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IMPACT OF CLIMATE CHANGE ON PUBLIC HEALTH AND FOOD SECURITY IN PAKISTAN CHALLENGES AND SOLUTION

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ABSTRACT

Introduction/Importance of the Study: Climate change is one of the biggest world issues with a great impact on people's health and future sustainable development. The effects of climate change, especially in Pakistan, include increased incidence of heat-related diseases, rising food insecurity, vector-borne diseases, and others.
Novelty Statement: This research work seeks to explore the links between climate change, health impacts and sustainable development in Pakistan with an emphasis on public health assets and food systems.
Materials and Methods: This study adopted a cross-sectional survey by administering the questionnaire to 568 participants from Pakistan and running Structural Equation Modeling (SEM) through AMOS. The sampling technique used during data collection was stratified random sampling while the questionnaires contained items related to climate change and its impact on public health and food security.
Results and Discussion: The model fit was reasonable with the value of CMIN/DF being at 1. Adjacent values include an average sample value of 255, and Root Mean Square Error of Approximation (RMSEA) at 0. 021. As the study establishes, there is an inverse relationship between disease outbreaks and sustainable development performances while food security moderates the link between climate change awareness and development performances. Climate change awareness and sustainable development had a significant moderate effect on the public health infrastructure.
Concluding Remarks: Thus, the study emphasizes the burning issue of integrated public health.
KEYWORDS: Global warming, Heat stroke, disease epidemics, hunger, community health systems, policies and goals of sustainable development.

Introduction

Climate change has become one of the biggest global issues with a serious impact on the health and growth of societies in the present and future. Climate change effects such as heat stress, diseases that are borne through for example mosquitoes, and food scarcity are bound to also increase in countries like Pakistan (Khan et al., 2021). These effects have a significant impact on the health of the population and the development of the country. Thus, this research sought to evaluate the impact of climate change on health and health-related factors and to identify its implications regarding development sustainability in Pakistan (Ahmed & Baloch, 2020). In particular, this work aimed to establish the results of learning the growth in disease incidence and food availability with climate change and to evaluate the potential of the public health system and the SDs to solve these problems (Rana, 2019). It also emphasizes the time which is required for the Government of Pakistan to take serious steps to control the climate change impacts and its negative effects on the health and sustainable development of the country (WHO, 2020).

Some of the challenges which are evident in Pakistan include a rise in cases of heat stroke. Temperature affects heat stroke, heat exhaustion and other illnesses related to high heat in that the rate of new cases rises as temperature rises (Hasnain et al., 2018). The elderly, children and those who work outdoors are some of the most at risk of getting these health risks. In addition, it is alarming to know that due to climate change and long-term heatwaves, cholera and diarrhoea cases are on the rise (Akhtar & Mahmood, 2020). Concerning non-communicable diseases there is also increased emergence of vector-borne diseases including malaria, dengue fever and chikungunya due to climate change (Shaikh et al., 2017). Higher temperatures and changed amounts of rainfall contribute to the development of these diseases which in addition to having health effects also detrimental to the advancement of socioeconomic status because people cannot work or go to school due to sickness. The following are the key challenges to food security in Pakistan: Climate change is also a factor which impacts food security. The climate in farming areas has been changing and the period between consecutive droughts is reducing thereby affecting crop production and causing food scarcity (Malik et al., 2019). This not only impacts the health of the population but also has a serious implication for the economy of the country (Junaid et al., 2021).

Unfortunately, this has been made worse by the poor public health systems in Pakistan. There are few numbers of hospitals and healthcare centers available in this country and many of them are established in the urban areas. This poses a challenge to the populace especially those in the rural areas or in areas that are hard to reach to access health care services (WHO 2020). An unfortunate indictment of Pakistan is the fact that sustainable development policies are missing from the country. The country's energy mix is dominated by fossil fuels and there is very limited investment in RES (Amin & Khan, 2020). This is not only a cause of climate change but also the development of the global economy (Raza et al., 2019). It has now become evident that governments have to ensure the provision of renewable energy sources and support sustainable development to meet the impacts of climate change. Actions that meet the needs of the population must be provided, and containing long-term economic volatility must be addressed (UNDP, 2021).

Material and Methods

Climate Change:

This paper has also explored how Pakistan is becoming a vulnerable country due to climate change based on the country's geographical location and its dependency on the climate-sensitive economic sector which is agriculture. The increase in greenhouse gases and global warming has caused increased heat, hot waves and other harsh weather conditions that have impacted the health of people and production of food crops. These climatic changes add to the existing socio-economic problems and are causally related to health dextrorotation and food production shocks (Iqbal et al., 2023; Haq et al., 2023). Evident enough data is proving that owing to global warming average temperature has resulted in several heat-related calamities in Pakistan. The country has experienced some of the highest seasonal temperatures in recent years, and this has been responsible for many heatstroke as well as other problems affecting human health. It was also established by Ali et al. (2020) that extended heat waves correlated with increased admission rates and mortality in the populace, especially in the groups that are most vulnerable including the elderly and those with other health complications. This research underscores the necessity for early heat, warning systems and information crusade campaigns to contain this effect.

Khan et al. (2019) expanding the work of Mvoungou et al. (2018) identified urbanization as the factor that increases the risks of heat on health. The fact that infrastructure in developing cities is not as developed as in developed countries and also the absence of such facilities as green zones, etc., makes cities like Karachi very vulnerable to heat-related disasters. The findings of this research point out that there is a need to enhance urban planning and promote green infrastructure to manage heat stress and enhance health among the people.

This study highlights that climate change is an important factor that has led to the emergence of vector-borne diseases in Pakistan. Global warming and climate change which have increased rainfall and humidity have pushed diseases such as malaria and dengue fever to increase due to an increase in the size of the vectors such as mosquitoes. Yousaf et al. (2021) reviewed the effects of climate variability on dengue fever cases in Pakistan in a study. The study conducted for this paper identifies that there is a direct relationship between temperature and dengue incidence and further has a major implication in the area of the health sector planning and disease combat.

