Green Human Capital Development

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Greening the Workforce: The Power of Investing in Human Capital

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ABSTRACT

Experts are interested in creating human capital's role in boosting economic growth. Some research has been done on using human capital to help lessen carbon emissions in developing countries, but more needs to be done. So, the study looked at how developing human capital can make a country more prosperous by making the environment more sustainable through labour-added technology. The study analyzed data from Pakistan from the years 1975 to 2020 and employed robust least squares regression, Granger causality, and innovation accounting matrix methods to estimate parameters. According to the robust least squares regression results, lowering carbon emissions and increasing human capital may be achieved by investing more in environmentally friendly research and development. However, a green development strategy will never materialize since the federal government needs to invest more money in education, healthcare, and improvements to the employment market. The Granger causality analysis confirmed that continued economic growth Granger causes carbon emissions on the one hand while causing increasing life expectancy and net enrolment rates on the other hand. R&D spending and labour-augmented technology Granger cause an increase in life expectancy by fostering the development of cleaner production methods, which in turn helps improve the long-term viability of healthcare in a nation. According to the innovation accounting matrix results, life expectancy and the net enrolment rate will be the essential human capital factors affecting carbon emissions over the next ten years. In addition to human capital, changes in the labour market, spending on research and development, and technology that helps people do their jobs also affect the green development agenda. Pakistan should spend more of its budget on human development through technical knowledge and research and development. This would help the country switch from fossil fuels to clean, green technologies and hybrid-energy efficient methods to reduce carbon emissions.

Keywords: Human development; Carbon emissions; Labor augmented technology; R&D expenditures; Pakistan.

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Ethics
No animal studies are presented in this manuscript.
No human studies are presented in this manuscript.
No potentially identifiable human images or data is presented in this study.

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1. INTRODUCTION

Several issues need to be addressed in today's world, including pollution, food, malnutrition, low school enrollment and completion rates, a lack of political power for women, and severe poverty (Sezgin et al., 2021). Sustainable growth has numerous issues, but environmental destruction is the largest (Rehman et al., 2022a). The persistent release of gases, notably carbon emissions and other pollutants, is a severe environmental hazard. Carbon emissions comprise more than 60% of all greenhouse gases (Bedir & Yilmaz, 2016). Manufactured, farmed, and shipped chemicals and waste products promote climate change, while human carbon emissions cause global warming. The melting glaciers due to rising temperatures affect our biosphere (Rehman et al., 2022b).

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Experts agree that burning energy makes a lot of CO2, which is a significant cause of the growth of greenhouse gases (Hanif et al., 2022; Khalil et al., 2022). Using fossil fuels causes global warming because it puts carbon into the air that should have been taken out long ago. Air pollution is worsening, which is terrible for public health (Mehmood et al., 2022; Shamsi et al., 2022; Bibi et al., 2022). People's health is worsening in Pakistan because of carbon emissions. Poor air quality leads to respiratory consequences include bronchitis, asthmatic infections, and lung problems; and neurological effects include high blood pressure, coronary disease, cardiac arrest, and dementia. Air pollution causes millions of premature deaths annually worldwide (Qureshi et al., 2016; Tehreem et al., 2020; Nizam et al., 2020). Any change to the environment will have many effects. Polluted air has an impact on the quality of the food we consume (Balasubramanian et al. 2021). Polluted air hurts the health and well-being of a community, as well as social problems like poverty, hunger, and a lack of job opportunities. More health problems are linked to nonrenewable energy sources like coal and oil (Murthy et al., 2021; Zeb et al., 2014; Anser et al., 2020). 64% of all the energy that Pakistan uses comes from sources that do not replenish themselves (Abid et al., 2020). Pakistan has pretty high levels of pollution, which has a significant effect on the climate of the country. It is the seventh country with the most pollution (Ul-Haq et al., 2022). How well students learn and how much they can do depends directly on how good their lives are (Bogdanovica et al., 2020). To fight the climate change crisis, steps must be taken immediately to cut air pollution (Wang et al., 2019).

The Intergovernmental Panel on Climate Change (IPCC) said that the leading cause of global warming was carbon emissions made by people. Because global warming is terrible for developed economies, more than 100 countries have signed the Kyoto Protocol to reduce CO2 emissions (Akbar et al., 2021). As a naturally occurring gas, carbon dioxide does not qualify as pollution. However, due to human activity, atmospheric Co2 levels have increased dramatically. Since 1987, when the amount of carbon dioxide in the air first went over the level considered dangerous, it has become clear that preventing more carbon emissions is not enough. We also need to get rid of the carbon in the air. Everyone should deny the existence of carbon. Increasing economic activity is a significant reason why the environment is getting worse. This means that policymakers need to act quickly to come up with and carry out the right solutions (Zafar et al., 2022). Renewable energy sources are essential in the fight against climate change because they help reduce harmful carbon emissions. We must put the development of renewable energy sources at the top of our list (Mahmood et al., 2019). Sustainable technologies can help reduce greenhouse gas emissions from environmentally responsible economic activity, so the government should pay attention (Cai et al., 2021).

Human capital development in Pakistan was hampered by a small federal budget for education, health care, and social safety nets. Because of this, a country doesn't invest as much money into research and development, hurting the economy and the environment. Pakistan's economy is in danger because of climate change, causing the biggest floods in recent days. The federal budget cannot fix the problem because economic and environmental policies are not strong enough. Based on the stated issue, the following research objectives have been made:

I. To examine the role of human capital formation (i.e., health, education, and income) on carbon emissions in Pakistan.

II. To assess the role of labor–associated work performance on the environmental sustainability agenda.

III. To analyze the role of labour-augmented technology on carbon emissions, and

IV. To determine the impact of R&D spending on carbon emissions in a country.

The stated objectives would be achieved using the robust least squares regression to reach some policy inferences.

2. LITERATURE REVIEW

In search of the literature review, it is evident that human capital formation is the possible solution to reduce carbon intensity. While ignoring technology innovation makes achieving this task impossible, requiring labour-augmented technology to achieve sustainable environmental targets worldwide. Using panel data from 126 nations from 1971 to 2020, Iqbal et al. (2021) examined the environmental devaluation caused by unfettered commerce, urbanization, and human capital. Regarding environmental impacts, free trade is harmful in the middle- and low-income nations but neutral in high-income ones. While trade has a negligible impact on low and medium-income nations, it has no discernible impact on high-income ones. While urbanization improves the quality of life overall, it harms the economy. When human capital is increased, pollutant emissions are decreased. Human capital can help economies everywhere cut pollution emissions. Therefore, governments should provide more money for education and training programmes to lessen humans' environmental impact. From 2000 to 2012, 44 countries in Sub-Saharan Africa were analyzed to determine the impact of environmental degradation on human development in connection to good governance (Asongu & Odhiambo, 2020). The findings indicate that higher government performance standards are necessary for positive results. The governing authorities have to devise a sound strategy to lessen the detrimental impact that CO2 has on the progression of humankind. Asongu (2018) looked at 44 sub-Saharan African nations between 2000 and 2012 to see how carbon emissions affected human development. All determined threshold values are stored in the policy radius. Emissions of carbon beyond the calculated threshold hurt human development. Policymakers should seek to curb carbon emissions to boost human progress. The effects of carbon emissions on food production, energy use, livestock, economic development, and population expansion in Pakistan were studied by Rehman et al. (2022a) using data from 1965-2019. The findings indicate that in the short term, population growth, rural population growth, livestock output, and economic expansion are all positively correlated with CO2 emissions and that there is a positive feedback loop between these variables and emissions. Alternatively, short- and long-term increases in urban population and food production are correlated negatively with increases in carbon emissions. Therefore, this research emphasizes the impact of carbon emissions on energy, food production, livestock, population expansion, and economic growth, all of which contribute to human advancement. As stated by Bieth (2021), the study's goal was to assess the impact of carbon emissions on economic growth and human development in the ASEAN and Japanese economies from 2007 to 2018. The findings demonstrate that carbon emissions significantly and directly impact economic growth. The rate of carbon emissions released is directly correlated with human progress. Wang et al. (2019) analyzed the impact of carbon emissions on the human capital index, financial growth, and globalization in OECD nations from 1990 to 2015. Human development contributes to environmental improvement and economic growth. Causality reveals a two-way relationship between economic growth and carbon emissions. Examining human development and globalization reveals a unidirectional relationship between the two variables and their associated increases in carbon emissions. According to the results, increased carbon emissions negatively impact globalization, the human capital index, and financial development. The impact of carbon emissions on Pakistan's economic growth from 1971 to 2017 is studied by Rehman et al. (2022b). The research showed that Pakistan's economy is improving thanks to transportation. Over time, a reduction in carbon emissions hurts economic growth. Increasing carbon emissions improve the economy's long-term viability. While emissions from other of Pakistan's major industries do little to boost the country's economy, both in the short and long term. Using balanced panel data from 2006-2016, Akbar et al. (2021) analyzed the reciprocal relationship between carbon emissions and health care costs in 33 OECD nations. Spending on public health, carbon emissions, and human development are all interconnected in a causal triad. There is a two-way causal link between public health funding and carbon emissions, with the former leading to the latter due to the energy required to support the latter. The improvement in health spending raises the quality of life, and the improvement in HDI induces greater healthcare spending due to the bidirectional causal link between the two variables. There is a damaging counter-causal link between growing carbon emissions and public health. Since carbon emissions are bad for people's health, it follows that those costs will go up. Based on the stated discussion, the study formed its first hypothesis:

H1: The investment in the human capital formation is likely to achieve environmental sustainability agenda by innovating ideas to reduce carbon emissions.

