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Rural Development and Education: Critical Strategies for Ending Child Marriages

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ABSTRACT

Gender inequality remains a prevalent global concern and has been identified as a significant contributing factor to the occurrence of child marriages. Child marriage is a serious human rights violation that has significant socio-economic effects on children, families, and communities. This study aimed to identify key determinants of child marriages through the use of multiple regression analysis. Child marriage was operationalized as the dependent variable, while wealth, unemployment, education, rural poverty, and gender inequality were employed as independent variables. The findings of the study revealed a positive correlation between rural poverty and child marriages, suggesting that areas of higher poverty may be associated with a greater incidence of child marriages. Additionally, the study found a negative relationship between knowledge and child marriages, indicating that the empowerment of local communities through education may serve as an effective strategy to decrease child marriages. The results of this study have important policy implications, and it is crucial that federal governments and administrative bodies prioritize measures to protect against child marriages in order to address gender inequality.

Keywords: Gender inequality; Child marriages; Rural Poverty; Unemployment; Education; Pakistan.

1. INTRODUCTION

The United Nations has established a comprehensive set of global objectives, known as the Sustainable Development Goals (SDGs), that are intended to promote the welfare and rights of all individuals and communities. One crucial aspect of this effort is the elimination of harmful social practices that disproportionately affect marginalized groups, such as women and girls. Within this context, SDG 5, which aims to achieve gender equality and empower all women and girls, places a particular emphasis on eradicating child, early and forced marriage as well as female genital mutilation.

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The United Nations has established a comprehensive set of global objectives, known as the Sustainable Development Goals (SDGs), that are intended to promote the welfare and rights of all individuals and communities. One crucial aspect of this effort is the elimination of harmful social practices that disproportionately affect marginalized groups, such as women and girls. Within this context, SDG 5, which aims to achieve gender equality and empower all women and girls, places a particular emphasis on eradicating child, early and forced marriage as well as female genital mutilation. This objective, outlined in Target 5.3, is critical for ensuring that all individuals, regardless of their gender, have the opportunity to live lives of dignity, autonomy, and self-determination (United Nations, 2022).

Marriage before a person reaches the age of 18 is considered a "child marriage," and this practice impacts millions of people worldwide. Sixty million marriages occur worldwide before the age of eighteen reports UNICEF. In addition to violating children's fundamental human rights, this damaging practice deprives them of their rights to health, learning, and safeguarding against violence, extortion, and assault (Duran & Eraslan, 2019). Both young men and women are touched by child marriage, which includes both legal and informal relationships, but females are hit worse. One-third of girls worldwide are married before they turn 18, and one-seventh get married before they turn 15. Roughly 10 million teen romances take place every year. While the rates of child marriage are greatest in West Africa, they are also higher in southern Asia, northern Africa/the Middle East, and Latin America. However, because of the sheer number of people living in southern Asia, over half of all young girls who are married off at a young age live there. Even amongst nations in the same region, there may be significant variations in incidence, with the highest rates seen in less industrialised or rural regions. Data from 47 nations shows that the median age of first marriage is rising; however, this is primarily a phenomenon among the daughters of well-to-do families. The rate of development is still too sluggish, sadly. While just 35% of women 20-24 have married before 18, 48% of women 45-49 have done so. Pregnancy at a young age raises the chances of mortality or long-term health problems, such as obstetric fistula. It is only one of the many adverse outcomes of child marriage (Svanemyr et al., 2012).

Children, especially those from poor socioeconomic areas who were already marginalised and neglected, have been struck by the COVID-19 epidemic. Particularly vulnerable to the pandemic's long-term effects—including child labour, child trafficking, child marriage, sexual exploitation, and death—are children from underprivileged backgrounds. Mainly at risk are girls and women, who face discrimination and danger because of their gender and social position as outcasts (Rahiem, 2021). In addition, the epidemic has made domestic violence more likely. According to the United Nations Population Fund, domestic and sexual violence worldwide increased by 20% during the epidemic. Preliminary statistics from police agencies in the United States indicate that COVID-19 may affect domestic violence in certain areas more than in others. As of March 2020, there was a rise of 22% in Portland for domestic violence-related arrests, 18% in San Antonio for complaints about family violence, 27% in Alabama for calls about domestic violence, and 10% in New York City for reviews of domestic violence cases. In addition, a European WHO affiliate reported a 60% rise in emergency calls from women whom an abusive spouse had threatened during lockdowns implemented in several European towns. Human rights activists in Bangladesh surveyed 53 of the country's 64 districts in June 2020 and found that 4622 women had been subjected to mental torture, 1839 had been subjected to physical abuse, and 203 had been sexually molested. The National Women's Commission of India reports a 94% rise in domestic rape incidents during the lockdown, putting over half a billion women in India in danger (Padmanabhan, 2022).

Teaching and learning about the mental, emotional, physical, and social elements of sexuality is referred to as comprehensive sexuality education (CSE). The program's ultimate goal is to equip young people with the self-awareness, self-responsibility, self-respect, and self-respect for others that they need to make responsible decisions that will benefit themselves and others, as well as the self-respect and self-respect for others throughout their lives. UNESCO, the United Nations Educational, Scientific, and Cultural Organization, emphasizes the significance of CSE programmes that are factually sound, progressive in character, age-appropriate, and regionally meaningful. Youth reproductive and sexual health rights need a focus on sex education (Nadeem et al., 2020).

The prevalence of child marriage in Pakistan is high, especially in the province of Sindh and the country's rural regions. Child marriage is harmful because it violates the rights of children as defined by several international and local laws, which have been formed in response to the roots and practices of child marriage. The practice has far-reaching repercussions for both children and civilization as a whole. This piece will focus on the legal initiatives the United Nations and other international bodies took to reduce the prevalence of child marriage across the globe. Marriages between minors are examined in the context of civil rights and women's rights, and many international conventions and treaties draw attention to this problem. The participating states must ensure that their national legislation is consistent with the spirit of the conventions and treaties to which they are signatories. Similarly, Islamic law plays a significant role in Pakistan's internal legal system. Therefore, Islamic and international law are included in the analysis (Nazirullah et al., 2021).

The prevalence of child brides is incredibly high in Pakistan, a country with some of the world's worst gender inequalities. In Pakistan, young girls are more vulnerable to maternal morbidity and death because of child marriage since it is linked to multiple pregnancies (within 24 months of each other), unplanned pregnancies, and abortions. Diarrhoea, newborn mortality, and death in children younger than five all rise with the prevalence of child marriage in Pakistan. Notably, women who got married young had a higher chance of not having access to professional prenatal care, of having their babies delivered by untrained people, and of having their babies at home, all of which raised the likelihood of problems such as postpartum haemorrhage (Nasrullah & Raza, 2014; Acharya et al., 2018; Krukowski et al., 2022). The United Nations adopted its first resolution on the issue of child, early, and forced marriage in November 2014. Most member nations have agreed to co-sponsor the resolution because of its historical significance. Pakistan, a country with a vast and youthful population and a high risk of child marriages due to low education levels, was one of the first to raise the problem (Al-Moushahidi & Jehna, 2015).

Due to the increased risk of illness and diseases accompanying malnutrition, approximately half of all fatalities among children under five (3 million deaths yearly) may be attributed to it. South Asia and sub-Saharan Africa had the worst stunting rates and wantedness among the world's children in 2011. This affected at least 165 million children. Women of childbearing age are also disproportionately affected by malnutrition. Low birthweight babies are more vulnerable to early childhood illnesses and death due to the

effects of maternal malnutrition. Premature exposure to these hazards increases the likelihood that a child may have growth retardation, which can have lasting and detrimental effects on the student's intellectual, psychomotor, and healthcare. The necessity of acting during pregnancy and the first two years of life is emphasised because most of the permanent harm caused by starvation occurs during these times (Das et al., 2016; Soliman et al., 2021). Among Asian countries, South Asian ones like Pakistan have the highest maternal mortality rate. Recent estimates place the annual global death toll for women in delivery and its immediate aftermath at roughly 295,000. About 20% of these fatalities occur in South Asia alone. Approximately 94% of maternal fatalities occur in low-income nations. A new study by the National Institute of Population Studies, titled "Pakistan Maternal Death Survey 2019," and supported by USAID, reveals striking demographic differences in maternal mortality rates between women residing in rural and urban areas of Pakistan. In Pakistan, there are 186 fatalities of mothers for every 100,000 births. This proportion is about 26% greater in rural regions than urban ones. It is crucial to provide women with expert assistance and protection during maternity, labour, and the postoperative period to reduce the risk of difficulties. Increased maternal death burden in rural areas can be attributed to several factors, including but not limited to economic hardship; inequalities in education; gender-based imbalances; inadequate and poor quality healthcare services; isolated areas; intercultural values; undernutrition and violence against women; unjustified allocation of resources; and the political landscape (Hanif et al., 2021).

Teaching and learning about the mental, emotional, bodily, and social aspects of sexuality is called comprehensive sexuality education (CSE). The program aims to help young people acquire the self-awareness, self-efficacy, self-responsibility, and self-respect that will serve them well throughout their lives (Nadeem et al., 2019). Child and adolescent sexuality education (CSE) programmes may assist in educating children and young people about sexual and reproductive health, equipping them with the information and skills they need to make educated choices about their sexual health and relationships. Additionally, it may aid in preventing child marriages by empowering young people to make mature decisions about when and with whom to create a family. As a result, CSE can potentially be an effective strategy in Pakistan to reduce the prevalence of harmful child marriages and boost maternal health (Subramanee et al., 2022). Adverse effects on children's mental, emotional, and social health are lasting results of the cultural norm of marrying off minors. It denies kids the chance for a healthy life, an education, and safety from abuse and exploitation. Women who start having children at a young age are at a higher risk of complications during pregnancy and childbirth. Their risk of experiencing violence and abuse at the hands of their spouses and in-laws is considerably higher. In addition, many young women who have been married off as children end up dropping out of school, limiting their potential for future success in both the workforce and their personal lives (Hamad et al., 2021).

Based on the stated discussions, the study assessed following possible research questions that crucial for developing an understanding about the stated issues in a country like Pakistan, i.e., first, how education levels affect the incidence of child marriages in rural areas. Specifically, whether higher education levels among girls in rural communities are associated with a lower likelihood of entering into child marriages. Second, whether there are differences in the education levels of girls who do and do not enter into child marriages, and whether these differences are more pronounced in rural compared to urban areas. Third, how wealth status influences the decision to enter into child marriages in low-income households. For example, whether families who are living in poverty are more likely to enter into child marriages as a means of financial stability. Forth, whether there are differences in the wealth status of families whose daughters do and do not enter into child marriages, and whether these differences are more pronounced in rural compared to urban areas. Fifth, unemployment rate is also another important area of research, i.e., whether the prevalence of child marriages is higher in rural communities with higher unemployment rates, and whether there is a relationship between unemployment and child marriage. Fifth, how poverty and unemployment are related to each other and how they influence child marriages. Gender inequality also plays a role in the incidence of child marriages. The sixth research question is how gender inequality affects the decision of parents to enter into child marriages, and whether this is more pronounced in rural compared to urban areas. Seventh, the study explore whether there are differences in the gender roles and expectations of girls who do and do not enter into child marriages. Finally, one of the key area of research is to investigate how education and economic empowerment programs can be implemented to reduce the incidence of child marriages in developing countries, Like Pakistan. The study investigate the effectiveness of different types of educational and economic empowerment programs in reducing the incidence of child marriages, and whether these programs are more effective in urban or rural areas. There is need to know whether there are specific groups of girls who are more likely to benefit from these programs, such as those who are living in poverty or who have lower levels of education. Based on the stated research questions, the following are the objectives of the study, i.e.,

I.   To investigate the relationship between education levels and the incidence of child marriages in rural areas.
II.   To examine the influence of wealth status on the decision to enter into child marriages in low-income households.
III. To determine the impact of unemployment rate on the prevalence of child marriages in rural communities.
IV.   To understand the role of poverty in the perpetuation of child marriages in rural areas, and
V.   To explore the influence of gender inequality on the incidence of child marriages in developing countries and how it varies in urban and rural areas.

The significance of this study lies in its ability to shed light on the complex and multifaceted nature of child marriages in Pakistan, and the ways in which they are affected by factors such as education, wealth, unemployment, rural poverty, and gender inequality. By understanding the underlying causes of child marriages in Pakistan, the study has the potential to inform the development of targeted and effective interventions aimed at reducing the incidence of child marriages and improving the well-being of girls and young women. Moreover, this study highlights the importance of addressing the root causes of child marriages in order to effectively combat the issue. By highlighting the relationship between poverty and child marriages, this study emphasizes the need for economic development and poverty reduction efforts in order to combat child marriages. Additionally, the study highlights the importance of addressing gender inequality, as it plays a significant role in the perpetuation of child marriages. Furthermore, the study also has

important policy implications, as it can inform the development of laws and policies aimed at reducing child marriages and protecting the rights of girls and young women. By providing an in-depth understanding of the factors that contribute to child marriages in Pakistan, this study can inform the design and implementation of effective policies and programs that can help to reduce the incidence of child marriages and improve the lives of girls and young women in Pakistan.

2. LITERATURE REVIEW

Child marriage has significant socio-economic effects on families and communities. Children who marry young are more likely to live in poverty, as they are often forced to leave school and enter into low-skilled, low-paying jobs. Child marriage also perpetuates a cycle of poverty and disadvantage, as children born to teenage mothers are more likely to be born with low birth weight and to experience malnutrition, which can lead to cognitive and developmental delays (Ziegert & Sulliva, 2022).

2.1. The Socio-Economic Effects of Child Marriage: A Human Rights Violation with Long-term Consequences

Child marriage has a detrimental effect on the socio-economic development of communities and nations. Child marriage hinders the achievement of the United Nations Sustainable Development Goals, particularly in relation to education, poverty, and gender equality (Hassan, 2020). Gular & Kucuker (2010) conducted a study to examine the negative effects of early marriages on the health of teens and children. The study was conducted in Afyonkarahisar province, Turkey, between 2000 and 2006, using a sample of adolescent girls who had been admitted to court and were receiving psychiatric outpatient treatment at a university clinic. The authors, who were psychiatrists, personally interviewed all subjects using a social mobility questionnaire. The results of the study indicated that most of the teens in the sample came from a lower socio-economic class and had aspirations for marriage after completing primary school. Additionally, the study found that these teens received very little sex education from their parents and that current institutional education programs at their schools were inadequate. Jalovaara (2013) examined the differences between the influence of social and economic factors on the breakdown of cohabitations and marriages in Finland. The study analysed information on the first marriages of women born between 1969 and 1981 using event-history techniques. Aspects of financial and educational success and income and employment were tracked throughout time to assess their effects on the study's overall findings. The research found that just around one in ten first-time cohabiting relationships lasts for an entire decade without ending in divorce or marriage. Of those that did last that long, three-quarters terminated in divorce or marriage. Child marriage laws in Sindh, Pakistan, were the subject of research by Bhanji & Punjani (2014). This article discusses the leading causes of child marriage, the importance of the problem and its consequences, and some public health interventions that may be taken to lessen the damage. The authors highlight that child marriage has declined worldwide over the last 20 years and is becoming more widely recognised as a human rights violation. Ozcebe and KucukBicer (2013) conduct a study on the issue of early and forced marriages in their country. They aim to define the causes of early marriages, the position of early marriages in national and international laws and to determine the frequency of the phenomenon. The study highlights the fact that early marriages are a significant child and girl issue in their society. The authors stress that preventing early marriages for whatever reason is essential for solving social contradictions, raising awareness about the issue and governmental actions on early marriages are crucial from the point of view of public health.

Duran and Eraslan (2019) conducted a study to identify the factors that influence women's decisions to enter into early marriages. The sample of the study consisted of 651 women who were within the age group of 30 and below and had gotten married during their childhood. The study found that education, poverty, and societal pressure were among the main reasons for early marriages. The authors of the study suggest that women in the at-risk group should be educated about the negative effects of early marriages and that those who have already entered into early marriages and are seeking support should be helped. They also recommend stricter legal sanctions to discourage child marriages. Gok (2016) delves deeper into the issue of child marriages and its impact on gender inequality. The study highlights the various dimensions of child marriages including legal, medical, economic, social and political perspectives. The study concludes that child marriages are a significant contributor to gender inequality in social, political and economic life and perpetuate the inequality faced by women. The study recommends several solutions to address the problem of child marriages including ensuring gender equality in adolescence, abandoning conditioning on gender roles, and increasing education levels and enforcement of laws. It is imperative that society takes a holistic approach to address the issue of child marriages, as it not only affects the individual but also perpetuates societal inequality. Socioeconomic variables contributing to child marriage in Bangladesh were investigated in research by Biswas et al. (2019). The research, which drew on four nationally representative cross-sectional surveys conducted over the last decade, revealed that the age-adjusted results were consistent with the anticipated age effects regarding the direction of the linked socioeconomic characteristics, but the impact sizes had altered. Cumulative linked mixed models (CLMM) were used to analyse the Bangladesh Demographic and Health Survey (BDHS) data between 2004 and 2014 and account for cluster effects to understand better the variables associated with risk. Although the research demonstrated that the cumulative effect increased significantly with time, the pace of progress was not promising when looking at the data as a whole rather than individual years. Using individual mortality data for 300,000 children in Bangladesh, Trommlerova (2020) investigates the negative impact of teenage pregnancy on early childhood mortality. According to the research, children of younger mothers had a greater risk of dying in their first year of life. However, postpartum, advantageous socioeconomic characteristics like money and education tend to compensate for the physiologic disadvantage of teenage delivery. According to the findings, around 18,700 children under five die yearly in Bangladesh due to teenage pregnancies. In their investigation of rural Bangladeshi perspectives on and experiences with child marriage, Fattah and Camellia (2020) go deep into the realities of this social phenomenon. The study's overarching goal is to analyse national conversations around child marriage and determine what variables contribute to their development. In 2014, researchers surveyed 3,344 residents of the Rangpur area in northern Bangladesh to acquire quantitative data to complement the

qualitative data gathered via group discussions and individual interviews with 64 participants. The results of this research suggest that the current definition of a good match has to be transformed into one of an equal match to solve the recurring issue of child marriages in all settings of Bangladesh.

The mental health and well-being of children and youth in Kenya were investigated in a research published by Mathai et al. (2022). Although several acts of parliament, policies, and global and local conventions to which Kenya is a signatory recognise and protect the mental health and well-being of children, the study notes that there is no digital system devoted solely to child and adolescent psychological wellness as a policy paper, which can be a restricting factor in the execution of psychiatric methods for children and youth. Research by Okunlola et al. (2022) looks at the information gap about marriage rates among Nigerian males over the age of 25. Using descriptive statistics, logistic regression, and cox regression models, researchers evaluated data from a 2016/17 Nigeria Multiple Indicator Cluster Survey of 7803 adult males (aged 18-34). About 35% of adult males in Nigeria have been married before, with the typical age of first marriage being about 24. Men with higher levels of education and those from middle-income families were found to be less likely to have ever been married and to postpone marriage. Conversely, males with more affluence were more likely to have a history of marriage and to postpone marriage. In their investigation of the connection between divorce and health, Sbarra and Whisman (2022) zeroed in on two main areas. The research begins by exploring the hypothesised links between divorce and health problems down the road. Second, the authors suggest that people's psychological and behavioural reactions to changes in their economic condition following divorce are a possible causative route. They stress the importance of this point. The Contingency Matrix-Based, Policy Application Model is investigated by Duadji and Tresiana (2022) as a tool for addressing the issue of child marriage. Researchers examined 2016-2019 data from the National Capacity Building Agency and gathered information using a profile-based methodology. The outcomes demonstrated the value of integrating the SDGs into the national strategy for reducing the prevalence of child marriage, enforcing primary policy changes, mapping local problem trends and their root causes, mapping regional-level derivative rules, and planning and developing at the regional and village levels.

In this research, Muzaffar et al. (2018) explore the topic of child marriages through material deprivation, lack of education, and discrimination based on gender. These studies shed light on the fact that when girls are married off at a young age, they are more likely to experience physical, emotional, and sexual assault and are more likely to drop out of school. The report highlights the need to make a significant effort to address the problem of child marriages because of the harm many adolescents present to society. To channel this demographic surge into a potent future resource for the nation, it is essential that this group of people be well-guided and trained in a positive and healthy atmosphere. The third wave of the National Family Health Survey (NFHS-3) was done in 2005-06, and Sacena and Mohanty (2013) used this data to examine many facets of child marriage in India. Their research is aimed towards five specific ends: first, to examine the differences in median age at first marriage for both sexes by category in each of the chosen states, and second, to calculate the proportion of the population that has never been married by age. Second, we want to analyse the state-level trends in the median ages of boys and girls getting married across the four major castes in the country. Third, look at the differences and trends in child marriage between sexes and social classes in the five states. This discussion aims to examine the cultural and social ideas contributing to the prevalence of child marriage in India. Finally, we use binary logistic regression models to discover socioeconomic characteristics related to marrying women under the statutory age of marriage. In their research, Muzaffar et al. (2018) consider child marriages within the framework of economic hardship, lack of education, and discrimination against women. These studies shed light on the fact that when girls are married off at a young age, they are more likely to experience physical, emotional, and sexual assault and are more likely to drop out of school. The report highlights the need to make a significant effort to address the problem of child marriages because of the harm many adolescents present to society. To channel this demographic surge into a potent future resource for the nation, it is essential that this group of people be well-guided and educated in a healthy and constructive atmosphere.

Based on the cited literature, the study formed the two research hypotheses, i.e.,

H1: There is a negative correlation between education levels and the incidence of child marriages in rural areas.

H2: Wealth status has a significant influence on the decision to enter into child marriages in low-income households, with poorer households being more likely to enter into child marriages.