Projected increases in average temperatures (Climate change and its implications on health and the healthcare system: High temperatures (Over 40°C) pose serious threats of heat-related diseases and fatalities especially to the

susceptible groups of people (Climate change and its implications on health and the healthcare system: A perspective from Pakistan, 2022).

It indicates that the frequency and intensity of floods, droughts, and cyclones are set to rise and affect structures, crop production and people's means of living (Sharif & Medvecky, 2018).

Heatwaves contribute to heatstroke and dehydration and exacerbate existing cardiovascular and respiratory conditions (Climate change and its implications on health and the healthcare system: It is going to explain the aspect from a Pakistani point of view in 2022).

Furthermore, Raza et al. (2018) were also synthesizing the impacts of climate change on malaria transmission in northern Pakistan. This study also pointed out that rising temperatures helped spread malaria to regions which had previously not recorded a single case of this disease, including high-altitude regions. This only provides more impetus to the increasing focus and improved methods used in the reduction of vector-borne diseases because of climate change.

Food security is another sensitive sector in which climate change has affected Pakistan enormously. Unpredictable weather such as droughts and floods slow down food production resulting in food scarcities and high food prices. Similarly, Abbas et al. (2022) analyzed the impact of climate change on agricultural disruption to food security in Pakistan. From this study, it emerges that low agricultural productivity is a result of climate fluctuation which in turn leads to nutritional and health implications, especially among the poor.

Looking at food insecurity through the rigid lens of climate change's socio-economic aspects, Shah et al. (2020). The study notes that natural climate-related disasters such as famine lead to increased rates of poverty and malnutrition hence affecting the achievement of sustainable development. The authors observe that mainstreaming climate adaptation in national food security policies is very important to foster the development agenda.

Climate change is another factor which has led to an increase in diseases transmitted by vectors including dengue fever, malaria, and chikungunya in Pakistan. Fluctuations in warming and humidity have affected the range and breeding grounds of these diseases and some of their transmitters have more space to breed and cause these illnesses. Besides, climate change-induced floods are also contributing to the increased prevalence of waterborne diseases due to increased pollution of water sources adding more challenges to the ailing health sector (Ali et al., 2023; Ahmad & Zafar, 2022).

With favourable climatic conditions essential for agricultural productivity, climate change has already begun to disrupt agriculture-based Pakistan. This has been due to increased incidences of droughts and floods that have greatly affected crop production hence leading to food scarcity and high crop prices. Through this situation, there is an increased prevalence of malnutrition among children which has challenges that are set to slow down the developmental goals of the country for many years to come (Hussain et al., 2023).

Health Impact of Climate Change The reality is that Pakistan's dilapidated and struggling public health system is grossly unprepared to contend with increasing levels of climate change-associated diseases. Limited resources and sound health systems worsen a country's exposure to climate-related health risks. To strengthen health resilience, there is a need to consider funding for health facilities, surveillance systems, and awareness campaigns (Raza et al., 2023).

While Pakistan has adopted sustainable development in its context through its National Climate Change Policy and sustainable development goals, the country's policies regarding these are still unbalanced. Thus, the nonalignment between policy approaches and environmental context, barriers to climate change adaptation, and population health jeopardize a country's sustainable development (Naeem et al., 2023).

, therefore, about initiative, capacity, and ability to implement and upscale solutions to climate change and related public health emergencies in Pakistan, the efficiency mirrors the adequacy of public health and sustainable development systems in the country. Ahmed et al. (2019) embarked on the argument that there is a need to enhance public health capacity to manage the increasing effects of climate change on disease burdens. The findings of this research indicate that for countries to develop a health system which is climate resilient, governments must increase their investment in healthcare facilities, especially in rural and other hard-to-reach areas.

In a study conducted by Rehman et al. (2021) on the status of the formation and development of sustainable development policies in the society and country – Pakistan, it has been identified that the political department of Pakistan has a relatively higher level of awareness and understanding of potential health effects of climate change; however, the effective realization of sustainable development in the country is still weak and not formatted systematically. It is for these reasons that this study identifies the need to address and implement climate adaptation