The influence of carbon emissions causal effect on the logarithm of the human development index in 33 OECD nations from 1992 to 2011 is investigated by Bedir and Yilmaz (2016). A Granger causality study supports the expansion hypothesis for the economies of Turkey, Spain, Luxembourg, Japan, Israel, Denmark, Ireland, Italy, Korea, Poland, Slovakia, and the United States. The conservation theory holds in the cases of the Czech Republic, Finland, Greece, Mexico, New Zealand, France, Estonia, and Chile. There is evidence for the feedback hypothesis in countries like Switzerland, Portugal, Iceland, and Norway. Neutrality is supported by data from the Netherlands, Sweden, Slovenia, the United Kingdom, Hungary, Austria, and Canada. People should use less coal, oil, electricity, and gas to reduce carbon dioxide emissions and protect the environment. However, this will hurt economic development and people's quality of life. So, the decline in human well-being is a direct result of the ineffectiveness of conservation programmes. From 1995-2018, Boonyasana and Chinnakum (2020) analyzed the effects of carbon emissions on human development and foreign tourism in Thailand. There is a unidirectional cause-and-effect relationship between tourism and human progress. Results indicate that tourism has a positive effect on human progress. The relationship between tourism and greenhouse gas emissions was reciprocal; emissions stifled progress toward human progress. Evidence suggests an inverse relationship, with tourism leading to lower emissions and human progress leading to lower emissions overall. Increases in carbon emissions will similarly affect human growth in terms of living standards. Further, rising levels of pollution will dampen tourist interest. From 1990 to 2017, Abid et al. (2020) analyzed the empirical relationship between Pakistan's environmental sustainability, renewable and nonrenewable energy consumption, human development index, and economic growth. The findings demonstrate a causal relationship between carbon emissions and economic growth caused by nonrenewable energy sources. Meanwhile, the reduction of carbon emissions and the resulting lessening of environmental degradation in Pakistan directly result from the country's emphasis on innovation, human development, and reusable energy. The Cointegration study demonstrated that all variables are linked over the long term. There are two directions of causality involving economic expansion, reusable and non-re-usable energy sources and carbon emissions. Short-term and long-term considerations are taken into account. The sustainability of the environment is tied to the interdependence of economic development, renewable energy, and nonrenewable energy sources. Lin et al. (2021) investigated the impact of technical human capital on China's carbon emissions from 2003 to 2017. The results indicate that technological human capital is contaminating the environment. There is a Kuznets curve for the environment in the model. The findings indicate that fostering human capital is essential to China's economic growth and will also benefit the environment. Mehmood et al. (2022) analyze the impact of G-11 nations' ages and natural resources on their emissions of carbon gases from 1990 to 2020. The results show that a one percent rise in the population's average age in the G-11 counties would result in a 13.41% decrease in carbon dioxide emissions. Increases in the economy, population, globalization, natural resources, and carbon dioxide emissions tend to follow a Kuznets curve that favours the environment. Age-related improvements in wisdom and experience have a moderating effect on carbon emissions in the G11 nations. The effects of CO_2 emissions on newborn health in Pakistan are analyzed by Naeem et al. (2021). The risk of CO_2 on the health of a newborn is quite low. In the near run, improved health care infrastructure will result in fewer child deaths, but this correlation will reverse. The rate of child mortality may be lowered temporarily by increasing urbanization. As GDP per person rises, infant mortality rates fall. Extreme poverty and high reproduction rates contribute to high rates of infant death. Due to poor living circumstances and inadequate healthcare, the low-income population has a higher infant and child mortality rate. In Pakistan, economic considerations impact child mortality more than carbon emissions. By including the control variables of economic growth and FDI into the model, Ahmed et al. (2022) investigate the impact of urbanization and industrialization on Pakistan's efforts to achieve carbon neutrality. Although there is a negative correlation between industrialization and economic development, the finding indicates that carbon has little influence on environmental degradation. FDI and urbanization negatively impact the environment by significantly increasing carbon emissions. Urbanization is a primary driver of environmental change. FDI provides evidence supporting the pollution haven hypothesis. Carbon noninterference was not found to be the case in Pakistan. Abbasi et al. (2022) examine the impact of Pakistan's energy consumption and emissions on different geographic regions from 1990Q1 to 2019Q4. This includes the country's financial sector, economy, new technologies, and globalization. The findings demonstrate that an increase in economic and financial factors may increase emission and consumption rates in the long and short term. Long-term energy usage may increase both consumption and area-weighted emission. Short-term, globalization may reduce emissions depending on consumption and region, but long term, it can raise emissions. Long-term, the benefits of technological progress to the environment are substantial. Based on the stated discussion, the study formed its second research hypothesis:

H2: Labour force participation rates tend to increase work-associated emissions, leading to worse health outcomes.

Using data from 1970 to 2016, Khan et al. (2021) analyze the impact of FDI, power consumption, and GDP on the ecosystems of Pakistan, China, and India. The environmental Kuznets curve for China and India is U-shaped. The panel causality test developed by Dumitrescu and Hurlin demonstrates a unidirectional relationship between environmental effects and economic development. However, in the case of Pakistan, a circular causality exists between environmental impact and FDI and between environmental damage and power consumption. In the case of Pakistan, both FDI and the usage of energy contribute to rising carbon emissions. Reducing carbon emissions in Pakistan from 1996 to 2019 is investigated by Mahmood et al. (2021). A rise in GDP increases emissions of carbon dioxide. This rule does not work over the long term and has the opposite impact during the short term. The institution of law and order may be stabilized to reduce carbon emissions. Long-term benefits may also result from the rule's tightening. While limiting corruption has a direct long-term influence on carbon emissions, its first- and second-lag effects are counterintuitive. As corruption rises, so do Pakistan's harmful carbon emissions. Wang et al. (2021) investigate whether there is a correlation between BRICS nations' public debt from 1990 to 2016 and their utilization of renewable energy sources and human growth. Using renewable energy boosts human growth. However, governmental debt hinders human progress. Public debt and renewable energy harm human progress. There is a two-way causal relationship between human progress and the use of renewable energy. The report concludes that the BRICS nations' policymakers should implement measures to promote renewable energy sources and bring public debt under control. Using Pakistani panel data from 1980 through 2018, Chien et al. (2021) analyze the effect of increased innovation, globalization, and renewable energy on slowing environmental degradation. In a direct and significant way, rising economic activity raises carbon emissions. Pakistan likewise has a validated environmental Kuznets curve. Advances in technology and the use of renewable energy sources hold great promise for enhancing environmental quality. This correlation holds across all quantiles. The expansion of Pakistan's economy into the global market has led to an increase in carbon emissions. Using renewable energy sources may slow down environmental damage in the near run. Cleaner energy, technological advances, and rising GDP may reduce carbon emissions and vice versa. However, for Pakistan, GDP directly causes globalization. The welfare of the environment necessitates the development of new technologies and the use of alternative sources of energy. even when globalization has negative consequences. Oad et al. (2022) analyzed the impact of tourism on Pakistan's environment from 1995 to 2014. Results indicate that over the long run, no one factor significantly affects CO_2 emissions. The decline in tourism directly results from the country's unstable economic and political climate. Improved educational opportunities, infrastructure, and leisure pursuits may all benefit from increased tourism, which can help lower unemployment. Therefore, tourism is beneficial to the economy and the environment. Sheraz et al. (2021) analyze the results of human capital, financial development, GDP, and energy usage for G20 nations outside the European Union from 1986 to 2018. The results show that economic growth and human capital increase is associated with lower carbon emissions. A clear correlation between energy use and GDP ultimately leads to carbon emissions. The beneficial impact of economic and human growth on carbon emissions has been mitigated, thanks to globalization. The income per capita and energy use are related in two ways. Clean and green environments and increased productivity may result from a combination of factors, including an effective monetary system, clean energy investments, and skill-based education promotion. Using data from 15 Asian nations from 1990 to 2014, Anwar et al. (2022) analyze the correlation between green energy, economic growth, financial development, agriculture, urbanization, and carbon dioxide emissions into the atmosphere. Results indicate that economic expansion, improved financial conditions, and urbanization contribute to higher atmospheric carbon emission levels. Carbon emissions are reduced by switching to clean and green energy, and agriculture's impact on emissions is negligible. One possible component in creating a more sustainable environment is incorporating more renewable energy sources into the energy mix. Ado (2021) attempt to analyze the impact of FDI, economic growth, financial development, and energy mix on Nigeria's carbon emissions from 1980 to 2019. FDI, financial growth, economic expansion, and increased energy consumption all benefit carbon emissions in the near term. Carbon emissions have steadily risen with FDI, financial development, GDP, and energy consumption. FDI and financial development all have a significant bearing on emissions of carbon dioxide. As a result, it is important to limit carbon emissions as much as possible to maintain a healthy ecosystem. Using time series data, Amin et al., 2021) investigated the effects of cultural diversity and international commerce on Pakistan's ecosystem from 1970 to 2015. These studies draw attention to the environmental effects of commerce. While a high per capita GDP is good for international commerce and investment, it is also a major contributor to greenhouse gas emissions. Consequently, the findings suggest that reducing economic development via reduced trade may have environmental benefits in the form of reduced carbon emissions. Basri et al., (2021) analyze the effects of 1990-2015 on Bangladesh's human development index (HDI), real gross domestic product (GDP), and open trade policies. The findings demonstrate a causal relationship between adopting renewable energy sources, carbon emissions, and actual GDP. No significant impact on human progress can be attributed to urbanization or liberalization. Consequences also demonstrate that switching to clean energy can boost human progress. From 1980 through 2019, Nasreen and Rafay (2022) examined the impact of technological advancements and the expansion of Pakistan's financial institutions. The study's findings show that environmental degradation is related to the economy in a way that is not mutually beneficial and that the link between technological innovation and environmental deterioration over time is true. An expansion in financial institutions and the continued use of antiquated technologies threaten Pakistan's natural resources. In contrast, technological advances and a reduction in financial institutions would help restore the country's pristine ecosystems. A study by Sohail et al. (2022), using time series data from 1990 to 2019, analyze how political conditions have impacted Pakistan's renewable energy and carbon emission. The ARDL model's results demonstrate that a stable political state mitigates environmental deterioration by reducing long-term carbon emissions. The nonlinear ARDL model shows that Pakistan's uncertain political scenario reduces the usage of renewable energy and has a long-term negative impact on the country's environment. Short-term political stability also aids efforts to better the environment and promote the use of clean energy. Improvements to the environment and the use of renewable energy sources need political stability. The study formed the third hypothesis based on the substantial reviewing the earlier literature:

H3: Labour-augmented technology would minimize carbon emissions and advance environmental sustainability.

Based on the cited literature, the following variables used in the pollution damage function:

I. The human development index (HDI) is a critical factor that helps mitigate carbon emissions.
II. The rise in the unemployment rate causes more deprivation in the labour force market, exposure to outdoor pollution and increases healthcare morbidities, and
III. Cleaner technology advancement helps to achieve the decarbonization agenda.

The study filled the gaps in the earlier literature on human development and mitigating carbon emissions from three different perspectives: First, the study used all the three critical factors of human capital formation as regressors in the pollution damage function, including health by measuring life expectancy, education by net enrolment rate, and income by GDP per capita, while the earlier studies mainly used the composite index of HDI as a regressor in studies (see, Hossain et al. 2021, Pervaiz et al. 2021, Adekoya et al. 2021). The composite index would not be able to find the individual effects of each human capital factor on the environmental sustainability agenda and leave the policy conclusions incomplete. Second, to measure the soundness of labour market reforms, the study used the labour force participation rate as a critical regressor of carbon emissions, which eventually would help assess worked-associated emissions in a country. The earlier studies mainly limited it to the government economic policies confined to assessing the policy options for mitigating carbon emissions (see, Ozturk et al. 2022, Murshed et al. 2022, Farooq et al. 2022). Finally, the earlier studies mainly used technology innovation as a separate factor to assess its role in pollution damage function (Rashid Khan et al. 2021, Shaheen et al. 2022, Zaman et al. 2022a,b, Awan 2021). In comparison, the need to remain focused on labour-augmented technology would help assess the technology-associated labour performance and its impact on reducing carbon emissions. Thus, the study used the interaction term of R&D expenditures with labour force participation to capture the labour-augmented technological impact on the environmental sustainability agenda in Pakistan.

3. MATERIALS AND METHODS

The study used carbon emissions as a response variable of the study. The human capital formation factors, including life expectancy, net enrolment rate, and income, served as crucial regressors of the study. Labour force participation rate and R&D expenditures served as the controlled variables of the study. In contrast, the interaction of both the factors served the labour-augmented technology as a moderator of the study. Pakistan's economy is taken as a case study and covered data from 1975 to 2020 for empirical examination that help to reach some conclusive sustainable policy marks. The data is taken from World Bank (2022) database. Table 1 shows the variables list for ready reference.

Table 1: List of Variables

Variables	**Symbol**	**Unit**	**A Priori Expectation**	**Theory Supported**
CO2 emission	CO2	kiloton	-----	-----
Life expectancy	LE	years	LE decreases with increase in carbon emissions	Wang and Li (2021) and Murthy et el. (2021)
Adjusted net enrollment rate	NER	% of primary school age children	NER decreases with increase in carbon emissions	Cui et al, (2022) and Balaguer & Cantavella (2018)
GDP per capita	GDPPC	Constant US$	GDP per capita increases with increase in carbon emissions	Van et al. (2018) and Chaabouni & Saidi (2017)
Labor force participation rate	LFPR	% of total population age 15+	LFPR increases carbon emissions	Wei et al. (2018) and Mani et al. (2020)
Research and development expenditures	R&D	Current US$	CO2 emission decreases with increase in RD expenditures	Mensah et al. (2018) and Fernández et al. (2018)
Labor-Augmented Technology	LAT	Interaction term of LFPR and R&D	CO2 emission decreases with increase in LAT	Turner et al. (2009) and Smulder & De Nooij (2003)

Source: World Bank (2022).

According to Amartya Sen's definition, development is the degree to which individuals are free and the extent to which constraints on that freedom are reduced. People often choose their professions when given greater leeway to make decisions (Hart & Brando, 2018). Poverty, corruption, insecure government, poor economic circumstances, poor health, and a lack of education impede growth and personal liberty (Osawe, 2015). Nonetheless, there are undeniable health, educational, and other fundamental gaping holes. Higher rates of life expectancy and educational attainment are indicators of a country's level of development. Life expectancy increases by nineteen years and educational attainment by seven years on average. Pakistan dropped from 2015's HDI rating of 147 to 2019's HDI ranking of 152 due to several factors. This drop in ranking on the HDI results from disparities in significant areas such as per capita income, public health, primary education, food, and shelter. Polluted air is one of Pakistan's most serious environmental issues, especially in the country's main cities. Air pollution has hit Pakistan's population and economy hard (Anwar et al. 2021). The emission of carbon dioxide has devastating effects on the ecosystem, so studying environmental deterioration in Pakistan is essential to see how it affects people's progress.

3.1. Theoretical Framework

3.1.1. Theory of Human Resource Development

Human resource theory explains the positive or negative impact management decisions have on a company's output due to employee actions. Optimizing staff and labour efficiency in small company organizations require considering the organization's behaviour and human resources acting on it. This may be achieved by reducing employee turnover (Chun et al. 2013). Human expertise is crucial to the success and longevity of any given organization. Everyone wins when a company invests in a person's growth as a resource. Human resource development specialists are seen as a unified whole across the person, the team, and the business. Worker output, education, and evolution are the three primary aspects of HRM (Piwowar-Sulej, 2021). According to Gilley & Maycunich (2000), there are primarily three domains where HRD is realized, i.e., learning, performance, and change.

I. *Performance Paradigm*

It is possible to boost the efficiency of the expert's work via training and improvement programmes for both the person and the company.

II. *Learning Paradigm*

Human resource development, or HRD, is the process of fostering individual and collective growth and development to maximize an organization's efficiency and productivity, and

III. *Change paradigm*

The connection between HRD and productivity is shown the change paradigm, leading towards win-win business strategy.

In Pakistan, the primary emphasis should be placed on human development since a low level harms human resource development. Changes in the workplace as a consequence of globalization are values demonstrating the need for the knowledge and skills of both individuals and organizations since organizational growth relies on HRD and ultimately results in a good society.