2.2. The Negative Health Consequences of Child Marriage

Child marriages can have negative health outcomes for the young girls involved, including an increased risk of maternal mortality and morbidity, as well as complications during childbirth. Additionally, child brides are often more susceptible to sexual and physical abuse, and have limited access to education and economic opportunities, which can further negatively impact their health and well-being. The practice of child marriage also perpetuates poverty and undermines global efforts to improve gender equality and reduce maternal and child mortality (Webb et al. 2023). The study conducted by Svanemyr et al. (2012) aimed to promote understanding, engagement, and responsibility among all actors in the area of women's reproductive health. Specifically, the study sought to address the rights of women and young girls to develop and reach their full potential, as well as the ability to make informed decisions about pregnancy. The study presented data on the prevalence and outcomes of various factors contributing to reproductive health issues, and recommended actions for prevention. The research by de Groot et al. (2012) looks at the effects of early marriage on females in Northern Ghana. A total of 1349 married women between the ages of 20 and 29 from 2496 households in Northern and Upper East Ghana participated in the research. An OLS and a logistic regression model were used to evaluate the link between child marriage and unfavourable outcomes for females. Lower levels of schooling, greater rates of poverty, and worse health outcomes were all shown to be connected with child marriage for females in Northern Ghana. These results corroborate earlier studies that have indicated that having a child while still a youngster may severely affect a girl's life, including fewer chances for her to get an education, higher rates of poverty, and worse health. Nasrullah et al. (2014) investigate the perspectives on child marriage held by women who

were married at a young age. Data was gathered via in-depth interviews and other qualitative techniques. The researchers used scholarly literature and their field experience to inform the interview topics. The study's results underscored the need to educate the public about the risks associated with child marriage, pass and strictly enforce laws prohibiting the practise, and advocate for women's civil, sexual, and reproductive health rights. Child marriages and unions have been shown to have harmful effects on the sexual and reproductive health of adolescents and young adults, which is why Taylor et al. (2019) set out to investigate these effects (AYSRH). This research employed a secondary cross-analysis of three qualitative studies to examine the role of social norms and community dynamics in the persistence of child marriages in Brazil, Guatemala, and Honduras. Findings from the research used an ecological framework to investigate the phenomenon's personal, local, and social contexts. Using information from the National Family Health Survey, Brahmapurkar (2017) investigates gender equality with female education, marriage at a young age, and domestic violence. Data from ever-married women of reproductive age in 15 states and 3 UTs throughout India were utilised for descriptive analysis. The research indicated that in rural regions, the gender gap in literacy and child marriages is more evident. It emphasised the detrimental effects of these variables on maternal health care and an increasing trend of violence against women despite a decreasing sex ratio at birth.

John et al. (2018) researched to enhance communication and bargaining abilities within marriages. Descriptive and inferential statistics data were used to investigate the impact of age at marriage on many aspects of marital satisfaction in Ethiopia. Data from 3396 unmarried or recently separated women aged 18-45, 32 in-depth conversations, and eight participant-led focus groups in designated locations formed the basis of the study. Marriage before age 12 was shown to have a significant, adverse effect on relationship quality in various dimensions via regression analysis. Rumble et al. (2018) performed their research to understand better the factors that lead to child marriage and partner selection in Indonesia. This research used information from the 2012 Indonesian Population and Health Survey, which was designed to represent the country as a whole. The researchers used multivariate models to calculate the link between changing demographics and economic conditions and underage marriage. The research concluded that living in a rural area is a health risk for child marriage. In contrast, higher levels of education, better health, and more media exposure all had protective impacts on marital outcomes. The research also showed substantial regional differences, highlighting the influence of religious, cultural, and other contextual variables on the prevalence of child marriage worldwide. Similarly, Mehra et al.(2018) analyse the results of a community-based intervention with many components on the rates of childbearing by teenagers in two Indian states. Diverse participants between 10 and 20 were selected via multi-level sampling for the research. A total of 1770 people filled out the survey, including 824 adult men and 944 adult females. The data were analysed using various statistical techniques, including cross-tabulation, chi-square testing, and logistic regression. The research also indicated that the median age of marriage was 1.2 years later for the children polled compared to their elder siblings, while the median age of contemplation was.85 years later, and the median age of years spent in school was 1.5 years later. Mulenga et al. (2018) research the causes of child marriage in Zambia's rural and urban areas and its effects on women's aspirations for having children. The research used a binary logistic and Poisson regression model to examine data from the 2013-2014 Zambia Survey. The research indicated that both urban and rural variables affect the prevalence of child marriages in Zambia and that weddings between minors affect the desired family size. The study's results suggest combining strategies to address the problem's underlying causes. Child marriage and reproductive outcomes are the focus of research by Yaya et al. (2019). This research examines how often marriages between minors and women in their twenties and thirties are in sub-Saharan Africa. In this research, data from the DHS surveys in thirty-four different countries in sub-Saharan Africa were analysed. In all, 62,015 20- to 24-year-old women participated in the polls between 2008 and 2017. The research concluded that women in sub-Saharan Africa might benefit from implementing laws and initiatives to reduce the prevalence of child marriage. In addition to lowering the overall rate of child marriage, programmes aimed at bringing about social change in this area could also increase the uptake of modern contraception, decrease the number of abortions women undergo throughout their lives, and lower the total number of children born to each woman. The study by Rana et al. (2019) aimed to evaluate the impact of family planning on mother and child health outcomes by considering the timing, spacing, and restriction of births. Three rounds of systematic random selection were employed to choose participants who would be representative of the population at large to assess their demographic and health characteristics. The study's results show that family planning effectively boosts mother and child health and nutrition. The results showed that many women still get married young, have children young, and have several children in close succession. Kumari &Shekar (2023) conclude that early marriage is a significant issue in Rajasthan, with a high prevalence of the practice among young girls in the state. Poverty, low levels of education, and cultural and societal norms are key determinants of early marriage in Rajasthan.

Based on the discussion, the study hypotheses the following:

H3: There is a positive correlation between the unemployment rate and the prevalence of child marriages in rural communities.

H4: Poverty is a significant factor in the perpetuation of child marriages in rural areas, and

H5: Gender inequality has a significant influence on the incidence of child marriages in developing countries, with the effect being stronger in rural areas compared to urban areas.

Despite the fact that child marriage is a significant problem in Pakistan, there is limited research on the specific socio-economic factors that contribute to its high incidence in rural areas. There is also a lack of research on the effectiveness of educational and economic empowerment programs in reducing the incidence of child marriages in Pakistan, particularly in rural areas. The following are the contribution of the study:

I. The study would contribute to the understanding of the relationship between education levels and child marriages in rural areas of Pakistan, providing valuable insights for policymakers and practitioners working to reduce the incidence of child marriages.

II. It would increase understanding of how wealth status and unemployment rate influence the decision to enter

III.   into child marriages in low-income households in rural areas of Pakistan, which would be useful for developing targeted interventions.

III.   It would assessed the role of poverty and gender inequality in the perpetuation of child marriages in rural areas of Pakistan, which would be useful for developing targeted interventions, and

IV.   Its open the wisdom to understand the effectiveness of educational and economic empowerment programs in reducing the incidence of child marriages in rural areas of Pakistan, which would be useful for developing targeted interventions and programs.

By providing insights on the socio-economic factors that contribute to child marriages in rural areas of Pakistan, this study would help to inform policies and programs aimed at reducing the incidence of child marriages in the country.

3. MATERIALS AND METHODS

The study aims to investigate the relationship between child marriages, education, wealth, unemployment, and gender inequality in Pakistan. The population of the study includes individuals over the age of 18 in Pakistan. A sizeable number of students was selected through convenience sampling, a technique in which researchers collect data from a readily available pool of participants, from KPK province of Pakistan. The questionnaire included 3 questions related to child marriages, 2 questions related to education, 2 questions related to wealth, 2 questions related to unemployment, and 2 questions related to gender inequality. The study hopes to understand the underlying causes of child marriages in Pakistan and inform the development of targeted and effective interventions aimed at reducing the incidence of child marriages and improving the well-being of girls and young women.

The dependent variable in the study was child marriages, while the independent variables were education, wealth, unemployment, rural poverty and gender inequality. Child marriages were defined as the union between two individuals where one or both parties are under 18 years of age, and it is often driven by economic considerations. Education was defined as the process of acquiring knowledge and skills, while wealth was defined as the accumulation of valuable assets. Unemployment was defined as the inability to find employment despite being actively seeking it, and rural poverty was defined as the lack of basic infrastructure and services in rural areas. Disparities in how men and women are expected to behave in public settings are considered one source of gender inequality.

3.1.   Theoretical Framework

The theoretical framework of this study is based on the concept of social determinants of health, which posits that factors such as education, wealth, and gender inequality play a significant role in shaping health outcomes (Zaman et al. 2016; Saleem et al. 2019; Anser et al. 2020). In the context of this study, the social determinants of health are applied to the phenomenon of child marriages in Pakistan. Child marriages are a complex and multifaceted issue, and the literature suggests that they are affected by factors such as education, wealth, unemployment, rural poverty, and gender inequality. Education is seen as a protective factor, as it provides girls and young women with the knowledge and skills necessary to make informed decisions about their lives, including when and whom to marry (Khan et al. 2019). Wealth is also seen as a protective factor, as it provides girls and young women with economic independence and the ability to make choices about their lives (Handayani et al. 2022). Unemployment, on the other hand, is seen as a risk factor, as it can lead to economic insecurity and pressure to marry at a young age (Liu et al. 2021). Rural poverty, which is characterized by a lack of basic infrastructure and services, is also seen as a risk factor, as it can limit girls' and young women's opportunities and increase their vulnerability to child marriages (Ramaswamy & Seshadri, 2020). Lastly, gender inequality, which refers to the unequal treatment or perceptions of individuals based on their gender, is also seen as a risk factor, as it can limit girls' and young women's opportunities and perpetuate the practice of child marriages (Khan et al. 2017, Deane, 2021). Overall, the theoretical framework of this study is based on the idea that child marriages in Pakistan are affected by a complex interplay of social determinants of health, including education, wealth, unemployment, rural poverty, and gender inequality. The study aims to explore the relationship between these factors and child marriages in order to inform the development of targeted and effective interventions aimed at reducing the incidence of child marriages and improving the well-being of girls and young women in Pakistan.

3.2.   Econometric Framework

To begin, descriptive statistics is used that provide an overview of the sample and the distribution of the variables. This includes measures such as mean, median, and standard deviation for continuous variables, and frequency counts and percentages for categorical variables. Frequency distributions based on a 5-point Likert scale is further be used to analyze perceptions of the effectiveness of educational and economic empowerment programs in reducing the incidence of child marriages. It provides valuable insights into the perceptions of the households surveyed and the effectiveness of these programs. Next, the study used multivariate regression analysis to investigate the relationship between child marriages and the independent variables. This include estimating a regression model, with child marriage as the dependent variable, and education level, wealth status, unemployment

rate, poverty, and gender inequality as independent variables. Its allow the study to examine the relative importance of these factors in predicting the incidence of child marriages and identify potential areas for intervention. Equation (1) shows the regression apparatus to address the answers of the study's research questions for further policy formulations, i.e.,

Child marriages = β0 + β1(Education level) + β2(Wealth status) + β3(Unemployment rate) + β4(Rural poverty) + β5(Gender inequality) + ε   *(1)*

In this equation, "Child marriages" is the dependent variable, which is the outcome of interest. The independent variables are "Education level", "Wealth status", "Unemployment rate", "Poverty", and "Gender inequality", and each of them is represented by a coefficient (β1, β2, β3, β4, and β5 respectively). These coefficients represent the relationship between each independent variable and the dependent variable, with positive coefficients indicating a positive relationship and negative coefficients indicating a negative relationship. The constant term (β0) represents the baseline probability of child marriages, and the error term (ε) represents any unexplained variability in the outcome.

4. RESULTS AND DISCUSSION

Table 1 shows the demographic survey of the respondents. Regarding the gender, the sample is 63% female and 37% male. This indicates that the majority of the respondents are female. This could be important to consider when interpreting the results of the study, as gender may be a significant predictor of child marriages. The age of the respondents is also provided, and the majority of the respondents are between 21 years to 25 years (34.8%), followed by 15 years to 20 years (23.9%), 26 years to 30 years (13%), and more than 30 years (28.3%). This could be important to consider when interpreting the results of the study, as age may be a significant predictor of child marriages.

Table 1: Demographic survey

Demographic Factors	Percentages (%)
- Gender	
Male	37
Female	63
- Respondents' Age	
15 years to 20 years	23.9
21 years to 25 years	34.8
26 years to 30 years	13
More than 30 years	28.3
- Education Level	
14 years of education	58.7
16 years of education	6.5
Others	34.8
- Respondent's Household Income	
20,000-30,000	41.3
30,001-40,000	8.7
40,001-50,000	19.6
More than 50,000	30.4

Source: Author's survey.

The education level of the respondents is also provided, and the majority of the respondents have 14 years of education (58.7%), followed by others (34.8%) and 16 years of education (6.5%). This could be important to consider when interpreting the results of the study, as education level may be a significant predictor of child marriages. The majority of the respondents fall in the income category of 20,000-30,000 (41.3%), followed by more than 50,000 (30.4%), 40,001-50,000 (19.6%), and 30,001-40,000 (8.7%). This could be important to consider when interpreting the results of the study, as household income may be a significant predictor of child marriages.

Table 2 shows the summary of responses to a questionnaire on child marriages and related factors. The responses have been collected on a 5-point Likert scale, with options for "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree." It provides the number of respondents that chose each option for each statement, as well as the percentage of the total respondents that chose each option. The statements in the table cover various aspects related to child marriages, including exploitation of basic rights of girls, negative effects on health, global phenomena, the importance of education and wealth, the role of unemployment and rural poverty, and gender inequality.

Table 2: Frequency Distribution in Percentage

Q.No.	Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Child Marriages						
1	Do child marriages exploit the fundamental rights of girls?	4.3	10.9	0.9	39.1	34.8
2	Child marriages negatively affect the health of the child.	4.3	13	6.5	45.7	30.4
3	Child marriage is a global phenomenon.	0	15.5	32.6	43.5	8.5
Education						
4	Education is essential for reducing child marriages.	2.2	2.2	10.9	37.0	47.8
5	Education improves analytical wisdom that helps to reduce child marriages.	0	2.2	8.7	41.3	47.8
Wealth						
6	Improving the wealth of society decreases child marriages.	4.3	21.7	32.6	30.4	10.9
7	Increasing job opportunities reduce child marriages in society.	0	19.6	17.4	37.0	26.1
Unemployment						
8	Unemployment creates division in society leading to an increase in child marriages.	2.2	10.9	26.5	45.7	15.2
9	Unemployment increases mental stress that one of the causes of child marriages.	4.3	15.2	13	41.3	26.1
Rural Poverty						
10	Child marriages occur in society due to poverty in rural areas.	6.5	6.5	13.0	52.2	21.7
11	Increasing income inequality increases child marriages in a country.	2.2	10.0	34.8	37	13
Gender Inequality						
12	Increasing the share of gender disparity in education leading a cause of child marriages.	0	8.7	34.8	39.1	17.4
13	Increasing the share of gender disparity in the labour market causes child marriages.	2.2	17.4	37	28.3	15.2

Source: Author's survey.

The majority of the respondents agreed that child marriages exploit the basic rights of girls (73.9%) and negatively affect the health of children (76.1%). They also agreed that child marriages are a global phenomenon (76.1%) and that education is important in regards to reducing child marriages (84.8%). Additionally, a majority of the respondents believed that improving wealth in society decreases child marriages (61.1%), increasing job opportunities reduces child marriages (63.5%), unemployment creates division in society leading to an increase in child marriages (71.4%), unemployment increases mental stress which leads to child marriages (67.4%), and rural poverty causes child marriages (74.4%). Furthermore, a majority of the respondents believe that increasing income inequality increases child marriages in a country (50%) and that increasing gender disparity in education and labor market causes child marriages (45.5%).

Overall, the responses suggest that majority of the respondents agree or strongly agree that child marriages exploit the basic rights of girls and negatively affect the health of children. They also agree that education is important in regards to child marriages and it improves analytical wisdom that helps to reduce child marriages. The respondents are also of the opinion that increasing wealth of the society decreases child marriages, and increasing job opportunities reducing child marriages in a society. They also agree that unemployment creates division in a society leading to an increase in child marriages and increasing mental stress which is a cause of child marriages. They also believe that rural poverty and increasing income inequality increases child marriages in a country. They also agree that increasing the share of gender disparity in education leading to a cause of child marriages and in labor market causing child marriages in a society. Table 3 shows the descriptive statistics of the variables.

Table 3: Descriptive Statistics

Variables	Minimum	Maximum	Mean	Std. Deviation
Child Marriages	1	5	3.7319	.78132
Education	1	5	4.2935	.69583
Wealth	1	5	3.4565	.89954
Unemployment	1	5	3.6522	.93017
Rural Poverty	1	5	3.6087	.81590
Gender Inequality	1	5	3.5109	.86596

Source: Author's survey.

The study examined several variables in relation to child marriages, including education, wealth, unemployment, rural poverty, and gender inequality. The response variable, child marriages, had a minimum value of 1.67, a maximum value of 5, a mean of 3.73, and a standard deviation of 0.78. This suggests that the majority of the values for child marriages fall within 0.78 of the mean (3.73) and are distributed around this value. Similarly, the variable of education had a mean of 4.29 and a standard deviation of 0.69, indicating that most of the values for education fall within 0.69 of the mean. The variable of wealth had a mean of 3.45 and a standard deviation of 0.89, indicating a similar distribution of values. Unemployment had a mean of 3.65 and a standard deviation of 0.93, Rural Poverty had a mean of 3.60 and a standard deviation of 0.81 and Gender Inequality had a mean of 3.51 and a standard deviation of 0.86.

The mean values indicate the average level of agreement or disagreement among the respondents for each variable. For example, the mean value of 3.731 for "Child Marriages" suggests that the average level of agreement among the respondents is somewhere between "Disagree" and "Neutral" on the Likert scale. The standard deviation values indicate the degree of variation or spread of the responses for each variable. A smaller standard deviation indicates that the responses are more tightly clustered around the mean, while a larger standard deviation indicates that the responses are more spread out. For example, the standard deviation of 0.781 for "Child Marriages" is relatively small, indicating that the majority of the responses for this variable are clustered around the mean value of 3.731. It is worth noting that, in general, the mean values are relatively low, which suggests that the majority of the respondents disagree or strongly disagree with the statements provided. Table 4 shows the multivariate regression estimates for ready reference.

Table 4: Multivariate Regression Estimates

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.030	.726		1.420	.163
	EDUCATION	.371	.160	.331	2.313	.026
	WEALTH	-.068	.143	-.078	-.472	.639
	UNEMPLOYMENT	-.151	.128	-.180	-1.182	.244
	RURAL POVERTY	.331	.171	.346	1.940	.059
	GENDER INEQUALITY	.199	.133	.220	1.496	.143

a. Dependent Variable: Child Marriages

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.777	5	1.755	3.756	.007
	Residual	18.694	40	.467		
	Total	27.471	45			

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565	.320	.234	.68362

Source: Author's estimate.

The "t" column shows the test statistic (t-value) for each independent variable. It is used to determine whether the estimated coefficient for each independent variable is statistically significant. The "Sig." column shows the probability (p-value) of obtaining a t-value as extreme or more extreme as the one computed from the sample, assuming that the null hypothesis is true. The results show that education, rural poverty and gender inequality are positively related to child marriages, while wealth and unemployment have a negative relation with child marriages. Education variable and rural poverty is statistically significant with p-value of .026 and 0.059, indicating that the relationship between education and child marriages is statistically significant. On the other hand, wealth and unemployment are not statistically significant, with p-value greater than .05, indicating that the relationship between these variables and child marriages is not statistically significant. In terms of the specific coefficients, the model estimates that for a one-unit increase in education, the child marriages is expected to increase by .371 units, holding all other variables constant. Similarly, for a one-unit increase in rural poverty, the

child marriages is expected to increase by .331 units. And for a one-unit increase in gender inequality, the child marriages is expected to increase by .199 units. On the other hand, for a one-unit increase in wealth, the child marriages is expected to decrease by -.068 units and for a one-unit increase in unemployment, the child marriages is expected to decrease by -.151 units, holding all other variables constant.

The results suggest that a lack of education, high levels of poverty in rural areas, and gender inequality are all factors that contribute to a higher incidence of child marriages. This may be because individuals in these circumstances may see child marriage as a means of financial security or a way to alleviate poverty. Additionally, a lack of education may also lead to a lack of knowledge and awareness about the negative consequences of child marriage. On the other hand, the results suggest that higher levels of wealth and lower levels of unemployment are associated with a lower incidence of child marriages. This may be because individuals in these circumstances have more opportunities for education and employment, and may be less likely to see child marriage as a necessity for financial stability. Additionally, individuals with higher levels of wealth may also have greater access to resources and services that can help prevent child marriage. It is important to note that the statistical significance of the results, as indicated by the p-value, suggests that there is a strong relationship between education and rural poverty and child marriage, while the relationship between wealth and unemployment and child marriage is not as strong. The results of this study align with previous research on the relationship between socioeconomic factors and child marriage. Previous studies have also found that a lack of education, poverty, and gender inequality are associated with a higher incidence of child marriage. For instance, Naveed & Butt (2020) argued that poverty, lack of education, and traditional customs are the main causes of child marriage in Pakistan. Child marriage has negative consequences on the physical and mental health of girls, as well as on their education and economic opportunities. The study concludes that efforts to reduce child marriage in Pakistan should focus on increasing access to education and economic opportunities for girls, as well as changing traditional attitudes towards child marriage. Das et al. (2022) provides a comprehensive overview of the different forms of child, early and forced marriage and unions, and the context in which they occur. It also highlights the diversity of factors that contribute to the persistence of these practices, showing that cultural and social norms, poverty, lack of education and gender inequality are among the most common drivers. The study also emphasizes that the consequences of such marriages and unions are severe and multifaceted, including physical and mental health issues, lack of education and economic opportunities, and increased vulnerability to violence and abuse. Research by Aggarwal et al. (2023) shows that young brides are more likely to struggle with mental health issues, including sadness and anxiety, than their never-married counterparts. The study concludes that child marriage is associated with negative mental health outcomes for adolescent girls and that efforts to reduce child marriage should also consider the potential mental health consequences for girls.