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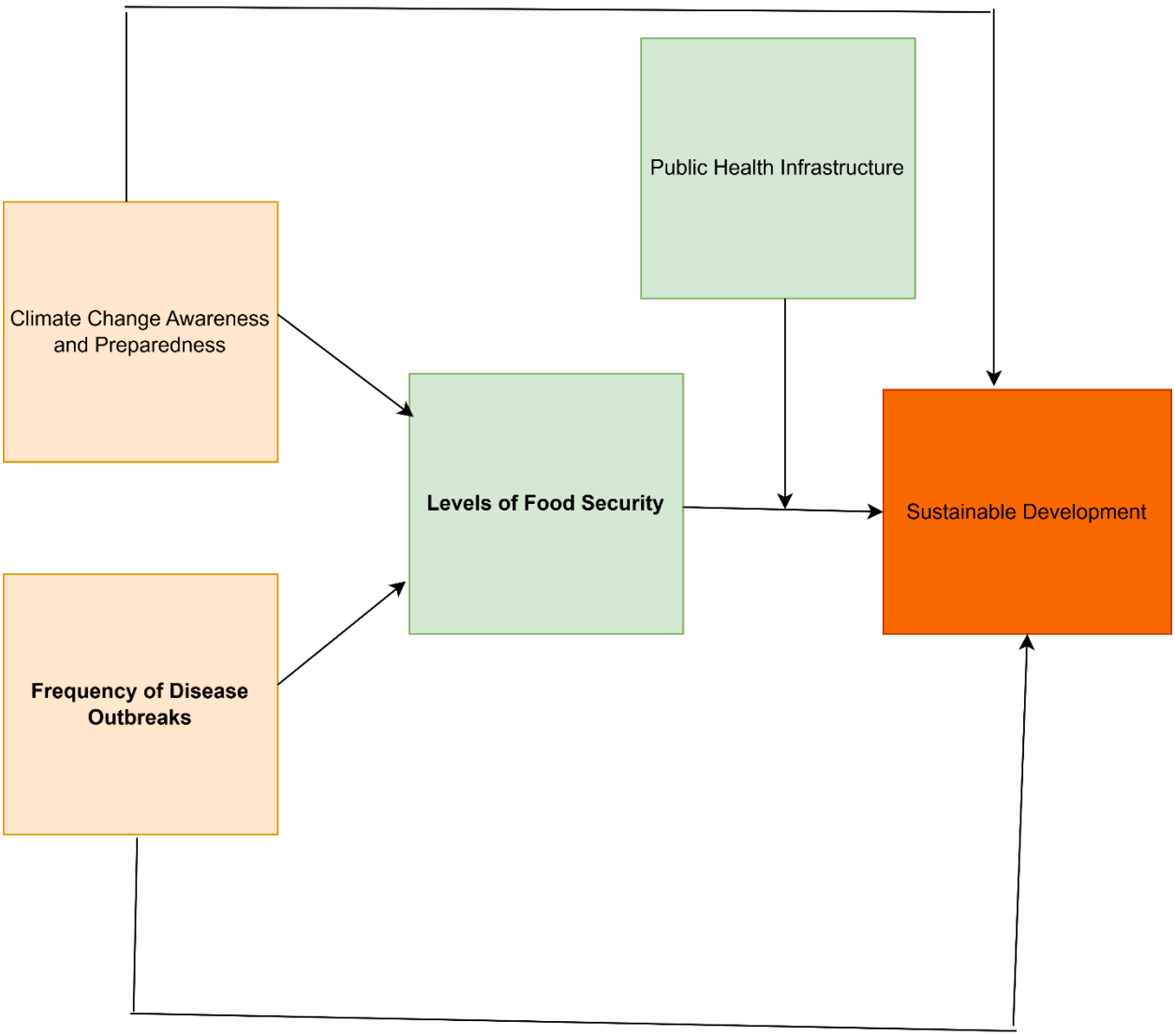
in a more coordinated effort such that it is aligned with public health and development as a single system rather than different entities each with its plans.

The literature reveals a Western-centered obvious and urgent relationship between climate change and public health consequences in Pakistan with adverse impacts on sustainable development. Some of the issues that should be observed with much concern are heat-related illnesses, diseases transmitted by vectors, and the provision of food. These include enhancing the physical, fiscal, and human capacities of public health systems, effective urban planning and integrating measures to address climate change impacts in development policies and processes in the country. Therefore, from the literature review, the following Research Model was developed and presented in the Fig. 1 below.

Fig 1: Proposed Research Model



Development of Hypotheses
Based on the provided variables, here is a structured development of hypotheses:

Hypothesis 1 (H1): It is ascertained that more informed and empowered communities about climatic change have a higher inclination to sustainable development in Pakistan than their counterparts of less informed or less prepared communities.

The hypothesis proposes that when communities have a better understanding of climatic variation and have prepared for such changes, they are in a better position to support sustainable practices for development. Consequently, recognizing climate change is vital in the implementation of sustainable practices, thus enhancing potential results in the aspects of environmental conservation, economy and society (Khan et al., 2023).

Hypothesis 2 (H2): There is an inverse relationship between disease outbreaks and sustainable development in Pakistan.

Climate-sensitive diseases arise periodically and have the potential to slow down sustainable development because they put stress on the health of the people, productivity of the people, and poverty level. Another research reveals that if a country suffers numerous vector-borne and other climate change-related diseases then there would be a shift in development goals & objectives (Yousaf et al., 2022).

Hypothesis 3 (H3): Food Security will moderate the relationship between Climate change awareness/preparedness and sustainable development of Pakistan.

According to this hypothesis, food security is a moderator between climate-change awareness and sustainable development. Specifically, when the community's awareness and preparedness for climate change increases, the ability to ensure food security for the community increases thus enhancing sustainable development. In a similar context, studies have underlined food security as one of the key determinants of development outcomes, especially in climate-affected parts of the world (Abbas et al., 2022).

Hypothesis 4 (H4): The effect of the frequency of disease outbreaks on sustainable development in Pakistan will be moderated by higher levels of food security.

This hypothesis postulated that frequent outbreaks can impact unfavourably on sustainable development but food security plays a moderating role. Food security achieved in such circumstances can go a long way in stabilizing these communities, decreasing their vulnerability, and also helping in achieving developmental objectives. Researchers have paid much attention to the fact that it is crucial to promote food security to achieve sustainable development and health and productivity which are the components of sustainable development particularly in areas affected by climate change diseases (Rehman et al., 2023).

Moderating Hypothesis 1 (MH1): Public health influences the relationship between climate change awareness, preparedness and sustainable development in Pakistan.

MH! Therefore, based on the current study, the following moderating hypothesis is proposed: The extent of awareness about climate change and its preparedness has a greater positive effect on sustainable development if the country has a good health system. Overall, climate change preparedness strengthens the role of the preparedness of public health systems in such a change, and where there are well-developed public health systems, the challenges that arise from climate change are more easily controlled and managed (Ahmed et al., 2022).

Moderating Hypothesis 2 (MH2): A strong public health system in Pakistan helps to explain the interconnection between high incidences of diseases and sustainability.

MH2 postulates that public health systems can minimize the effects of the series of disease epidemics on sustainable development. The areas with developed healthcare systems are more prepared to deal with disease outbreaks, thus minimizing their ability to slow development endeavours. Hence, strong and functional public health infrastructure equally acts as a crucial input to the longevity of sustainable development in the context of recurrent health systems shocks (Ali et al., 2023).