3.1.2. Theory of Human Capital Accumulation

As outlined by Gary Becker and Theodore Schultz, education and training are crucial to boosting worker output. Due to infrastructure improvements, the opportunity cost of attending school is reduced. Increasingly, workers' levels of education are being considered when hiring (Becker 1994, Schultz 1989). According to proponents of the human capital accumulation theory, the substitution of human capital accumulation for physical capital accumulation altered the development process, with profound effects on inequality (Bucci 2008, Feher 2009). More physical capital spurred economic growth in the early phases of the Industrial Revolution, but this has led to more disparity in development as resources have transferred from the government to individuals, who tend to spend less and save more. In the current era of economic development, growth is accomplished via the accumulation of human capital, stimulating economic expansion while mitigating the negative impact of an inclination to save. Human capital is defined by more than just the number of years spent in school, as stated by the theory of its accumulation (Beecker, 2009). Some other distinguishing features include how well someone has been educated, how well they have been trained, and how they feel about their profession. These factors help explain why employees' incomes vary so widely and why this variation is not just a function of their level of education.

3.1.3. Theory of Sustainable Environment

Ethical behaviour from one generation to the next, when present actions in economics and the environment, do not diminish the potential of future generations to enjoy the same standard of living (Anand & Sen, 2000). Sustainable intensification refers to increasing agricultural output without negatively impacting the environment or society. Both sustainability and intensification are treated with equal importance in this strategy (Loos et al. 2014). The ecosystem may be harmed if we do not consider it carefully. When we provide farmers access to modern farming equipment, we risk putting out of business those in the community who have built their livelihoods on maintaining and making traditional agricultural implements. This means that the income level is below the poverty line. Instead of relying on cutting-edge technology, we should make farmers more reliant on their ageing machinery (Behl et al. 2022). Third, the global consensus on the 2030 Agenda provides the essential framework for the government and every institution to strive toward a more sustainable future. There is less than a decade to accomplish these goals, but economies still confront numerous problems and obstacles. Sustainable cities and communities, life on land, and climate action are additional targets of the SDGs. Ecological intensification, agro-ecological intensification, and sustainable intensification aim to provide food for a growing population and economy without causing significant harm to society or polluting the natural environment (Pretty et al. 2018). Figure 1 illustrates how spending on research and development in education, health, and well-being may improve HDI. Human capital creation was enhanced, and a path was found toward cleaner technology due to technical advancements. Technology that augments human labour increased output, which in turn acquiesced to the need for environmentally sound methods of cutting carbon emissions.

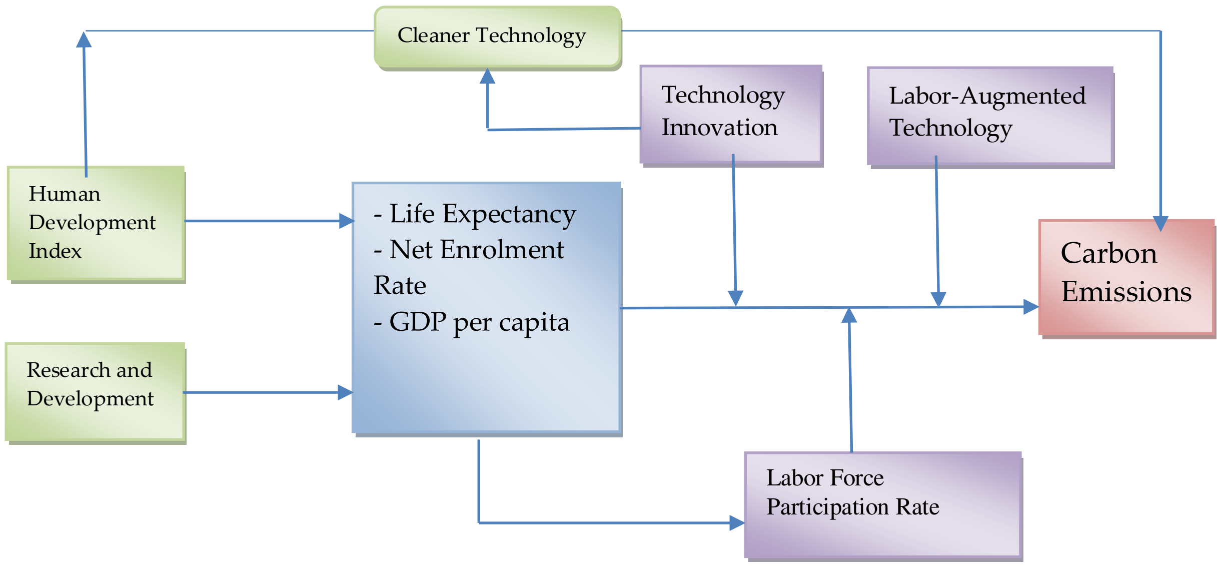

Figure 1: Theoretical Framework

Source: Author's self extract.

3.2. Econometric Framework

At first, the researchers utilized ordinary least squares (OLS) regression to estimate parameters. One primary tenet of ordinary least squares is that the equation's coefficient and error term are linear. The population-wide average of the error term must be 0, and independent variables must be completely unrelated. In this case, multicollinearity would not be an issue. The error term's variance must be kept constant, and the error term should follow a normal distribution, and autocorrelation should not be an issue.

3.2.1. Influence Statistics

The term "influential observation" refers to any observation that, if removed from the dataset, would cause a bigger change in the outcome of the equation that was estimated. In general, omitting an important observation will lead to a greater change in the parameter estimate than if the item were included. Two different aspects play a role in the observation. Firstly, from the mean of the independent variable, how much does the value of independent differ from it, also known as observation leverage, and secondly, the difference between the value predicted and its actual value, known as observation distance. Both of these concepts are referred to as observation distance. A total of six unique influences were used in time series analysis, referred to as CovRatio, HatMatrix, DRResid, RStudent, DFFITS, and DFBETAS, respectively.

3.2.2. Leverage Plots

The leverage plots are also diagnostic plots, which enable the influential observations to be identified using the leverage plots. The leverage is plotted along the X-axis on the graph, and the residual value is shown along the Y-axis at each point. The term "leverage" refers to the amount of variance seen in the coefficient if a particular observation is removed from the dataset used for the regression. After the model has been fitted, the errors in the outcome are referred to as residual. The residuals may not fully describe the form of the data in the model.

3.2.3. Robust Least Square Estimators

Robust least square is the choice approach when there are either significant outliers or essential data in the model to be detected. The OLS approach uses this as a stand-in. The strategy used here lessens the effect of outliers and more accurately represents the data. It is common to practice using the M estimator, S estimator, and MM estimate from the family of Robust approaches, all of which rely on the principle of order statistics and various weighting methods. To reduce high inefficiencies and identify outliers in dependent variables, Huber introduced M-estimation in 1973 (Huber, 1973). When deriving the probability function for a given parameter, M-estimation occurs. Thus, it is a pivotal step in the scoring process. Rousseeuw and Yohai (1984) introduced S-estimation, a computationally demanding approach for identifying outliers among independent variables. By relating slope and intercept values, the S-estimator may be used to lessen the scale measure of mistakes. The S-estimator is an example of a method that uses least squares to decrease the variance of the errors. Yohai (1987) introduced MM estimation. It is used to find extreme values in the dependent and independent variables. Blending S with M-estimation, this method. Equation (1) shows the variables for estimation by RLS procedure, i.e.,

$$CO2 = \alpha_0 + \alpha_1 LE + \alpha_2 NER + \alpha_3 GDPPC + \alpha_4 LFPR + \alpha_5 R\&D + \alpha_6 LAT + \varepsilon$$
$$\therefore \frac{\partial(CO2)}{\partial(LE)} < 0, \frac{\partial(CO2)}{\partial(NER)} < 0, \frac{\partial(CO2)}{\partial(GDPPC)} > 0, \frac{\partial(CO2)}{\partial(LFPR)} > 0, \frac{\partial(CO2)}{\partial(R\&D)} > 0, \frac{\partial(CO2)}{\partial(LAT)} < 0 \quad (1)$$

Where, shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, R&D shows research and development expenditures, and LAT shows labour-augmented technology.

