Climate-Induced Flooding Contributes to Infectious and Zoonotic Disease Transmission: A Case Study of 2022 Floods in Pakistan

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AUTHOR'S DECLARATION

I Ameema Shahid Abbasi hereby state that my MS thesis titled "Climate-induced flooding contributes to infectious and zoonotic disease transmission: A case study of 2022 floods in Pakistan" is my own work and has not been submitted previously by me for taking any degree from National University of Sciences and Technology, Islamabad or anywhere else in the country/ world.

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DEDICATION

“To my Papa, Mom, brother, and special sister Ashna, you have all shown me how a family's love and support enables one to achieve their milestones, even when the road is bumpy. This research is dedicated to all the vulnerable people in our society who are subjected to structural violence and disproportionately affected by diseases during disasters. I want to be their voice, as disease transmission is not just a biological phenomenon but also a result of sociopolitical injustices that make marginalized segments of society even more susceptible to diseases.

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LIST OF ACRONYMS

CCHF	Crimean-Congo Hemorrhagic Fever
CHIKV	Chikungunya Virus
DENV	Dengue Virus
DHIS	District Health Information System
DRR	Disaster Risk Reduction
EID	Emerging Infectious Diseases
GIS	Geographic Information System
IDs	Infectious Diseases
IDSR	Integrated Disease Surveillance and Response
NDMA	National Disaster Management Authority
NIH	National Institute of Health
RVF	Rift Valley Fever
VBD	Vector-Borne Diseases
WASH	Water, Sanitation, and Hygiene
ZDs	Zoonotic Diseases

ABSTRACT

Pakistan, a country frequently plagued by severe flooding, faces increasing vulnerability to climate-induced disasters due to climate change, resulting in serious public health concerns. This study examines the 2022 floods in Pakistan to explore the relationship between climate-induced floods and the transmission of infectious and zoonotic diseases. The research employs an exploratory case study methodology, combining thematic analysis of semi-structured interviews with experts in disaster management, public health, and climate change, qualitative content analysis of national policy documents, and geospatial mapping of flood-affected districts. Guided by Nancy Krieger's Ecosocial theory and the One Health approach, the study reveals three critical issues hampering effective public health responses: gaps in public health infrastructure, inadequate policy integration, and socio-economic and sociodemographic factors that amplify vulnerability in flood-prone areas. Geospatial analysis indicates that Sindh, Balochistan, Punjab, and Khyber Pakhtunkhwa provinces were most affected by the 2022 floods, with Punjab and Khyber Pakhtunkhwa at the highest risk of disease outbreaks. Despite limitations related to data availability and qualitative analysis, the findings underscore the need for strengthened disease surveillance, One Health implementation, and coordinated policies to mitigate future climate-related health crises, enhance community resilience, and improve public awareness.

Keywords: Climate-induced floods, infectious diseases, zoonotic diseases, public health, Pakistan, geospatial mapping, One Health approach, disaster management, vulnerability, Ecosocial theory

CHAPTER 1: INTRODUCTION

1.1 Background

The reality of climate change is undeniable, as it is redefining the delicate equilibrium of our ecosystems with impacts that extend beyond geographic boundaries. Since 1850, the average temperature of the land and oceans has increased by 0.11° Fahrenheit (0.06° Celsius) per decade. According to NOAA's 2023 annual climate report, this rate has accelerated to 0.36° F (0.20° C) per decade, more than three times faster than before(Lindsey & Dahlman, 2024). The effects of climate change are far-reaching, impacting everything from human health to global ecosystems.

Pakistan, a country marked by diverse climates and terrains, is a microcosm of climatic variance. The balance between the Indus River, the hilly regions of the north, and the barren plains of Balochistan reflects a nation deeply connected to its geophysical profile. Most of Pakistan's 216.5 million people (as of 2019) live in areas adjacent to the Indus River, which experienced catastrophic flooding in July-August 2022. Additionally, significant earthquake events are frequent in the northern and western mountains (World Bank Group, 2021). This geographical diversity makes Pakistan particularly vulnerable to the complex effects of climate change.

Climate change is one of the leading causes of natural disasters, with floods being particularly severe and surpassing other types of natural disasters globally. Pakistan, having experienced devastating floods numerous times, is highly vulnerable to these impacts. The country ranks 5th in the 2023 Global Climate Risk Index in terms of vulnerability to climate change. The catastrophic floods of 2022, which inundated one-third of the country and displaced 33 million people, highlight this vulnerability. The floods resulted in estimated damages amounting to 3.3 trillion PKR (US$15.2 billion) for the year. The total economic losses were estimated at 2 trillion PKR, equivalent to US$14.9 billion (UN Habitat, 2023). For about 2.3 million houses were badly damaged and destroyed which resulted in the displacement of over 8 million people. The floods also decimated 1.7 million hectares (4.4 million acres) of crops, killed over 800,000 livestock, and

pushed more than 8 million people into poverty. Furthermore, there was an urgent need of rehabilitation and reconstruction of basic infrastructure, as more than 2,000 health-related facilities and 30,000 schools were reported to have been destroyed, making the situation even more difficult for the authorities(United Nations OCHA, 2023). Pakistan has never seen a disaster of this scale; it was much worse than the 2010 floods(PDNA, 2022).

Pakistan is among those countries, which are prone to monsoons, making it a key study for climate-induced disasters. Floods in 2022 were not new for the country, as it has experienced flooding multiple times in the past, resulting in massive destruction of infrastructure, crops, and loss of life. Many studies discuss how regions where hazardous activities are practiced and human-animal-environment interactions are prevalent experience a higher transmission of infectious and zoonotic diseases due to flooding(Chowdhury et al., 2021). Factors such as loss of biodiversity, globalization, and climate change disrupt ecosystems and influence zoonotic disease transmission (Aguirre, 2017). These studies underscore how floods have exacerbated the spread of infectious and zoonotic diseases, posing significant public health challenges.

Disasters such as heat waves, droughts, and the floods are parts of the regular occurrences in Pakistan because of the river systems and mountain ranges making it susceptible to floods. Hence disease risk is well seen in places such as Sindh where the incidence of floods is prevalent(Braam, Chandio, et al., 2021). The effects of climate change have been realized in the coastal settlements where air quality, food production, human health and water availability have been affected(Jabeen et al., 2022). Increased cases of VBDs in the country have been linked with climate change (Rupasinghe et al., 2022). The epidemiological patterns of major VBDs like Japanese encephalitis, West Nile, Crimean-Congo hemorrhagic fever (CCHF), malaria, dengue, chikungunya, and leishmaniasis are shifting due to climate change(Williams et al., 2021). However, Pakistan's vector and disease monitoring systems remain inadequate (Arbo et al., 2022). Long-term surveillance is crucial to understanding the impact of climate change on vector-borne diseases (M. Ali et al., 2021).

The rise in communicable diseases such as acute diarrhea, cholera, malaria, and dengue during floods has been documented by Pakistan’s Ministry of Planning, Development & Special Initiatives (GOP, 2022). For example, malaria cases surged from 400,000 nationwide in 2021 to over 1.6 million in 2022 in the 60 districts supported by the global fund. This significant increase

in malaria cases following the floods suggests that the actual number of cases may be much higher (WHO, 2023a). In November 2022 alone, seventy suspected diphtheria cases were reported in flood-affected districts of Sindh, Punjab, and Khyber Pakhtunkhwa (KP). This rising frequency of infectious diseases highlights the increased vulnerability of flood-affected populations (Muzzamil et al., 2023).

Flood survivors face numerous challenges, including lack of proper healthcare and sanitation, disease outbreaks, and inadequate access to clean water, proper toilets, medical supplies, and sufficient food. Diseases like malaria, cholera, scabies, lumpy skin disease, dengue fever, hand, foot, and mouth disease, and other animal diseases are common in these areas. Children living in camps for displaced people are particularly susceptible to infectious diseases such as diarrhea, skin infections, malaria, typhoid fever, acute respiratory infections, and malnutrition. Within two months of the floods, the United Nations reported nearly 100,000 cases of malaria (Burke et al., 2023).