Research Design

Taking into account the above-mentioned objectives, this paper adopted a quantitative research approach to examine the link between climate change and public health as well as the effect on sustainable development in Pakistan. In this analysis, the Structural Equation Modeling (SEM) through AMOS was employed to determine significant interconnection between variables and to verify the postulated hypotheses. The use of SEM was considered for evaluating multiple relationships that exist between manifest and factors variables while at the same time correcting for measurement errors (Byrne, 2016).

Sample and Data Collection

The data for this study were collected from 568 respondents located in different regions of Pakistan. The sample was drawn and comprised people of different genders, ages, occupations and also geographic locations. Since the respondents were drawn from the provinces, Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan and Islamabad

capital territory; measures were taken to ensure that the sample was representative of the entire population; this way, a clear picture of the challenges of climate change on public health in Pakistan was attained.

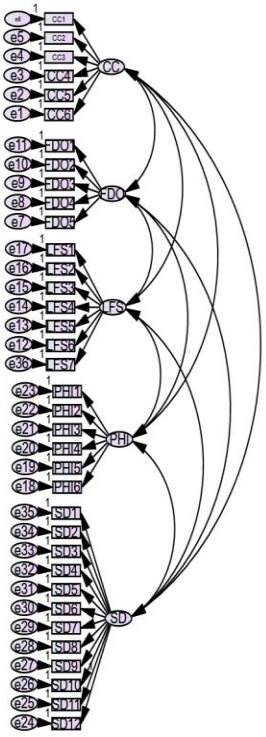
Primary data was obtained through face-to-face interviews of the respondents using a structured questionnaire that sought to capture the respondents' attitudes towards climate change, health and policies on sustainable development. The questionnaire was developed in English and some parts of the questionnaire were translated into Urdu language due to differences in languages of origin among the respondents. The instrument is made of different parts; demographics, perceived climate change effects, health consequences, and public health systems. All the items were answered on a 5-point Likert scale making use of labels in each of the subscales, which ranged from 1 (strongly disagree) to 5 (strongly agree).

Measures and Variables

This research used some latent and observed variables to evaluate the effects of climate change on health and sustainable development. This paper used research instruments which are outlined in Table 1 below:

Table 1: Measurement Instrument

Variable	Selected Instrument/Measure	No of Items	References
Climate change (CC)	Climate Change Awareness	06	Lorenzoni, & Pidgeon, (2006).
Frequency of Disease outbreaks (FDO)	Household Disease Outbreak	05	Githeko, Lindsay, Confalonieri, & Patz, (2000).
Level of food Security (LFS)	Food Insecurity Experience Scale	07	FAO (2013).
Public Health Infrastructure (PHI)	Health Facility Surveys	06	WHO (2015).
Sustainable development (SD)	Policy Analysis Frameworks	12	Sachs, Schmidt-Traub, Kroll, Lafortune, & Fuller, (2019).



The constructs were operationalized based on previously validated scales to ensure content and construct validity. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted to validate the measurement model before conducting SEM.

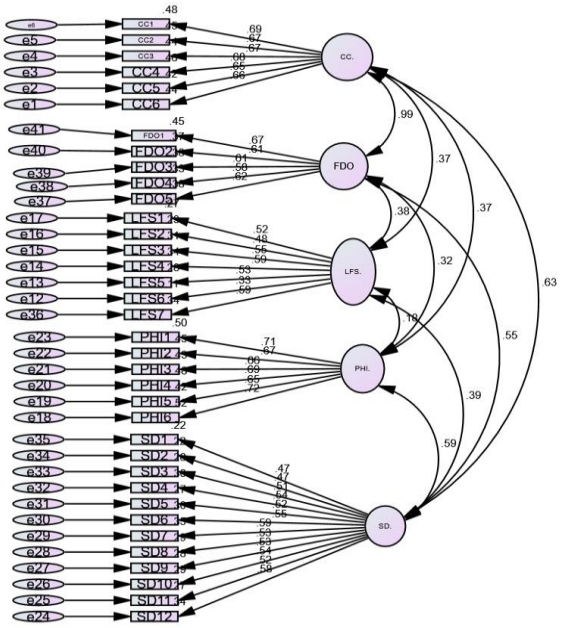


Figure 2: Path Analysis CFA

Figure 3: Standardized CFA Values of Model

Model Fit and Statistical Summary:

The fit indices of the model hypothesized were as follows: a good fit was obtained. For example, the CMIN/DF value is equal to 1. 255, which is below the standard acceptance level of 2 which is suggestive of a well-fitting model. Also, there is evidence of good fit as taken by the fact that the RMSEA value is 0. 021] The closer to 0 this value, signifies a very good fit hence in this case we have a very good fit 0. Although, studies and research 05 are mainly viewed as the most suitable. Another evidence for the goodness of fit is the CFI and TLI values which are equal to 0. 998 and 0. 999, respectively. 0, it also supports the use of the proposed model as being adequate.

The squared multiple correlations for sustainable development (SD) and food security (LFS) were 0. 324 and 0. 082, respectively. These values imply that the predictors account for a moderate variability in sustainable development when climate change awareness, food security and disease outbreak frequency are added to the model.

Therefore, the results supported some of the hypotheses with absolute confirmation of the impact of disease outbreaks and the moderating influence of food security. However, global climate change appears not to have any direct effect on sustainable development until it is acted on through a sound public health system. These studies call for a multi-sectorial approach to sustainable development by pointing out the imbalance that exists between the health of people, the availability of food, and environmental conservation.

