% | 2.450 | 3.520 |

Before discussing the symmetric effect of variables, we checked the co-integration between variables, in the ARDL framework and the results are shown in table 5.5 According to Pesaran et al., (2001), if the F-stat value, which is 7.999 in our study, is greater than the critical value of the upper bound it indicates the presence of symmetric co-integration among variables. Since the critical values suggested by Pesaran et al., (2001) are appropriate for large sample sizes, we have compared the F-stat value with the critical values, the critical values are given in table 5.4. Because the F-stat value in table 5.4 is greater than the upper bound value at the 1% level of significance, we determined that the variables have a long-run equilibrium relationship.

Table 5.6

*ARDL Long-Run Results*

| **D.esi** | **Coef.** | **Std. Err.** | **T** | **P>t** |
|---|---|---|---|---|
| ECM | -0.988 | 0.196 | -5.040 | 0.000 |
| Subsidy | 0.065 | 0.035 | 1.850 | 0.078 |
| Development expenditure | -0.060 | 0.029 | -2.080 | 0.049 |
| Trade | -0.130 | 0.031 | -4.240 | 0.000 |
| Urbanization | -0.204 | 0.006 | -35.660 | 0.000 |

Table 5.7

*ARDL Short-Run Results*

| D.esi | Coef. | Std. Err. | T | P>t |
|---|---|---|---|---|
| ESI | 0.623 | 0.168 | 3.720 | 0.001 |
| Subsidy | -0.180 | 0.058 | -3.100 | 0.005 |
| LD. | -0.203 | 0.063 | -3.250 | 0.004 |
| L2D. | -0.154 | 0.057 | -2.680 | 0.014 |
| L3D. | -0.199 | 0.050 | -3.940 | 0.001 |
| L4D. | -0.063 | 0.037 | -1.710 | 0.102 |
| Developmental expenditure | -0.062 | 0.035 | -1.760 | 0.092 |
| LD | 0.006 | 0.027 | 0.230 | 0.817 |
| Trade | 0.113 | 0.051 | 2.230 | 0.036 |
| LD. | 0.043 | 0.042 | 1.030 | 0.314 |
| L2D. | 0.131 | 0.043 | 3.070 | 0.006 |
| L3D. | -0.003 | 0.046 | -0.060 | 0.955 |
| Urbanization | 1.6338 | 0.6840 | 2.390 | 0.026 |
| LD. | 0.490 | 0.662 | 0.740 | 0.467 |
| _cons | 85.610 | 13.971 | 6.130 | 0.000 |

R-squared: 0.7508 Adj R- squared: 0.5356

Tables 5.6 and 5.7 of the ARDL approach show the long-run and short-run results. The results show that the subsidy has a significant impact on environmental sustainability. However, it has a positive effect in long run moreover in the short run it has an adverse impact on environmental sustainability. In the short term, a 1% increase in a subsidy result in a 0.18% reduction in environmental sustainability. When the government gives subsidies to the infant industries, which are encouraged to increase their production, they do not use the latest technology in production, which can harm the environment in the short run. To maintain environmental sustainability, it is not a good strategy to only increase the government subsidy, policymakers should understand more about the effects of production and the environment on per-unit products. (Qiao and Su, 2021). While in the long run, when subsidies are raised by 1%, environmental sustainability increases by 0.65% because, due to government subsidies, the firm may have enough adjustments to move towards the latest technology to attain environmental sustainability in long run (Bo et al. 2019).

In the case of development expenditure, it has a significant but negative effect on environmental sustainability in the long run and short run. Our results show that if development expenditure is increased by 1% environmental sustainability is decreased by 0.060% in the long and short run it will decrease by 0.062% in Pakistan. The findings of Asif et al., (2021) shows that environmental damage is caused by development expenditures. Development expenditure is a government investment or resources used to carry out economic development strategies that might improve socioeconomic status and encourage economic growth (Abdullah and Maamor, 2010). However, increase in economic activities results in a scale effect therefore, long-term and short-term CO2 emissions raise in Pakistan as a result of economic expansion (Khan et al. 2020; Zhang et al. 2021). Development expenditure also reduces forestation (Sathler et al. 2018). It is impossible to achieve economic progress in developing countries like Pakistan without environmental degradation because many times government development expenditure programs neglect the environmental aspect in developing countries.