3.2.4. Granger Causality Test

The Granger Causality method investigates how variables are causally linked to one another. This statistical test aims to determine whether or not the usage of one variable can aid in the detection and forecasting of another. The hypothesis is rejected if it is larger than the probability value at that level. Instead of determining whether X is responsible for Y, the Granger causality test looks at whether X may be used as a predictor of Y. The absence of an explanation for the variance in y using x at a later time is the Null hypothesis, and. X(t) was not considered a Granger cause of Y(t). The granger test is a theoretical method for determining whether or not two variables are connected at a given time. For Granger causality, the VAR framework in equation (2) has shown for reference, i.e.,

$$\begin{bmatrix} \ln(CO2)_t \\ \ln(LE)_t \\ \ln(NER)_t \\ \ln(GDPPC)_t \\ \ln(LFPR)_t \\ \ln(R\&D)_t \\ \ln(LAT)_t \end{bmatrix} = \begin{bmatrix} \tau_0 \\ \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \\ \tau_5 \\ \tau_6 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \sigma_{11t}\sigma_{12t}\sigma_{13t}\sigma_{14t}\sigma_{15t} \\ \sigma_{21t}\sigma_{22t}\sigma_{23t}\sigma_{24t}\sigma_{25t} \\ \sigma_{31t}\sigma_{32t}\sigma_{33t}\sigma_{34t}\sigma_{35t} \\ \sigma_{41t}\sigma_{42t}\sigma_{43t}\sigma_{44t}\sigma_{45t} \\ \sigma_{51t}\sigma_{52t}\sigma_{53t}\sigma_{54t}\sigma_{55t} \\ \sigma_{61t}\sigma_{62t}\sigma_{63t}\sigma_{64t}\sigma_{65t} \end{bmatrix} \times \begin{bmatrix} \ln(CO2)_{t-1} \\ \ln(LE)_{t-1} \\ \ln(NER)_{t-1} \\ \ln(GDPPC)_{t-1} \\ \ln(LFPR)_{t-1} \\ \ln(R\&D)_{t-1} \\ \ln(LAT)_{t-1} \end{bmatrix} \quad (2)$$
$$+ \sum_{j=p+1}^{d\max} \begin{bmatrix} \theta_{11j}\theta_{12j}\theta_{13j}\theta_{14j}\theta_{15j} \\ \theta_{21j}\theta_{22j}\theta_{23j}\theta_{24j}\theta_{25j} \\ \theta_{31j}\theta_{32j}\theta_{33j}\theta_{34j}\theta_{35j} \\ \theta_{41j}\theta_{42j}\theta_{43j}\theta_{44j}\theta_{45j} \\ \theta_{51j}\theta_{52j}\theta_{53j}\theta_{54j}\theta_{55j} \\ \theta_{61j}\theta_{62j}\theta_{63j}\theta_{64j}\theta_{65j} \end{bmatrix} \times \begin{bmatrix} \ln(CO2)_{t-j} \\ \ln(LE)_{t-j} \\ \ln(NER)_{t-j} \\ \ln(GDPPC)_{t-j} \\ \ln(LFPR)_{t-j} \\ \ln(R\&D)_{t-j} \\ \ln(LAT)_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix}$$

Equation (3) shows Granger causality for multivariate system, i.e.,

$$CO2_t = c_1 + \sum_{i=1}^{2}\beta_1 CO2_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i} + \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \quad (3)$$

$$LE_t = c_1 + \sum_{i=1}^{2}\beta_1 LE_{t-i} + \sum_{i=1}^{2}\beta_2 CO2_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i} + \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \quad (4)$$

$$NER_t = c_1 + \sum_{i=1}^{2} \beta_1 NER_{t-i} + \sum_{i=1}^{2} \beta_2 LE_{t-i} + \sum_{i=1}^{2} \beta_3 CO2_{t-i} + \sum_{i=1}^{2} \beta_4 GDPPC_{t-i} + \sum_{i=1}^{2} \beta_5 LFPR_{t-i} + \sum_{i=1}^{2} \beta_6 R\&D_{t-i} + \sum_{i=1}^{2} \beta_7 LAT_{t-i} + \varepsilon \quad (5)$$

$$GDPPC_t = c_1 + \sum_{i=1}^{2} \beta_1 GDPPC_{t-i} + \sum_{i=1}^{2} \beta_2 LE_{t-i} + \sum_{i=1}^{2} \beta_3 NER_{t-i} + \sum_{i=1}^{2} \beta_4 CO2_{t-i} + \sum_{i=1}^{2} \beta_5 LFPR_{t-i} + \sum_{i=1}^{2} \beta_6 R\&D_{t-i} + \sum_{i=1}^{2} \beta_7 LAT_{t-i} + \varepsilon \quad (6)$$

$$LFPR_t = c_1 + \sum_{i=1}^{2} \beta_1 LFPR_{t-i} + \sum_{i=1}^{2} \beta_2 LE_{t-i} + \sum_{i=1}^{2} \beta_3 NER_{t-i} + \sum_{i=1}^{2} \beta_4 GDPPC_{t-i} + \sum_{i=1}^{2} \beta_5 CO2_{t-i} + \sum_{i=1}^{2} \beta_6 R\&D_{t-i} + \sum_{i=1}^{2} \beta_7 LAT_{t-i} + \varepsilon \quad (7)$$

$$R\&D_t = c_1 + \sum_{i=1}^{2} \beta_1 R\&D_{t-i} + \sum_{i=1}^{2} \beta_2 LE_{t-i} + \sum_{i=1}^{2} \beta_3 NER_{t-i} + \sum_{i=1}^{2} \beta_4 GDPPC_{t-i} + \sum_{i=1}^{2} \beta_5 LFPR_{t-i} + \sum_{i=1}^{2} \beta_6 CO2_{t-i} + \sum_{i=1}^{2} \beta_7 LAT_{t-i} + \varepsilon \quad (8)$$

$$LAT_t = c_1 + \sum_{i=1}^{2} \beta_1 LAT_{t-i} + \sum_{i=1}^{2} \beta_2 LE_{t-i} + \sum_{i=1}^{2} \beta_3 NER_{t-i} + \sum_{i=1}^{2} \beta_4 GDPPC_{t-i} + \sum_{i=1}^{2} \beta_5 LFPR_{t-i} + \sum_{i=1}^{2} \beta_6 R\&D_{t-i} + \sum_{i=1}^{2} \beta_7 CO2_{t-i} + \varepsilon \quad (9)$$

3.2.5. Generalized Variance Decomposition Analysis (GVDA)

Using variance decomposition analysis, one can see how much information each variable contributed to the other variables in an autoregression model. It determines how much variation in error may be anticipated for each variable due to a disturbance in some other variables. It is helpful to do a variance decomposition analysis because:

- It reveals the significance of the shock responsible for explaining the variance of the variables in our model, and
- It demonstrates how the significance of the shock may evolve. Since inevitable shocks do not account for short-term volatility but longer-term shifts in the model.

Equation (4) shows into GVDA operator, i.e.,

$$\begin{aligned}
&Var(\sigma(CO2, LE) = Var(E[\sigma \perp LE]) + E[Var(\sigma \perp LE)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LE)] \\
&Var(\sigma(CO2, LE) = Var(E[\sigma \perp NER]) + E[Var(\sigma \perp NER)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, NER)] \\
&Var(\sigma(CO2, LE) = Var(E[\sigma \perp GDPPC) + E[Var(\sigma \perp GDPPC)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, GDPPC)] \\
&Var(\sigma(CO2, LFPR) = Var(E[\sigma \perp LFPR]) + E[Var(\sigma \perp LFPR)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LFPR)] \\
&Var(\sigma(CO2, LE) = Var(E[\sigma \perp R\&D]) + E[Var(\sigma \perp R\&D)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, R\&D)] \\
&Var(\sigma(CO2, LE) = Var(E[\sigma \perp LAT]) + E[Var(\sigma \perp LAT)] \\
&\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LAT)]
\end{aligned} \quad (10)$$

4. RESULTS AND DISCUSSION

Table 2 displays descriptive statistics. With a mean and median of 97184.63 kton and kton, respectively, CO2 has huge variations of possible values. The range of emissions values is from -20,837 kiloton to +22,838.08 kiloton. There is a 55335.79 standard deviation. Since the kurtosis of CO2 emissions is only 0.452, its distribution may be normal since the skewness and kurtosis values are less than 3. The average life expectancy in Pakistan is close to 62 years, with a mean of 61.865, a median of 62.171, and maximum and lowest values of 67.273 and 55.0288, respectively. The typical platykurtic curve has a kurtosis value of 1.878, a skewness value of -0.199, and the standard deviation value of the human lifespan is 3.678 years. Similarly, as a whole, the net enrolment rate has a mean of 59.015% and a median of 55.298%. Values for NER range from a high of 68.189 to a low of 55.298%, which demonstrates that the enrolment rate is merely 59%. There is a 5.030 standard deviation value of it. Since NER's kurtosis value is just 1.750 (less than 3), we may infer that its platykurtic curve is normal. The GDP per capita in Pakistan is US$1032.255, with a high of US$1502.891 and a low of US$599.6920. The standard deviation is US$255.803, and the skewness and kurtosis are also normal (0.059 and 2.073, respectively). Pakistan's labour force participation rate is close to 50%, with a mean of 47.779, a median of 50.065, minimum and maximum of 52.030 and 32.200, respectively. The LFPR distribution has a negative skew with a standard deviation of 2.793 and a leptokurtic curve with a value of 35.635. Low progress in R&D is reflected in its mean value of 0.226, the median value of 0.155, the maximum value of 0.632, and the lowest value of 0.109. The kurtosis value of 5.398 indicates a leptokurtic distribution with a long tail positive skew, and a kurtosis value of 0.119 indicates a standard deviation of 0.119. Finally, the median value for labour-augmented technology is 155.415, and the mean is 250.250. The range goes from -788.411 to +93.342. A positive skew of 1.275 and a platykurtic curve with values of 3.936 characterize the distribution of the data.