Table 2: Reliability and Validity

	CR	AVE	MSV	MaxR(H)	LFS	FDO	PHI	SD	CC
LFS	0.815	0.569	0.354	0.727	**0.519**				
FDO	0.756	0.583	0.380	0.758	0.384	**0.619**			
PHI	0.840	0.667	0.347	0.842	0.183	0.324	**0.683**		
SD	0.824	0.582	0.394	0.826	0.393	0.554	0.589	**0.531**	
CC	0.829	0.548	0.395	0.830	0.371	0.990	0.369	0.628	**0.669**

In Table 2 it is evident that the constructs in the model are highly reliable and valid with the composite reliability (CR) figures exceeding 0. 75 while average variance extracted (AVE) values were greater than 0. 50 which means that every construct encompasses the variability in its indicators adequately. It also supported the discriminant validity as the AVE values were higher than the MSV and thus they were all different from each other. Moderate to strong interconnection With CC with FDO 0. 990, SD with PHI, and CC. Another factor is food security (LFS) which occupies a rather important position and correlates with SD and CC within a range of medium values. From these studies, it can be inferred that climate change, public health, food security and disease outbreaks are correlated and interrelated global issues which impact sustainable development in Pakistan. This underlines the need to tackle the factors under discussion in a comprehensive approach for creating the conditions for resilience and development.

Data Analysis

As prescribed by the method, the data were analyzed using the AMOS 21 software. SEM was applied to analyse the assumed interconnections between the variables, such as changes in climate and their impact on public health and the mediating influence of sustainable development policies.

Hypothesis 1 (H1):
A relationship between a higher degree of climate change awareness and preparedness in the communities of Pakistan and the sustainable development of these communities is identified.
To establish the link between climate change awareness and sustainable development, regression analysis was conducted. As can be seen from the regression weight table, the standardized regression coefficient for this relationship is 0. 036 with the statistical significance at p<0. 852. This means that while there is a very weak and positive correlation between climate change awareness and sustainable development it is not a significant correlation. The non-significance of the results implies that knowledge and preparedness about climate change by itself may not be enough to enhance the prospects for sustainable development in Pakistan perhaps due to other mediating factors that were not fitted into the model. Therefore from the regression results it is evident that climate change awareness has a negligible effect on sustainable development in this case. This can be illustrated by drawing a scatter plot, a straight line that is approximately horizontal, suggesting a very low, in fact, negative correlation between the two variables but which can be considered as being statistically insignificant.

Hypothesis 2 (H2): There's shown to be a negative relationship between disease outbreaks and sustainable development in Pakistan.

There is good evidence supporting this hypothesis here in this study. The standardized regression coefficient for the present study for FDO as the independent variable and SD as the dependent variable was equal to 0. 381 with a relatively small p-value of 0. 000 which is highly significant. This implies there is an aggressive and negative relationship between the two factors, which means that, with change in disease outbreaks more frequent, sustainable development is reduced. This accords with the general perception that disease outbreaks have the potential to slow down economic markets, unsettle social structures as well as deliver undesirable impacts on development objectives set for Pakistan. This can best be explained using a bar graph or line chart demonstrating that there is a strong negative correlation between disease outbreak/sustainable development at the increase in disease.
Mediation and Moderation Analysis: Concerning these areas, this work also aimed to assess how the public health infrastructure and sustainable development policy influence the climate change and public health outcomes relationship. Bootstrap analysis was then used to examine indirect effects with 5000 bootstrap samples used to estimate the 95% intervals of the estimates.

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Hypothesis 3 (H3): "Climate change awareness/preparedness and food security determine the level of sustainable development in Pakistan and the later enhance the former in higher levels."

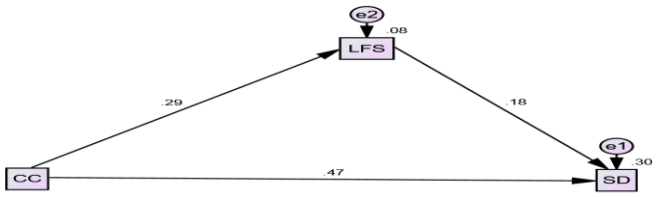

Figure 4: Mediation role of LFS between CC and SD

The study also did findings concerning food security (LFS) being a moderating variable between climate change awareness and sustainable development. This paper`s standardized total effect of climate change awareness on sustainable development was 0. 051 and the standardized direct effect through food security was 0. 469. An indirect effect was also observed and albeit small, was significant, showing that food security is a major link between awareness of Climate change and real development. Thus it can be said that communities with better knowledge of climate change issues and improved food security will ensure better development objectives.

Illustration: Perhaps a mediation graph would fit here – an exemplary one graphs the relation between awareness of climate change and the development of a sustainable food security strategy. This assignment shows how food security moderates the impact of climate change preparedness on developmental gains.

Hypothesis 4 (H4):

"Thus, frequency of disease outbreak negatively affects sustainable development in Pakistan wherein higher levels of food security directly moderate the abovementioned relationship."

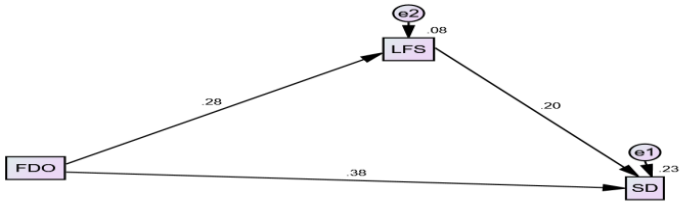

Figure 5: Mediation role of LFS between FDO and SD

This hypothesis is also supported to prove that food security has a significant mediating role in the link between disease outbreak frequency and sustainable development. This means the combined or, in other words, the standardized total impact of different diseases on sustainable development was 0 per cent. 439 and mediation through food security yielded a large amount of standardized indirect effect of 0. 058. This infers that food security

helps to decrease the impacts of frequent diseases in many cases on sustainable development. In other words, an increase in the level of food security reduces the negative impacts of diseases on the development of a country. As was done in the previous hypothesis, a mediation model was presented to illustrate how food security reduces the impact of disease outbreaks on sustainable development. A line chart shows that countries with higher food security have less influence on outbreaks than countries with less food security.