Long-term trade openness has a negative impact on environmental quality due to an increase in atmospheric carbon dioxide emissions (Pata, 2019; Asiedu et al. 2021; Usman et al. 2022) which indicates that it will negatively affect environmental sustainability. Our findings show the same result that trade has a statistically significant but negative impact in the long run. If trade is raised by 1%, environmental sustainability will decrease by 0.11%. As a result of an increase in trade, net deforestation will also increase in developing countries (Abman and Lundberg, 2020). Reduction in forest area will harm environmental sustainability. In the short run, it has a significantly positive impact on environmental sustainability. As trade and growth increase revenue, the demand for environmental legislation will also rise (Cole and Elliott, 2003). Therefore, its results improve environmental sustainability, while in the long run; they lead to overproduction in the domestic country, which harms the environment.

Urbanization significantly and positively affects environmental sustainability in the short term, because it allows many people to afford ecologically friendly techniques and services. Urbanization encourages innovations and especially green technologies (Borck and Pflüger, 2019). Our findings show that, in the long run, urbanization has a statistically significant and negative impact on environmental sustainability that is if urbanization increases by 1%, environmental sustainability decreases by 0.20% cent, because cities currently hold over 50% of the worldwide people. According to Ali et al., (2019), as a result of urbanization, carbon emissions have increased in the long run. Apart from developed countries, the rate of urbanization in emerging nations is steadily increasing (Sadorsky, 2014). Urbanization cannot be regulated by law, hence everyone is free to travel from one place to another as they like. By 2050, developing countries are predicted to have urbanized at a rate of nearly 65 per cent (Shahbaz et al. 2016). Jobless people from rural areas frequently relocate to cities in search of work. Thus the excessive population in urban areas increases the water demand, industrial goods and transportation. This movement causes environmental issues in cities as well as infrastructure difficulties. Urbanization won't be a problem when it comes to passing legislation to stop environmental damage in the nation. The increase in carbon dioxide emissions is directly related to urbanization (Ali et al. 2017).

## 5.5 Non-linear Auto Regressive Distributed Lag Model (NARDL)

As indicated in table 5.5.3, the NARDL model's conclusions are obtained from Eq. (13), which splits Subsidy, Trade, and Development expenditure into positive and negative shocks. In its initial phase, this study takes the developmental expenditure variable also to check the asymmetric relationship with environmental sustainability, but the results show that the F-stat for asymmetric relationship in the case of development expenditure is insignificant therefore we have not considered the positive and negative shocks of development expenditure and entered this variable in the model as a variable having a symmetric effect. However, this study examined that subsidy and trade have an asymmetric effect on environmental sustainability.

Table 5.8

*Co-integration Test Statistics*

| Test statistics | Value |
|---|---|
| F_PSS | 6.2598 |
| t_BDM | -4.8134 |

Table 5.9

*Critical Values*

| | Critical values | |
|---|---|---|
| Level of sig | I(0) | I(1) |
| 1% | 4.030 | 5.598 |
| 5% | 2.922 | 4.268 |
| 10% | 2.458 | 3.647 |

Before discussing the asymmetric effect of subsidy and trade, we checked the co-integration between variables, in the NARDL framework and the findings are shown in table 5.9 According to Pesaran et al., (2001) when the F-Stat value (6.26) is greater than the critical value of the upper bound it indicates the presence of asymmetric co-integration among variables. Since the critical values suggested by Pesaran et al., (2001) are suitable for large sample sizes, we have compared the F-stat value with the critical values suggested by Narayan (2005), the critical values are given in table. Since the F-stat value given in table is greater than the upper bound value at a 1% level of significance, we can conclude that the variables have a long-run equilibrium relationship.