Overall, these studies highlight that child marriage is a complex and multifaceted issue that is driven by a variety of factors, including poverty, lack of education, and traditional attitudes and customs. They also demonstrate that child marriage has severe and wide-ranging negative consequences for girls and young women, including physical and mental health problems, lack of education and economic opportunities, and increased vulnerability to violence and abuse. Efforts to reduce child marriage must take into account the diverse and interrelated factors that contribute to the persistence of this practice, and address the consequences of child marriage for girls and young women.

5. CONCLUSIONS

This study aimed to identify key determinants of child marriages and found a positive correlation between rural poverty and child marriages. Additionally, the study found a negative relationship between knowledge and child marriages, indicating that education may serve as an effective strategy to decrease child marriages. Prioritize measures to protect against child marriages, such as increasing access to education for girls and young women in rural areas. Implement policies and programs that aim to reduce poverty in rural areas, as this may also decrease the incidence of child marriages. Address gender inequality by promoting gender equality and empowerment of women and girls in order to decrease the occurrence of child marriages. Governmental and administrative bodies should provide support and resources to communities and organizations working to prevent child marriages. Monitoring and evaluation of these policies and programs should be conducted regularly to assess their effectiveness and make necessary adjustments. There are a few policy recommendations specifically in the context of Pakistan:

I.   Increase funding for education, particularly for girls in rural areas, to promote education and empowerment of young women and reduce poverty, which may decrease the incidence of child marriages.

II.   Implement policies and programs that aim to reduce poverty in rural areas, such as providing economic opportunities, credit, and micro-finance services to families in order to increase their economic stability and reduce the need for child marriage as a financial coping strategy.

III.   Increase awareness about the negative effects of child marriage and the importance of education through public education campaigns and community engagement programs, particularly in rural areas.

IV.   Strengthen legal protections for children and young women against child marriage and ensure that laws and policies are enforced effectively, and

V.   Increase the availability of support services for girls and women who are at risk of or affected by child marriage, such as counseling, health care, and safe houses.

It's essential to recognize that child marriage is not just an individual problem but a structural one that requires a comprehensive approach and the involvement of different sectors and stakeholders. Child marriage is a violation of human rights and it's not just the responsibility of the government but also of the communities, civil society, and the media to work together to end this practice. Only a comprehensive and multi-dimensional approach can ensure that the rights of children are protected, and that child marriages are prevented, and effectively addressed.

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

All data associated with this study are present in the paper.

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Overcoming Vaccine Skepticism in Pakistan: A Cross-Sectional Study of Public Knowledge, Attitudes, and Behaviors towards COVID-19 Vaccination

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ABSTRACT

This study examines the knowledge, attitudes, and perspectives of the public towards COVID-19 immunization in Pakistan. A cross-sectional survey was conducted using a well-structured questionnaire and distributed through internet means. The results showed that socio-economic variables such as age, gender, education level, and wealth are essential predictors of vaccination uptake. Highly educated, wealthy, and urban residents have a positive attitude towards vaccination. The media plays a critical role in distributing information and shaping attitudes. Effective communication and availability of information also significantly contribute to illness susceptibility and prevention behavior. The study suggests that the government and healthcare system can improve public awareness and adopt preventive behavior to combat the COVID-19 pandemic.

Keywords: COVID-19 Pandemic; Vaccine phobia; People's perception; Attitude; Preventive behavior; Pakistan.

1. INTRODUCTION

Since its introduction, the novel COVID-19 virus has disastrously affected societies' health, social, and economic aspects (Qiao et al., 2020). Around 80846181 persons have been infected, and 1762319 fatalities have been documented worldwide. In Pakistan, 1273560 confirmed cases had been recorded, with 28456 fatalities till November 2020 (GoP,2020). To contain the epidemic and preserve lives, many preventative measures have been implemented, including face masks, quarantine, and vaccinations. Vaccinations have been an efficient method of controlling pandemics (Ward et al., 2020). Numerous vaccinations are accessible worldwide, but issues with public acceptability continue. Public skepticism regarding vaccinations has become a worldwide concern (Dubé et al. 2013; Larson et al., 2016). COVID-19's fourth wave is very sluggish compared to the preceding three waves. Pakistan's government has pledged $1.1 billion to acquire vaccines. In Pakistan, healthcare personnel and paramedics are initially vaccinated, and the vaccine is now offered to the public for free. According to the World Health Organization, vaccine hesitancy is one of the world's most severe threats to public health today. The majority of the world's population is averse to vaccination because they are unaware of its benefits (World Health Organization, 2020). The issue of vaccine reluctance is prevalent around the globe.

Vaccine hesitancy is a significant concern for the Pakistani government since a considerable deal of fake news, deception, and incorrect ideas exist in the minds of the Pakistani people. While Pakistan has a supply chain difficulty with vaccines, the government has secured 40 million doses from the WHO, China, the United States of America, the United Kingdom, and Germany. The government has set a goal of 70 million vaccinations by 2021 (Khan, 2021). Numerous factors contribute to vaccine acceptability, the most significant of which are disinformation, erroneous beliefs, and fake news. Religious conspiracy theories against polio vaccinations and now against COVID-19 vaccines may influence public opinion about vaccine uptake (Islam et al. 2021).COVID-19 epidemic hurt Pakistan's health care system, economy, and social life.Pakistan's government has imposed restrictions on the spread of the virus and is making significant attempts to contain it via immunization. In Pakistan, various vaccinations are available, including those manufactured by Pfizer, Sinovac, and Sino pharm. The rising issue of vaccination hesitancy has been a source of contention for the administration. Pakistan's vaccination efforts are minimal compared to other countries (Tahir et al., 2021).

The research aims to address the following potential questions: what is the public's reaction to COVID 19 vaccination? Many of them are hesitant due to their ignorance of the health advantages. May they believe it is dangerous? The second question is: How do individuals believe that the COVID-19 vaccination has negative health consequences? Due to massive awareness campaigns about contagious diseases and quality education, individuals are more confident about vaccination. Larson et al. (2018) describe how education significantly influences growing people's faith in the health care system and health information. In this context, the third question is: Do highly educated individuals have a lower level of resistance to COVID -19 vaccination? Islam et al., (2021) discovered that many socioeconomic characteristics substantially influence people's attitudes toward vaccination, leading to fear and hesitation about vaccine uptake. The remaining questions are in line as follows:

- Do socioeconomic factors influence people's awareness of health communication?
- Do young individuals express less apprehension regarding COVID -19 vaccination? And
- Does increasing health information via the media promote public knowledge of COVID -19 vaccination?

The following prospective research goals have been developed to address the aforementioned study issues:

I.   To analyze the numerous demographic characteristics that may influence public opinion on COVID-19 vaccine uptake in Pakistan.

II. To ascertain the individual and socioeconomic variables influencing the public's reaction to the COVID-19 vaccination uptake in Pakistan, and

III. To provide policy recommendations based on the study's results.

Numerous researches is conducted to have a thorough understanding of the issue. It was discovered that many social factors such as income, age, education, marital status, and gender had a substantial influence on people's perceptions of COVID-19 uptake, similar to the findings of Viswanthet al.,(2021) and Verger &Dubé (2020).

Vaccine reluctance is the primary impediment to resolving the world's chronic COVID-19 epidemic. Our nation is likewise confronted with the same issue, and communities must be vaccinated entirely to minimize the occurrence of this disease. Numerous research is conducted in this area to ascertain the numerous aspects that may impact the vaccination process. This research examines the many characteristics such as age, income, education, marital status, and occupation that may influence people's attitudes and behaviors towards COVID-19 vaccination uptake in Pakistan. The data is gathered from a representative sample of people from different regions of Pakistan using a well-designed questionnaire. The survey is administered by WhatsApp using a Google form. The findings will be obtained using hierarchical regression.

The study is divided into different sections. The introduction is covered in the first section. The second section provides a literature review, and the third section covers the research methodology. The fourth section describes the findings, and the last section discusses the conclusions and suggestions based on the study findings.

2. LITERATURE REVIEW

Some of the literature is examined to acquire deep insight into the topic. Recent research linked to this subject is classified into several subgroups depending on the hypothesis created are divided into distinct subgroups.

2.1. Impact of education and other socioeconomic variables on COVID-19 immunization uptake

The current research that has been conducted in different regions of the globe. For instance, Singh et al. (2020) studied knowledge and perspective regarding universal safety measures during the early phase of the COVID-19 epidemic in Nepal. Online cross-sectional research was done involving 871 respondents were undertaken. It was discovered that most of the participants had a good attitude toward the universal safety precautions of COVID-19. It was also noted that knowledge, age, educational level, career type, and monthly household income had considerable influence. Also, it was noted that misconceptions and misunderstandings

concerning COVID also occur. Serwaa et al. (2020) undertook an online poll to ascertain Ghanaian citizens' awareness, risk perception, and readiness about the COVID-19 epidemic. It was discovered that although public awareness of the condition is generally high, disparities occur among the least educated. Additionally, it was discovered that the study population is somewhat equipped to react to the COVID-19 sickness. The research emphasizes the necessity of educational efforts in rural areas through the Internet and mass media broadcasts. Irigoyen-Camacho et al. (2020) performed cross-sectional research to determine the influence of income level and perceptions of COVID susceptibility and severity on stay-at-home preventative behavior in a sample of older individuals in Mexico. A cross-sectional survey was done by telephone with 380 interviewees aged 65 years or older. Educational attainment was related to remaining at home, with the overall impact being primarily mediated by the perceived vulnerability. It was advised that government assistance should focus on low-income and less educated older persons to increase pandemic preparedness habits. Islam et al. (2021) performed exploratory research on Bangladesh residents' knowledge, attitudes, and perceptions of COVID-19 vaccination. A cross-sectional e-survey of 1658 participants was undertaken for this aim. The findings were produced by the use of a multiple regression model. Around 61% of the population had vaccinations, and over 90% felt that vaccines must have adverse effects. Higher education, nuclear families, and prior vaccine use were associated with significantly more favorable opinions regarding vaccination, with the majority of respondents being female. Salimi et al. (2020) studied the general public in North America has a strong comprehension of COVID-19. Cross-sectional research was undertaken using an internet source to assess public awareness of COVID-19, risk perception, and pandemic preparedness measures. A descriptive analysis was conducted on the whole population. The findings indicate that a young and educated sample of North Americans has a high awareness of COVID-19 and that a sizable proportion of the population also practices preventative actions. The stated findings corroborate our first hypothesis:

H1: Education has a beneficial effect on people's attitudes toward COVID-19 vaccination.

Similarly, Bae and Chang (2021) examined the influence of COVID-19 risk perception on behavioral intentions regarding tourism in South Korea during the first pandemic wave. A structured questionnaire was sent to 877 South Korean citizens through an internet survey, and attitude was a mediating factor between practical risk perception and behavioral intention. Gender and marital status acted as a partial moderator of the putative link between factors. Rodriguez-Besteiro et al. (2021) investigated Spanish university students' risk perception, psychology, and behavior. Three hundred volunteer university students were questioned using an online questionnaire. The research factors include perceived COVID-19 risk, psychological profile, dietary and dental health, and physical activity habits. The research found that female students had a greater impression of risk from COVID illness. Additionally, the female had a significant degree of anxiety awareness, neuroticism, and receptivity to experience. Males consumed more soft drinks, meat, and rice and had poor personal hygiene. Ceccato et al. (2021) studied the effect of age on perceptions of COVID-19 emergency in Italy during the pandemic. The research explored age-related changes in pandemic-related emotions, cognitive attitudes, and behavioral responses. An online poll was done with persons aged 18 to 85 years old from various demographic groups. The findings indicated that elderly persons exhibit less unpleasant feelings than their younger and middle-aged counterparts. Additionally, it was shown that older adults had a positive attitude toward resolving the situation. Kricorian et al. (2022) performed a study to ascertain the American public's attitudes and experiences about COVID-19 immunization. The findings indicated that those with less education, a lower income, and a rural location believed vaccines were harmful. However, those with higher education, a higher income, and a city-dwelling class believed vaccines were safe. Thus, the stated findings lead to the study's second hypothesis, i.e.,

H2: People with a high income and married status have a favorable attitude toward COVID 19 vaccination.

Khubchandani & Macias (2021) shown that vaccination hesitation was high among African-Americans (41.6%) and Hispanics (30.2%). Multiple regression models suggest that vaccination reluctance is substantially associated with sex, education, occupation, income, the presence of children in the household and political affiliation. Guidry et al. (2021) examine the willingness of individuals to get the COVID -19 immunization with and without emergency use authorization. Seven hundred eighty-eight people in the United States of America were polled online to determine vaccination's demographic and psychological characteristics. Age, race, positive subjective norms, high perceived behavioral control, a favorable attitude toward vaccines, and high perceived sensitivity to COVID-19 were significant predictors of readiness to take the vaccination. The investigations bolster our argument made in the third hypothesis, which is as follows:

H3: Socioeconomic factors significantly affect how individuals perceive COVID -19 immunization.

2.2. The government's and social networks' roles in containing the COVID-19 epidemic and immunization efforts

The following research demonstrates social media's critical role in sharing information about COVID-19 illness and its preventative measures. Additionally, these studies demonstrate the effectiveness of government programs for pandemic control in different regions of the globe.

Wise et al. (2020) examined changes in risk perception and self-reported protective behavior in the United States during COVID-19. In 1591, cross-sectional and longitudinal research was done on persons residing in the United States. The study's variables include the relevance of risk perception and preventive behavior in the event of a pandemic. The findings underscored the critical nature of risk perception during a large-scale epidemic. It was discovered that social separation and handwashing habits are crucial for preventing illness transmission. Mahmood et al. (2020) examined Pakistan's general public's attitude, perception, and knowledge of COVID-19. The study performed a cross-sectional survey using an online Google form. A total of 1000 people were interviewed. The results indicated that 42.9 percent of participants were aware of COVID through social media, which was the primary source of information. The participants had a high level of awareness about the illness and a favorable attitude toward preventative measures. Additionally, it was determined that the government made reasonable efforts to contain the outbreak. Kumari et al. (2021) conducted a qualitative study involving focus group discussions and thematic analysis to ascertain current knowledge, attitudes, perceptions, and concerns about COVID vaccines in the Indian population. Eight focus groups were formed in this study, with participants chosen via purposive sampling. The findings indicated that the public had mixed opinions about the COVID Vaccine. It was thought that channeling the appropriate signals would boost people's willingness to accept vaccines. Honarvar et al. (2020) investigate the knowledge, attitudes, risk perceptions, and behaviors of adults in Iran about COVID-19. This research aims to educate policymakers on how to handle the COVID-19 pandemic. A population-based survey was done in Shiraz by conducting face-to-face interviews using a multistage stratified and cluster sample. It was discovered that the sickness had a detrimental influence on most participants' everyday activities. Additionally, it was shown that participants followed news on national broadcasting channels and social media platforms. Motta Zanin et al. (2020) assessed public perceptions of risk associated with the COVID -19 health emergency in Italy. The research sought to ascertain the Italian public's perception of health risks. A questionnaire was sent to 9000 persons in Italy and other countries. The findings indicated that mass media had a considerable influence on respondents' level of knowledge and emotion. Neuburger and Egger (2021) investigated travel risk perception and behavior. This research aimed to assess the perception of travel risk and travel behavior in Germany, Austria, and Switzerland. The data were obtained at two periods in time: during March 2020, a sample of 1158 tourists was analyzed, and the second sample of 212 travelers was investigated. Cluster analysis was conducted. The findings indicated a considerable rise in pandemic risk perception. Additionally, it was shown that travel risk perception and travel behavior are related to time. Aldarhami et al. (2020) performed research in Saudi Arabia during COVID-19 on public perception and commitment to social distance. A countrywide online poll of 5105 people was undertaken. It was discovered that a high level of knowledge about remaining at home is mainly connected with female participants who have a high level of education and money. It was determined that the general application of social distancing was adequate. Additionally, it was found that the Saudi Ministry of Health's planned approach has been beneficial in raising public awareness and strengthening social distancing practices. Al-Amer et al. (2022) examined vaccination intentions for COVID-19 in the first year of the pandemic among health care professionals and the general public worldwide. A systematic review and beta analysis were used to explore seven databases for COVID-19 intention-related material published on or before 31 December 2020. This review includes 30 papers. COVID-19 vaccination intention varied from 27.7 percent to 93.3 percent throughout the first year of the pandemic. The findings demonstrated that sociodemographic disparities, risk perception, and sensitivity to COVID -19 vaccine characteristics affected vaccination intentions. Rubaltelli et al. (2020) identified environmental and psychological factors influencing how people respond to the COVID -19 epidemic in Italy. Two cross-sectional studies were conducted, the first with a sample size of 992 respondents and the second with 103 respondents during the outbreak's start and the lockdown, respectively. The findings indicated that media exposure affected Italy's risk perception and preventive behavior. In the second wave, it was discovered that emotion risk perception is associated with expected protective behavior. Additionally, this information will be helpful in the coming months to determine who was most affected by stress and subsequent preventative measures during the epidemic.

2.3. Public opinion on COVID-19 vaccination

The following research has been undertaken worldwide to ascertain public opinion towards vaccination, i.e., Shahin and Hussien (2020) examined the risk perception of COVID-19 illness among the general population in the Middle East. A cross-sectional online survey was conducted with 723 participants from Saudi Arabia, Egypt, and Jordan, utilizing a simple sample approach. The results indicated that Egyptian participants had a lower mean score for perceived effectiveness in dealing with COVID illness. Additionally, a positive link was discovered between the perceived severity of COVID-19 illness and self-efficacy to manage the condition. Seale et al. (2021) studied the Australian public's attitude and behavior about the COVD-19 vaccination. A cross-sectional online survey of the Australian population aged 18 and above was conducted. The study included both univariate and multivariate logistic regression models. Overall, respondents had a favorable view of immunization. It was proposed that the government use effective communication and strategy to aid in the disease's containment. Biasio et al. (2021) tested COVID-19 literacy in the general public using an online survey to ascertain their knowledge and beliefs. It was noticed that conducting a poll over the internet is the

most appropriate way for determining the general public's vaccination literacy during an epidemic. Ward et al. (2020) performed four online questionnaires to ascertain the adult population's sentiments regarding vaccination in France. Attitudes regarding vaccines were substantially linked with political partisanship and involvement with the political system. Qiao et al. (2020) investigated risk exposures, perceptions, unfavorable attitudes about universal immunization, and acceptability of COVID-19 among South Carolina college students. According to an online poll of 1062 college students, perceived severity and fear of COVID-19 were favorably connected with vaccine acceptance. However, increased risk exposure and a negative attitude toward general immunization were adversely correlated with vaccine acceptance. Burke et al. (2021) examined perceptions and intentions in international research on Enablers and Barriers to COVID -19 Vaccine Uptake. The study evaluated factors affecting vaccination hesitation, health beliefs, and individual characteristics such as wealth, age, religion, altruism, and collectivism. Four thousand three hundred three respondents from Australia, Canada, New Zealand, England, and the United States were questioned using a well-structured questionnaire. The findings indicated that vaccination uptake was significantly influenced by faith in vaccine approval, perceived vaccine efficiency for protecting others, and conspiracy ideas. Individual and societal variables of COVID-19 vaccination uptake in the United States were studied by Viswanath et al., (2021). The poll surveyed 1012 individuals. The study investigated risk perception, exposure to COVID-related media coverage, political party affiliation, and faith in scientists. The findings reveal that race, risk perception, media exposure, political affiliation, and trust in scientists play a role in an individual's vaccination uptake. Saeed et al. (2021) investigated the adverse reactions and perceptions of the Sinopharm vaccination in the United Arab Emirates. Demographic information was gathered through an online survey of the adult population. The results indicated that post-vaccination side effects were modest and predictable for both doses (first and second), with no occurrences of hospitalization. The findings of this research will aid in the decrease of vaccination reluctance among people. Caserotti et al. (2021) examined the relationship between COVID -19 risk perception and vaccination reluctance in Italian citizens. This research aims to examine the characteristics that influence vaccination uptake for COVID-19 compared to seasonal flu and determine how this process proceeded under lockdown. It was discovered that more persons were willing to get vaccinations during the lockdown period than during the pre-lockdown phase. Psychological and demographic aspects were shown to be beneficial in improving health communication to increase response during epidemics.

This research aims to determine how the general population in Pakistan feels about the uptake of COVID-19 immunization. Because most research is conducted in industrialized countries, very little research has been undertaken in the Asian context. The people of Pakistan have been battling to keep the epidemic under control, which has had a catastrophic effect on all segments of society. This research aims to examine the numerous individual and socioeconomic determinants of vaccination uptake among Pakistani citizens. It may provide some more information to researchers and policymakers to assist them in dealing with the epidemic in our area.

3. MATERIALS AND METHODS

This section contains detailed information on the data-gathering strategies used, the model's estimate, and the variables included in the investigation.

3.1. Data Collection

The information is gathered via a well-structured questionnaire using a five-point Likert scale by taking into account the numerous demographic characteristics of the relevant population.

3.2. Study's Population

The study population consists of persons living in Pakistan above the age of 18. Gender, age, income, marital status, education, employment position, and place of residence are just a few of the demographic parameters to consider.