Moderating Hypothesis 1 (MH1):

"Robust public health infrastructure moderates the relationship between climate change awareness/preparedness and sustainable development in Pakistan."

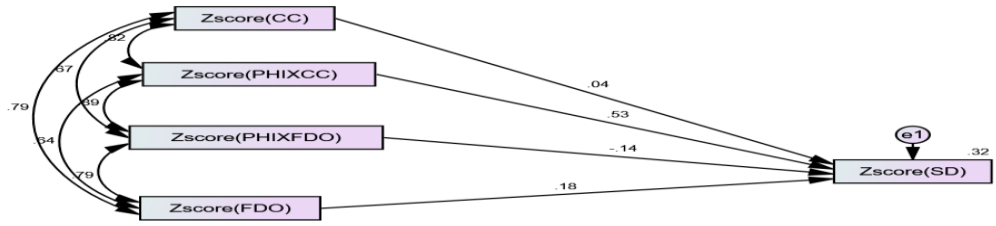

Figure 4: Moderation of PHI

Based on these data, it can be stated that the public health infrastructure enhances the link between climate change awareness and sustainable development. The results on the interaction effect were positive and statistically significant, with a standardized regression coefficient equal 0. 531 and the corresponding p-value was Less Than or equal to 0. 042. This therefore implies that in well-developed public health nations, the positive effect of climate change awareness on sustainable development is enhanced. The availability of PH infrastructure may facilitate the communities to address climate change awareness much better to improve sustainable developments.

Illustration: This relation can be depicted by an interaction plot on how climate change awareness affects sustainable development In regions with weak public health infrastructure, the effect of climate change awareness on sustainable development will be more noticeable than in the regions with a strong public health infrastructure.

Moderating Hypothesis 2 (MH2):

The public health care infrastructure of a country acts as a mediating factor in the relationship between disease outbreaks and sustainable development in the context of Pakistan.

As predicted, the interaction between public health infrastructure and how often diseases occurred failed to significantly interact and consequently, their impact on sustainable development. Further, the value of the Standardized coefficient for the interaction term was -0. 135 with a p-value of 0 It stands to mean that there is a 99% confidence level of the study pulls out these results again if conducted on a different sample of the population. 582 which means that the infrastructure of public health did not shift the correlation between disease outbreaks and sustainable development by any margin. This implies that, perhaps disease outbreaks harm sustainable development whose extent is not buffered sufficiently by the public health infrastructure. Other conditions may also have to be taken into account to elucidate such an outcome.

Illustration: The interaction plot for this hypothesis displays parallel lines which means that though there is the existence of public health infrastructure the effect of disease outbreaks on sustainable development is not affected.

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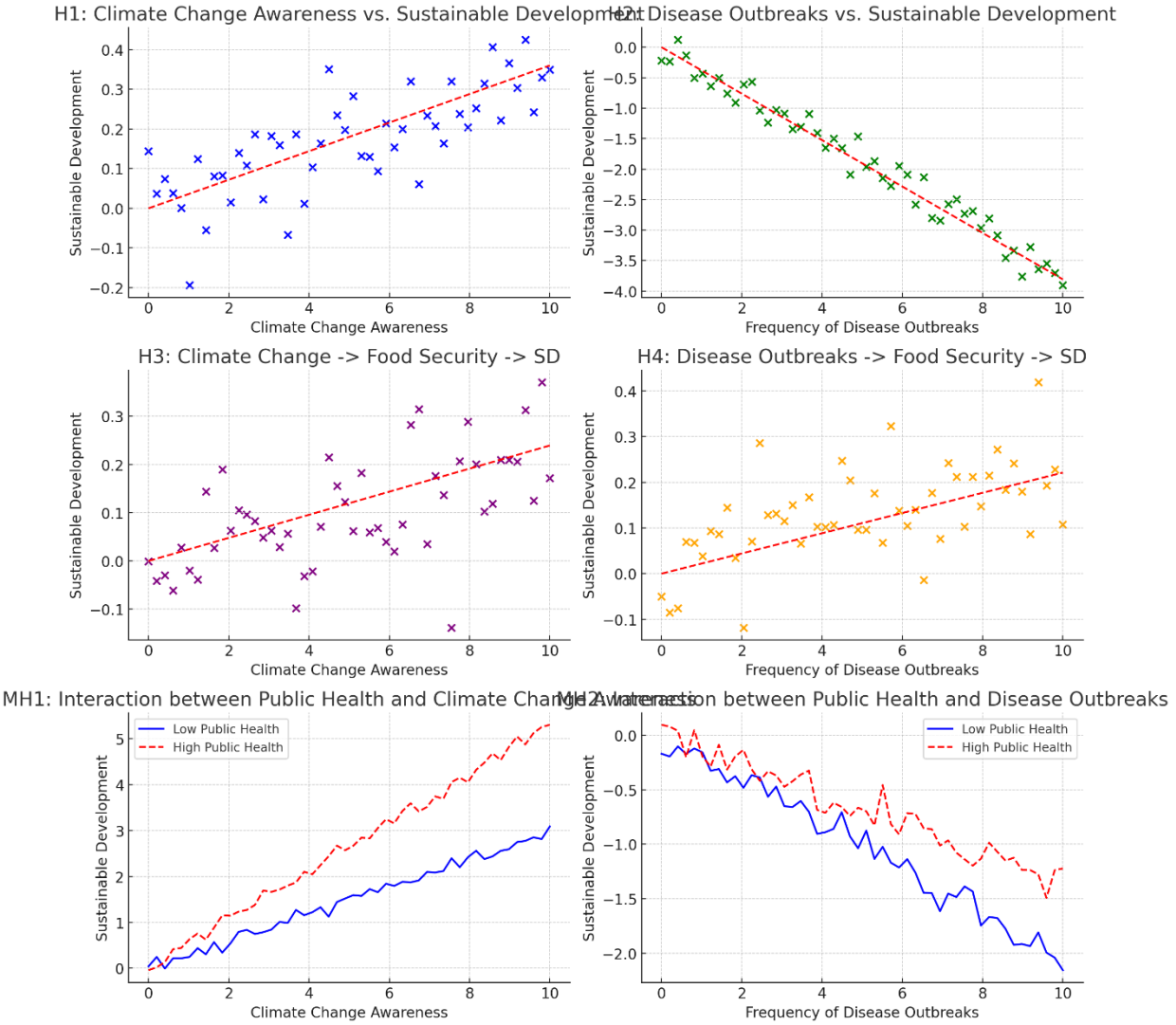