Table 2: Descriptive Statistics

Methods	CO2	LE	NER	GDPPC	LFPR	LAT	RNDE
Mean	97184.63	61.865	59.015	1032.255	49.777	250.250	0.226
Median	89745	62.171	55.298	1011.018	50.065	155.415	0.155
Maximum	208370	67.273	68.189	1502.891	52.030	788.461	0.632
Minimum	22838.08	55.028	55.298	599.692	32.200	93.3420	0.109
Std. Dev.	55335.79	3.678	5.030	255.803	2.793	173.868	0.119
Skewness	0.452947	-0.199	0.733	0.059	-5.543	1.275	1.723
Kurtosis	2.179099	1.878	1.750	2.073	35.635	3.936	5.398

Note: CO2 shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, LAT shows labour-augmented technology, and RNDE shows R&D expenditures.

According to the correlation matrix shown in Table 3, all suggested measures of human capital formation (i.e., longer life expectancy, higher education levels, and higher wealth levels) are positively connected with carbon emissions. Given these findings, it is clear that the country's green development plan would be hampered unless substantial investments are made in healthcare infrastructure to reduce hospital waste. Additionally, there will be short-term increases in building emissions associated with establishing educational infrastructure, but long-term improvements in education lead to innovative ideas for dramatically reducing carbon emissions. Income is linked to carbon emissions, encouraging more environmentally friendly business practices. Positive correlations ($r = 0.328$, $r = 0.719$, and $r = 0.550$) were discovered between the number of people actively looking for work, the use of labour-augmented technology, research and development expenditures, and carbon emissions. This finding suggests that improvements to the labour market should emphasize providing workers with creative and environmentally friendly ways to enhance their working conditions and communities.

Table 3: Correlation Matrix

Variables	CO2	LE	NER	GDPPC	LFPR	LAT	RNDE
CO2	1						

LE	0.967	1					
	(0.000)	-----					
NER	0.880	0.807	1				
	(0.000)	(0.000)	-----				
GDPPC	0.985	0.987	0.847	1			
	(0.000)	(0.000)	(0.000)	-----			
LFPR	0.328	0.305	0.328	0.290	1		
	(0.025)	(0.038)	(0.025)	(0.049)	-----		
LAT	0.719	0.704	0.804	0.721	0.235	1	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.115)	-----	
RNDE	0.550	0.5380	0.693	0.550	0.188	0.974	1
	(0.000)	(0.000)	(0.000)	(0.000)	(0.209)	(0.000)	-----

Note: CO2 shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, LAT shows labour-augmented technology, and RNDE shows R&D expenditures. Small bracket shows probability value.

There is also a positive relationship between a country's life expectancy and level of education, its income, the amount of work done by its citizens, the amount of technology enhanced by its workforce, and the amount spent on research and development. The critical variables in raising a country's educational attainment are economic growth, labour work, labour-augmented technology, and research and development spending. Worker productivity, R&D spending, and the use of technology to enhance workers' abilities have increased alongside GDP throughout time. Finally, a country's R&D spending increase leads to a rise in labour-augmented technology. Based on the estimates, Figure 2 plots the influence statistics and finds different possible outliers in the given model.

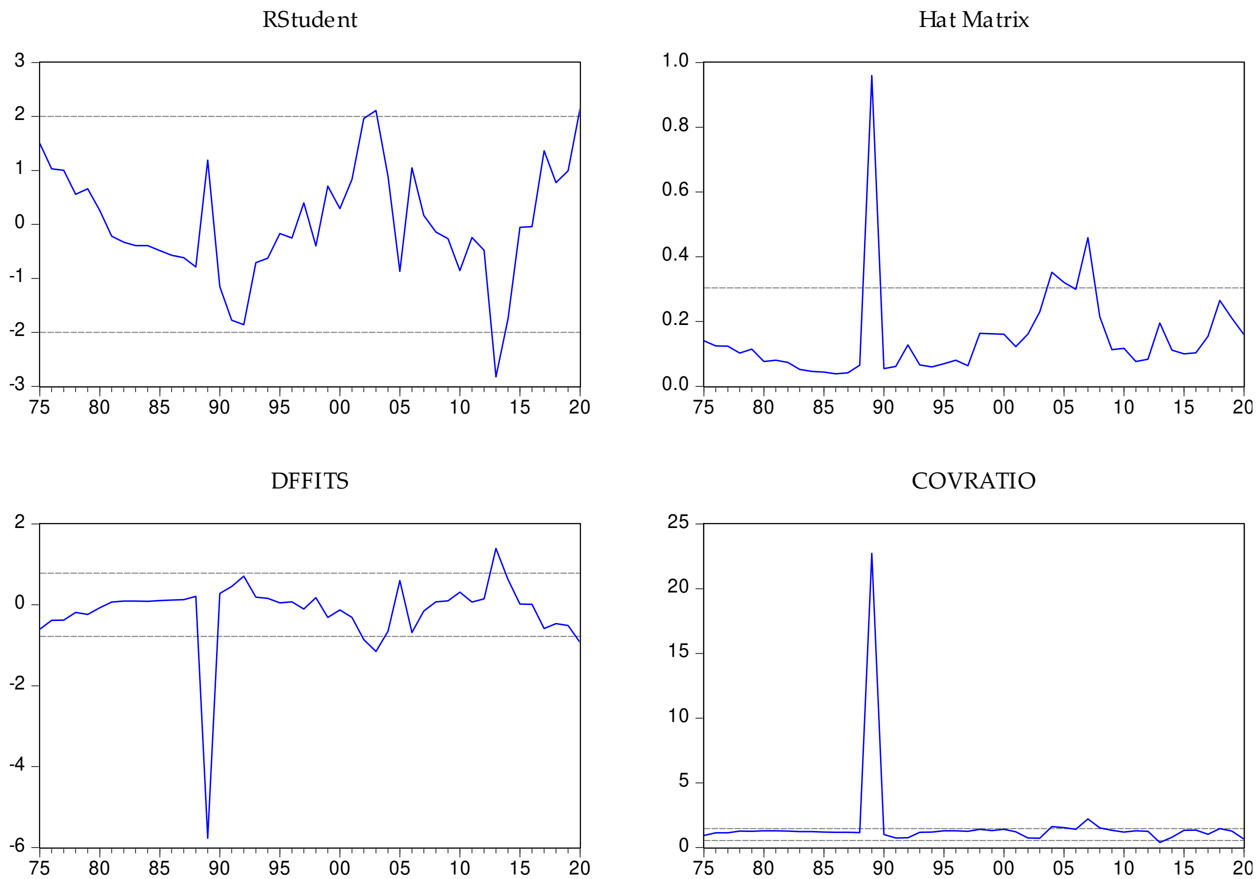

Figure 2: Influence Statistics

Source: Author's estimation.

The data gathered from RStudent revealed two possible anomalies between 2003 and 2013. Statistics based on the HatMatrix revealed that 1989, 2004, and 2007 each had a distinct possibility of becoming an outlier. In addition, the figures provided by DFFITS corroborated the three potential outliers at three distinct points in time, namely 1989, 2003, and 2013. Last but not least, the COVRATIO figures highlight two potential outlier years: 1989 and 2017. The next step is to check these outliers in the dependent and their explanatory variables based on the statistics. Figure 3 shows the leverage plots of the variables. The findings demonstrated the extensive variance ranges present in the model's explanatory variables. The variables have significant deviations from their respective means. The estimations of the regression coefficients may have been negatively influenced by the high leverage points, which have led to skewed and inconsistent results. Therefore, using the Robust Least squares (RLS) regression is a suitable explanation since it handles outliers from the variables and delivers robust, sound parameter estimates. Table 4 shows the RLS-M estimates and found that life expectancy, net enrolment rates, and labour-augmented technology have a positive relationship with the carbon emissions. On the other hand, R&D expenditures helps to mitigate carbon emissions in the premises of human capital formation. Without significant expenditures on healthcare infrastructure to decrease hospital waste, the green development goal of the nation would be impeded (Kruk et al. 2018). While there will be an increase in construction emissions during the first stages of developing educational infrastructure, this will be more than offset by the long-term benefits of better education, which will lead to novel approaches to drastically cutting carbon emissions. Companies are incentivized to adopt greener procedures by having their earnings depend on their carbon output (Gulzari et al. 2022, Khan et al. 2022).