3.3 Sampling Techniques and Sample of the Study

Purposive sampling (also known as non-probability sampling) is used to select the sample for this study.Purposive sampling is a method of selecting participants for a research project based on the researcher's assessment of who will be most suited. It is both cost-effective and time-effective to do this. When only a few primary data sources are accessible, this is the most suitable strategy for choosing a sample. The information is gathered from various cities in the KPK and Punjab provinces of Pakistan. Individuals from Lahore, Islamabad, Rawalpindi, Faisalabad, Peshawar, Abbottabad, Mardan, Swaabi, Charsada, Mansehra, Battagram, and Haripur are included. A total of 273 questions have been completed using WhatsApp using a Google form. It is decided to use the methodology of purposeful sampling to save the researcher's time and money. It is also the most convenient method of collecting data for our study project.

3.4 Data collection and analysis

The information is gathered via the use of a well-structured questionnaire. All respondents completed the questionnaire and sent it

by postal mail, email, and a WhatsApp group. Affective perceptions of individuals regarding COVID-19 immunization are the dependent variables; perceptions of risks, behavior control measures used to avoid exposure to harmful information, and attitudes toward vaccine uptake are independent factors. In the current research, I questioned participants, "do you believe that the COVID - 19 immunization is effective?" and "do you closely adhere to the preventative measures?" As an additional inquiry, I asked them what their thoughts were on whether or not their relative should be vaccinated and what they thought about news and information from the media. In addition, questions on subjective norms and social distance have been introduced.

3.5. Theoretical Framework

The fear appeal theory has been extensively used in health management to determine the effect of threat information on an individual's behavioral shift toward preventative actions (Floyd et al., 2000; Ruiter et al., 2014). This theory comprises two theoretical frameworks: one is based on protection motivation theory, while the other is based on the extended parallel process model. PMT (protective motivation theory) takes four types of information into account.

i)   The noxiousness of a described incident,

ii)   The efficiency of the depicter's response,

iii)   The likelihood of occurrence, and

iv)   Self-efficacy depicters described by Rogers, 1975: Maddux & Roger, 1983.

Individuals' attitudes about response are influenced by the elements listed above. However, as Witte (1992) noted, EPPM (extended parallel Process model) enhanced prior fear appeal PMT in three ways.

i)   PMT considers the danger-avoidance process, while EPPM considers the fear-avoidance process.

ii)   EPPM views fear as the primary variable to regulate and serve as a preventative element in cognitive processes.

iii)   It considers how individual variations may influence one's assessment of danger and effectiveness.

EPPM was advanced to E-EPPM by So et al. (2013), who cited fear and anxiety as significant risk perception elements. Additionally, they discovered that worry, rather than fear, is the primary motivator for taking preventative action. Fear helps theory aids in deciphering patient location information in order to take preventative action during a pandemic. According to this logic, research conducted by Wu. et al. (2021) examined perceived patient location information related to citizen fear and attitude during a pandemic. According to fear appeal theory, patient location information may manage crises and promote patient health.COVID-19 has elicited significant anxiety, motivated mainly by worries of death and infection. The rapid spread of coronavirus necessitates social seclusion, exacerbating anxiety and sadness. According to the "Anxiety Buffer Hypothesis," self-esteem functions as a buffer against feelings of isolation, anxiety, and sadness. Self-esteem is a depression-fighting element. Psychological health may be improved physically via the use of Targeted Psychological Interventions (Rossi et al., 2020).This research takes three things into account: To begin, we evaluate the public's stance toward vaccination. The judgment is vaccinated regardless of whether it is safe or hurts human life. Finally, to examine public opinion to determine if the government's participation is adequate to deal with a pandemic.

3.6. Data Analysis

The following sequential stages were used in the research to analyze the data, i.e.

Step –I: Chronbach's alpha reliability analysis

Cronbach's alpha, also known as coefficient alpha, quantify the trustworthiness of data. Internal consistency is another term for reliability. This alpha is used to evaluate multiple-choice questions in surveys that use the Likert scale. Cronbach's alpha is employed when categorical variables are included in the research, and it indicates how these questions are linked to the study's items. Yahaghi et al. (2021) employed the Cronbach's alpha to determine the dependability of their data. They discovered a value of 0.89 for subjective norms on vaccine uptake. 0.94 in terms of attitude toward vaccination uptake. 0.92 for COVID-19 vaccination intention. Similarly, Tahir et al. 2021 employed Cronbach's alpha to determine the trustworthiness of data collected in research on Pakistani community attitudes on readiness to pay for the COVID-19 vaccine and its acceptability.

Step-II: Respondents' demographic information

Numerous demographic factors of respondents are addressed in this study since these qualities may differ across individuals and may significantly impact our research domain. The study examined a variety of demographic and socioeconomic parameters in the study's variable construct.

Step-III: Frequency Distribution

In the primary research, frequency distributions summaries enormous data sets. It is mainly used to give probabilities to each possible result of a recurring event. Consider the following example of election results and test scores organized by percentile.

Histograms may be used to visualize a frequency distribution. When dealing with vast amounts of data, the form of the histogram resembles a bell curve, which represents the normal distribution. Frequency distributions are especially effective for summarizing and assigning a probability to massive data sets.

Step-IV: Descriptive Statistics of the Variables

Descriptive statistics illustrate the characteristics of the data used in the main investigation. Its primary objective is to summarize the samples and different metrics of the variables under investigation. There are two forms of descriptive statistics. 1. Measures of central tendency, and 2. Variability indices (spread). The mean, median, and mode are all included in the measure of central tendency. In contrast, the standard deviation, variance, minimum and maximum variables, Skewness, and Kurtosis are all included in the measure of variability.

Step-V: Correlation Matrix

Correlation is the linear link between two or more factors. It denotes the predictive link and correlation of variables based on their strength. It also conveys causal information, albeit not consistently. Numerous correlation coefficients exist, and Pearson correlation coefficients for linear relationships and Spearman's rank correlation coefficients for nonlinear relationships are used to explaining variable relationships.

Step VI: Multiple Regression

The OLS regression technique is utilized to assess the public's knowledge, attitude and preventive behavior about the use of COVID-19 vaccine in Pakistan. The dependent variable of the study is "Fear of Vaccine (denoted by FOV)" while the regressors included "Attitude Towards the Use of Vaccine (denoted by ATUOV)", "Intentions Towards Vaccine Uptake (denoted by INTVU)", "Preventive Behavior (denoted by PB)", and "Access to Information (denoted by AINFO)". The study used the following demographic factors as controlled variables, including Gender (denoted by GENDER), Age (denoted by AGE), Education (denoted by EDU), Employment status (denoted by EMPLOY), Marital status (denoted by MS), Household income (denoted by INCOME), and residence type (denoted by RESID). Equation (1) shows the following empirical equation for estimation, i.e.,

$$FOV = \beta_0 + \beta_1 ATUOV + \beta_2 INTVU + \beta_3 PB + \beta_4 AINFO + \varepsilon \qquad (1)$$

Step VII: Paired Samples t- Test

The final step is to utilized the paired samples t-test statistics between the controlled variables and the main outcome variable, i.e., FOV. The statistics would be helpful to assessed the variations between the two-paired of the variables to reach some conclusive inferences. The significant t-statistics value would allow to see the variations in the regressand that infused due to the controlled variables of the study.

4. RESULTS AND DISCUSSION

The data is gathered utilizing a well-structured questionnaire and various communication methods such as WhatsApp, Facebook, and email. The participants have a high level of education and are above 18. The responders are provided with the link to the google form. Consent is obtained prior to data collection. Gender, age, education, marital status, work status, residence, and household income are all provided as responses. The poll surveyed 198 male representatives and 75 female representatives. One hundred ninety respondents are between the ages of 20 and 30, while 34 respondents are between 30 and 40. Twenty-nine respondents are above the age of 40. One hundred twenty-six respondents have a bachelor's degree, whereas 52 respondents have a master's degree. 46.2 percent of participants are graduates. One hundred twenty-nine respondents are single, 72 are married, and remaining 72 respondents are committed to married with someone. Seventy-one respondents have a monthly income of more than 100,000 Pakistani rupees. In comparison, 60respondents have a monthly income of between 20,000 and 30,000 Pakistani rupees, 38 respondents have a monthly income of between 30,001 and 40,000 Pakistani rupees, and 46 respondents have a monthly income of between 40,001 and 50 thousand Pakistani rupees. One hundred fifty-seven respondents live in rural parts of Pakistan, while the remaining 116 live in metropolitan areas. Table 1 shows the demographic survey of the respondents.

Table 1: Demographic Survey of the Respondents

Survey	Frequency	Percentages (%)
Gender		
Male	198	72.5
Female	75	27.5
Age		
20-30 years	190	69.6
31-40 years	54	19.8
>40 years	29	10.6
Education		

Survey	Frequency	Percentages (%)
10 years of schooling	14	5.1
12 years of schooling	16	5.9
Graduate	126	46.2
Masters	52	19.0
M.Phil.	20	7.3
PhD	45	16.5
Marital Status		
Single	129	47.3
Married	72	26.4
Others	72	26.4
Employment		
Self-employed	174	63.7
Employed in either government or private job	87	31.9
Unemployed	12	4.4
Residence		
Rural	157	57.5
Urban	116	42.5
Household Income		
PKR20,000 – 30,000	60	22
PKR30,001 - 40,000	38	13.9
PKR40,001 – 50,000	46	16.8
PKR 50,001 – 60,000	54	19.8
PKR 60,001 – 100,000	4	1.5
>PKR100,000/month	71	26

Source: Author's survey.

The variables' descriptive statistics are shown in Table 2.The mean score for several questions answered by participants is shown in the given table. The questionnaire includes 13 questions on fear of COVID-19 vaccination, attitudes toward vaccine use, intentions toward vaccine use, preventative behavior, and access to information. All questions used a five-point Likert scale, with 1 indicating significant disagreement and 5 indicating agreement.

Table 2: Descriptive statistics

Variables	Number of Observations	Minimum	Maximum	Mean	Std. Deviation
Fear of COVID-19 Vaccine Uptake (FOV)	273	1	5	3.0916	1.05320
Attitude towards vaccine uptake (ATUOV)	273	1	5	4.0733	0.86291
Intention towards vaccination (INTVU)	273	1	5	4.2894	0.91080
Preventive behavior (PB)	273	1	5	3.9846	0.63471
Access to information (AINFO)	273	1	5	4.0623	0.85629

Source: Author's survey.

According to Table 2, the mean score for fear of vaccination is 3.0916, whereas the mean score for attitude toward vaccination is 4.0733. Similarly, 4.2894 for vaccination intention and 3.9846 for preventative action. The mean value of access to information is 4.0623 with a standard deviation value of 0.8562. Fear of COVID-19 vaccination uptake has a higher standard deviation, indicating widespread vaccine phobia in a country. Table 3 shows the Cronbach' alpha value of the study's items.

Table 3: Cronbach's Alpha Estimates

Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
FOV1	47.967	33.488	0.057	0.670
FOV2	47.761	35.609	-0.050	0.678
ATUOV1	46.743	31.059	0.370	0.608
ATUOV2	47.022	32.375	0.209	0.634
INTVU1	46.648	29.611	0.482	0.588
INTVU2	46.685	30.614	0.436	0.598
PB1	46.750	33.644	0.295	0.625
PB2	47.172	32.275	0.259	0.626
PB3	46.853	29.478	0.492	0.586
PB4	46.838	31.533	0.387	0.608
PB5	47.241	28.831	0.447	0.589
AINFO1	46.802	31.880	0.269	0.624
AINFO2	46.985	32.603	0.150	0.647

Source: Author's survey.

The statistics show that the Cronbach's Alpha value is greater than 0.55of each items, hence we safely conclude that the dependability of the items close to each other's and the regression estimates would be helpful to assessed the variations between the regressors and regressand of the study. Table 4 shows the correlation matrix.

Table 4: Correlation Analysis

Variables		FOV	ATUOV	INTVU	PB	AINFO
FOV	Pearson Correlation	1	-.260**	-.183**	.077	-.027
	Sig. (2-tailed)		.000	.002	.205	.660
	N	273	273	273	273	273
ATUOV	Pearson Correlation	-.260**	1	.565**	.242**	.156*
	Sig. (2-tailed)	.000		.000	.000	.010
	N	273	273	273	273	273
INTVU	Pearson Correlation	-.183**	.565**	1	.333**	.253**
	Sig. (2-tailed)	.002	.000		.000	.000
	N	273	273	273	273	273
PB	Pearson Correlation	.077	.242**	.333**	1	.218**
	Sig. (2-tailed)	.205	.000	.000		.000
	N	273	273	273	273	273
AINFO	Pearson Correlation	-.027	.156*	.253**	.218**	1
	Sig. (2-tailed)	.660	.010	.000	.000	
	N	273	273	273	273	273

Source: Author's survey. Note: Correlation is significant at the 0.01 level (2-tailed) **, and 0.05 level (2-tailed)*.

Table 4 shows Spearman's rho correlation among various factor. Fear of COVID -19 vaccination is negatively correlated with

attitude towards vaccine uptake and intention towards vaccine uptake. On the other hand, there is a positive correlation between intention, prevention, and access to information regarding vaccine uptake. Preventive behavior and access to information positively correlated with the intention toward respondent vaccination. Finally, there is a positive correlation between access to finance and preventive behavior.

According to Table 5, attitudes toward vaccine uptake and preventative behavior positively and negatively affected the fear of COVID-19 vaccination uptake. The finding suggests that a more favorable attitude toward vaccination uptake significantly reduces the anxiety of COVID-19 vaccine uptake. On the other hand, increased preventative behavior heightened anxiety about COVID-19 vaccination uptake. The findings of this study corroborate those of Liu and Chu (2022), Kotta et al. (2022), and Jankowska-Polaska et al. (2022). Liu and Chu (2022) contended that the more trust built-in healthcare practitioners, the more favorable views for vaccine usage and intention would grow. The study concludes that healthcare practitioners should have a favorable attitude about vaccination safety to avert a COVID-19 pandemic. Kotta et al. (2022) established a multidimensional scale to measure vaccination reluctance for COVID-19 and discovered that fear is a critical and essential scale for assessing vaccine phobia among the general population. Jankowska-Polaska et al. (2022) found that health workers' engagement in pushing for vaccination and pro-health practices is crucial for COVID-19 protection. As a result, pro-health activities foster a more favorable attitude toward vaccine use.

Table 5: Regression Estimates

Model		Unstandardized Coefficients		Standardized Coefficients	t-stats	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.686	.480	-----	7.680	.000
	Attitude towards vaccine uptake	-.298	.086	-.244	-3.456	.001
	Intention towards vaccination	-.118	.085	-.102	-1.384	.168
	Preventive behavior	.282	.104	.170	2.723	.007
	Access to Information	.000	.075	.000	-.003	.998

Source: Authors' survey. Note: Dependent variable: FOV.

The paired samples t-test was performed to determine the relevance of respondents' demographic features about their anxiety about vaccine use. For convenience, Table 6 summarizes the paired samples' t-test statistics.

Table 6: Paired Samples t-Test Estimates

Models		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	AGE – FOV	-1.6813	1.27515	.07718	-1.83326	-1.52938	-21.786	272	.000
Pair 2	EDU – FOV	.57875	1.69727	.10272	.37652	.78099	5.634	272	.000
Pair 3	MS – FOV	-1.30037	1.26661	.07666	-1.45129	-1.14945	-16.963	272	.000
Pair 4	EMPLOY –FOV	-1.68498	1.20646	.07302	-1.82873	-1.54123	-23.076	272	.000
Pair 5	RESID – FOV	-1.66667	1.15311	.06979	-1.80406	-1.52927	-23.881	272	.000
Pair 6	INCOME - FEAR	.32234	2.21678	.13417	.05821	.58648	2.403	272	.017
Pair 7	GENDER - FEAR	-1.81685	1.17861	.07133	-1.95728	-1.67642	-25.470	272	.000

Source: Authors' survey.

The findings indicate that all demographic characteristics are associated with fear of the COVID-19 vaccination, indicating that they are significant factors of vaccine uptake in a country. The age of respondents might be beneficial in making a swift choice regarding whether or not to use vaccination. Compared to their younger counterparts, the elderly age group exhibits less vaccination anxiety. Respondents with a higher level of education were keener to take up the vaccination, while those with a lower level of

education expressed more anxiety about using the COVID-19 vaccine. In comparison to singles, married couples are more committed to vaccination uptake. Individuals who are self-employed or get employment are more inquisitive about vaccination uptake than those who are jobless. Persons who live in urban areas are more aware of the COVID-19 susceptibility and the significance of coronavirus vaccination to avoid contracting this disease. However, people who live in rural regions are less likely to be vaccinated due to a lack of information about infectious diseases. The high-income group is more concerned with their health and is more prepared to pay for it; their vaccine uptake is larger than that of the low-income group. Finally, males are less fearful of vaccination uptake than females.

5. CONCLUSIONS

The aim of the study is to find the public attitude towards the use of COVID-19 vaccination in the Pakistan's economy, as the country strive hard to limit the exacerbation of COVID-19 cases by its strategic wisdom and strict compliance of the given guidelines by the WHO. The results of the study show that attitude towards vaccine uptake and preventive behavior has a positive and negative impact on fear of COVID-19 vaccine uptake in a country. The higher the attitude towards uptake of COVID-19 vaccine mainly decreases the fear of vaccine uptake in a country. On the other hand, the increase preventive behavior among the masses in a country increases the fear of vaccine uptake in a country. Hence, based on the result, the following policies are suggested to contain the virus and minimize the fear of vaccines uptake in a country, i.e.,

i) Effective communication has a favorable effect on people's attitudes about vaccine uptake.
ii) The media is crucial in disseminating information on risk perception and sickness acceptance.
iii) Education and access to information have a significant impact on sickness susceptibility and risk awareness.
iv) Prevention is crucial for building self-efficacy and avoiding sickness.
v) Health education initiatives increase public awareness and assist in the control of pandemics.
vi) Public health practitioners contribute to increased awareness of COVID-19 vaccine uptake.
vii) The media and mass communication are vital in boosting public knowledge of pandemics; and
viii) Friends, family, and civil society are critical in sharing current information on vaccine safety.

As the epidemic spreads and is unlikely to vanish, we have to be prepared to face new variant attacks. There is an opportunity to work on such a research area for globally shared prosperity.

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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The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

Annexure –A
QUESTIONNAIRE

Part A : Demographic Survey

  I.   Gender: _____

  II.   Age: ………………years

  III.   Education: literate? Y/N If literate, highest qualification……………

  IV.   Employment Status
- Self Employed……….
- Profession……………..
- Unemployed………….

  V.   Marital Status
- Married
- Single
- Others

  VI.   Household Income
- 20,000 -30,000
- 30,001 – 40,000
- 40,001 – 50,000
- 50,001 – 60,000
- 60,001 – 100,000
- > 100,000

  VII.   Residence
- Rural
- Urban

Part B: Items

a. Fear of Vaccine

S.No.	Questions	Strongly Disagree	Disagree	Neutral	Strongly Agree	Agree
1	Do you have a fear of vaccines?					
2	Do you think that the COVID-19 vaccine has some adverse effects on human health?					

b. Attitude

1	Do you think you should take the vaccine on a priority basis?					
2	Do you think that the COVID-19 vaccine is safe?					

c. Intentions towards vaccine uptake

1	Do you want to get a vaccine?					
2	Do you want to get the vaccine for your family and relatives?					

d. Preventive Behavior

S.No.	Questions	Strongly Disagree	Disagree	Neutral	Strongly Agree	Agree
1	Do you wash your hands regularly?					
2	Do you sanitize your belongings?					
3	Do you purchase washing and sanitizing products for your hygiene?					
4	Do you wear face masks?					
5	Do you maintain social distance?					

E. Access to Information

1	Do you have access to news about the disease?					
2	Do you have money and facilities available to be vaccinated?					

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

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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.

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 CO2 emissions on newborn health in Pakistan are analyzed by Naeem et al. (2021). The risk of CO2 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 CO2 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.
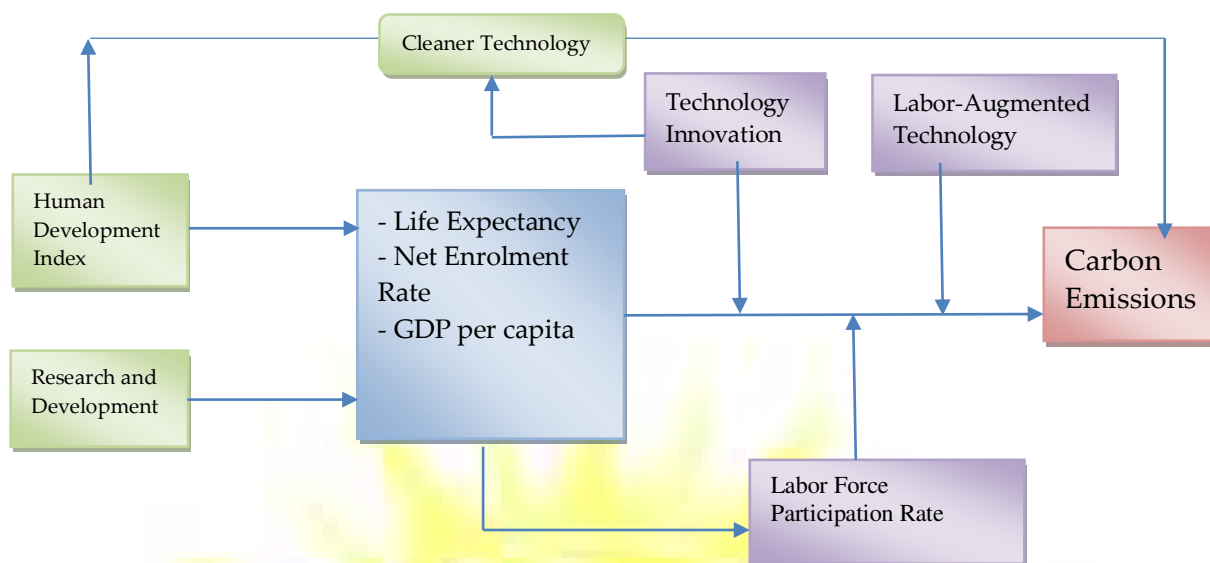
Figure 1: Theoretical Framework
Source: Author's self extract.