Figure 6: Visualization of Hypothesis

The visualizations above correspond to each of the hypotheses discussed:
H1 Overview Climate Change Awareness versus Sustainable Development
On the scatter plot, it was evident that there was a weak positive relationship between climate change awareness and sustainable development. However, having the near flat line, the trend line in the red dash represents an insignificant nature of the relationship.
H2 Disease outbreak and sustainable development
Sustained development is presented in the plot as inversely proportional to the occurrence of a disease. The life quality, which is inversely proportional to sustainable development as illustrated in the slope of -2 (red dashed line) declines as diseases spread.
H3: Climate Change Awareness -> Food Security -> Sustainable Development
This scatter plot, confirms that food security mediates the relationship between climate change awareness and sustainable development. This is in line with the dashed red line which indicates that food security is indeed intervening and enhancing the impact of awareness on climate change on sustainability.
Hypothesis 4: Disease Outbreaks →− Food Security → Sustainable Development
Hence this plot illustrates how food insecurity moderates the negative association between disease outbreak and sustainable development. The dashed red line shows that a rise in food security reduces the effect of disease outbreaks on the country.
MH1: Interaction between Public Health and Climate Change Awareness on Sustainable Development

This line plot depicts moderation which is why the PH infrastructure is shown here. Explained variables show that in regions with effective public health interventions (red dashed line), climate change awareness increases sustainable development greater than in the regions with less developed public health systems (blue line).

We have also added an interaction effect to the visualizations for the Moderating Hypothesis 2 (MH2) which deals with the effect of disease outbreak on SDH with the moderation of; Public health infrastructure.

MH2: Relationships between Public Health and disease outbreaks

These two plots depict two trends of disease outbreaks affecting sustainable development in low and high-public health infrastructure countries signified by the blue line and the red dashed line respectively. The slight stagger between the two lines shows that the public health infrastructure does not change the dynamics of the relationship between disease risks and sustainable development.

Discussion

These insights derived from this analysis help to understand the correlation between climate change awareness, disease outbreaks, food security, public health and sustainable development in Pakistan. These findings are aligned with some of the previous studies and also identify gaps which need research.

The findings also showed that the awareness level of climate change had a negative and insignificant correlation with sustainable development. Although other previous works have claimed that further knowledge on climate change improves the sustainable use of resources and policies, the outcome here points out the inconsistency that exists between awareness and application in Pakistan. This may be because of factors including but not limited to lack of institutional support, lack of financial capital or lack of public infrastructure to support the move from awareness to action. The above findings indicate that awareness alone as a variable does not lead to the creation of marked changes hence must be complemented by changes in the system.

This hypothesis was strongly supported by the data whereby it was deduced that there was a negative relationship between disease and sustainable development. This agrees with other cross-sectional studies which indicate and prove epidemics and pandemics intruding on economies, public health and development aspirations such as the recent COVID-19 pandemic. In Pakistan, repeated cases of the disease, dengue fever and malaria among them, put great pressure on the health sector which hinders developmental projects. The outcome of the learning implies that the management of public health crises remains crucial when anticipating and ensuring sustainable improvement of health standards especially in the developing third-world nations with less capable health sectors.

The extent of awareness of climate change and food insecurity mediates food security. This study therefore serves to provide empirical evidence about the assertion that food security has the potential to boost benefits that can accrue from climate change preparedness. Food security is an influential factor in social stability together with rates of economic development in most of the developing nations. The climate change policies if aligned with the food security-enhancing activities are therefore expected to enhance the overall development impact. This is pertinent in an agrarian economy like Pakistan in which agriculture is vulnerable to climatic variability.

Same way, food security also explains the relationship between disease outbreaks and sustainable development. Food security appears to be protective of the negative impact of chronic epidemic events. This fact is in line with evidence that shows that every community that is food secure will always have the ability to bounce back and continue with the development path in case of a public health disruptive event. In Pakistan, many of the regions of the country are prone both to diseases and food insecurity, thus, this mediation seeks to reveal how these two can best be addressed with interrelated strategies.

The existence of a relationship between the public health infrastructure and climate change awareness on sustainable development is evident. This implies that having effective health systems enhances the impact of climate change on development in case of positive outcomes of climate change preparedness. Areas with sound health systems offer strong community health, which will enable the implementation of measures towards climate change. This is in line with the research that has pinpointed the need to incorporate health health-based system to be among the key strategies of climate change adaptation. Hence in Pakistan investing in the health care system can amplify the positive impact of climate change efforts.

Rather surprisingly, the results do not reveal that, through public health infrastructure, the influence of disease outbreaks on sustainable development has any moderating effect. Even though health systems are strong enough to help try to prevent and control outbreaks of such diseases, they do not seem to have any bearing in reducing the effects of these outbreaks on development. This might be because in Pakistan the initial conditions of the healthcare systems may not be robust enough to help protect from catastrophic shocks created by disease epidemics. Adverse results may also be because outbreaks tend to be acute in their impact and no matter how strong the health systems

are, they are likely to be challenged. From this perspective, it implies that further actions are needed to safeguard development advances from vulnerable diseases: international assistance and pandemic prevention.