In August 2023, Pakistan saw a significant increase in confirmed malaria cases following the 2022 monsoon floods. In the first week alone, the total number of confirmed cases reached 41,685, a 34% increase from the previous week. The number of cases continued to rise in subsequent weeks, surpassing the threshold for a provincial epidemic. The most affected districts included Dadu and Badin in Sindh, and Kharan and Kachi/Bolan in Balochistan (OCHA, 2023). Existing statistics of diseases as expressed by government agencies clearly explain effects linking environmental change due to floods and subsequent health disorders. Risk factors for developing severe manifestations, death, and other infectious diseases include population displacement, restricted access to water and sanitation, and healthcare disruption.

In 2021, Global Health Security Index Pakistan remained at 130th out of 195 countries possessing only 30.4 scores. The GHS Index divides a country's biological threat preparedness into six subcategories that depicts its ability of preventing, detecting and responding to biological threats. Of all these areas, Pakistan was especially poor in several areas. More importantly, Pakistan does not appear to have a national law, a policy or a plan related to zoonotic diseases as noted by (GHS Index 2021). This exemplifies a clear indication that there is need for the government to come up with measures that will help enhance health security in the nation.

Climate change in the form of floods and the amplified rate of the infectious and zoonotic diseases have negatively contributed towards Pakistan's progress in attaining sustainable development goals and targets or the SDGs. Targets under the area of concern, SDG 3, includes; 3.3 dealing with reduce of neglected tropical diseases and water borne infections and 3.9 among them are affected by the health challenges which include reducing deaths from communicable diseases. Floods are also interfering with the water and sanitation targets of SDG 6 as well as targets 11.5 and 11.6 of SDG11, which are, because of severe floods, reduction of the total number of deaths and the number of people affected by disasters, which are essential in fulfilling the goals. However, it is challenging because the floods destroy much needed services and structures. Concerning the sustainable development, it is imperative to reduce health risks because of climate-induce floods. This entails enhancing the capability of health facilities in identifying a potential epidemic and closely following it, sustainable water management measures that can endure and promoting education besides increasing the awareness among public on possible transmission of infectious and-zoonotic diseases during floods.

1.2 Problem Statement

Changes in freshwater, terrestrial, and marine, ecosystems are very evident due to adverse impacts of climate change. This has brought cases of extinction of indigenous species, increase in the frequency of diseases and overall deaths of species, which can be considered the initial examples of extinction due to climate change (UN 2022). Vectors such as the mosquitoes and ticks may change due to alterations in ecosystem that may be prompted by climate change(Paz, 2024). Pakistan is among top ten countries, which are extremely vulnerable to the effects of climate change. Extreme heatwaves, droughts and floods are among many natural disasters that are making this country even vulnerable. One-third of the country was ravaged due to recent floods in 2022. These floods primarily affected Sindh and Balochistan and led to 1700 causalities, affecting 33 million people (UNV-World Bank 2023).

Therefore, scientists set out to examine that climate-induced floods are influencing infectious and zoonotic disease transmission. For instance, Subedi et al. (2022) explored how the spread of zoonotic diseases exacerbate due climate change and floods. Glaciers act as source of microbes that maybe spread epidemics and floods pollute water sources leading to Leptospirosis and water borne diseases to occur. In addition, climate change affects the behavior of vectors

resulting in a higher transmission rate of diseases such as malaria and dengue fever where there is flooding in areas affected. Besides, climate change has the potential of influencing the incidences of climate-sensitive infectious diseases including those transmitted through food and water (Cissé, 2019).

This situation might further be exacerbated due to socioeconomic and socio-demographic factor. Consequently, making communities even susceptible to disease, residing in flood-prone areas. Study showed that people from certain demographics, for example age and gender face health issues before, during and after floods. Author identified that few demographics like elderly people, children and women were disproportionately being affected. Low socio-economic status or education, existing ailments, severity, medication interruptions and prior flood experiences are among many other factors that increase vulnerability of people (Lowe et al., 2013).

Climate-induced floods in Pakistan affect public health badly, putting some provinces at a greater risk. Flooding aggravates the situation for the communities, leading to increased transmission of infectious and zoonotic diseases, especially in provinces where flooding has always been a major issue, due to their economic and demographic conditions.

Kurtzer and Abdullah (2022) have pointed that how the destruction of the infrastructures affected the provision of aid and made Pakistan's existing climate economic and public health challenges worse. These causes include factors like climate change, the poor management of water resources, corruption, and the deforestation problem in Pakistan as well as other political instabilities. Flooding is regardless of its duration, a disaster of significance with well-defined impacts on food security, health and vulnerable groups and persons especially women and the minorities.

UNICEF (2023) pointed out that flood-affected areas lack access to safe drinking water for more than 10 million people, including children. Families are compelled to consume and use water, which might be contaminated with germs that can cause diseases. Hence, an attempt should be made to evolve a multi-sectoral framework for minimizing effects of climate related floods on incidence of, communicable and zoonotic diseases in Pakistan.

1.3 Significance of the Study

The outcomes of the current study aim at benefitting various sectors including public health field, environment and disaster management. Knowledge of climate change-induced floods and its link with infectious and zoonotic diseases is therefore paramount to addressing disease risks that are new and old. Thus, due to evaluating the relationship between floods and diseases, evaluating the groups and regions vulnerable to such situations, and the overall impact of climatic changes on health, thus including the socio–economic and sociodemographic characteristics of the population is important. Therefore, this research pursues the goal of providing recommendations for the formation of policies and interventions in this sphere based on realities on the ground.

It is therefore necessary that this research be conducted with aims of determining how floods enhance the spread of infectious and zoonotic diseases. From a health perspective, it describes the current relationship between the climate related shocks, especially floods and their contingent health effects on the people of Pakistan in the short term and the long term. The research seeks to identify high-risk zones and populations, and, with the help of epidemiological data, to estimate the probable victims of diseases caused by floods. This information, in turn, supports the development of specific intervention strategies, such as medical interventions.

The study also explores the trend of disease incidence and prevalence in relation to its socioeconomic and sociodemographic predictors. By examining these factors, the study contributes to the growing body of knowledge about the connections between environmental contexts, social systems, and health. Moreover, the findings presented here may be useful for estimating the adverse health effects that floods pose to the population, for informing disaster risk reduction measures, and for guiding decision-making in disaster preparedness and response.

Specifically, understanding how floods impact the contamination and sanitation of water sources is essential for examining disease transmission routes. Such knowledge could enhance concepts of sanitation and water supply management. For policymakers, urban planners, and public health workers in Pakistan, the findings could inform the necessary formulation of policies, action plans, and strategies for mobilizing resources to address the effects of climate change, particularly with respect to floods and disease transmission in relation to public health indicators.

1.4 Scope of the Study

The findings of this research may provide valuable information for various ministries in Pakistan to assess the effects of climate change-induced floods on the transmission of communicable and zoonotic diseases. This study is highly relevant to a range of stakeholders. For example, the Ministry of Climate Change can use the findings to update strategies related to flood management and community vulnerability. The Ministry of National Health Services could benefit from recommendations aimed at improving disease detection and response during floods. The NDMA could enhance its coordination of disaster responses and health services, while the Livestock and Dairy Development Departments could focus on zoonotic diseases by linking human and animal health initiatives. The Ministry of Planning, Development & Special Initiatives, with its role in planning and decision-making, can prioritize flood risks in development projects. Additionally, Provincial Health Departments and District Health Authorities could improve their disease control measures.