Table 5.10

*Asymmetry Statistics*

| | Long-run F-stat | Asymmetry P>F | Short-run F-stat | Asymmetry P>F |
|---|---|---|---|---|
| Subsidy | 392.900 | 0.000 | 12.840 | 0.004 |
| Trade | 117.900 | 0.000 | 13.860 | 0.003 |

Note: Long-run effect [-] refers to a permanent change in exog. var. by -1

This study also demonstrated that the asymmetric effect exists between subsidy and trade using the F-stat and the values are given in table. Results show that the asymmetric relationship between subsidy and environmental sustainability is significant in both the long run and short run. Similarly, in the case of the asymmetric relationship between trade and environmental sustainability, the value is statistically significant in the long run and short run.

Table 5.11

*Long-Run Results of NARDL*

| **Variables** | **Coef.** | **Std. Err.** | **T** | **P>t** |
|---|---|---|---|---|
| ECM | -0.980 | 0.536 | -1.828 | 0.001 |
| Subsidy +ve | 0.919 | 0.222 | 4.140 | 0.002 |
| Subsidy –ve | 0.133 | 0.099 | 1.350 | 0.205 |
| Trade +ve | -0.803 | 0.174 | -4.620 | 0.001 |
| Trade –ve | 0.198 | 0.083 | 2.390 | 0.036 |

In the above table, 5.11 show the long-run results of NARDL. The relationship between subsidy and environmental sustainability results shows that subsidies have a statistically significant effect in positive shock while in negative shock its effect is statistically insignificant. In positive shock when subsidies increase by 1% the environmental sustainability will increase by 0.91% in the long run because, in the long run, due to government subsidies, the firm may have enough adjustments to move towards the latest technology to attain environmental sustainability in long run (Bo et al. 2019). The government also subsidizes sustainable goods. The government will have enough finance to subsidize the invention of electric cars since electric vehicles are becoming an immensely important part of the solution related to environmental pollution issues (Dong, 2022). In positive shocks the substitution effect dominates. In negative shock, if a subsidy is decreased by 1% then the environmental sustainability will increase only by 0.13% because if the government removes the subsidy on energy, the consumption of energy will also decrease so the environmental sustainability will increase but its impact is insignificant as shown in the results. Subsidies have more effective in positive shocks rather than in negative shocks.

The relation between trade and environmental sustainability is statistically significant in positive and negative shocks. However, when trade is increased by 1% environmental sustainability will decrease by -0.80. An expansion in the trade may increase energy consumption because it is frequently in use for transport and industrial generating (Asiedu et al. 2021). Economic growth induced by trade expansion always has clear and definite effects on environmental sustainability by emitting greenhouse gases or depleting natural resources. While in case of negative shock if the trade is decreased by 1% environmental sustainability will be increased by 0.19% because when the trade becomes decease the exports of the countries will also decrease, so the domestic industries produce less, and this less production in industries leads to the environmental sustainability. As we see in the time of COVID when many industries almost closed, at that time improvement in environmental quality has been seen in many developed and developing countries (Wang et al. 2022) The results show that trade has positive and more effective environmental sustainability in the negatives shocks, while in the positives shocks trade has effective but its impact is negative on environmental sustainability.