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.,

$$CO2_t = c_1 + \sum_{i=1}^{2}\beta_1 CO2_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \quad (3)$$

$$LE_t = c_1 + \sum_{i=1}^{2}\beta_1 LE_{t-i} + \sum_{i=1}^{2}\beta_2 CO2_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \quad (4)$$

$$NER_t = c_1 + \sum_{i=1}^{2}\beta_1 NER_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 CO2_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \tag{5}$$

$$GDPPC_t = c_1 + \sum_{i=1}^{2}\beta_1 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 CO2_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \tag{6}$$

$$LFPR_t = c_1 + \sum_{i=1}^{2}\beta_1 LFPR_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 CO2_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \tag{7}$$

$$R\&D_t = c_1 + \sum_{i=1}^{2}\beta_1 R\&D_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 CO2_{t-i} + \sum_{i=1}^{2}\beta_7 LAT_{t-i} + \varepsilon \tag{8}$$

$$LAT_t = c_1 + \sum_{i=1}^{2}\beta_1 LAT_{t-i} + \sum_{i=1}^{2}\beta_2 LE_{t-i} + \sum_{i=1}^{2}\beta_3 NER_{t-i} + \sum_{i=1}^{2}\beta_4 GDPPC_{t-i} + \sum_{i=1}^{2}\beta_5 LFPR_{t-i}$$

$$+ \sum_{i=1}^{2}\beta_6 R\&D_{t-i} + \sum_{i=1}^{2}\beta_7 CO2_{t-i} + \varepsilon \tag{9}$$

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.,

$$Var(\sigma(CO2, LE) = Var(E[\sigma \perp LE]) + E[Var(\sigma \perp LE)]$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LE)]$$

$$Var(\sigma(CO2, LE) = Var(E[\sigma \perp NER]) + E[Var(\sigma \perp NER)]$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, NER)]$$

$$Var(\sigma(CO2, LE) = Var(E[\sigma \perp GDPPC) + E[Var(\sigma \perp GDPPC)]$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, GDPPC)]$$

$$Var(\sigma(CO2, LFPR) = Var(E[\sigma \perp LFPR]) + E[Var(\sigma \perp LFPR)] \tag{10}$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LFPR)]$$

$$Var(\sigma(CO2, LE) = Var(E[\sigma \perp R\&D]) + E[Var(\sigma \perp R\&D)]$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, R\&D)]$$

$$Var(\sigma(CO2, LE) = Var(E[\sigma \perp LAT]) + E[Var(\sigma \perp LAT)]$$

$$\Rightarrow Var(E[\sigma \perp CO2]) \le Var(\sigma[CO2, LAT)]$$

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.
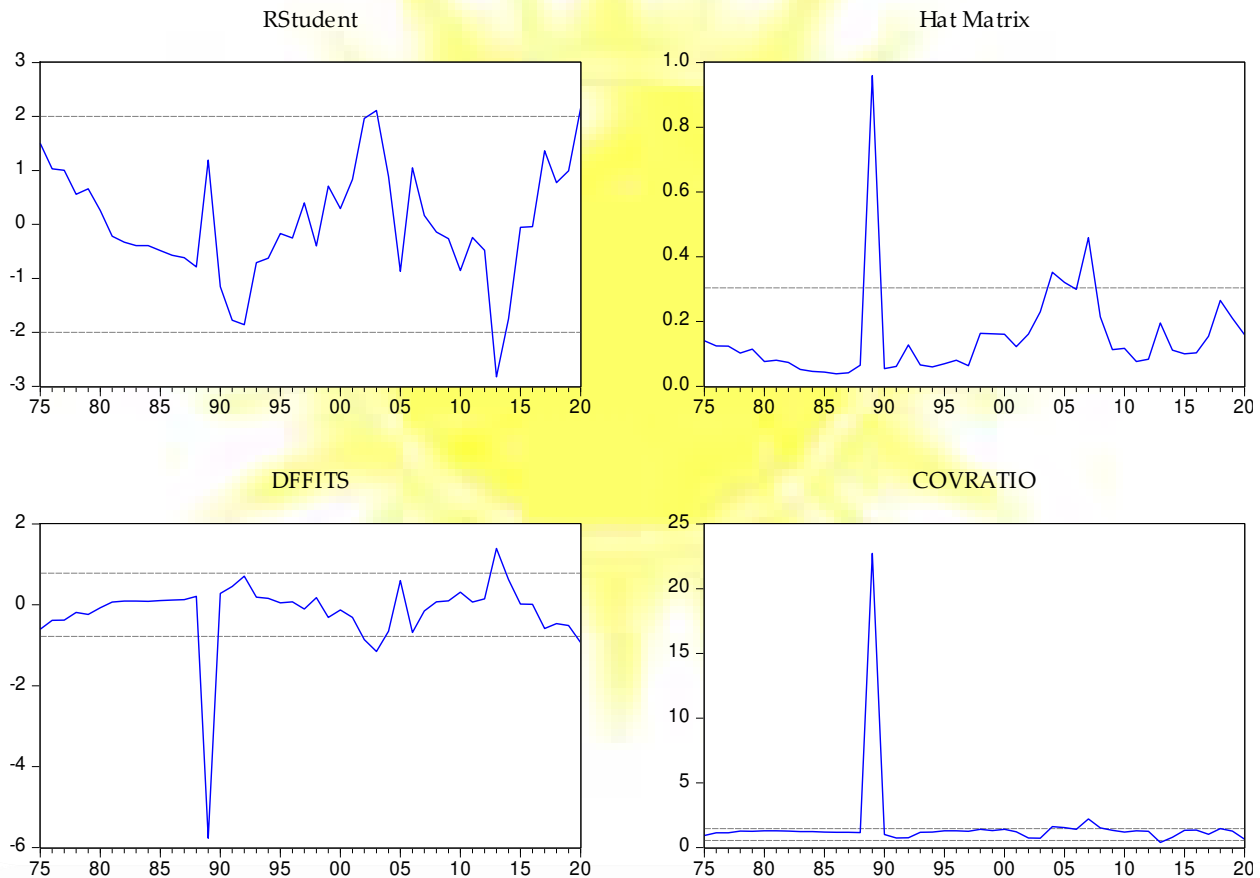
Figure 2: Influence Statistics
Source: Author's estimation.

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).
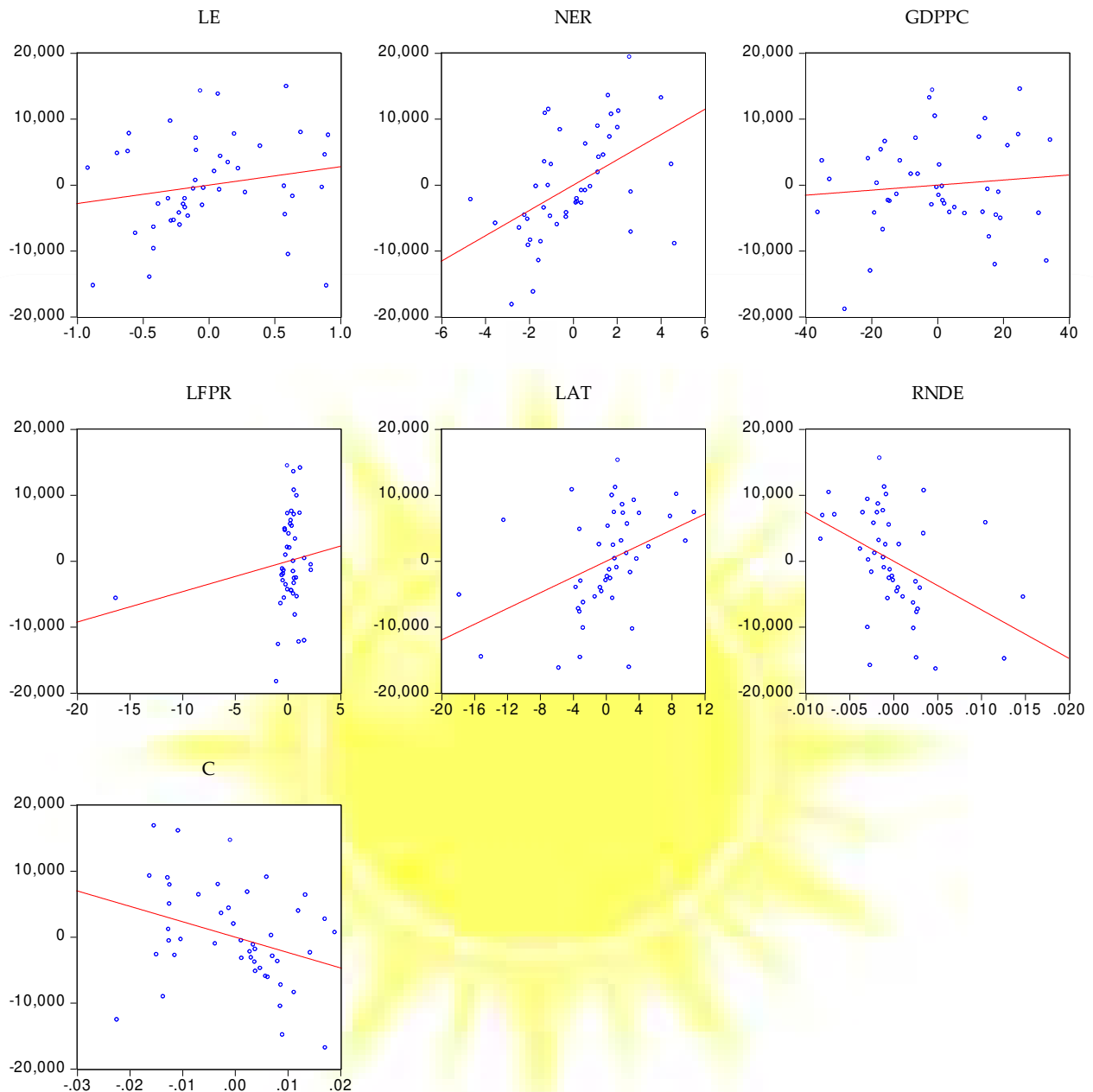
Figure 3: Leverage Plots

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.
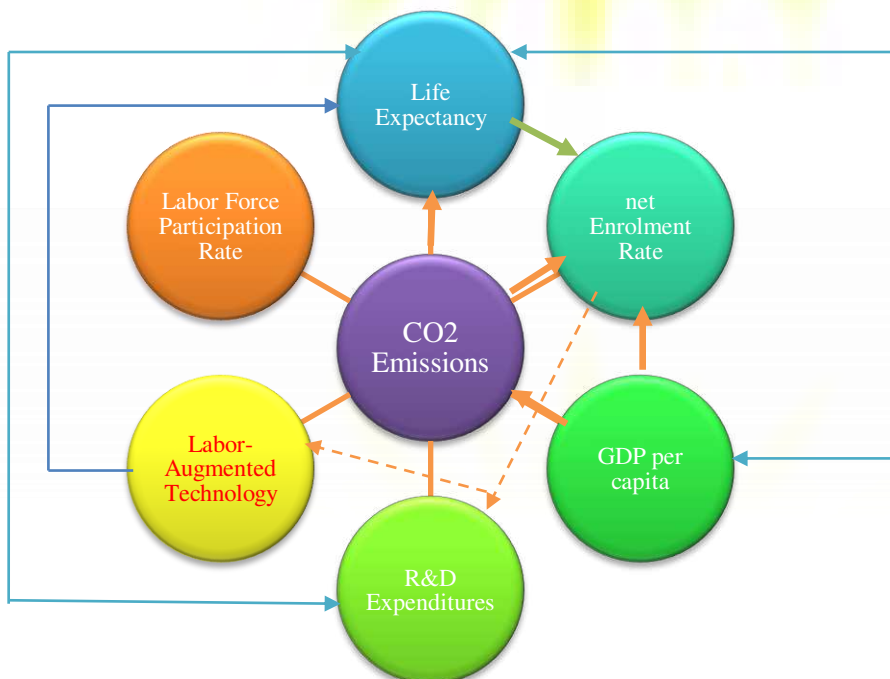
Figure 4: Granger Casualty Estimates
Source: Author's self extract.

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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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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Unveiling the Carbon Footprint of Europe and Central Asia: Insights into the Impact of Key Factors on CO2 Emissions

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ABSTRACT

This study delves into the intricate relationship between carbon dioxide (CO_2) emissions and crucial variables in Europe and Central Asia from 1990-2021. By examining the impact of renewable energy, industry value added, foreign direct investment (FDI), gross domestic product (GDP) per capita, and population density on CO_2 emissions using the autoregressive distributed lag (ARDL) method, the study uncovers intriguing findings. The study reveals a significant negative correlation between linear per capita income and CO_2 emissions in both the short and long run. Moreover, it confirms the inverted N-shaped environmental Kuznets curve (EKC) relationship between the variables. The study further highlights the unfavorable impact of renewable energy and industry value added on CO_2 emissions, pointing to the fact that their growth increases CO_2 emissions. On the other hand, population density is found to be a vital factor in reducing CO_2 emissions. FDI is identified to have a negative and insignificant impact on CO_2 emissions, suggesting that it may not be an effective tool for reducing carbon emissions in the region. The insights from this study have significant implications for policymakers in the region to design and implement effective strategies to reduce CO_2 emissions.

Keywords: Carbon emissions; Economic growth; Renewable energy; FDI inflows; Industry value added, Population density; ARDL estimator.

1. INTRODUCTION

In recent years, climate change has emerged as one of the most significant challenges facing humanity, despite its seeming distance and theoretical nature for many individuals. The threats of global warming pose a serious risk to people all over the world, with human activities being the primary contributors to this problem. Greenhouse gas emissions, particularly carbon dioxide (CO_2), have been identified by scientists as the most significant factor driving climate change (Lv and Xu, 2019). Researchers have extensively investigated the factors underlying greenhouse gas emissions, and it is widely acknowledged that CO_2 output resulting from the combustion of renewable energy sources is the primary natural variable contributing to greenhouse gases. In 2011, the use of renewable energy sources to promote economic growth and improve human health resulted in 33.2 billion metric tons of global carbon emissions (Wang et al., 2018).
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Carbon dioxide, which accounts for 58% of overall global energy consumption, is one of the most important greenhouse gases. CO2 is a significant warmth (greenhouse) gas that is released into the atmosphere through human activities such as deforestation and fossil fuel combustion, as well as natural processes such as volcanic eruptions and respiration. While global temperatures have been fairly stable and benign, over the past two centuries, 97% of climate scientists and experts believe that human activities have significantly altered the Earth's atmosphere, leading to global warming. As temperatures continue to rise, the greenhouse gas effect typically absorbs a certain amount of energy in a way that protects the environment from extreme cold, but the significant contribution of human-generated greenhouse gases to global warming cannot be ignored. This is due to the presence of fossil fuel emissions in the atmosphere, which increase the volume of greenhouse gas emissions (Shahzad et, al ,. 2015). In the IPCC 5th assessment study, it was found that human action had caused more than 95% of the temperature increase on our planet (Afridi et al., 2019). The emission of radiation serves to warm the planet, while the accumulation of radiation from the sun by aerosols actively warms the air, rather than allowing sunlight to be absorbed by the research carried out by various agencies for climate and environmental research.On the other hand, analysis has shown that CO2 emissions are lower in high-income nations, as they recognize the importance of their environment and work to maintain balance. This paper aims to explore the factors that are contributing to massive CO2 emissions in Europe and Central Asia. Many nations are reducing their agricultural practices and transitioning towards more developed sectors, such as industry. However, estimates indicate that reducing agricultural development can negatively impact the environment, leading to global pollution. Deforestation is also a significant concern, with many countries having already exceeded the limits of total forest cover. People in rural areas often rely on natural resources for their livelihood, with forests being a major source. These forests are essentially factories that utilize excessive CO2 from the environment for their life, but economies are destroying this wealth at an alarming rate.

During the early stages of development, the primary concern for many nations is earning money at any cost, regardless of the impact on natural resources. Low levels of literacy and poverty among people are other factors that contribute to CO2 emissions. Many of the world's most environmentally polluted cities are in low-income countries, where people are generally less concerned about the environment and natural resources. Cities are the centers of energy consumption and consequently face significant environmental pressure. Sustainable use of natural resources has become increasingly important in recent years, as industrial revolutions have changed the economic landscape, with nations competing with each other in this rapidly evolving environment (Chen, 2023).Environmental degradation is the phenomenon that occurs when any disturbance is perceived to have a negative impact on the environment. The collapse of the earth, the destruction of the atmosphere through the consumption of natural resources such as air, water, and soil, and the extermination of wildlife are all examples of environmental degradation. This degradation results from the deterioration of the environment through the depletion of air, soil, and water resources, as well as the extinction of wildlife, the destruction of ecosystems and habitats, and pollution.

In recent years, global climate change has become a common concern for humanity. The characteristic nature of current ecological problems is that they are triggered by human-induced processes, rather than natural ones. Reckless commercialism and economic development have begun to show harmful effects on humanity. The primary cause of greenhouse gas emissions is human activity, including the burning of fossil fuels, which releases CO2 and other organic compounds into the atmosphere (Ahmad et al., 2017).Urbanization, industrialization, under-population development, and deforestation are some of the leading causes of environmental degradation, which results in a reduction in the variety and quality of natural resources. When water supplies become more damaging to the environment due to urbanization and industrial development, it contributes to the destruction of ecosystems (Tyagi et al., 2014).Various forms of greenhouse gases contribute to the degradation of the climate, resulting from significant increases in population, per capita income, and the use of exhaustible and polluting technology resources. The natural resources of the earth are being depleted, and the climate is being damaged by pollution of the air, water, and soil, which ultimately leads to environmental degradation.According to the United Nation report (2017) of Sustainable Development Goals 2017 global warming has a significant and disturbing effect throughout the world. Global average temperatures have steadily increased, breaking the record over the pre-industrial age of around 1.1 degrees Celsius. The size of worldwide glaciers in 2016 declined to 4.14 million square kilometers, the second lowest ever. Climatic CO2 concentrations exceeded 400 parts per million.

Environmental degradation has become one of the top ten hazards formally warned by high ranking Panel on Risks, Challenges as well as Transition. Earth degradation takes different forms. When ecosystems are destroyed or natural resources are depleted, leading to climate change and pollution, the environment is ultimately degraded (Andersen et al. 2023). Different types of human activities contribute to environmental degradation, such as substantial population growth, constantly rising per capita income, and the use of exhaustible and polluting technology resources. Various drivers of environmental degradation include increasing population, persistently rising economic growth, polluting and resource-depleting technologies, and the destruction of natural habitats (Chertow, 2000).Countries face environmental challenges at every level of income, with some managing the

challenges of managing natural resources and pollution more effectively than others (Norway, as compared to China). Rapid population growth, the use of fossil fuels, and per capita income growth pose serious threats to climate stability and the diversity of ecosystems in both developing and developed nations. Reliance on fossil fuels, overfishing, deforestation, pollution, overuse of water resources, and waste accumulation tend to deteriorate (Ahmed et al. 2022).

FDI represents a significant driver of carbon dioxide emissions, although the precise relationship between FDI and environmental degradation remains uncertain (Seker et al., 2015). FDI is a prominent feature of the modern global economy, and its potential impact on environmental sustainability is a fiercely debated issue. Developed nations face a particularly critical challenge, as they are perceived as attractive havens for polluting industries worldwide (McGuire 1982, Copeland and Taylor 1995). Various factors such as political instability, country risk, and interest rates can influence foreign investment. In such contexts, weak environmental regulations may increase FDI inflows. In recent decades, FDI globalization has significantly expanded, bringing not only mutual funds but also incentives to transfer technology from investors to host nations. This has led to job growth, managerial and technical expertise inflows, and improved organizational skills, along with increased competitiveness (Kobrin, 2005). According to Haug and Ucal (2019), FDI has no long-term statistically significant impact, although export declines can reduce per capita carbon dioxide emissions in the long run. However, export increases do not have a positive significant impact, and they can drive up carbon dioxide emissions per capita. Developing nations lack essential infrastructure and are hampered by economic and social instability, uneducated and unskilled populations, and constrained economies that impede their development. Thus, the transition of technologies in such countries is crucial to advance their economic growth (Bengoa, M., & Sanchez-Robles 2003). However, foreign investment has had a negative impact on environmental protection in India and China, according to Baek et al. (2009). FDI inflows rose significantly from $317.430 billion in 2004 to $2516 billion in 2012, largely due to less strict regulations.