This study also supports the achievement of several Sustainable Development Goals (SDGs). It contributes to SDG 3, particularly Targets 3.3 and 3.9, by focusing on interventions for water-borne and vector-borne diseases. Enhancing water quality and sanitation in flood-affected areas aligns with SDG 6, especially Targets 6.1, 6.2, 6.3, and 6.6. The research also supports SDG 13, through Targets 13.1 and 13.2, by promoting adaptation to climate change, resilience, and the integration of climate considerations into policies. Moreover, it contributes to SDG 15, particularly Targets 15.1 and 15.3, by addressing ecosystem health and land degradation management. The study also aids in achieving SDG 11, by establishing early warning systems and disaster risk reduction frameworks, and SDG 12, Target 12.2, through improved resource utilization and environmental management.

This research assists in achieving broader sustainable development targets by providing evidence-based recommendations for health, disaster risk reduction, climate change adaptation, and environmental management in Pakistan. Policymakers, public health authorities, and researchers can benefit from this work. Governmental authorities can make evidence-based decisions on disaster preparedness and response measures, while public health departments can implement effective strategies to prevent disease outbreaks in flood-prone areas. Researchers can gain a deeper understanding of flood-related disease transmission, guiding future interdisciplinary

collaborations. Altogether, this work contributes to the goal of improving public health and bridging the gap between research and practice.

1.5 Research Questions

1) How do climate-induced floods contribute to infectious and zoonotic disease transmission?

2) What socio-economic and socio-demographic factors contribute to communities' vulnerability to climate-induced floods and the subsequent increase in infectious and zoonotic disease incidence in Pakistan?

3) What are the geographical hotspots in Pakistan that were affected by the 2022 floods and are susceptible to increased transmission of infectious and zoonotic diseases?

1.6 Research Objectives

This study aims to achieve the following main objectives:

- To investigate the relationship between climate-induced floods and the transmission of infectious and zoonotic diseases in Pakistan.
- To assess the socioeconomic and sociodemographic factors contributing to increased vulnerability to climate-induced floods and the incidence of infectious and zoonotic diseases in Pakistan.
- To identify and delineate geographical hotspots in Pakistan that are flood-prone and highly susceptible to outbreaks of infectious and zoonotic diseases.

CHAPTER 2: LITERATURE REVIEW

Floods caused by climate change are constantly occurring and raise important environmental and health concerns worldwide, especially in Pakistan(OCHA Services, 2023). These floods foster the emergence and spreading of infectious and zoonotic diseases through disturbing ecosystems and affecting the population, and by degrading sanitation systems, which increase the chances of pathogens' transfer(WHO, 2023). There is a need to disentangle the interaction between climate change floods and disease transmission, to be able to successfully prevent such occurrences and adapt to future changes(Hathaway & Maibach, 2018). This literature review aims primarily at revealing these interactions in the context of Pakistan and defines the additional research directions and interventions that should be pursued.

2.1 Introduction to the Nexus of Climate-Induced Floods, Public Health, and Socioeconomic Impacts in Pakistan

Natural disasters and climate change are increasingly critical issues, exemplified by the devastating floods in Pakistan in 2022 (Youde, 2023). The global temperature rise of 1.1°C above pre-industrial levels, driven by fossil fuel consumption and unsustainable land practices, exacerbates risks like heavier rainfall, frequent flooding, and intense heatwaves, significantly impacting ecosystems, human health and economy of the country (Raza et al., 2023)

Climate change-induced factors such as altered storm patterns, rising sea levels, and intense rainfall contribute to more severe floods, especially in developing countries like Pakistan (Lin et al., 2016; Liu et al., 2013). The increased intensity of floods, particularly in urban and arid areas, highlights the urgent need for improved disaster preparedness and management(Arnell & Gosling, 2016; Alifu et al., 2022; Rözer et al., 2022; Lloyd Chikwiramakomo et al., 2021).

Research in India and Pakistan underscores the interplay between rising temperatures, socioeconomic factors, and disaster impacts, revealing gaps in disaster management systems and the necessity for enhanced forecasting, technology, and public awareness(Charak et al., 2024; Ashraf et al., 2023; Manzoor et al., 2022)

Floods disrupt agriculture, reduce income, and exacerbate disease incidence, creating significant public health challenges, including increased cases of waterborne diseases like cholera

and diarrhea (Durodola, 2019; D. Ahmad & Afzal, 2022; Sajjad et al., 2020; Majeed et al., 2023; Muhammad & Noor, 2023).

Effective management of these health challenges requires integrated efforts across sectors to enhance community resilience and mitigate the socioeconomic impacts of climate-induced floods(Houghton & Castillo-Salgado, 2017; M. M. M. Islam et al., 2017).

2.2 Overview of Infectious and Zoonotic Diseases

Infectious diseases are caused by pathogens like bacteria, viruses, fungi, or parasites, transmitted from person to person. Zoonotic diseases, a subtype of infectious diseases, are transmitted between animals and humans. About 73% of new Emerging Infectious Diseases (EIDs) are zoonotic; 25% originate from domestic animals and 30% are viral(Tomori & Oluwayelu, 2023).Examples include COVID-19, malaria, HIV, and tuberculosis(Kalawat & Mohan, 2023).

Other zoonotic diseases, such as monkeypox, Ebola, and avian influenza, can be transmitted via food, water, vectors like fleas and ticks, or contact with animals(Zucca et al., 2022; Holloway, 2022). They may also spread through contaminated animal products or insect vectors(M. Iqbal et al., 2020; Salman et al., 2023). These diseases are linked to environmental changes and increased human-animal contact(Kanki, 2013).

Such things as the prevalence of the coinfections in a given region, high density of population, or high viral load of the viruses can increase the transmission. Vector borne, waterborne, airborne and direct contact transmission has been identified as causes of the infectious and zoonotic diseases(Richard et al., 2016).

2.3 Impact of Climate Change on infectious and zoonotic diseases

It is predicted that climate change might enhance the number of infectious and zoonotic diseases by extending favorable areas and days(Sips et al., 2023). Different studies suggest that climate change has profound impacts on the emergence, spatial distribution and severity of these diseases. Other factors can also play a role in disease processes, as Altizer et al. (2013) have also pointed out; climate change affects infectious diseases, socio-economic factors but but control measures have a role too.

Research shows the extant literature that suggests climate change affects the epidemiology of zoonotic diseases(Cao et al., 2023; Esmaeilnejad et al., 2018). Cao et al. (2023) focus on the

changes in risk associations to climate change in China, while Esmaeilnejad et al. (2018) correlate climate changes to endemic conditions in Iran.

According to some of the recent studies including Philson et al. (2021), Tajudeen et al. (2021), and Bartlow et al. (2019), climate change has become a critical factor influencing the affectation of zoonotic diseases. In the article by Philson et al. (2021) discuss, the future trends in tick-borne zoonotic diseases have raised and, Tajudeen et al. (2021) underline the importance of distinguishing between climate change and loss of biodiversity, and Bartlow et al. (2019) highlight and predict zoonotic disease responses to climate change.

The reviewed literature clearly establishes the need to find the link between climate change and infectious/zoonotic diseases in order to facilitate adequate disease control and prevention.

2.4 Relationship between Floods and Disease Transmission

Floods are among the common natural disasters and they have severe immediate and cumulative effects on health. These floods lead to diseases and cause skin diseases, Gastro enteritis and Zoonotic diseases like leptospirosis especially under climate change (Paterson et al., 2018).

Research shows that flooding often increases the incidence of mosquito-borne diseases (MBD) such as dengue and malaria, though some diseases may temporarily decline(Coalson et al., 2021). In southeastern Australia, flooding in the spring-summer seasons raises the risk of Ross River virus outbreaks, suggesting enhanced mosquito control could be beneficial(Tall & Gatton, 2020).

Public health interventions are crucial for diseases like bacillary dysentery, conjunctivitis, and leptospirosis, with the strongest impacts seen in the 0–9 ten-day period following floods in Guangxi, China (Ding et al., 2019).