Table 5.12

*Short-Run Results of NARDL*

| Variables | Coef. | Std. Err. | T | P>t |
|---|---|---|---|---|
| Environmental sustainability | 1.679 | 0.425 | 3.950 | 0.002 |
| L2. | 0.920 | 0.326 | 2.820 | 0.017 |
| L3. | 0.478 | 0.243 | 1.960 | 0.075 |
| Subsidy +ve | -0.042 | 0.051 | -0.820 | 0.430 |
| L1. | -0.652 | 0.143 | -4.560 | 0.001 |
| L2. | -0.317 | 0.114 | -2.780 | 0.018 |
| L3. | -0.185 | 0.089 | -2.080 | 0.062 |
| L4. | -0.157 | 0.068 | -2.320 | 0.041 |
| Subsidy –ve | 0.379 | 0.150 | 2.520 | 0.029 |
| L1. | 0.380 | 0.116 | 3.280 | 0.007 |
| L2. | 0.287 | 0.118 | 2.430 | 0.033 |
| L3. | 0.185 | 0.114 | 1.620 | 0.134 |
| L4. | 0.180 | 0.071 | 2.550 | 0.027 |
| Trade +ve | 0.154 | 0.085 | 1.800 | 0.099 |
| L1. | 1.081 | 0.283 | 3.830 | 0.003 |
| L2. | 1.047 | 0.236 | 4.430 | 0.001 |
| L3. | 0.838 | 0.177 | 4.730 | 0.001 |
| L4. | 0.301 | 0.154 | 1.960 | 0.076 |
| Trade –ve | -0.119 | 0.064 | -1.860 | 0.090 |
| L1. | -0.336 | 0.146 | -2.300 | 0.042 |
| L2. | -0.216 | 0.102 | -2.120 | 0.058 |
| L3. | -0.182 | 0.069 | -2.620 | 0.024 |
| Developmental expenditure | -0.103 | 0.031 | -3.290 | 0.007 |
| Urbanization | -0.446 | 0.097 | -4.580 | 0.001 |
| Cons | 167.569 | 35.694 | 4.690 | 0.001 |

The short-run results of NARDL are presented in table 5.12. The value of environmental sustainability which is 1.679 shows the persistence that how the value of environmental sustainability is value is effect by the previous value. In the short run, subsidies show an insignificant impact in the case of positive shocks while negative shocks it has significant and positive impacts on environmental sustainability. If a subsidy is decreased by 1% the environmental sustainability is increased by 0.37% because if the government removes the subsidy on energy, the consumption of energy will also decrease so it leads to environmental sustainability in the short run.

Trade has a significant impact on environmental sustainability both positive and negative shocks. Results show that positive shocks of trade have more effective for environmental sustainability in the short run. If trade is increased by 1% environmental sustainability is increased by 0.15% in the short run. Increasing market accessibility can create the opportunity for entrepreneurs to produce new commodities, services, and techniques to combat global warming. Moreover, the rise in revenue brought about by trade may cause humanity to demand greater quality of the environment, i.e. reduced greenhouse gas pollutants. As trade and economic growth increase revenue, the demand for environmental regulations will also rise (Cole and Elliott, 2003). On the other hand, if a trade is decreased by 1% the environmental sustainability will decline by 0.11% in the short run. Due to trade the amount of innovation and awareness about environmental sustainability policies also reduces. The lack of knowledge about global regulations regarding environmentally friendly production techniques and products causes environmental sustainability to decline.

On average the NARDL results of the development expenditures and urbanization have a statistically significant but negative impact on environmental sustainability. These two variables have no asymmetric relationship with environmental sustainability.

## 5.6 Diagnostic Test

### 5.6.1 CUSUM and CUSUM Square Test

The CUSUM-of-squares test is effective at identifying changes in conditional model variables regardless of whether the variance of the regression error is included in the set of variables shifting, particularly at the end of the sample.