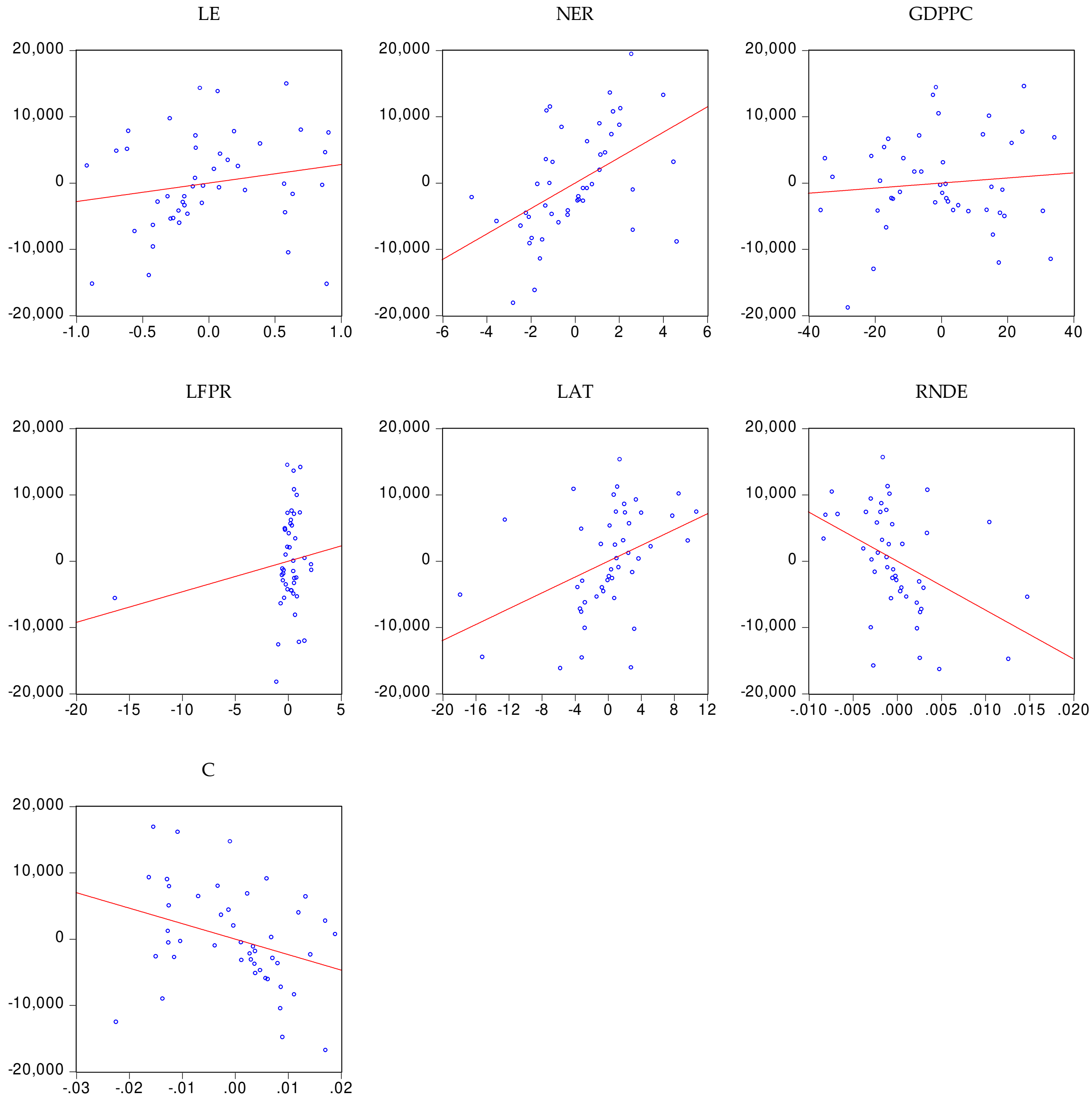

Figure 3: Leverage Plots

Note: CO2 shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, LAT shows labour-augmented technology, and RNDE shows R&D expenditures. Small bracket shows probability value.

The study found a positive relationship between the use of labour-augmented technologies and the release of greenhouse gases. Based on these results, labour market reforms might benefit from focusing on giving employees opportunities to use their imagination and green sensibilities to better their workplaces and local neighborhoods. According to the findings of their investigation, Ma et al. (2022) conclude that the shift toward digital technology will result in lower levels of carbon emissions. As a result of Lee and Min's (2015) discovery of an inverse link between technology and carbon production, it is recommended that enterprises transition toward environmentally friendly technology in order to reduce their impact on the environment. Raihan et al. (2022) argued that carbon emissions reduction is an essential topic at global conferences, emphasizing emissions from overseas businesses. The causes, effects, and mitigation strategies, such as the Paris Agreement, for climate change, must be held to account. Spending significant research and development is necessary to achieve these goals. Davy et al. (2021) concluded that global companies rely heavily on Innovation to internalize their product innovation capabilities and maintain such high levels of investment. They play a crucial part in shaping climate policy by driving down carbon emissions reduction efforts. Bano et al. (2018) concluded that individuals may be able to reduce their carbon footprint with the aid of education and technology. Pakistan is seeing a rise in pollution levels due to a dearth of competent personnel. Capital infusions enable businesses to relocate to countries with fewer regulations. As a consequence, the environmental effects of transnational activity in various areas will be amplified by an increase in pollution and a depletion of natural assets. Thus, determining the overall impact of corporations on the environment is challenging. Even if a company can demonstrate that it has cut emissions in one country, it does not mean it has cut emissions elsewhere.

Table 4: RLS-M Estimates

Dependent Variable: CO2				
Variables	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
LE	5416.592	2019.767	2.681	0.007
NER	3197.950	469.610	6.809	0.000
GDPPC	-88.440	52.588	-1.681	0.092
LFPR	144.284	375.873	0.383	0.701
LAT	1028.780	178.521	5.762	0.000
RNDE	-1280457	213756.1	-5.990	0.000
C	-310478.7	92831.91	-3.344	0.000
Robust Statistics				
R^2	0.770	Adjusted R^2		0.735
Rw^2	0.993	Adjust Rw^2		0.993
Rn^2	3383.867	Prob(Rn^2		0.000
Diagnostic Tests				
Jarque-Bera	0.074	Heteroskedasticity		1.253
Prob.value	0.963	Prob.value		0.300

Note: CO2 shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, LAT shows labour-augmented technology, and RNDE shows R&D expenditures. Small bracket shows probability value.

Figure 4 shows the Granger causality estimates for ready reference. The Causal estimates confirmed the emissions-led life expectancy and educational attainment, growth-led emissions and education, and life expectancy-led education attainment. The bidirectional relationship between economic growth and life expectancy implies that continued economic growth increases healthcare sustainability. At the same time, the reverse also holds where life expectancy causes continued economic growth in a country. R&D expenditures and labour-augmented technology Granger cause life expectancy. Educational attainment Granger causes R&D expenditures and labour-augmented technology in s country.

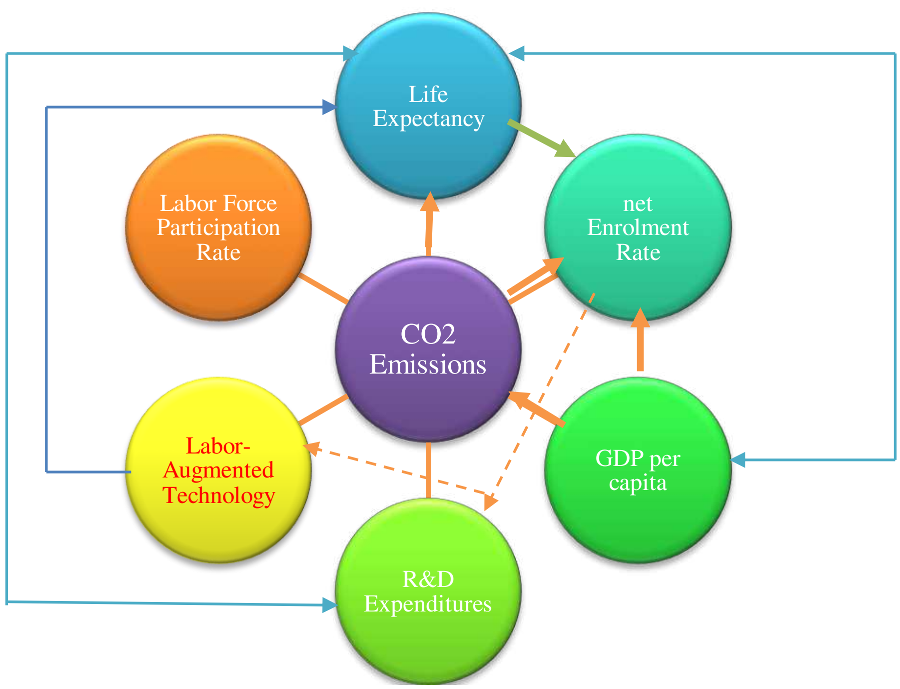

Figure 4: Granger Casualty Estimates

Source: Author's self extract.