In Pakistan, floods increase vulnerability to communicable and zoonotic diseases, including Crimean Congo Hemorrhagic Fever (CCHF), due to inadequate healthcare and climate change (Braam, Jephcott, and Wood 2021). Disease outbreaks such as dengue, malaria, and chikungunya are more likely during floods (Riaz & Javed, 2022). Additionally, S. Ali et al. (2017) link climate change with rising pest and disease risks, including flooding and temperature increases.

Dengue fever or waterborne diseases are another threat which was seen during floods and COVID-19 outbreak in Pakistan(Tabassum et al., 2023). Ahmed et al. (2017) opine that there is need to carry out more research on echinococcosis and is in agreement with Bokhari et al. (2013) who observed higher isolation of E. coli pathotypes during floods in Pakistan.

Many diseases have been associated with flooding in Kenya and some of them are the vector borne and water borne diseases, thus there is a need to enhance epidemiological data (Okaka & Odhiambo, 2018). Climate change, global warming, excessive rains and floods pose more threats to the people in Pakistan with threat of risky diseases such as brucellosis (Somani, 2023; Khan et al., 2020; M. Iqbal et al., 2020).

Disaster preparedness, environmental management, as well as health concerns should therefore be dealt with; hence, there is a need to deal with the following vulnerabilities; for example inadequate vaccination, displacement and so on.

2.5 Infectious Disease Outbreaks Associated with Floods

The floods that occurred in Pakistan in 2010, 2011 and 2012 elevated the prospect of vectors-borne diseases including dengue fever (Bostan et al., 2017). The survivors of the flood were also more inclined to die from fatal respiratory infections as noted by (Vikas, 2020). The records of earlier times reveal the association between climatic fluctuations and disasters with disease incidence(McMichael, 2015). In Pakistan with regards to floods, bacillary dysentery, influenza, tuberculosis, Japanese encephalitises and leptospirosis are few diseases that have been reported(Ding et al., 2019). Flood relief operation is a good time for the transmission of Peste des Petits Ruminants (PPR)(M. Munir et al., 2013).

Floods are a severe problem in Pakistan because tuberculosis, dengue, malaria, and hepatitis continue to be serious diseases(T. G. Shaikh et al., 2022). Flooding during monsoon also brings into focus important requirement of disease surveillance and disease control (Baqir et al., 2012).

Studies outside Pakistan also reveal that the other world regions also have higher incidence of malaria, cholera, and diarrhea (Okaka & Odhiambo, 2018; Suk et al., 2020). Flood related diseases are reported in Kenya, Mozambique and in some parts of Europe. The incidence of waterborne diseases like cholera is high in the countries that are affected by floods and in the

flooded areas of Pakistan, which shows the connection between floods and diseases (Umair et al., 2023).

Therefore, flood borne disease outbreaks that occur in Pakistan need development of disease early reporting system, disaster contingency and efforts for public health management cross-sectoral relationship, indicating association of floods and infectious diseases.

2.6 Zoonotic Disease Transmission Dynamics during Floods

Floods cause different zoonotic diseases from consuming products from infected animals, contact with infected animals and through vectors (Zambrano et al., 2014; Abebe et al., 2020). Transmission happens through direct contact with diseased animals, animal secretions, food stuffs, water and surfaces that have been contaminated with the disease pathogens(Vasco et al., 2016). Flood affect leptospirosis by damaging water system and distribution networks; bringing bacteria into water sources and also raising interaction between humans and animals (Mavrouli et al., 2022).

Similar to, arthropod vectors including fleas, ticks and mosquitoes also contribute to the disease transmission(Razgūnaitė et al., 2019). It is equally important to understand these vectors and hosts and this will help in the control process(Kain et al., 2021). Zoonotic disease spillage depends on environment and societal factors notably land transformation (Hassall et al., 2023). It is important to understand the transmission mechanisms for the livestock trade(Zahoor et al., 2018; Majiwa et al., 2022).

Severe flooding increases the threat of zoonotic diseases as the water is likely to contain urine of rodents(Esteve-Gassent et al., 2014). Microorganisms including but not just limited to Noroviruses, Campylobacter spp. , Giardia spp. , Cryptosporidium spp. Water-borne pathogens such as Vibrio parahaemolytus, Salmonella, and Shiga toxin-producing E. coli are usually found in floodwaters(Hörman et al., 2004; Keenum et al., 2021). Furthermore, presence of Salmonella typhimurium in groundwater and upsurge of skin and respiratory, gastrointestinal and vector-borne diseases is concerning(Tempark et al., 2013; Kurien et al., 2022).

Such diseases as leptospirosis and cryptosporidiosis are zoonotic diseases which tend to increase during flooding because of contamination (Deem & Brenn-White, 2020). Flooding also dislodges the small mammals, and this makes the chances of rodent related diseases high(Kim et

al., 2013; Okaka & Odhiambo, 2018). To control and eradicate diseases and other health issues, human, animal, and environmental health need to be linked for the developing countries such as Pakistan using the 'One Health concept' (Mubarik Ali & Norina Jabeen, 2022; Braam, 2022; O. A. Shaikh et al., 2023a; Yasmeen et al., 2022a; S. U. Ali et al., 2023).

2.7 Environmental Factors Influencing Disease Transmission in Flood-Prone Areas

In flood affected zones, following different factors are impact the spread of diseases; the presence of water and excessive moisture increases mosquito breeding and the growth of water-borne diseases. Influence of temperature and humidity affects availability and productivity of the disease transmitting vectors and/or pathogens (Sharma et al., 2022; Kouamé et al., 2022; Bett et al., 2022; Mavrouli et al., 2022). In addition, floods affect diseases due to changes in parameters like land use and displacement of wildlife among others- especially vector borne diseases including malaria and schistosomiasis as stated by (Pedro et al., 2020).

Flooding cause water to become contaminated making it to be a carrier of diseases such as cholera and giardiasis. Shelter, water and sanitation also present these risks, thus environmental tracking of contaminants constitutes an essential intervention for controlling diseases (Ahern et al., 2005; Schwartz et al., 2006). This is complemented by stagnant water and pollution by sewage that also cause diseases (Mark et al., 2015).

In flood situation, there is increased movement of water and hence water-borne diseases and the contact between the contaminated flood water and the ground water boosts diseases like typhoid, cholera, leptospirosis, malaria and dengue (Shankar et al., 2020). The lack of proper water treatment facilities puts the people at risk of getting cholera through contaminated sources of water. Standing floodwater disturbs microbial ecology and contributes to spreading of diseases (M. T. Islam et al., 2007).

Floods result in sewage pollution which in turn affects water borne disease transmission, air pollution and climate change as stated by (Patel et al., 2015). Problems such as leakage of sewage and water logging becomes worse in the course of the rainy season and in wet conditions hence an there is an increase in the poor quality of water and abundance of diseases (Anas et al., 2023; Kondo et al., 2002).

Hence, the following aspects of floods are important; hygiene, water and sanitation, and resilience involve critical measures in determining both the health risks and environmental outcomes of floods.

2.8 Socioeconomic and Sociodemographic Determinants of Floods and Disease Vulnerability

Significant factors that define vulnerability to climate related flood and infectious diseases include age, race, gender, and socioeconomic status(Qi et al., 2022). Effective flood management relies on understanding socioeconomic vulnerability(Deepak et al., 2020), with increased vulnerability linked to demographic, socioeconomic, and health factors (Narendr et al., 2020). Key factors include geographical location, infrastructure, and socioeconomic context (Adelekan, 2010).

Socioeconomic factors predict susceptibility to diseases, with poverty and low status heightening risks(Braam, Jephcott, et al., 2021b). So, addressing poverty and social inequality is crucial for mitigating disease risks(Asaaga et al., 2021; Quinn & Kumar, 2014).

Rana et al. (2023) found multidimensional poverty and climate vulnerability closely related, with Nowshera more vulnerable than Charsadda. Hossain et al. (2023) highlighted impacts on housing and health in Bangladesh, recommending targeted measures. Babanawo et al. (2023) stressed improving sea defenses and incorporating socioeconomic aspects in flood management.