Figure 5.1

*CUSUM Test*

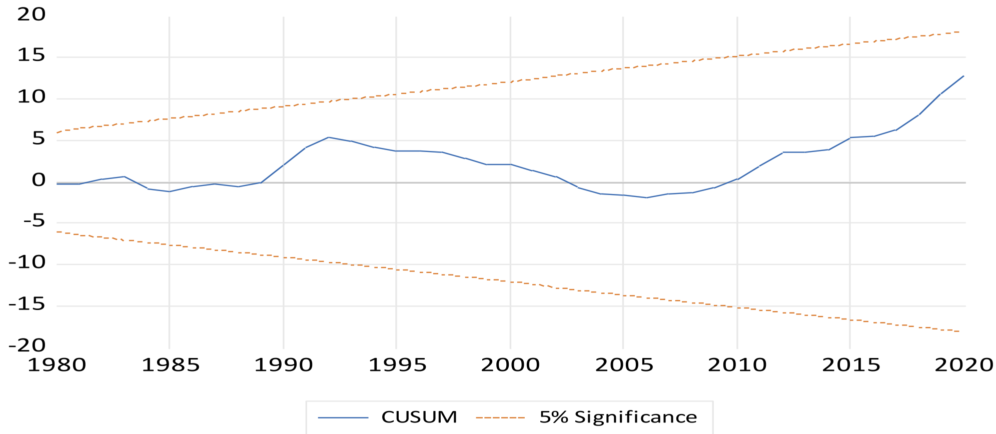
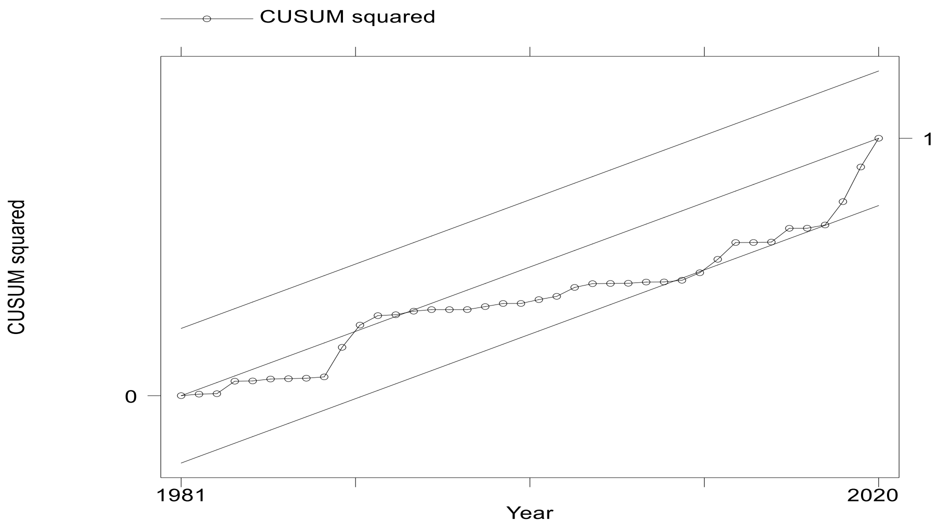



Figure 5.2

*CUSUM Square Test*



To check the stability of the model the cumulative sum of recursive residuals of square (CUSUM Square) and the CUSUM test is used. The above graph shows that the data is stable.

## 5.7 Some Other Diagnostic Tests

Table 5.13

*Some Other Diagnostic Tests*

| Model Diagnostics | Stat. | P-value |
|---|---|---|
| Portmanteau test up to lag 19 (chi2) | 23.74 | 0.2064 |
| Breusch/Pagan heteroskedasticity test (chi2) | 1.40 | 0.2490 |
| Ramsey RESET test (F) | .3393 | 0.7977 |
| Jarque-Bera test on normality (chi2) | 4.33 | 0.1148 |

Table 5.13 shows some diagnostic tests of the model. Table 5.13 shows that there is no heteroskedasticity and no serial correlation. The Ramsey Regression Equation Specification Error Test (RESET) shows there is no misspecification in the model. While the Jarque-Bera test shows the normality of the data.

# CHAPTER 6

# CONCLUSION

The main aim of this study is to check the impact of fiscal policy on environmental sustainability. We use the current subsidies and development expenditure as a proxy of fiscal policy. We also examined the non-linear effect of current subsidies and development expenditures on environmental sustainability. But after applying the Wald test, we found that only subsidies have an asymmetric effect on environmental sustainability.