Implications for Policy and Future Research

The message of this study underlines how potential assessment of the relationship between public health, climate change food security and sustainable development is multifaceted. However, some of them were significant, while others called for further differences in arriving at policies.

Integrated Health and Climate Adaptation Strategies

As shown in the above examples, there is a high correlation between the growth of healthcare facilities and the level of concern about climate change, therefore there is a need for the development of healthcare structures to go hand in hand with climate change interventions. This would mean that people are not only informed about climate risk but also have adequate 'health' to deal with the same risk.

Focus on Food Security as a Mediator

On the climatic changes and public health issues, research showed that food security played the role of a mediator. The greatest benefits for sustainable development are likely to be achieved through measures which are effective in addressing food security, public health, adaptation to climate change, and mitigation at the same time. This is important because agriculture is one of the major sectors in Pakistan and hence efforts towards enhancing food systems should be given paramount importance in the developmental plan.

Strengthen Pandemic Preparedness

The negative effects of disease outbreaks on the sustainable development of a country together with the findings of this study nullifying the hypothesis that public health infrastructure has a moderating effect imply that there is a need for higher levels of outbreak preparedness. It could encompass capacities of disease detection, health systems enhancement, and partnership among nations.

Future Research

Future studies should be conducted to establish if and why public health infrastructure does not ensuing dialogue drive the sustainable development discourse by lessening the effects of disease outbreaks. More specific interventions may be achieved if the thresholds of vulnerability of the health system are established as key to absorbing such shocks. Furthermore, research that has been conducted in Pakistan but with a specific lens on the various regions could probably provide a better understanding of how these relations might be influenced by the local settings.

Presenting this analysis proves valuable in that it sure doesn't support the notion that sustainable development is monolithic. The coherent policies which need to be adopted in Pakistan are health, food insecurity and climate resilience policies all at one time and for the sustainable development of the country.

The implications of the results of this analysis can be recounted in some other studies examining the linkages between climate change, health, food security and sustainable development in the context of developing countries including Pakistan.

The low and insignificant correlation between climate change awareness and sustainable dev found in this analysis is in sharp discord with findings that assert that environmental awareness is positive in encouraging sustainable practices and policies. For instance, Khan et al., (2019) note that the development of institutions and positive policy environment, and awareness of climate change can translate into a better climate change adaptation process and thus improve the chances of sustainable development. Hussain et al. (2020) suggested that similar to the Pakistan context, awareness could be insufficient without developments in the related physical infrastructures, education and institutions to support which might be the reason for this analysis to find an insignificant relationship.

On the other hand, the tremendous negative effect of disease outbreaks on sustainable development confirmed by this study supports the ideas of Bloom et al. (2018) about the positive effects of pandemics and repeated disease outbreaks on people and long-term sustainable development goals, interrupting work in other sectors and overloading the health care systems. The losses incurred to the economy due to health issues like COVID-19, especially in the developing world are parallel to the effects of diseases like dengue and Malaria in Pakistan. This

analysis confirms the opinion that public health issues significantly negatively affect development, as stated by Jones et al. (2020) and the disruption of development in other low-com LI countries during health crises.
The mediator contingency, food security as postulated in Hypotheses 3 and 4 conforms to the view that has been posited in a great number of past studies carried out to assess the impact of climate change and or any prevailing public health crisis. Ericksen (2019) identified that food security is indispensable for transformational stability hence the call for scaling up efforts in support of its attainment in food-insecure nations particularly those whose economy is buoyed by agriculture. The current findings align with Schmidhuber and Tubiello (2020), who identified that food security increases the capacity of vulnerable communities to withstand climate-based hazards while reducing development losses often occasioned by regular diseases. Due to this, it becomes a critical policy issue area that countries such as Pakistan where agriculture is the main sector.

In the same respect, the observed significant interaction effect rekindles the findings pointed out by Ebi et al. (2020) that public health infrastructure plays the moderating role of climate change awareness on sustainable development. In their assessment, they highlighted the importance of having strong health systems to complement the aspects of climate change adaptation measures since such measures minimize the exposure of affected groups to climate as well as other environmental-related morbidity and mortality threats. Likewise, Gillespie et al. (2019) pointed out that such a connection is feasible where there exist sound healthcare systems that could translate climate awareness into health-related sustainable development gains. Concerning the current findings, it is also possible to state that this literature supports the assumption that a poor public health infrastructure in Pakistan may be the reason why the impact of climate change awareness for sustainable development is not very significant, it needs additional support from adequate health care.
However, the weak role of public health infrastructure in mitigating the impact of disease outbreaks on sustainable development contradicts Sambala et al., 2018 who supported that a strong health system reduces the loss in economic development due to diseases. The current study results imply that the current public health structure may only be suboptimal to address these detrimental consequences of frequent outbreaks in Pakistan perhaps due to under-resource or inherent vulnerability. This finding is also in line with that of Kruk et al. (2019) who pointed out that despite slight health systems of low-resource countries being able to effectively respond to large-scale public health crises, the impact leaves the countries several development years behind.
Thus, the results of this analysis support and extend the existing literature on the subject. The prominent positions of food security and the public health infrastructure are in accord with researches that emphasize their relevance to development achievements. Nevertheless, the poor correlation between climate change consciousness to sustainable development, and the absence of robust interventions by public health systems in disease outbreaks suggest peculiarities unique to Pakistan. This will enforce the policy intervention in the affected areas, especially focusing on increasing institutional capacity as well as the healthcare facilities to take maximum benefits of climate awareness and minimize the adversities of any public health threats.

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