Hamidi et al. (2022) used the Social Vulnerability Index to identify high flood risk areas, noting that low elevation and poor education increase vulnerability. D. Ahmad, Kanwal, and Afzal (2023)suggested policy actions like flood-tolerant crops for vulnerable areas in Muzaffargarh.

Hossain, Sohel, and Ryakitimbo (2020) linked floods to unemployment and lower income. Lee et al. (2021) demonstrated the effectiveness of forecast-based risk management in Bangladesh. A study in Zimbabwe found malaria prevalence linked to social factors (Manyangadze et al., 2022).

Lee et al. (2021) identified that floods disproportionately affect the elderly, females, and those with health conditions. Chitre et al. (2024) discussed increased risks for children from zoonotic and vector-borne diseases. Magalhães et al. (2023) highlighted the need for poverty eradication to control disease transmission.

Oruganti et al. (2023) emphasized One Health approaches for zoonotic diseases, noting gender-specific risks. Bambra (2022) called for addressing inequalities to improve health outcomes for Emerging Infectious Diseases.

Tate et al. (2021) and Halima & Shirakawa (2022) observed worsened impacts for vulnerable groups. Integrating socioeconomic stress into vulnerability assessments is crucial(Hjerpe & Glaas, 2011). Hasan et al. (2022) and Ayala & Estrugo (2014) highlighted the role of socioeconomic status and sanitation in disease risks. In Noumea, socioeconomic indicators linked to higher dengue rates(Zellweger et al., 2017).

In summary, demographic, socioeconomic, health, and cultural factors are key for effective disaster risk reduction and climate adaptation.

2.9 Public Health Challenges and Response in Flood-Affected Areas

Water and vector borne diseases, damage to health facilities, mother and child health are some of the public health impacts that have been felt in the recent floods. Flooding has raised the rates of waterborne diseases thus showing the need for the medical teams to attend the affected and ensure they get the necessary supplies(Raza et al., 2023b). Ochani et al. (2022) have documented that some of the health impacts of floods in Pakistan include skin diseases, diarrhea, among other diseases that were made worsen by contaminated water and mosquito bites. The floods also affected mental health and availability of reproductive health services.

The stagnant water, which is left behind after flood, exposed the people to diseases such as malaria and dengue fever due to the increased breeding of mosquitoes. Hygiene and sanitation was poor in the camps, the facilities were overcrowded, and this had the effect of increasing the spread of diseases. Flooding had affected health care facilities, which limited people's access to medical care and raise their health concern(Nadeem, Sahito, et al., 2023). Pakistan flood affected areas were at high risk of infectious and zoonotic diseases. Heavy downpour and floods had spread water borne diseases such as cholera, malaria, typhoid, dengue fever, scabies, polio and viral hepatitis A(O. A. Shaikh et al., 2023b) (Nasir et al., 2023)(Khan et al., 2023).

Health care is a big issue that is not well equipped to handle a pandemic, there is little funding for research and development, and the public is unaware of the issue (Muhammad & Noor, 2023). Insufficient mental health services have been highlighted by the fact that floods have

influenced negative mental health outcomes including psychological distress, anxiety and post-traumatic stress disorder in women(Nadeem, Ahsan, et al., 2023).

It is imperative to expand healthcare, access to clean water, sanitation, disaster preparedness and response, funding of research and development, awareness campaign, as well as sustainable development to overcome these challenges (Raja et al., 2023). Policy is also important to discuss the health problems of floods regarding the transportation and logistics. In order to address these issues it is important to establish an obstetrics field hospital that has personnel and plans in place for disasters (Warsi & Mansoor, 2023).

2.10 Case Studies and Research Findings on Flood-Related Health Impacts in Pakistan

Flooding has long been a major health threat in Pakistan, causing diseases, injuries, and restricted access to healthcare. A systematic review of literature from 2003 to 2022 identified common outbreaks of fever, dengue, and gastrointestinal diseases among displaced and unhygienic populations, with long-term psychological impacts also noted(Farah et al., 2023).

Case Study 1: Super Floods and Vaccination Disruption: The 2022 "super floods" disrupted health services, putting children at risk of polio and measles, highlighting the need for urgent improvements in vaccination programs (I. Ali & Hamid, 2022).

Case Study 2: Post-Flood Infectious Disease Spread: Monsoon floods and landslides in 2022 affected 33 million people, causing gastrointestinal, skin, eye, and respiratory infections due to poor sanitation (Khan et al., 2023).

Case Study 3: Skin-related Ailments and Waterborne Diseases: A 2023 study reported increases in skin diseases, burn injuries, heatstroke, and waterborne diseases like cholera and diarrhea, emphasizing the need for comprehensive disaster preparedness (Jadoon et al., 2023).

Case Study 4: The 2010 Flood Crisis: The 2010 floods, impacting 20 million people and causing 1,800 deaths, led to increased gastroenteritis, malaria, and respiratory infections, disproportionately affecting lower-income groups(Warraich et al., 2011).

Case Study 5: Health Challenges in Flood-Affected Areas: In 2022, widespread flooding affected a third of the country, exacerbating cholera and malaria risks and highlighting the inadequacy of health infrastructure and government response (Sarkar, 2022).

Case Study 6: Infectious Diseases Post-Monsoon Flooding: The floods in KPK in 2010 also had a direct effect on the health sector where the people of the province suffered from diarrhea, skin diseases, malaria and respiratory diseases(Baqir et al., 2012).

Case Study 7: Prolonged Flooding and Health Emergency: Heavy flooding was also constant in the country and had increased water and vector-borne diseases with burdening of health care facilities requiring preventive measures (A. Iqbal et al., 2023).

Case Study 8: Viral Outbreaks and Health Hazards: Studies have shown that weak disaster response exacerbates viral, water-related, and vector-borne diseases, stressing the need for comprehensive disease management strategies(Saeed & Piracha, 2016).

Case Study 9: Water-Mediated Infections from Torrential Rainfalls: Shabbir et al. (2022), have stated that torrential rains have led to stagnant water and poor sanitation, increasing malaria and dengue in Southern Punjab, highlighting the need for urgent humanitarian aid.

Case Study 10: Flooding and Child Health: Flooding severely affects children, increasing risks of malnutrition and water-related diseases due to compromised breastfeeding practices(Ochani, Aaqil, Nazir, Athar, & Ullah, 2022).

Case Study 11: Water-Borne Diseases in Flood-Affected District Khairpur Mirs: In Khairpur Mirs, waterborne diseases like malaria, diarrhea, and typhoid were prevalent, with malaria being the most common (S. Ali et al., 2023).

Overall, these case studies underscore the urgent need for improved public health measures and disaster management to mitigate the health impacts of flooding and ensure continuity of essential services.

2.11 Managing Animals during floods

Integrating medical and veterinary services is crucial for addressing the needs of both people and animals in disaster-affected areas. The One Health approach, which includes veterinary public health, is vital for controlling zoonotic diseases and ensuring food safety during disasters(Kumar, 2022).

The One Health Animal Disaster Management (OHADM) framework emphasizes the inclusion of animals in all disaster management phases. It promotes prevention, integration

between humans and animals, and overcoming prejudice(Meral, 2023). An Ethics of Care approach extends health concerns to animals, guiding resource management and policy (Anthony & De Paula Vieira, 2022).

In the U.S., inadequate animal health infrastructure and public health awareness have been highlighted during disasters. Improved involvement of pet owners and federal guidelines for animal care in disasters can enhance preparedness(Heath & Linnabary, 2015). Disaster management should incorporate wildlife conservation, education, and respect for indigenous knowledge(Ha, 2024). Animal disaster management programs should include trained personnel and foster cooperation with pet and livestock owners (R. Thakur & Dogra, 2022).