We constructed the index of environmental sustainability because the data on environmental sustainability data is not readily available. For the construction of the index, we have considered the land, air and water dimensions.

The result of ARDL shows that the subsidies have a positive impact on environmental sustainability while developmental expenditure, trade and urbanization harm environmental sustainability in long run. In the short run subsidy and development expenditures have a negative impact on environmental sustainability. Trade and urbanization have a positive impact on environmental sustainability.

To check the non-linear effect of fiscal instruments, this study examines the asymmetric relationship between developmental expenditure and environmental sustainability, but the results show that the F-stat for the asymmetric relationship is insignificant, so we do not consider the positive and negative shocks of development expenditure. However, we used subsidies and trade to examine the asymmetric relationship. NARDL results show that the subsidy is more effective for environmental sustainability in positive shock rather than in negative shocks in long run. In positive shocks, trades negatively impact the environment while in negative shocks it has a positive impact in long run. The short-run result of NARDL shows that in positive shocks subsidy have a negative and trade have a positive impact on environmental sustainability. In case of negative shocks subsidy has a positive and trade has a negative impact on environmental sustainability.

## 6.1 Policy Recommendations

As a result of multiple environmental deteriorations and depletion of natural resources all around the earth, academics and policymakers have focused their attention on what triggers the destruction of the environment. The search for a healthy environment has evolved into a worldwide concern, a problem affecting more than one country. Climate change is generating extreme storms in every part of the world, disturbing economies and harming the lives of millions of people.

Strategic environmental assessments and cost-benefit evaluations of all development projects must be used to promote an effective mechanism for internalizing environmental costs in mainstream making decisions and the regulatory regime in Pakistan. Enhance the capabilities of union councils, tehsil municipal authorities, as well as regional authorities (local level), to enhance the environmental governance at all sectors and community-level environmental management. Environmental restrictions to reduce pollution must be properly implemented through effective monitoring and incentives. The process should eventually lead to the presentation of a "green budget" that includes genuine expenses to the environment in all financial decision-making.

To maintain a healthy environment, the government should subsidize environmentally friendly products and services that would make them more affordable as compared to non-environmentally friendly alternatives. The use of environmentally friendly products and services, such as electric vehicles and renewable energy sources, may rise as a result, while non-sustainable alternatives may decline. This may minimize the overall negative effects of production and consumption on environmental sustainability.

They should promote future environmental conservation, management, and resource management.

Government should give subsidies on the items which promote a clean environment and spend on those developmental projects which do not affect the environment. Although development expenditure is the basic need for the development of the economy especially in developing countries if they invest in the industrial sectors, they should keep them away from the residential areas. They must consider environmental regulation as a main aspect of their developmental projects.

Trade also affects the environment if the products that are produced in industries are using greenhouse gas emissions technologies. To improve trade with a clean and green environment, they must improve culturally, socially, economically, and environmentally appropriate solutions.

When creating measures to decrease environmental degradation, policymakers should emphasize the country's degree of economic growth rather than urbanization, because urbanization has a direct impact on rising carbon dioxide emissions. Throughout all areas, facilitate the execution of water and sanitation policies and programmes. Installation of Combined Wastewater Treatment plants in all major manufacturing areas to assure the treatment of contaminated effluent discharged into bodies of water. Regular scientific monitoring of water aquifers and drinking water bodies in all cities. Improve hospital training programmes across the country to ensure the sustainable and environmentally friendly management, transport, and storage of hazardous substances, contaminated equipment, and waste in the hospital. Increase public awareness campaigns on water and sanitation issues in urban areas via social media.

## 6.2 Suggestions for Future Studies

This study used annual data; future studies can use data with different time intervals, such as quarterly, which will improve the accuracy of the conclusion. In developing countries, penal data can be performed because the environment does not affect just one country it also affects the countries around them.

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