The findings of the variance decomposition are shown in Table 5. The first three periods are considered "short run," whereas periods seven and beyond are considered "long run." Carbon's decomposition reveals that beginning with period 1, carbon relies entirely on itself, decreasing through time to a value of 65.53% in the short run, indicating that the variation is captured by CO2 output. The average lifespan, the number of students enrolled in school, the national income per person, the labour force participation rate, the output of scientific research, and the effectiveness of labour-enhancing technologies all contribute by varying amounts: 22.28%, 5.94%, 0.78%, 4.21%, 1.18%, and 0.05%, respectively. Any sudden increase or decrease in CO2 levels alters the atmosphere by 57.5 percent over time. Comparatively, the effects of LE, NER, GDP share, LFPR, R&D, and LAT are as follows: 19.04%, 8.77%, 0.48%, 7.19%, 5.76%, and 1.22%, respectively.

Table 5: Generalized VDA Estimates

Period	S.E.	CO2	LE	NER	GDPPC	LFPR	LAT	RNDE
1	3895.432	100	0	0	0	0	0	0
2	6232.821	93.18835	3.120029	0.106694	0.990374	1.314378	1.067468	0.212704
3	8923.517	65.53095	22.28322	5.944670	0.783273	4.215497	1.136471	0.105912
4	10884.14	52.55261	29.65894	10.22815	0.706909	5.638781	0.954308	0.260301
5	12230.85	52.07575	28.76146	10.41653	0.566158	6.349776	1.045058	0.785259
6	13692.66	55.87640	25.74919	9.021032	0.536066	6.252295	1.652451	0.912565
7	15387.32	58.00649	23.89534	8.030999	0.425270	6.340060	2.578415	0.723427
8	17190.24	57.42482	22.99846	7.995846	0.478982	6.772689	3.467177	0.862031
9	19042.21	56.74469	21.50205	8.423458	0.555600	7.133401	4.357192	1.283613
10	21058.98	57.50819	19.04738	8.779560	0.481513	7.195916	5.360290	1.627148

Note: CO2 shows carbon emissions, LE shows life expectancy, NER shows net enrolment rate, GDPPC shows GDP per capita, LFPR shows labor force participation rate, LAT shows labour-augmented technology, and RNDE shows R&D expenditures.

Comparatively, the variance decomposition of LE reveals that the variable accounts for 99.77% of the total variation, dropping to 91.68% in the short term after accounting for the effects of exogenous factors, including CO2, NER, GDP per capita, LFPR, R&D, and LAT (in that order of importance). However, in the long term, LE captures just 37.47% of the variance, whereas the other components account for over 63%. Similarly, if we examine the variance decomposition of labour-augmented technology, we find that this component accounts for just 7.05 percentage points of the total variance in the short term, while the remaining 93.3 percentage points come from other sources. Similar to the short term, LAT captures 11.95% of the variance in the long term, while the other factors account for about 88%. The results conclude that life expectancy has a greater variance in carbon emissions for the next ten years, followed by educational attainment, labour force participation rate, and labour-augmented technology. In comparison, the country's per capita income on carbon output over time will be the least influenced.

The overall results conclude that developing environmental laws and many programmes, initiatives, and efforts to stimulate and finance R&D activities should consider that innovation may have a favourable, detrimental, or weak impact on carbon emissions (Hsu et al. 2021, Du et al. 2021). When it comes to protecting the environment, the government's attention should be laser-focused on advancing research and development initiatives that work to cut down on carbon emissions and boost their utilization (Ma et al. 2022, Ogbeide-Osaretin & Orhewere 2022). Nations have vowed to end fuel grid stability and cease funding energy projects in oil and coal-using nations. This is a big step in fighting climate change (Lin & Zhao, 2022). Rising energy prices have led to increased support for nuclear power, and popular opinion has a part in deciding whether to build renewable power plants for green development (Andal et al. 2022, Azam et al. 2023). In most countries, such investments have little public support. The speed with which energy-intensive industries in the nation can reduce their overall emissions and the impact of higher fuel prices on labour demands will determine the economic ramifications of corporate emissions. In order to meet rising labour demands, organizations must be able to quickly and easily swap from power methods to employment ones. By influencing consumer spending, personal income taxes drive up the price of labour and reduce labour's share of economic production (Taylor et al. 2021). The impending climatic crisis necessitates drastic measures, including massive expenditures on energy infrastructure. Since more considerable systemic change is necessary, economic policies should work to overcome market shortcomings rather than implementing a worldwide carbon price, affecting human capital development (Vence & López Pérez 2021, Hepburn et al. 2021).

5. CONCLUSIONS

Carbon emissions caused by people are a significant cause of the world's warming climate, which is causing widespread damage. The lack of human capital development has made it harder for Pakistan to adapt and develop new ideas, making environmental degradation and global warming worse. This problem has worsened because the federal government has not put enough money into health care, education, and the job market. This makes it harder to reach the goal of sustainability. The main goal of this study is to find out how human progress and carbon emissions in Pakistan are related. So, the data set includes information from 1975 to 2020. The findings indicate that increasing carbon emissions hurt healthcare sustainability. The favourable impact of carbon dioxide emissions on human life expectancy is attributable to consumption rather than economic production. Moreover, more money will not magically make everyone healthy. While the results show that a country's carbon emissions increase somewhat due to economic development as education levels improve, they also show that education may lessen the effects of global warming on the poor. A decreased carbon emissions level was related to increased research and development investment. Research and development (R&D) result in the discovery of new goods and processes, increased efficiency, and innovations in the production chain, all of which may help lower carbon emissions. Because carbon-intensive industries tend to be highly capital-intensive, the right pricing strategy will lower the relative demand for capital and lower capital returns relative to wages. Further, it increases the demand for labour across the economy, explaining the positive correlation between labour-augmented technology and carbon emissions. Estimates of Granger causality indicated that economic expansion was responsible for increased emissions and educational attainment. In contrast, higher levels of education were shown to be the primary cause of R&D investment and labour-enhancing technology. The VDA predicts that changes in life expectancy, educational attainment, labour market reforms, research and development spending, and labour-augmented technology will impact global carbon emissions during the next decade.

Sustainable development initiatives mainly adopting ecological initiatives to minimize carbon emissions, improve biodegradable waste management, and promote alternative energy sources. Clean power is costly, and most nations rely on nonrenewable fuels despite pollution, environmental consequences, and health inequalities. Higher education correlates with carbon emissions, suggesting that individuals with more education are better prepared for environmental issues. The significance of protecting the environment presents intellectuals with the challenge of determining the most effective ways to achieve maximum benefit in nutrition, literacy, hunger, power, the climate, and other areas of welfare, as well as how accomplishing specific goals may influence accomplishing other goals. The danger of climate change may be reduced by increasing the education level of the people, and people are more likely to be vulnerable if educational advancement is slowed down. The reduction in emissions that would result from a smaller population might be more than offset by the economic growth resulting from improved academic achievement. Learning about climate change and how to adapt and mitigate it is a priority for education. Individuals may be better ready to deal with climate risk if they have access to a high-quality educational system. Suitable learning environments might help students become more flexible and open to new ideas and practices. The educational system is a possible influence on global warming via the spread of clean technologies. Learning and education play a role in creating new things, such as cutting-edge technology and their widespread use. Today, environmental co-benefits assessment is a standard practice in evaluating development initiatives. The physical aspect of finance frequently has material co-benefits in higher education. Given the importance of education to the development of green technology, it stands to reason that fuel co-benefits could be significant if investments are made to improve education quality. Further, it would increase the cognitive abilities of the workforce and the economy's capacity to increase the supply of abilities in response to emissions trading.

Ethical approval

All international standards have been adopted and compliance.

Informed consent

The study was conducted with equal participation by all authors.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

The data is freely available at World Development Indicators published by World Bank (2022) at
https://databank.worldbank.org/source/world-development-indicators

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