Proper early warning and disease control measures are essential to prevent epidemics and control disease transmission among animals (S. D. Thakur, 2022). Risk assessment helps veterinarians plan and respond effectively to disasters, despite challenges like funding and staffing (Katoch, 2022). Efficient data management enhances disaster planning and community welfare, although more research is needed on tools for livestock societies(D. Thakur, 2022).

Post-disaster interventions should address animal welfare, considering the type of disaster and livestock conditions(Suman, 2022)

2.12 One Health Approach in Disaster Management-Flood Response

The "One Health" concept emphasizes the interconnectedness of human, animal, and environmental health. It highlights the need for an integrated approach to address issues like zoonotic diseases (e.g., brucellosis, anthrax, and rabies), antimicrobial resistance, foodborne illnesses, pollution, and ecosystem degradation. Collaboration among human health care providers, veterinarians, environmentalists, and other scientists is essential for achieving Sustainable Development Goals(Erkyihun & Alemayehu, 2022).

This approach is critical for managing zoonotic diseases, such as COVID-19 and Ebola, by focusing on prevention and control of outbreaks. Effective disease control in animals can prevent epidemics that affect humans, as One Health surveillance monitors both known and emerging pathogens(Horefti, 2023; Hayman et al., 2023).

Human and animal health workers must collaborate to understand disease transmission and manage contributing factors like urbanization, deforestation, and climate change. Floods, which

pose risks through waterborne diseases and impact wildlife habitats, necessitate a coordinated response from health professionals, emergency managers, veterinarians, environmentalists, and communities to develop effective strategies(Topluoglu et al., 2023).

2.13 Gaps in Knowledge

Research on the impact of climate-induced floods on zoonotic diseases in Pakistan reveals significant gaps. While there is considerable literature on climate change and flooding's effects on infectious diseases, direct studies on floods caused by climate change and zoonotic diseases in Pakistan are lacking. The evidence base is weak, with limited epidemiological data on zoonoses in flood-affected areas and insufficient recognition of livestock's role in disease transmission during floods.

Additionally, the connection between climate-induced displacement and disease, along with the role of livestock in this context, remains underexplored. Despite identifying diseases like leptospirosis, dengue, and chikungunya as linked to climate change(Lau et al., 2016; Bostan et al., 2017; R. Ahmad & Javed, 2022), research specifically examining flood impacts on zoonotic disease transmission and socio-economic factors in Pakistan is scarce. There is also a lack of understanding regarding how flood-induced biodiversity changes affect disease dynamics(Keesing & Ostfeld, 2021).

While some research has reviewed measures to combat zoonotic diseases (Yasmeen et al., 2022), assessing these measures' effectiveness in the context of climate change-induced floods is needed. Future research should include longitudinal studies, advanced modeling, and exploration of invasive species' roles in disease transmission (Roy et al., 2023). Findings from similar studies (e.g., Quintanilla, 2022)could help develop effective preventive measures and strategies.

CHAPTER 3: THEORETICAL FRAMEWORK

Establishing the associations between floods, climate change, and the spread of infectious and zoonotic diseases, while also understanding the vulnerabilities of affected populations, is a significant advancement in healthcare. This approach integrates environmental and social factors as captured in the ***One Health*** and ***Ecosocial*** theories.

Historically, public health focused on individual outcomes with little attention to social determinants, but as Braveman, Egerter, and Williams (2011) noted, these determinants are now recognized as crucial, especially in disaster contexts like floods. However, the One Health model, which addresses the health of people, animals, and the environment, has limitations, particularly in its quantification and lack of integration with social sciences. In contrast, Ecosocial frameworks offer a comprehensive view by exploring the interactions between personal, interpersonal, and environmental factors. For example, the Eco-Health strategic approach applies critical realist paradigms to more effectively understand interconnections between environment, society & economy(Albrecht et al., 2008).

These models assist in establishing the area, which might be lacking the right policy and response towards the hazard in order to develop good interventions that could minimize vulnerability to diseases, and health related impacts of floods in Pakistan. These frameworks help policymakers and responders reduce the impacts of floods and outbreaks, as well as facilitate the process of the link between ideas formulated at a theoretical level and practice.

3.1 One Health Approach

The One Health is a concept that deals with humans, animals, and the environment and it encourages solution seeking from a holistic viewpoint because of its interconnectivity in the issue solving of distinct varieties of health issues. This framework is useful when addressing Infectious and zoonotic diseases during floods in the perspective of Pakistan. Because of the interconnectivity between humans and animals and the overlapping of their living spaces; it is important to prevent drug resistance in zoonotic diseases(Scott et al., 2020).

The One Health approach integrates efforts to preserve and enhance the health of humans, animals, plants, and the environment, involving multiple stakeholders to promote health and

manage health and environmental risks. It also underscores the importance of safe food, clean water, energy, air quality, and climate change mitigation (FAO et al., 2022)

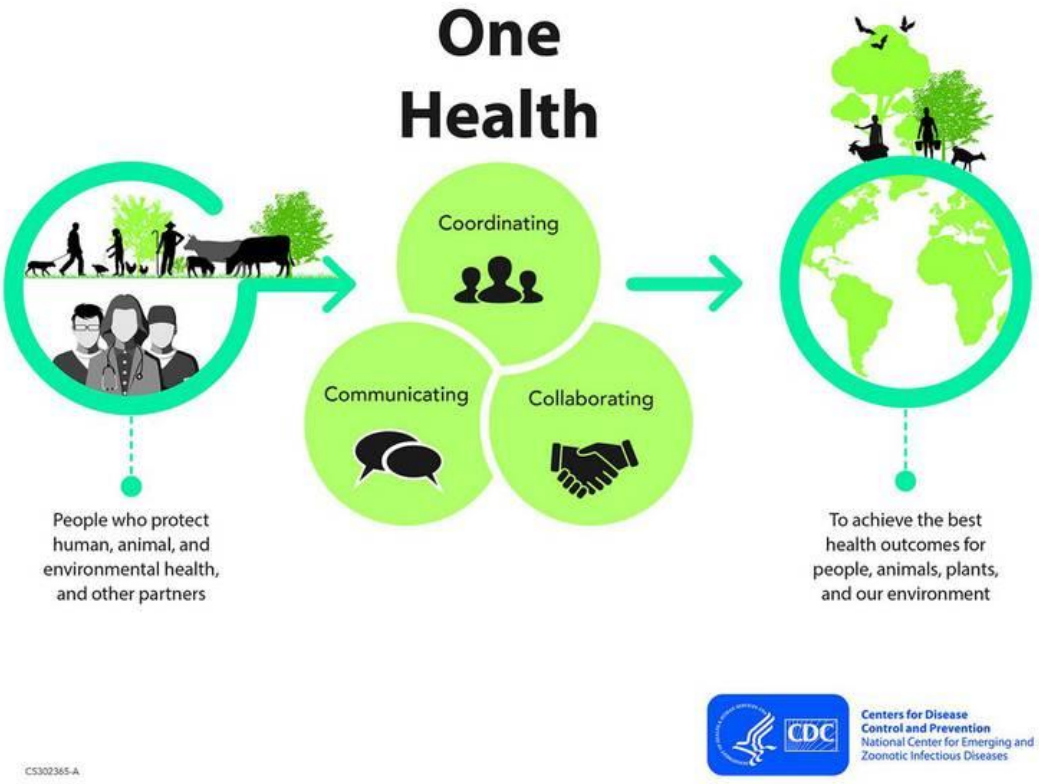

Figure 1: One Health. Source: Centre for Disease Control and Prevention CDC (2019)

3.1.1 Critique on One Health Approach

The One Health approach, while valuable for fostering research, surveillance, and interdisciplinary collaboration in disease control, faces several critiques. Its lack of a well-defined concept, leadership, and common vision allows flexibility but also raises ethical concerns, such as the culling of healthy animals, which may cast doubt on the approach's goals and values. Acting as a "boundary object," One Health mediates various stakeholder perspectives but can obscure potential disputes and ethical issues, necessitating regular reassessment to meet ethical standards and balance stakeholders' needs (van Herten et al., 2019).