The relationship between economic growth and environmental degradation, particularly the emission of carbon dioxide, has been extensively studied in the literature (Imran et al. 2023; Wang et al. 2023). Numerous studies have found a positive association between GDP growth and carbon emissions, particularly in emerging nations (Imran et al. 2022; Shaheen et al. 2022). The Atmosphere Kuznets Curve, which shows an inverted U-shaped relationship between economic growth and environmental degradation, has been used to explain this association. However, recent studies have suggested that positive growth in real income may decrease CO2 emissions and nonrenewable energy usage, while increasing N20 (Yahya& Lee, 2023).The relationship between economic development and the environment is often seen as conflicting, particularly in developing countries where economic development, industrialization, and resource use are given top priority. However, some studies have suggested a negative and nonlinear relationship between CO2 emissions and economic development (Zaman et al. 2022; Anser et al. 2022).The choices made regarding economic development and environmental protection in the present world will have an impact on future generations. Concerns about climate change and global warming have led to increased research into the relationship between economic development and pollution. Increasing income leads to increased production of goods and services, which can have a positive impact on the economy but also increase greenhouse gas emissions. Therefore, the development agenda should focus on the use of modern technologies and the creation of new applied research, which are the main drivers of economic growth, to minimize the negative impact on the environment.In addition to population density, urbanization is also a key factor in carbon dioxide emissions (Akhtar et al. 2022). Urbanization is often associated with economic growth and higher standards of living, but it also leads to increased energy use and transportation emissions. According to Zhang et al. (2021), urbanization has a significant positive effect on carbon dioxide emissions in China. In addition, the type of energy used for electricity generation also plays a significant role in carbon dioxide emissions. Countries that rely heavily on coal as an energy source tend to have higher emissions compared to those that rely more on renewable energy sources such as solar or wind power (Pombo et al. 2023). Furthermore, it is worth noting that population growth and density are not the only factors that contribute to carbon dioxide emissions. The behavior of individuals and businesses also plays a crucial role in the level of emissions. The choices that people make regarding transportation, energy use, and waste management can significantly impact emissions. Policies and regulations can also play a critical role in reducing emissions, such as promoting the use of public transportation, incentivizing the use of renewable energy, and implementing carbon pricing mechanisms (Lim & Prakash, 2023).

It is important to address the impact of carbon emissions on the environment and human life. The focus on population density, FDI, GDP, and renewable energy as potential factors affecting carbon emissions in Europe and Central Asian countries is a significant step in addressing this issue. By understanding the relationship between these factors and carbon emissions, policymakers can develop effective strategies to reduce greenhouse gas emissions.It is worth noting that population density, FDI, GDP, and renewable energy are interconnected factors that may influence carbon emissions in different ways (Khan et al. 2022; Jia et al. 2022). For example, higher population density may result in more energy consumption, which can lead to increased carbon emissions. FDI and GDP may also be related to energy consumption and hence contribute to carbon emissions. In contrast, renewable energy sources like solar and wind power may offer an alternative to fossil fuels, thus reducing carbon emissions.

Overall, this research can provide valuable insights into how different factors impact carbon emissions and inform policies that can lead to a more sustainable future.It is true that a healthy environment is closely linked to a stable and sustainable economy. However, increased economic activities have led to environmental degradation, which poses a threat to sustainability efforts. Climate change is a major consequence of this degradation and has gained significant attention in the literature.

The present study is therefore motivated to examine the impact of various factors, such as FDI, renewable energy, and industry value added, on CO2 emissions in Europe and Central Asia. This research is important in understanding the underlying factors that contribute to carbon emissions and can help inform policies to mitigate their impact on the environment.The research aims to address important questions regarding the impact of human activity on the environment in Europe and Central Asia. Specifically, the objectives are to investigate the effects of different factors, such as industries, renewable energy, population density, and per capita GDP, on carbon dioxide emissions. The study seeks to identify the relationship between these variables and the level of CO2 emissions, in order to better understand the environmental challenges facing the region and inform policy decisions aimed at achieving a more sustainable future. By exploring these factors, the research will provide insights into the key drivers of emissions and the most effective strategies for reducing them.

2. LITERATURE REVIEW

This section offers a high-level summary of the research conducted on the effects of the energy mix, businesses, Capital, Income per capita, and demography on CO2 emissions. One way to maintain a stable economy is to safeguard the environment. Unfortunately, human interference in the form of expanded economic activity has led to a deterioration in air sustainability. The study by Honma (2015) examined the connection between international commerce and sustainability reporting in 98 countries from 1970 to 2008. The global economy was shown to improve sustainability impact, although its effect on climate varied with countries' GDP per capita. To evaluate the effect of trade on diverse natural indicators, the research also presented an ecological effectiveness measure. The effects of free trade, productive capacity, trade deepening, and air quality were studied by Hua and Boateng (2015) across 167 countries from 1970 to 2007. Researchers observed a U-shaped correlation between the quality of life and economic damage in these countries, a phenomenon known as the EKC. The research urged world leaders to consider environmental concerns while allocating resources and expanding economies throughout the globe. From 1976 to 2009, Tang and Tan (2015) analyzed data on emissions, FDI, power usage, and wage activity in Vietnam. Co2 emissions were shown to be positively influenced by energy use and economic growth and negatively influenced by urbanization. The EKC was also supported by the data, demonstrating that with industrial prosperity comes an increase in biodiversity loss followed by a decline. The research suggested using green technology to cut down on pollution. Ohlan (2015) examined the relationship between CO2 emission in India and factors such as energy consumption, wealth creation, open trade, and population size from 1970 to 2013. A positive correlation between carbon pollution and each outcome variable was discovered immediately and during the research. The research suggested legal measures to reduce the impact of these causes on carbon output. Shahbaz et al. (2015) examined the connection between development and CO2 emissions in India from 1970 to 2012. Asymmetry in information was found among the components by co-integration and asymmetric causality analysis. Negative thermal efficiency and adverse financial growth shocks affected productivity expansion. Using the structural VAR method, Ahiakpor et al. (2019) looked at the connection between Ghana's monetary stimulus and trade linearization during 2012-2017. Inflation has been rising in Ghana as the country's trade volume has increased, and this study aimed to determine how well the financial system has been at stemming that tide. According to the research, policymakers should consider the degree of trade linearization when setting interest rates. Khan and Ozturk (2020) analyzed yearly balanced data from 17 Asian countries between 1980 and 2014 to examine the correlation between FDI and emissions. A positive impact of FDI on carbon footprint was discovered, lending credence to the "Pollution Haven Hypothesis." Nevertheless, open trade and ecological sustainability were also significant effects of Capital. According to the findings, healthy growth and development may be attained if economic policies are devised to direct foreign resources towards ecologically friendly enterprises. Leitao (2018) used time series data from 1980-2013 to analyze Portugal's EKC and its association with climate change. The research indicated that although high9r per capita income raises emissions, higher annual income quadratic decreases them. Carbon output was shown to be inversely linked to free trade and FDI. The analysis found that Portugal has a high dependence on its energy infrastructure. Using time series data from 1975-2016, Naz et al. (2018) looked at the connection between REC, Investor influx, wage activity, and emissions. The research concluded that fossil fuels rise with wealth creation and Capital inflows, but they drop dramatically with the use of renewables. The research results contradicted the EKC hypothesis, which found a reverse U-shaped correlation between a nation's economy and carbon footprint. The findings also backed up the "Contamination Haven supposition," the theory that FDI might harm a country's ecosystem. The report suggests enforcing environmental and economic regulations to integrate REC into existing energy assets, which may decrease CO2 emissions and boost personal income and FDI inflows. Using ten-year balanced panel data

from 1996-2005 for 84 countries, Chang and Li (2019) looked at the impact of FDI and economic growth on emissions across demographics. Using inhabitants and estimated numbers as threshold parameters, the researchers discovered an inverted U-shaped EKC connection between CO2 emissions and economic growth across various demographic groupings. Pollutants rose sharply with rising FDI in low-population systems. The research shows that greater carbon pollution is associated with higher manufacturing value creation, whereas decreased emissions are associated with increased energy utilization. Based on the stated discussion, the study's first hypothesis is as follows:

H1: There exists an inverted N-shaped relationship between CO2 emissions and economic growth, such that emissions increase initially with economic growth, decrease after a certain threshold level is reached, but increase again at higher levels of economic growth.

The relationship between India's labour force and Financial development was a wash across the research period. Using social network analysis, Aller et al. (2015) analyzed the connections between commerce and the natural world in 177 nations between 1996 and 2010. Significant environmental implications were discovered for the trade network and total commerce. The economic influence of the trade network improved the efficiency of the atmosphere in low-income countries while negatively impacting the climate in high-income ones. The research backed up the pollution heaven theory and demonstrated that the entry of multinational firms into developing nations is terrible for the environment. Capital structure, open trade, and environmental integrity were all studied by Al-Mulali et al. (2015) across 23 European nations between 1990 and 2013. The research found that carbon emissions rise with commercial, urban, and financial growth but fall with free trade. It was suggested in the report that incentives for pure energy firms and investments, free trade to promote non-polluting firms and levies on polluting industries would all help businesses make the switch to clean, ecologically sustainable sectors.Using data from 1971 to 2010, Alvarado and Toledo (2017) examined the connection between production and environmental loss in Ecuador. A long-term link between plant cover, urbanization, and actual Output was discovered using co-integration and error correction models. These factors were also shown to have short-term correlations, albeit no evidence of Granger causality was discovered. According to the research results, environmental rules in Ecuador should be independent of the country's expanding economy and metropolitan areas. Energy conservation, FDI, urbanization, and Pollutant emissions were all factors that Behera and Dash (2017) investigated for 17 nations in the South and Southeast Asia area between 1980 and 2012. Power consumption, FDI, and CO2 emissions were found to be co-integrated across all income levels using the Pedroni co-integration approach. It was shown that middle-income nations' carbon emissions co-integrated with the use of conventional energy, capital formation, and urbanization. The research found that carbon emissions in the SSEA area were most affected in middle-income nations where conventional energy consumption and FDI play a role. Ozturk and Oz (2016) looked at the connection between energy requirements, jobs, direct investment, and Pollutant emissions in Turkey from 1974 to 2011. Long- and short-term EKC hypotheses were supported in Turkey. FDI improved the state of the climate, especially in the near term, but a negative FDI coefficient indicated a reciprocal causal relationship between FDI and carbon emissions. In Turkey, too, evidence corroborated the development theory, pointing to a one-way causal relationship between energy use and progress. Including electricity usage, wealth creation, and economic progress.The effects of increased productivity and globalization on environmental stewardship in 36 Sub-Saharan African nations were examined by Kwabena et al. (2017). According to Kuznet's hypothesis of the ecological impact of financial development and productivity, the researchers concluded that the latter two factors improved ecosystem sustainability and quality. In contrast, internationalization had a detrimental effect on wildlife preservation and stewardship of natural resources. Investment in fuel cells, greenways, and evolution goods was suggested in the research as a means of fostering sustainability. From 1994 to 2012, Allard et al. (2017) analyzed 74 countries' CO2 emissions, Income per capita, open trade, scientific advances, use of clean energy, and democratic accountability. Except for the upper middle class, they discovered a negative relationship between REC and CO2 emissions and an N-shaped EKC. The research suggested that eco-friendly technologies be promoted to counteract global warming. From 1970 to 2011, Adams et al. (2017) analyzed data from 38 African countries to see whether there was a correlation between urbanization and ecological pollution. Despite political factors, they nevertheless discovered a long-term equilibrium between urbanization and resource depletion. To resolve the link between urbanization and biodiversity loss, the research suggested considering the impact of political factors. From 1980 to 2010 Özokcu and Özdemir(2017) compared the environmental issues of developing economies in 52 low-income nations with those of 26 high-income countries. For the first model, they discovered an N-shaped connection with a cubic functional form, while for the second model, they discovered an inverted N-shaped curve. Researchers concluded that a rising economy could not save the planet by itself. The impact of overseas investment, power usage, wealth maximization, and inclusive growth on carbon dioxide emissions in Kuwait was studied by Salahuddin et al. (2015). As revealed by the authors' co-integration analysis, short-term and long-term CO2 emissions are triggered by economic growth, resource utilization, and overseas investment. The report suggested that Kuwait cut down on its emissions by increasing its carbon capture, synthesis, and silos, decreasing domestic power system subsidies, and investing in decarbonizing. From 1971 to 2013, researchers Aye and Edoja (2017) looked at 31 emerging countries and the impact of

economic growth on CO2 emissions. Instead of a U-shaped link between economic expansion and Pollutant emissions, they discovered no EKC. The rise in population and reliance on oil also increased atmospheric carbon output. The study suggested using alternative energy and switching to systems with lower emissions. Based on the stated discussion, the following hypotheses are as follows:

H2: There exists a negative relationship between CO2 emissions and renewable energy demand, such that higher demand for clean and green energy sources leads to lower emissions.

H3: There exists a positive (negative) relationship between CO2 emissions and FDI inflows, consistent with the pollution haven (halo) hypothesis, whereby foreign investment in countries with weaker (higher) environmental regulations leads to higher emissions.

The E7 countries were studied by Tong et al. (2020) to determine the relationship between power use, wealth creation, and air pollution. Research conducted on Turkey, Mexico, Indonesia, and the People's Chinese Republic revealed no evidence of a correlation between rising productivity, rising power usage, and rising carbon emissions. The research concluded that we need to switch to renewable energy sources like wind and solar. Thermal efficiency and industrial growth were analyzed in terms of their impact on air pollution in Pakistan by Khan et al. (2020). CO2 emissions were shown to be positively correlated with both fuel use and national activities. From 1990 to 2015, Danish et al. (2020) studied the OECD countries' transportation of atmospheric co2 in connection to their growth, analysis, transportation, real income, and other factors. The research concluded that production negatively impacts the environment, whereas population size and real income are positive. The study suggested that OECD countries lessen their carbon impact by switching to more fuel-efficient automobiles.Research into the causes of atmospheric CO2 emissions has been done several times.In order to determine what aspects of society are responsible for shifts in CO2 emissions, Rahman et al. (2022) undertook research in Malaysia. The authors analyzed data from 1982 through 2018 using ARDL. Findings suggested that using natural gas and electricity did not affect carbon pollution. Nonetheless, CO2 emissions were positively impacted by the use of coal and oil and the presence of foreign workers and tourists. It was also concluded that there was an increase in CO2 emissions at the outset and a subsequent drop as national wealth climbed. From 1990 to 2019, Hafeez et al. (2022) analyzed data from China to determine what variables influence the country's CO2 emissions from economic activity. The study used the ARDL and NARDL regression methods to examine the information. Long-term CO2 emissions from either production or use were shown to not correlate with output growth. Although several factors contribute to rising CO2 output, energy use in the economy stood out as particularly important. The NARDL findings also revealed that economic growth only served to lower spending CO2 emissions. The findings also revealed that rising CO2 emissions are tracked by increasing electricity use in the economy. Kwakwa (2022) examined CO2 emissions in Ghana between 1971 and 2018 to see how economic progress, war expenditure, and other factors affected production. The study used ECM for temporal analysis and co-integration for a longer-term perspective. According to the results, overpopulation, modernization, and warfare, all contributed to higher CO2 emissions, but public spending was associated with a gradual decline in emissions over time. The data supported the EKC, which posits a U-shaped link between CO2 emissions and income. The study suggested using sustainable methods to cut down on carbon output. Based on the literature, the study's ext hypothesis is as follows:

H4: There exists a negative (positive) relationship between CO2 emissions and industry value added, consistent with the hypothesis that sustainable (unsustainable) production and consumption practices can lead to lower (higher) emissions.

Human interference due to rising economic activity threatens a clean environment, which is essential to continue economic progress. Alternative sources, enterprises, capital flows, national income, and current population are only some areas that have been the focus of research into their potential roles in CO2 emissions. Power consumption, ecotourism, and the employment of immigrant labour have contributed to rising CO2 emissions in the Malaysian economy, which Rahman et al. (2022) investigated. Their findings revealed that although power demand and the employment of overseas labour had no noticeable influence on CO2 emissions, coal and oil usage did. The research also discovered an initial rise in CO2 emissions and a subsequent drop as national wealth climbed. The energy sector was determined to be a significant contributor to CO2 emissions in China's economy from 1990 to 2019, according to an analysis by Hafeez et al. (2022). Despite the lack of a correlation between Income and manufacturing CO2 emissions over the long run, an increase in income was associated with a decrease in CO2 emissions from both sources. From 1971 through 2018, Kwakwa (2022) analyzed the effects of manufacturing, advancement, and non-developmental spending, as well as warfare, on Ghana's emissions. CO2 emissions increased with demographic, modernization, and military while decreasing with expenditure. Evidence from the research was consistent with an EKC, which indicates a U-shaped link between emissions and wealth but in the opposite direction. To lower carbon output, the research suggested eco-friendly technology. Seri and de Juan Fernandez (2022) examined the relationship between income and emissions in twenty-one Latin American countries. According to their findings, national knowledge, technology, and policy were more critical than Affluence in explaining differences in CO2

emissions across countries. The final hypothesis of the study is as follows:

H5: There exists a positive relationship between CO2 emissions and population density, consistent with the population-led emissions hypothesis, whereby higher population densities lead to higher emissions due to increased energy consumption and transportation demands.

2.1. Contribution of the Study

Based on the given hypotheses and variables, the study has the following contribution of the study, i.e.,

- **Economic Growth Hypothesis**

This research has the potential to add to the current discussion concerning the link between economic development and environmental sustainability by presenting evidence for a U- or N-shaped connection between CO2 emissions and economic growth. Considerable ramifications may result for those tasked with balancing economic development and environmental conservation in light of this finding.

- **Renewable Energy Demand Hypothesis**

This research has the potential to add to the expanding body of literature on renewable energy's ability to cut GHG emissions and slow global warming. The study's findings might emphasize the significance of policies and incentives that encourage the development and use of clean energy sources by demonstrating a negative link between CO2 emissions and demand for renewable energy.

- **FDI Inflows Hypothesis**

Either the pollution haven or pollution halo theory might be supported by the findings of this research, adding to the ongoing discussion regarding the environmental effects of overseas investment. The results might be used to improve environmental regulations and the policies that govern how international corporations operate in host nations.

- **Industry Value Added Hypothesis**

Evidence supporting the link between CO2 emissions and industrial value added might be gathered from this research, which could be a valuable addition to the growing body of literature on environmentally responsible production and consumption. The results might be used to shape policies and procedures that encourage environmentally responsible and sustainable manufacturing.

- **Population Density Hypothesis**

This research has the potential to provide light on the factors that contribute to carbon emissions in highly populated regions and shed light on the link between population density and these emissions. The results help shape urban emission reduction strategies and initiatives, including those prioritizing public transit, green construction practices, and renewable energy.

3. MATERIALS AND METHODS

3.1. Introduction

In this section, the study discuss the methodology used for collecting data, including sample size, data sources, indicators, and their definitions. The study also provides an overview of the estimation technique used for the empirical analysis.

3.2. Sample Data

The analysis is based on time series data collected from Europe and Central Asian economies from 1990 to 2021.

3.3. Data Source

The data ranges from 1990 to 2021 and comes from the World Bank (2022). The effect of population density (POP), renewable energy (RENG), GDP per capita (Y), foreign direct investment (FDI), and industrial value addition (IND) on carbon emissions (CO2) is studied using aggregate data for Europe and Central Asia.

3.4. Theoretical Foundations

3.4.1. Green Inverted-N Growth Hypothesis

According to this view, economic development and environmental protection may coexist if we adopt measures to foster a green economy. In particular, it suggests that the correlation between economic development and greenhouse gas emissions follows an inverted-N pattern, with emissions rising with GDP expansion until a tipping point is reached and then falling further as the economy shifts to a greener, more sustainable model. The hypothesis proposes that investments in renewable energy, green infrastructure, sustainable manufacturing techniques, and eco-friendly policies might ease this shift. It also hints at the potential for these investments to have beneficial knock-on impacts in other areas of the economy, such as employment growth, innovation, and competitiveness. Overall, the green inverted-N growth hypothesis serves as a framework for academics and policymakers to examine the dynamics of green growth and the tensions between economic progress and environmental safeguards.

3.5. Econometric Framework

The goal of the empirical approach is to identify the factors that contribute to CO2 emissions. The study develops the following model for time series data for empirical research:

$$CO2_t = \beta_0 + \beta_1 FDI_t + \beta_2 IND_t + \beta_3 POP_t + \beta_4 RENG_t + \beta_5 Y_t + \beta_6 Y^2_t + \beta_7 Y^3_t + \mu_t \tag{1}$$

For a more in-depth look at how these variables interact over time, we use the ARDL estimate strategy and the following model version.

$$\Delta\,CO2_t = a_0 + \sum_{i=1}^{l} b\Delta CO2_{t-i} + \sum_{i=1}^{l} c\Delta Y_{t-i} + \sum_{i=1}^{l} d\Delta FDI_{t-i} + \sum_{i=1}^{l} e\Delta IND_{t-i} + \sum_{i=1}^{l} f\Delta RENG_{t-i} + \sum_{i=1}^{l} g\Delta Y2_{t-i} + \sum_{i=1}^{l} h\Delta Y3_{t-l}$$

$$+\sum_{i=1}^{l} i\Delta POP_{t-l} + \beta_1 CO2_{t-1} + \beta_2 Y_{t-1} + \beta_3 FDI_{t-1} + \beta_4 IND_{t-1} + \beta_5 RENG_{t-1} + \beta_6 Y2_{t-1} + \beta_7 Y3_{t-1} + \beta_8 POP_{t-1} + E_t \tag{2}$$

Where Δ denotes the first difference operators.

In order to determine the presence of a long-term relationship, an F-test, also referred to as ARDL-Bounds testing (Pesaran et al., 2001), is conducted using equation (2) and the null hypothesis. The stationarity of the variables at the first difference is irrelevant for this F-test. If the calculated F-value exceeds the upper limit, the null hypothesis is rejected, and a long-run relationship is concluded. On the other hand, if the F-value is less than the smaller of the two critical values, the null hypothesis is accepted, and no relationship exists between the variables. It is important to note that there is no interdependence among the variables. While the error correction term (ECT) determines the long-run connection, the ECT model helps assess the short-run model coefficient. The equation is as follows:

$$\Delta CO2_t = \eth_0 + \sum_{i=1}^{l} \eth_{1i}\Delta CO2_{t-i} + \sum_{i=1}^{l} \eth_{2i}\Delta Y_{t-i} + \sum_{i=1}^{l} \eth_{3i}\Delta FDI_{t-i} + \sum_{i=1}^{l} \eth_{4i}\Delta IND_{t-i} + \sum_{i=1}^{l} \eth_{5i}\Delta RENG_{t-i} + \sum_{i=1}^{l} \eth_{6i}\Delta Y2_{t-i} + \sum_{i=1}^{l} \eth_{7i}\Delta Y3_{t-i} +$$

$$+\sum_{i=1}^{l} \Delta\partial POP_{t-l} + \pounds ECT_{t-1} + E_t \tag{3}$$

Where Δ denotes the first difference operators.