Additionally, theoretical concerns have been raised regarding which health is prioritized within the One Health paradigm and the challenge of defining health to include human, animal,

and environmental aspects. Critics argue that the approach sometimes prioritizes human and animal health at the expense of the environment and fails to address the environmental consequences of large-scale developmental projects(Selter & Salloch, 2023; CHOI, 2022).

Despite these critiques, the One Health approach remains useful in the context of Pakistan's efforts to tackle infectious and zoonotic diseases during floods. It highlights the interconnectedness of human, animal, and environmental health, promotes integrated surveillance across species and environmental factors, and underscores the need for interdisciplinary cooperation to address gaps in fragmented policies and improve disease management strategies during flood events.

3.2 Ecosocial Theory

Ecosocial theory, developed by Nancy Krieger in 1994, bridges the gap between social and biological sciences in epidemiology by emphasizing the interplay between biological, psychosocial, and social factors in shaping health outcomes. The theory posits that the social systems responsible for oppression and inequality are critical determinants of health, surpassing the limitations of the traditional biomedical model by incorporating the effects of social, economic, and environmental factors on health (Krieger, 2001).

One of the core propositions of Ecosocial theory is that human biology is shaped by experience and that social contexts at various scales produce disease patterns (Krieger, 2012). In the context of infectious and zoonotic diseases during floods in Pakistan, this theory helps elucidate how factors like poverty, infrastructure deficits, and climate change exacerbate vulnerability and influence response efforts. It also highlights how socioeconomic status affects exposure, vulnerability, and resilience, considering historical and spatial power dynamics(Krieger, 2012).

The theory seeks to explain health differential between population groups; how differential exposure, resistance and susceptibility to disease cumulates, the role of agency and accountability(Krieger, 1994).

The COVID-19 pandemic has further exposed global, national, and subnational health inequalities(Hanage et al., 2020)(Bassett et al., 2020). Ecosocial theory demonstrates that social factors, including poverty and inequality, combined with environmental conditions, worsen health inequities during floods in Pakistan. Vulnerable populations suffer most from inadequate infrastructure, poor healthcare, and unsanitary living conditions. Understanding the relationship

between these structural factors and disease spread is crucial for implementing effective response strategies and achieving policy objectives.

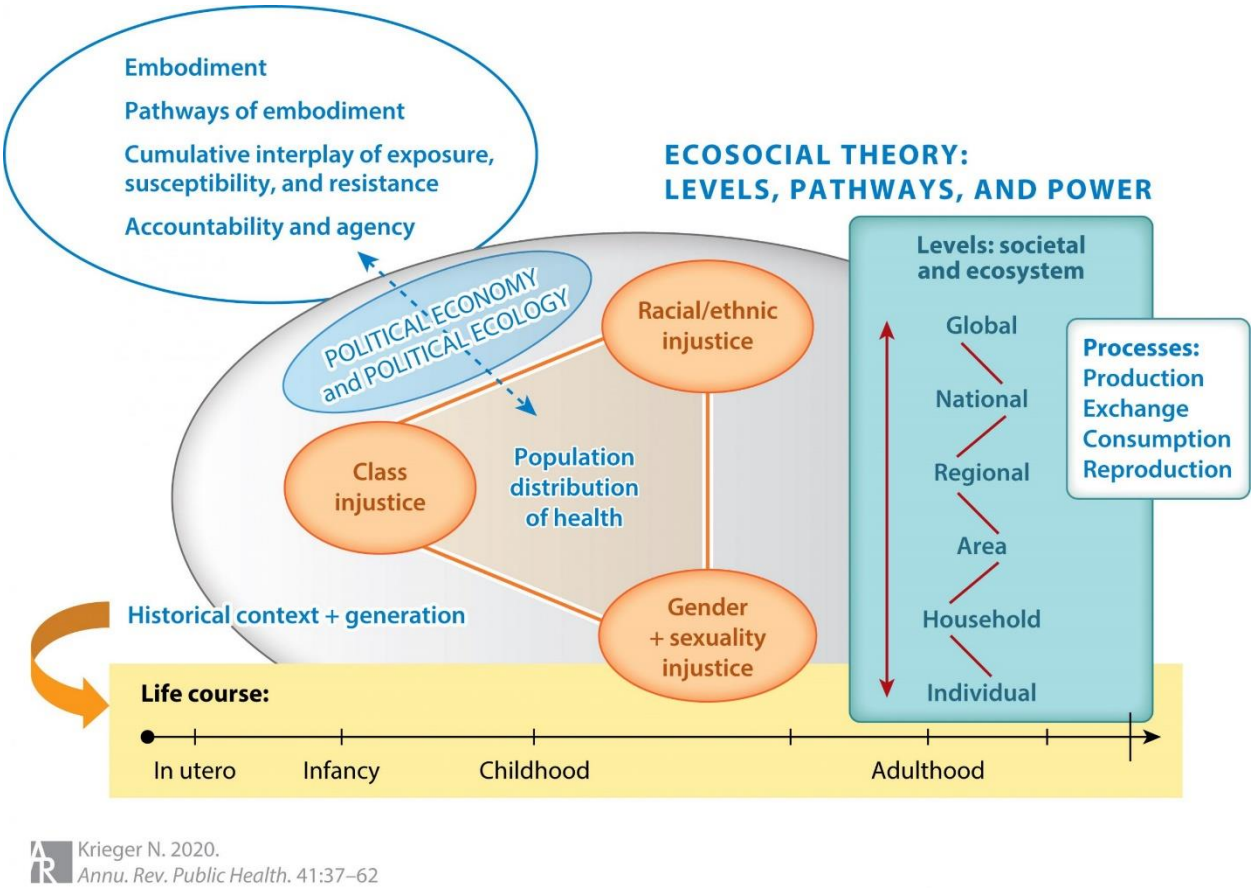

Figure 2: Ecosocial Theory of Disease Distribution. Source: Illustration by Krieger (2020)

3.2.1 Critique on Ecosocial Theory

Krieger's empirical application of Ecosocial Theory has faced criticism due to multiple shortcomings and methodological issues in its application. For instance, Krieger associates hypertension with self-reported discrimination, which she interprets as "internalized oppression" (Conde & Gorman, 2009). However, she acknowledges the difficulties in identifying appropriate methods for analyzing the multiple and interrelated factors that define health, particularly when these analyses are based on theoretical formulations without strong empirical support(Krieger, 2012). While Krieger critiques the flawed and prejudiced quantitative data often used to analyze and contrast health inequities, she does not offer substantial discussion on how current quantitative data gathering procedures could be improved or expanded (Krieger, 2012).

Price (2014) further argues that Krieger's Ecosocial Theory may fail to embody the cross-disciplinary work known as "condisciplinarity," which critical realism deems essential for addressing real-world complexities. Although the theory captures social, biological, and environmental factors, critics suggest it cannot fully harness the multiple disciplinary approaches necessary for effectively addressing health inequities. This critique highlights a potential weakness in Krieger's approach, particularly in relation to meeting interdisciplinary demands.

Nancy Krieger (2012) also emphasizes the need for a "critical and integrated approach" to tackling health inequities, suggesting that understanding the social relations that produce inequality is crucial. She advocates for research conducted from multiple perspectives using diverse methods, aiming to develop an elaborate model that addresses the root causes of health inequalities.

While Ecosocial Theory provides valuable insights into the historical, political, and socio-economic factors underpinning health inequities, it struggles to explain how and why individuals become diseased and how societies function in ways that influence disease prevalence. This limitation stems from its reliance on epidemiological research and quantitative methods, which may not fully capture the social determinants of health, including environmental, animal, and human health factors. To overcome these limitations, this study employs the One Health approach, which focuses on multidisciplinary cooperation and integrates information from human, animal, and environmental health sectors. This approach offers a broader conceptualization of health risks and coping strategies than those provided by Ecosocial Theory.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Research Design

The present research is an *exploratory case study*, which aims to analyze the effects of the 2022 climate change induced flooding and the development of infectious and zoonotic diseases in Pakistan, study uses a combination of both primary and secondary research data and findings. According to Yin (2003), such type of case study is applied where it is difficult to determine the specific intervention's results that are being investigated.