4. RESULTS AND DISCUSSION

The study investigates the relationship between CO2 emissions and several independent variables. Table 1 shows the descriptive statistics of the variables. The mean value of CO2 emissions per capita is 7.655 metric tons. Over the period from 1990 to 2021, the minimum and maximum values of CO2 emissions are 6.576 and 9.477 metric tons, respectively. The standard deviation for CO2 emissions is 0.701, based on a sample of 32 observations.

Table 1: Descriptive Statistics

Methods	CO2	FDI	IND	POP	RENG	Y
Mean	7.655	3.379	25.068	32.054	10.088	19996.390
Median	7.600	3.229	24.501	31.806	8.447	20704.030
Maximum	9.477	8.890	30.224	33.631	19.006	24298.910
Minimum	6.576	1.1946	22.865	30.742	5.706	15659.940
Std. Dev.	0.701	2.407	2.011	0.897	3.756	2880.040
Skewness	0.750	0.527	1.098	0.454	0.927	-0.204
Kurtosis	3.600	2.740	3.1891	1.876	2.742	1.648

Note: CO2 shows carbon emissions, FDI shows foreign direct investment, IND shows industry value added,
POP shows population density, RENG shows renewable energy generation, and Y shows income.

On average, 32,054 people live every square kilometre in Europe and Central Asia. Over this same period, the lowest population density was recorded at 30.742/square km, while the highest was at 33.631/square km. The standard deviation for population density is 0.897. The average value-added in Europe and Central Asia's industrial sectors is 25.086. Throughout the period covered by the data, the greatest value created by the industry was 30.224%, and the lowest was 20.742%. For the same set of 32 data, the standard deviation of industries' value added is 2.011%. Ten percent of the energy used in cities comes from renewable sources. For the same time frame, the highest and lowest percentages of renewable energy were 19.00% and 5.706%, respectively. The standard deviation of renewable energy is 3.755%. In terms of GDP, the typical person in the country has a total of $2,996.39 in their bank account. During this period, the GDP per capita peaked at $24299.91 and bottomed out at $15659.94. The GDP per capita standard deviation is $2,880.04. Between 1990 and 2021, Europe and Central Asia will get around 3.379% of incoming Investment. FDI inflows peaked at 8.890% and bottomed at -1.194% throughout the same period, suggesting a general upward trend. According to data from 32 cases, the standard deviation of FDI inflows is 2.407%. The average GDP per capita squared is 4.08%. During that period, the square of GDP per capita peaked at 5.90% and dropped to 2.451 %. A statistical analysis of 32 data yields a standard deviation of 1.141% for the square of GDP per capita. There is an average 8.470% increase in cubic GDP per capita. The GDP per capita cube peaked at 13.431% and bottomed at 3.84% throughout the same period. The standard deviation of the cube of GDP per capita is 3.410%. The correlation matrix is shown in Table 2.

Table 2: Correlation Matrix

Variables	CO2	FDI	IND	POP	RENG	Y
CO2	1					
FDI	-0.226 (-1.272) [0.213]	1 ----- -----				
IND	0.812 (7.644) [0.000]	-0.309 (-1.784) [0.084]	1 ----- -----			
POP	-0.656 (-4.767) [0.000]	-0.029 (-0.161) [0.872]	-0.808 (-7.519) [0.000]	1 ----- -----		
RENG	-0.550 (-3.613) [0.001]	-0.133 (-0.737) [0.466]	-0.726 (-5.797) [0.000]	0.979 (26.930) [0.000]	1.000 ----- -----	
Y	-0.640 (-4.566) [0.000]	0.220 (1.239) [0.224]	-0.881 (-10.22) [0.000]	0.932 (14.120) [0.000]	0.877 (9.998) [0.000]	1 ----- -----
Y2	-0.630 (-4.452) [0.000]	0.185 (1.036) [0.308]	-0.862 (-9.345) [0.000]	0.945 (15.868) [0.000]	0.896 (11.063) [0.000]	0.998 (97.746) [0.000]
Y3	-0.619 (-4.325) [0.000]	0.150 (0.832) [0.411]	-0.841 (-8.536) [0.000]	0.955 (17.686) [0.000]	0.912 (12.248) [0.000]	0.993 (48.624) [0.000]

Note: small bracket shows t-value while large bracket shows probability value.

According to the data, a positive relationship exists between carbon emissions and the value created by industries (r=0.812). However, FDI (r=-0.226), population density (r=-0.656), RENG (r=-0.550), and economic growth (r=-0.640), as well as their square (r=-0.630) and cubic (r=-0.619) transformations, all exhibit a negative connection with CO_2 emissions. Population density, RENG, income, the square of income, and the cubic of income are all negatively correlated with the value contributed by industries. In addition, the level, square, and cubic forms of economic growth are all positively correlated with the demand for renewable energy, suggesting that higher demand for renewable energy is connected with better economic growth. Based on these results, it is plausible that carbon emissions could be reduced by enacting laws that boost the use of renewable energy, encourages sustainable economic development, lower population density, and put constraints on the value provided by industries. The estimated unit roots are shown in Table 3.

Table 3: Unit Root Test Estimates

Variables	Level	First Difference	Decision
CO2	-1.507	-2.292**	I(I)
FDI	-2.371	-5.314*	I(I)
IND	-1.222	-7.587*	I(I)
POP	-3.693**	-1.301	I(0)
RENG	-1.925	-3.799**	I(I)
Y	-2.437	-5.646*	I(I)
Y^2	-3.172	-6.100*	I(I)
Y^3	-3.724**	-6.498*	I(0)

Note:* and ** denotes 1% and 5% level of significance respectively.

The outcomes of the stationary test utilizing the ADF test are shown in Table 3. According to the test, population density and the cubic transformation of GDP are both confirmed to be stable at their starting levels, with no discernible long-term trend. Although some variables seem to follow a random walk with drift, evidence of stationarity appears only after the data has been differentiated once. The validity of future time series analysis and policy consequences relies heavily on these discoveries. Testing estimates for ARDL-Bounds are shown in Table 4.

Table 4: ARDL-Bounds Testing Estimates

Estimation model	CO2 = f (FDI, IND, POP, RENG, Y, Y², Y³)
Lag order	(1, 0, 0, 0, 0, 0, 1, 0)
Test statistics	Value
F-statistics	9.305

Source: Author's estimate.

The results of a bound test were done on the ARDL model to check for the presence of a long-run relationship. All of the independent variables, including FDI, IND, POP, RENG, Y, Y2, and Y3, have calculated F-statistic values that are more than the upper critical limit value of 3.9 at the 1% significance level, indicating a statistically significant long-term connection with the dependent variable CO2. These results suggest that the impacts of the independent factors on CO2 are likely to be long-lasting and have significant policy consequences. Prices for the diagnostic tests are shown in Table 5.

Table 5: Diagnostic Test Estimates

R^2	0.941
Adj. R^2	0.916
DW	1.646
Jarque–Bera normality test	0.870 (0.646)
Breusch–Godfrey serial correlation LM test	2.366 (0.120)
Heteroskedasticity test: White test	0.804 (0.617)
Ramsey's RESET test for the functional form	1.059 (0.302)

Note: Parenthesis values are the probability value.

The outcomes of the ARDL model's diagnostic tests are shown in Table 5. The model fits the data well, as shown by the high R-squared value of 94%, and the modified R-squared value verifies this with no loss of degrees of freedom. According to the Jarque-Bera normality test results, this model is regularly distributed. According to the LM test, no serial correlation exists between the variables in question. The diagnostic test results show that the ARDL model is robust for analyzing the correlations between CO2 and the other variables (FDI, IND, POP, RENG, Y, Y2, and Y3). The ARDL interim and final projections are shown in Table 6.

Table 6: ARDL Estimates

Variables	Coefficient	Std. Error	t-statistic	Probability
Long-run Estimates				
FDI	-0.043	0.033	-1.301	0.207
IND	0.347	0.154	2.252	0.035
POP	-4.055	1.005	-4.034	0.000
RENG	0.926	0.240	3.855	0.000
Y	-0.024	0.008	-2.859	0.009
Y²	1.321	4.221	3.123	0.005
Y³	-2.331	6.971	-3.346	0.003
C	265.042	83.402	3.177	0.004
Short-run Estimates				
D(Y²)	8.391	7.791	10.769	0.000
CO2(-1)	0.368	0.194	1.894	0.072

Variables	Coefficient	Std. Error	t-statistic	Probability
FDI	-0.027	0.023	-1.192	0.246
IND	0.219	0.101	2.174	0.041
POP	-2.562	0.713	-3.592	0.001
RENG	0.585	0.100	5.814	0.000
Y	-0.015	0.006	-2.319	0.030
Y^2	8.391	3.301	2.545	0.018
Y^3	-5.741	2.191	-2.619	0.016
ECT_{t-1}	-0.631	0.058	-10.754	0.000

Note: CO2 shows carbon emissions, FDI shows foreign direct investment, IND shows industry value added,
POP shows population density, RENG shows renewable energy generation, and Y shows income.

Table 6 displays the estimated model's short- and long-term outcomes. Population density negatively influences carbon emissions, statistically significant at the 1% level. Hence, a long-term reduction in CO2 emissions of 4.055 metric tonnes per person results from a one-unit rise in population density. This finding is consistent with the theory that, as a nation develops, its citizens become more conscious of the dangers posed by CO2 emissions and take steps to safeguard the environment, such as cutting down on their energy use, as a response. Table 6's findings have economic ramifications that imply strategies to promote population density sustainably may aid in the long-term reduction of carbon emissions. The carbon footprint of cities may be reduced by government support for sustainable urbanization laws that promote the growth of compact, energy-efficient communities with well-planned public transit networks, green areas, and access to basic amenities (Nasr et al. 2023). By incentivizing individuals to live more sustainably, these policies can improve people's quality of life, boost economic growth, and reduce carbon emissions (raihan et al. 2023). Similarly, the data suggests encouraging clean energy sources like renewable energy and decreasing the economy's reliance on companies that produce large amounts of carbon emissions. This is a means for governments to promote sustainable development while reducing the negative impacts of climate change. In sum, the results stress the need for a more all-encompassing strategy for sustainable development that considers the interconnected nature of economic development, environmental security, and social progress. Sustainable development policies can improve economic growth, environmental quality, and social well-being, all while lowering national emissions (Bondarenko et al. 2023).

At the 5% level of significance, the coefficient of industries is likewise significant, suggesting that a one-unit shift in industries leads to a 0.347 metric tonne increase in CO2 emissions per capita in the long term. This finding agrees with prior research that linked industrialization to higher CO2 emissions. There are substantial economic ramifications stemming from companies' beneficial impact on CO2 emissions, especially for emerging nations looking to industrialize and expand their economies. The leaders of these nations must strike a delicate balance between economic progress and environmental protection if they want to achieve sustainable development. Governments should create laws and regulations that encourage green and sustainable industries to lessen the adverse effects of industrialization on the environment and reduce carbon emissions (Fang, 2023). Politicians would look at less carbon-intensive and more ecologically friendly ways to boost the economy, such as encouraging the service industry (Ulucak & Baloch, 2023).

Regarding CO2 emissions, FDI does not make a difference in the long or short term. Nevertheless, other research has indicated that FDI may help reduce carbon emissions and increase energy efficiency over time if green technology is used. In this case, the investment technology may already be clean and based on green technology, which might explain why the FDI coefficient was not statistically significant. This finding has substantial repercussions for the economy, politicians, and corporations. Countries that depend significantly on FDI for economic development may need to find other ways to reduce carbon emissions, such as encouraging renewable energy sources and enacting more efficient energy legislation. Companies that invest internationally may need to think about the environmental rules and practices of those nations to which they contribute (Olaoye & Sornarajah, 2023). In order to do this, they may, for example, calculate the carbon emissions caused by their investments and actively search for ways to put their money into renewable energy (Lin et al. 2023). Overall, the findings of this research show that FDI has little to no influence on CO2 emissions, suggesting that other variables, such as population density and industrialization, need greater scrutiny.

There is a negative and a positive long-term association between per capita income and CO2 emissions, whereas the squared and cubic variables indicate a negative and a neutral correlation. At the 1% significance level, the coefficients point to an inverted N-shaped EKC connection. So, there is a threshold income over which the quality of the environment improves with further economic growth. Consequences for the economy may be substantial due to the inverted N-shaped EKC connection revealed in the research. Developing nations often see an initial rise in carbon dioxide emissions due to industrialization, and increased energy consumption as per capita wealth rises (Ray et al. 2023). Nevertheless, if the standard of living rises over a certain point, the public and the government become more aware of the harmful impacts of CO2 emissions, prompting more spending on green technologies, energy efficiency measures, and environmental legislation. Carbon emissions may fall as a result of this, despite the rising wealth (Wang et al. 2023). This research hints at the potential success of programmes that seek to boost economic development while minimizing environmental deterioration. It is worth noting, nevertheless, that different nations may have different economic, social, and environmental thresholds at which environmental quality begins to improve.

Both the long- and short-term CO2 emissions are favourably affected by the coefficient of renewable energy. Most studies have shown that renewable energy is critical in lowering emissions; therefore, this finding goes against that trend (Dogan et al. 2023). The research could have missed the mark since it needed to consider the availability of advanced, low-cost renewable energy generation methods that would help eliminate the discrepancy. This finding might be explained by the fact that renewable energy sources still

need to be competitive with conventional, nonrenewable ones (Mohideen et al. 2023). High upfront investment costs for renewable energy infrastructure, the lesser energy efficiency of renewable sources, and a lack of government incentives and subsidies are all to blame (Sun et al. 2023). Another explanation might be that different kinds of renewable energy sources should have been considered in the research, which could affect CO_2 emissions. A rise in CO_2 emissions could result from a country's reliance on hydropower, which necessitates the building of big dams and can have substantial environmental repercussions (Kulat et al. 2023).

Finally, the error correction coefficient is statistically negative, meaning that the system corrects for imbalance at a rate of 63% every year. This indicates that the variables rapidly recover to long-term equilibrium values following a shock.

5. CONCLUSIONS

Insights are provided into the interplay between CO_2 emissions and critical economic and social factors throughout Europe and Central Asia from 1990 to 2021. Evidence from this research supports the presence of an inverted N-shaped EKC in which CO_2 emissions climb in tandem with increasing per capita income up to a certain threshold when they begin to fall and then increase. The research also discovered a substantial negative link between per capita income and CO_2 emissions in both the short and long term, indicating that policies focused on increasing income development may have a good influence on lowering CO_2 emissions. The significant adverse effect of renewable energy and industrial value added on CO_2 emissions is also highlighted. Expanding these industries must be managed appropriately, and using cleaner energy sources must be bolstered if plans to reduce CO_2 emissions are to be successful. Policymakers should consider population density when crafting carbon emission reduction plans, as suggested by the research. Regarding reducing carbon emissions in the area, the study's conclusion that FDI has a negative and small influence suggests that authorities should look at other approaches.

The results of this research have important significance for regional policymakers, especially in creating efficient methods to cut down on CO_2 emissions. According to the findings, policymakers should manage the expansion of companies with a large carbon footprint while prioritizing policies that encourage renewable energy and efficient resource use. Decreased CO_2 emissions also depend on policies seeking to raise incomes while protecting the environment. Policymakers should also explore steps to lower population density in high-emission regions when promoting sustainable urbanization. Given that FDI has a negative and negligible effect on CO_2 emissions, governments should look elsewhere for ways to cut carbon output in the area. Possible actions include strengthening pollution restrictions, encouraging the use of renewable energy, and funding research into emission-cutting innovations. This research has certain caveats, one of which is its limited applicability to areas with differing economic and social situations because of its narrow geographical emphasis. The research also uses secondary data, which might include measurement errors or other forms of bias. Additionally, the study only analyses a small subset of the potential factors that influence carbon emissions; future studies should include more variables. This study lays the groundwork for further investigation into the effects of factors like energy efficiency measures and technological advancement on carbon emissions. To better understand the environmental difficulties in the area, a more critical study of the connection between CO_2 emissions and other environmental variables like air pollution or deforestation is needed. Finally, comparing and generalizing the results might be beneficial by expanding the research to include other locations with diverse economic and social situations.

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The Influence of Values, Beliefs, and Norms on Succession Planning and Organizational Culture: An Investigation of Their Role in Long-Term Success and Survival

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ABSTRACT

Succession planning is a crucial activity within an organizational framework as it facilitates achieving objectives. This process involves identifying individuals who can assume managerial roles within the organization, ensuring that the organization can continue to operate efficiently even in the absence of key personnel due to retirement, resignation, or unfortunate circumstances such as death. Consequently, this study aims to investigate the effect of succession planning and its impact on organizational sustainability by examining evidence from a business organization. To gather data for this study, a combination of questionnaires and personal interviews was employed. Seventy questionnaires were distributed, and fifty completed copies were collected and subsequently organized for analysis. The study primarily focuses on individuals in top and middle-level management positions. The findings of this research demonstrate a significant influence of succession planning on the survival of organizations. Specifically, the results reveal the processes involved in transferring formal knowledge and preserving institutional retention, ultimately contributing to the organization's long-term viability. Moreover, this study underscores the importance of career development in ensuring the organization's existence, particularly in the university setting. Employees perceive career development as a prerequisite for advancement and fulfilling the succession requirements of the organization. Consequently, this emphasis on career development ensures the perpetuity and survival of the institution. In overview, succession planning is vital to organizational success by enabling a seamless transition of managerial responsibilities. The findings of this study highlight the significance of succession planning in organizational sustainability and underscore the positive impact of career development in meeting succession needs. Ultimately, these efforts contribute to the longevity and survival of the institution.

Keywords: Succession planning; Organizational sustainability; Institutional retention; Knowledge; Career development.

1. INTRODUCTION

Succession planning is a deliberate and strategic decision made by organizations to cultivate and nurture the ongoing development of their employees, ensuring stability in critical positions and facilitating the achievement of business objectives (Okwueze & Akanu, 2023).

An organization's human resource strategy must consider its employees' availability and long-term value to maintain a competitive advantage (Hamadamin & Atan, 2019). Companies with solid organizational structures make a concerted effort to train and develop employees for executive-level positions in advance of any potential leadership gaps that may arise as a result of retirement, sickness, death, or unexpected resignations (Boyd et al., 2015; Mokhber et al., 2017).

Successful succession planning or talent pool management involves the creation of a pipeline or progression of potential leaders throughout the organization's leadership structure. This contrasts replacement planning, focusing solely on identifying backup candidates for specific senior management positions (Garavan et al. 2023). It is essential to consider the retention of key employees and the potential consequences their departure may have on the business (Liu-Lastres et al. 2023). Organizations utilize succession planning to recruit and develop employees who can fill each key role. Successful succession planning involves identifying and recruiting top talent, then training and developing that talent to be ready to take on more responsibilities. According to the available evidence, succession planning is most successful when it begins with defined goals (Jain & Gautam, 2016; Jasir et al. 2023). Rapid incorporation of new technology poses a challenge for measuring and achieving effective performance, as highlighted by Dewi and Fitrio (2022). However, organizations must recognize the importance of their human resources even in the face of modern technology. Rothwell (2001) further suggests that succession planning management ensures the continuity of leadership development to fill expected key positions and foster innovation. He recognizes that a proactive and systematic employee development process yields greater benefits for organizations progressing and navigating the dynamic challenges of a vibrant business environment. Atmaja et al. (2023) argued that succession planning is a control mechanism for dynamic organizations to align human capital needs with business goals.

Continuity planning is crucial for organizations to focus on identifying and developing potential managers or leaders, reducing the need to recruit talent externally (Teng-Calleja et al. 2023). Instead, internal talent development should be the primary focus for organizations in order to cultivate and nurture leaders in the face of attrition. Succession planning is an integral part of the organizational strategic planning process, integrated with developing and implementing the business plan. Hence, progressive organizations ensure that individuals receive appropriate training and developmental opportunities to meet future organizational requirements (Simkhada, 2023). Succession planning aids organizations in formulating strategic business plans and multiple growth strategies while enhancing employees' ability to adapt to the ever-changing environmental demands (Chapman Cook & Karau, 2023).

1.2   Objectives of the Study

The study aims to achieve its objectives by using questionnaires and in-person interviews. The primary focus of this research is to investigate a specific firm and analyze the impact of succession planning on the organization's ability to sustain and grow. Furthermore, the study seeks to examine the significance of succession planning and cultural norms in ensuring the long-term viability and success of the organization. Finally, the transmission and preservation of formal knowledge in institutional retention, crucial factors for organizational longevity, will be assessed through this research. Moreover, this study intends to assess the effectiveness of the University's career development programs in meeting the organization's succession requirements. Additionally, it aims to demonstrate how succession planning can contribute to the prosperity and expansion of businesses. Ultimately, the study's findings will provide valuable insights for developing guidelines to ensure the long-term viability of institutional frameworks.

1.3.   Research Questions

These are the study's research questions:

I.   What succession planning approaches are utilized by universities in their succession planning efforts?

II.   How does succession planning impact the ability of universities to sustain operations and facilitate expansion?

III.   What are the processes involved in implementing succession plans within universities?

IV.   What experiences have universities had in developing and implementing succession planning processes?

These research questions aim to investigate the different approaches universities employ in succession planning, analyze the effects of succession planning on universities' ability to operate and grow, understand the implementation processes of succession plans, and gather insights from universities' experiences in developing and executing succession planning initiatives. By addressing these questions, the study will provide valuable information and insights into succession planning within the university context.

2. LITERATURE REVIEW

The research aims to learn about the building blocks of a successful succession strategy. Succession planning entails preparing persons in advance to take on positions of authority. In his study on leadership succession, Rothwell (2015) highlighted the

significance of thinking forward to future leaders' roles. The primary emphasis of this research is the literature on ensuring the continuity of leadership via succession planning, which is grounded on his previous work. Rothwell uses "important roles" and "critical positions" interchangeably, referring to positions vital for an organization's survival and continuity. Individuals function as leaders within their organizations and possess competencies and unique qualities crucial for organizational effectiveness and success. Leadership permeates the organization, and leaders influence policy by selecting, empowering, training, and developing skills and abilities aligned with organizational objectives. Effective leadership utilizes power to modify and motivate competencies to achieve the organization's mission (Muthimi & Kilika, 2018). In addition, the development of young leaders inside an organization and the leadership development curriculum are all included in leadership succession planning (Vito et al., 2023; Yirci et al., 2023). Finally, it helps leaders and workers feel more connected to the company, which is essential for retaining current and future leaders (Hess et al., 2014; Downs, 2017; McCowan, 2020' Khairy et al., 2023).

This research aims to fill several existing gaps in knowledge. Firstly, it seeks to demonstrate the value of succession planning and its impact on an organization's continued survival and growth. Additionally, it explores how values, beliefs, and conventions influence succession planning and company culture. Furthermore, the effective transfer of formal knowledge and the preservation of institutional retention, both crucial for organizational survival, will be investigated in this research. Moreover, the study can contribute to understanding how career advancement benefits organizations and can be utilized to address succession planning concerns. Lastly, the study's significant contribution lies in providing empirical evidence that succession planning is vital for the ongoing success and expansion of businesses. By implementing succession plans, organizations can ensure smooth operations even after the departure of key employees due to retirement, resignation, or death (Morrow, 2023). This study examines a business organization, focusing on upper and middle management. As a result of this research, businesses can develop succession plans that secure the company's continued existence.

3. MATERIALS AND METHODS

In order to perform the study methodically and scientifically and achieve valid data and conclusions, the research design is essential. Therefore, an exploratory approach was used for this investigation. With this method, researchers may survey a cross-section of the community they are interested in learning more about and then extrapolate their findings to the whole (Robson, 2002). This study employs an experimental research approach and seeks to gain complete insights into the influence of succession planning on organizational survival and development in the context of the chosen business organization via the collection of both primary and secondary data. There will be 132 participants in this analysis. However, exclusively 50 people were chosen as the study's sample size. The sample included 17 upper-level managers and 33 lower-level managers. Table 1 provides a summary of the sample's demographics.

Table 1: Categories, Population, and Sample Size

Category	Population	Male	Female	Total	Percentage
Top Management	37	11	6	17	34
Middle Management	95	21	12	33	66
Total	**132**	**32**	**18**	**50**	**100**

Source: Field Survey

Table 1 details the demographics of the research participants by category, including total population size, gender, total count, and percentage distribution. The research covers two levels of management: upper and lower. The Top Management division has 37 individuals, 11 males and six females. There are 95 people in Middle Management, including 21 males and 12 females. There will be 50 participants in the trial, comprising 32 males and 18 females. The percentages show how many people in each group make up the whole.

3.1   Data Sources

Information needed to answer the study's primary research questions is gathered during the data-collecting phase. For this objective, we evaluated several different approaches and data sets. Data may be divided into two broad types: primary and secondary. Primary data is information gathered mainly for a research project from its source. This information has never been used before and is entirely novel. Depending on the question at hand, researchers might collect primary data via surveys, interviews, observations, or experiments. Secondary data, on the other hand, has already been acquired for another reason by another group of

researchers or an institution. Literature, papers, databases, and historical records are all examples of acceptable data sources. Insights and background for the study may be gleaned from secondary data. Researchers may more successfully achieve their study goals and answer their research questions when combining primary and secondary data. Also, we were able to draw trustworthy conclusions from our research by including both primary and secondary sources in our analysis.

3.2   Population

Employees at the University of Education, Winneba, are the subjects of this research. Senior faculty and staff of the College are represented here. One hundred thirty-two (132) individuals comprise the University's entire staff.

3.3   Sampling Techniques

To compel study subjects, the investigator used a conventional random selection method. Each member of the population has the same chance of being selected using this sampling method. The researcher used this strategy to ensure a balanced sample of workers participated in the study and to reduce the possibility of bias. In addition, a more realistic representation of the University of Education, Winneba staff as a whole may be obtained by this method.

3.4   Data Collection Instruments

Because of the specifics of the information needed for the study, a questionnaire was chosen as the data collection method. With the help of the questionnaire, data collection was made more systematic. In this approach, respondents were sent a set of questions ahead of time and asked to reply using the alternatives or open-ended/closed format given. The questionnaire provided a consistent and systematic approach to obtaining data from a large sample quickly and easily. As a result, the study goals were met, and the influence of succession planning on organizational development and continuity was investigated using a questionnaire used as the research instrument.

3.5   Data Analysis Technique

The study goals were addressed by thoroughly reviewing, classifying, tabulating, and analyzing the acquired data. Both qualitative and quantitative approaches were used in the investigation. However, due to the exploratory character of the study, the researcher relied heavily on a qualitative method for most of the analysis. The replies were analyzed for recurring themes, patterns, and narratives to provide context for the quantitative data. This approach enabled a complete comprehension of the participants' views, experiences, and insights about succession planning and its effect on the development of the company as a whole. The numerical data from the questionnaire replies were also analyzed using quantitative methods. This involved summarizing the data, calculating frequencies, percentages, or other statistical measures to identify trends, relationships, or patterns within the data. Integrating qualitative and quantitative methods in the analysis provided a comprehensive and nuanced understanding of the research findings. The emphasis on qualitative analysis allowed for a rich exploration of participants' perceptions and experiences, while quantitative analysis provided statistical support and additional insights to complement the qualitative findings.

4. RESULTS AND DISCUSSION

Individuals join organizations with specific needs, skills, and expectations, seeking a work environment that allows them to utilize their abilities to fulfill those needs. When organizations can offer such opportunities, it enhances the likelihood of increasing employee commitment. In this study, the researcher investigated the commitment and attitude of employees at the University. The findings regarding employees' commitment and attitude are depicted in Figure 1.
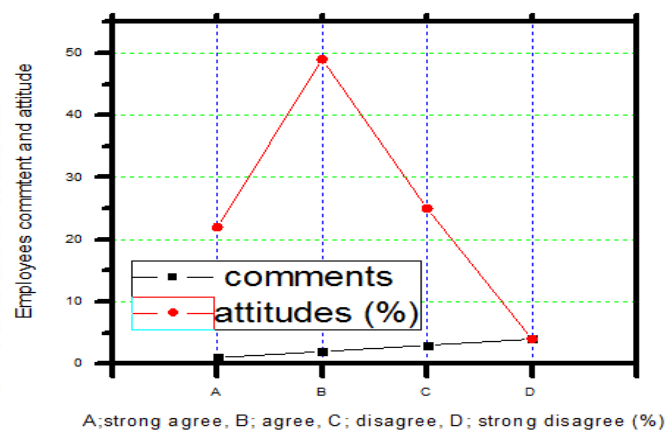

Figure 1: Employee Comments and Attitude (%)

Source: Field survey.

In Figure 1, it can be observed that 23 (22%) of the respondents strongly agree that they actively engage in University activities, while 52 (49%) respondents agree with this statement. On the other hand, 26 (25%) respondents disagree, and 4 (4%) strongly disagree. This result indicates that nearly half of the respondents, which constitute the majority, do not actively involve themselves in the University's activities. This finding aligns with the perspective of Rhoades and Eisenberger (2002), who argue that if management fails to involve employees, their level of participation in organizational activities will be limited, potentially hindering the achievement of succession planning objectives. Figure 2 shows the employee satisfaction with the existing working conditions.
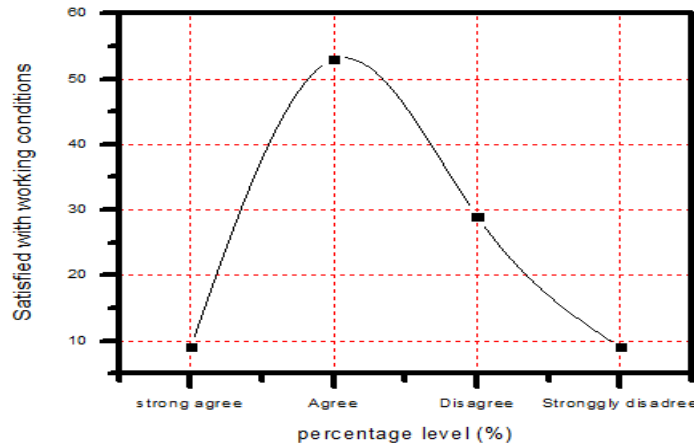
Figure 2: Employee Satisfaction with Working Conditions (%)

Source: Field survey.

In Figure 2, it is evident that 9 (9%) of the respondents strongly agree that they are satisfied with the working conditions at the University. Additionally, 56 (53%) respondents agree with this statement. However, 31 (29%) respondents disagree, and 9 (9%) strongly disagree with being satisfied with the working conditions. This indicates that most employees at the organization are indeed satisfied with the working conditions, which contributes to their ability to perform at their best. When employees are content with their working environment, it can positively impact their motivation and productivity (Elrayah & Semlali, 2023). Figure 3 displays the percentage distribution of respondents' feelings of happiness and comfort with their responsibilities at work. It provides insight into how employees perceive their level of satisfaction and ease in carrying out their job duties.
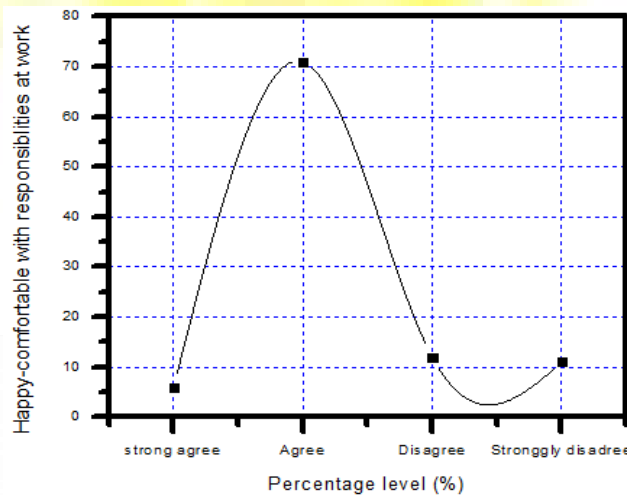

Figure 3: Employee Happiness and Comfort with Work Responsibilities (%)

Source: Field survey.

In Figure 3, it can be observed that 12 (11%) of the respondents strongly agree that they are satisfied with their responsibilities at work. Furthermore, 75 (71%) respondents agree with this statement. On the other hand, 13 (12%) respondents disagree, and 5 (6%) strongly disagree with being satisfied with their work responsibilities. The findings indicate that most workers expressed satisfaction with the quality of services they provide to their customers. This suggests that employees feel content and fulfilled in carrying out their assigned tasks and responsibilities (Mahmud et al., 2023). Figure 4 illustrates the level of agreement regarding the work environment being conducive for employees. The percentages indicate the distribution of responses among the participants in the study.
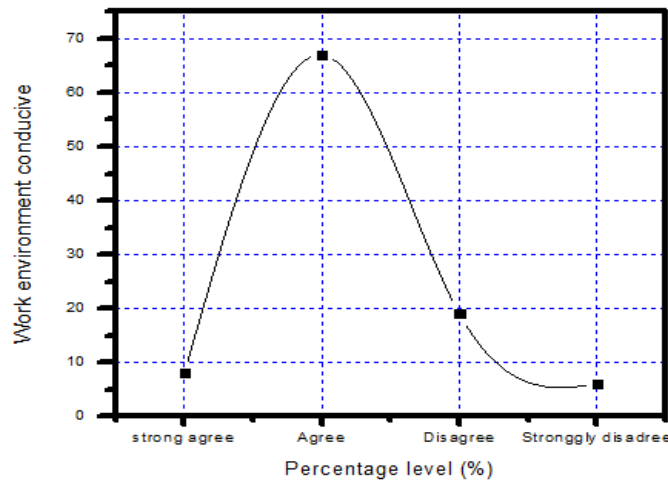
Figure 4: Satisfaction with Conducive Work Environment (%)

Source: Field survey

Figure 4 shows that eight respondents strongly agreed, 70 agreed, 20 disagreed, and seven strongly disagreed, constituting 8%, 67%, 19%, and 6%, respectively. These findings indicate that most respondents expressed comfort and satisfaction with the working environment provided by the organization. The results suggest that the organization has created a conducive work environment promoting employee well-being and productivity (Baquero, 2023). Figure 5 displays the level of satisfaction among respondents regarding monetary benefits.
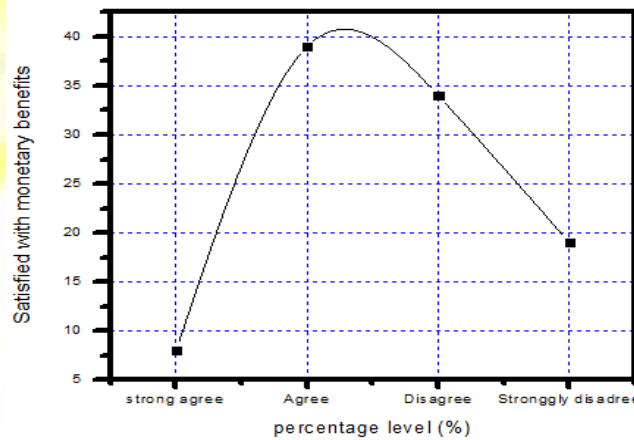
Figure 5: Satisfaction with Monetary Benefits (%)

Source: Field survey

According to the figure, eight respondents (8%) strongly agreed that they were satisfied with the monetary benefits, 41 respondents (39%) agreed, 36 respondents (34%) disagreed, and 20 respondents (19%) strongly disagreed. The results indicate that a significant portion of the respondents expressed dissatisfaction with the monetary benefits provided by the organization. Most respondents (53%) disagreed or strongly disagreed with their satisfaction with the monetary benefits. This suggests that there is room for improvement in addressing the concerns and expectations of employees regarding their financial rewards within the organization (Presslee et al. 2023).
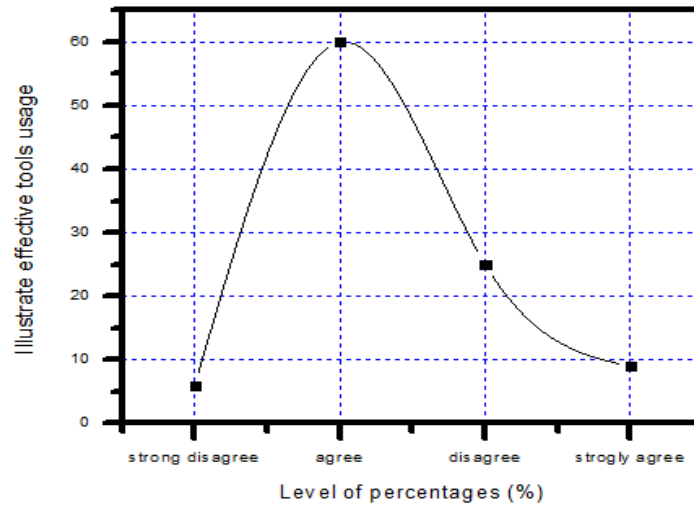
Figure 6: Effective Tool Usage (%)

Source: Field survey

According to the figure, six respondents (6%) strongly agreed that they have the right tools and equipment to do their job, 63 respondents (60%) agreed, 26 respondents (25%) disagreed, and ten respondents (9%) strongly disagreed. This indicates that most respondents (66%) agreed or strongly agreed that they have access to the necessary tools and equipment to carry out their work effectively. The results suggest that many employees have access to the required tools and equipment, which can contribute to their performance and productivity (Maqsoom et al .2023). This finding aligns with previous research emphasizing the importance of providing employees with the appropriate working tools to enhance their motivation and improve performance, thereby contributing to the organization's succession planning efforts (Ololade et al., 2023; Huang et al. 2023). Having the right tools and equipment can positively impact employees' ability to fulfill their job responsibilities and play a crucial role in preparing them for future leadership roles within the organization. Figure 7 visually presents the responses regarding whether the employees were consulted when changes were about to take place at the organization.
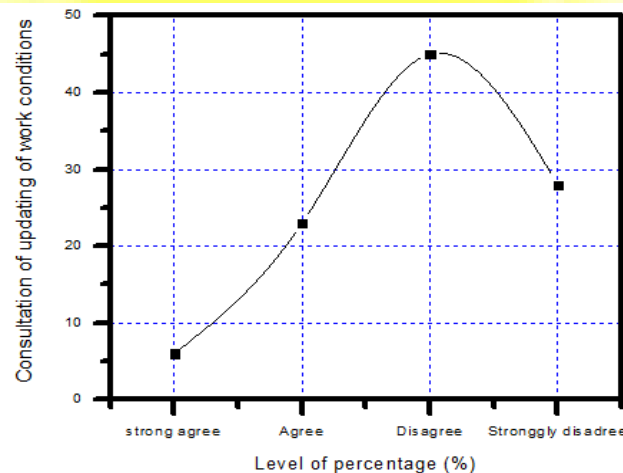

Figure 7: Consultation of Updating Work Conditions

Source: Field survey

According to the figure, six respondents (6%) strongly agreed that they were consulted during organizational changes, 24 respondents (23%) agreed, 45 respondents (43%) disagreed, and 30 respondents (28%) strongly disagreed. This indicates that most employees (71%) expressed needing to be adequately consulted when management implemented organizational changes. However, the results suggest that most employees need more involvement and participation in decision-making processes during organizational changes. This finding implies that the employees' voices and perspectives must be more effectively considered, resulting in reduced support and contribution to the success of the change initiatives (Bhat et al.. 2023). Changes implemented without employee consultation and involvement are less likely to be supported by the employees (Aselage & Eisenberger, 2003; González-González et al. 2023). In order to enhance employee commitment and engagement during periods of change, management must prioritize effective communication, consultation, and involvement of employees (Barach et al. 2024). By actively involving employees in decision-making and providing opportunities for their input, organizations can foster a sense of ownership

and alignment, leading to increased support and successful implementation of changes (Bushe & Lewis, 2023).

This study's discussion section emphasizes many key results with regard to staff participation and satisfaction at the University. Half of the respondents are not actively participating in University activities, which might be a problem for succession planning. This fits well with the findings of other studies that highlight the value of including workers in organizational activities as a means of increasing their involvement and engagement in their work. However, most workers are pleased with their roles and responsibilities as well as the overall atmosphere at their workplace. However, many respondents were unhappy with the financial incentives provided by the company, which may have consequences for both retention and future leadership development. The findings also reveal that many respondents felt they were not consulted prior to organizational changes, which may have dampened their enthusiasm for the initiative. Previous studies have shown that when workers have input into the decision-making process and see changes as within their control, they are more inclined to support them (Vanderfaeillie et al., 2023; Manoharan et al. 2023). There are a number of major implications for the University's management and succession planning strategies based on the results of this research. Management should take into account including workers in decision-making processes and offering suitable monetary advantages in order to increase employee participation and engagement (Dako-Gyeke et al., 2023; Al-Zoubi et al. 2023). The University also has to provide a pleasant workplace for its staff and make sure they have all they need to do their jobs well (Casimiro-Andújar et al. 2023). Additional elements that may influence employee participation and pleasure in the workplace are also worthy of investigation in future studies (Asghar, 2023).

5. CONCLUSIONS

The study's conclusions hold significant implications for policymakers concerned with organizations' long-term viability and development. It is recommended that companies prioritize succession planning to mitigate any disruptions caused by sudden leadership changes. Establishing systematic processes for identifying and developing potential successors becomes crucial in ensuring a smooth knowledge transfer when key personnel retire. The research highlights the importance of fostering a knowledge-sharing culture and career advancement within organizations. This involves providing employees with structured training and development opportunities to support their professional growth in the medium term. In addition, businesses need to recognize that career advancement and succession planning require ongoing commitment, dedicated resources, and continuous attention. By actively seeking and preparing potential successors, organizations can ensure a sustainable pipeline of capable leaders for the future. In addition, encouraging professional growth across all employees contributes to building a talent pool that can effectively meet future leadership needs. In summary, policymakers should take note of the study's findings and implement measures to prioritize succession planning, facilitate knowledge sharing, and promote career advancement within organizations. By doing so, businesses can enhance their long-term viability, adapt to leadership changes, and nurture a skilled workforce capable of driving continued success.

The research includes significant limitations that need to be taken into account, though. To begin, the research only looks at one firm, which may reduce the broader applicability of the results. Second, data from surveys and interviews are self-reported, which might introduce bias in the results. Third, other tiers of workers aren't included in the research except for upper and middle management. Fourth, the research does not take into account other elements that may affect organizational performance in addition to succession planning's effect on the continuation and expansion of the business.

The research includes significant limitations that need to be considered. First, the research only looks at one academic institute, which may reduce the broader applicability of the results. Second, data from surveys and interviews are self-reported, which might introduce bias in the results. Third, other tiers of workers are not included in the research except for upper and middle management. Fourth, the research does not consider other elements that may affect organizational performance in addition to succession planning's effect on the continuation and expansion of the business. Several avenues of inquiry emerge from the study's limitations:

1. To make the results more generalizable, future studies might use a bigger sample size that covers numerous businesses.
2. Different data-collecting procedures might be used in future research to lessen response bias.
3. Entry-level workers might be included in future studies on succession planning's effects.
4. Leadership, organizational culture, and external environmental variables are only some of the potential predictors of organizational performance that might be investigated in further research.
5. Further study might examine the efficacy of various succession planning techniques in ensuring the continued existence and expansion of existing businesses.

Ethical approval

Not Applicable.

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.

Data and materials availability

All data associated with this study are present in the paper.

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