Primary data was obtained from information defined as beliefs and experiences of the identified target audience, namely disaster management professionals, officials of public health organizations, as well as climate change scholars and specialists via semi-structured interviews. Secondary data included disease prevalence collected from the National Institute of Health (NIH), District Health Information System (DHIS) Punjab and national policies of Pakistan for qualitative content analysis (QCA). Using qualitative content analysis employs an analysis of these policies for flood and disease control. Flood impact mapping using Geographic Information System (GIS) evaluates the pattern of the spatial distribution of flood impacts and its correlation with diseases. To explain multiple dimensions of the problem in Pakistan, the research is based on both Nancy Krieger's Ecosocial theory and One Health approach.

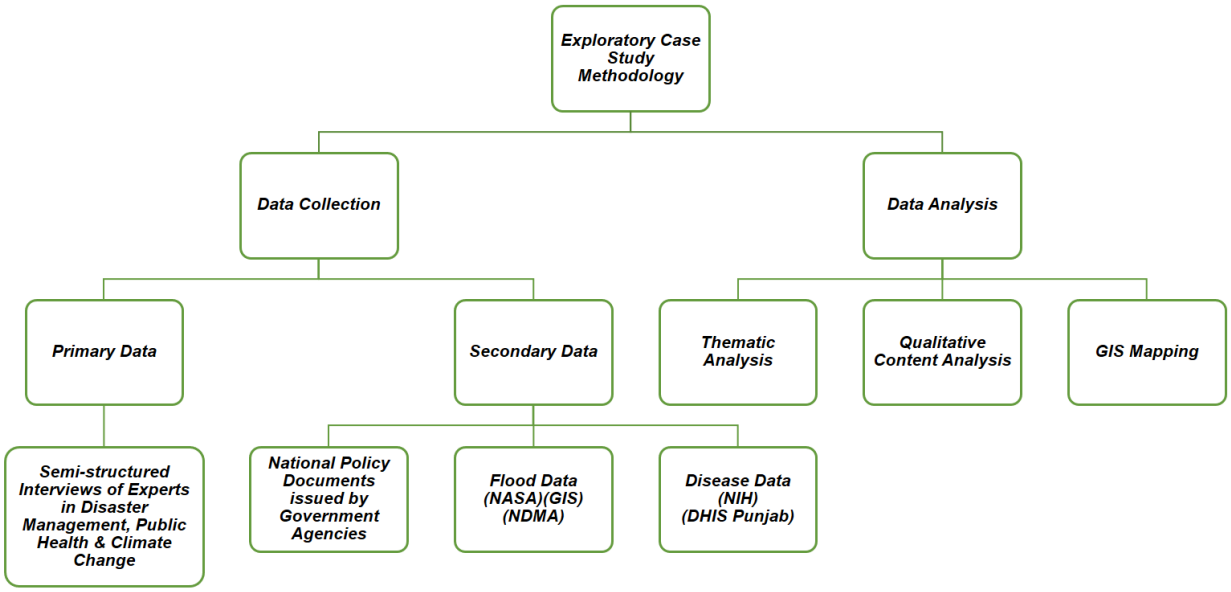

Figure 3: Research Methodology

4.1.1 Data Collection

Qualitative Data Collection

Semi-Structured Interviews: The participants for interviews were then identified purposively, 16 professionals with the prime focus on flood management and public health in the specific regions from healthcare, government, Non-governmental organizations and academic institutions and universities. Interviews were primarily conducted in person, but online platforms were used if in-person meetings were not possible. Each interview lasted 45 to 60 minutes and was recorded with the participants' consent. The interviews focused on perceptions of health and infectious and zoonotic diseases, the socio-economic effects of floods, contribution of sociodemographic vulnerability and the effectiveness of existing policies. The recordings were transcribed in detail, and thematic analysis was applied to identify major themes.

National Policy Documents issued by government authorities: This study analyzed key policy documents related to climate change, disaster management, and public health, including the National Climate Change Policy (2012), National Disaster Risk Reduction Policy (2013), National Health Vision Pakistan 2016-25, National Water Policy (2018), and National Environmental Policy (2005). Using qualitative content analysis, the study examined how these documents

address the cross-sectoral impacts of climate change, such as floods and disease transmission. The analysis aimed to identify major patterns, shortcomings in the policies, and potential suggestions for improvement.

Quantitative Data Collection

Flood Data: NASA satellite imagery raster data, along with district and river boundary shapefiles, were used to map flood-affected areas. The flood extent was mapped using satellite data, and Geographic Information System (ArcGIS) was employed to overlay this data onto district boundary shapefiles, allowing for analysis of flood spatial density across districts. Detailed flood mapping was achieved by applying overlay and clipping techniques within ArcGIS.

Disease Data: Disease incidence data from June to October 2022 was collected from the National Institute of Health (NIH) for all provinces, and from the District Health Information System (DHIS) for Punjab due to incomplete NIH data. This data was integrated with Geographic Information System (GIS) to analyze the spatial dispersion of diseases. It was superimposed on district boundary shapefiles with river boundaries overlaid, providing an overview of disease incidence in flood-affected areas and examining any correlations between disease prevalence and flooding.

4.1.2 Data Analysis

Qualitative Data Analysis

Thematic Analysis: All the interviews were transcribed verbatim to preserve the participants' unprocessed answers. Initial coding emphasized on the effects of floods, diseases, and socio/economic and sociodemographic factors. Phenomenographic and contextual approaches were used to develop these codes from the data obtained. The codes identified were then categorised into subthemes and themes. The present study used Ecosocial theory and One Health approach to obtain socio-environmental factors that escalate disease transmission during floods, highlighting the role of changes in environmental health leading to disease transmission.

Qualitative content analysis: The validity of policy formulation documents has been assessed through a qualitative content analysis in order to assess the extent to which the documents deal with the issue of flood occurrence due to climate change and spread of diseases. It entailed policy area classification, the identification of socio economic and sociodemographic inputs and

policy intervention appraisal. Some of them exposed the gaps in the current policies and made suggestions on how to optimise the use policy instruments in relation to the needs of the population.

Quantitative Data Analysis

Geospatial Analysis

Flood-Affected Areas Mapping: The boundaries of the districts and the rivers were obtained from shape files and the flood extent data obtained located and superimposed on the district and river boundaries. ArcGIS based overlay and intersection technique produced district maps depicting the spatial distribution of floods in Pakistan of 2022.

Disease-Affected Areas Mapping: District boundary shapefiles and disease incidence data were imported into ArcGIS to create a choropleth map of disease prevalence. This map enhanced the spatial understanding of disease distribution relative to river margins and highlighted regions with high disease incidence during the floods.

Identifying Disease Vulnerability Hotspots: To identify areas with elevated flood and disease risk, flood and disease data were overlaid in GIS. This cross-mapping revealed hotspots with high flood impact and disease transmission. Additional vulnerability maps were created, emphasizing districts like Punjab and Khyber Pakhtunkhwa (KPK) as particularly vulnerable.

4.2 Limitations

There are some limitations in the study and they are as follows. The availability of the disease vulnerability hotspots in this study may be undermined by under reporting of disease data from the affected districts in the country. Also, the analysis of the qualitative data entails guessing the perceptions and, therefore, can distort the results and their accuracy because of the factor of biasses. Other factors that may affect the validity of the geospatial analysis includes; incongruencies that may exist in the structures used to combine the diverse data sources such as differences in data quality and spatial coverage.

4.3 Ethical Considerations

In the course of the study, high ethical values were maintained. Participants interviewed in these categories gave consent voluntarily and all interviews were conducted anonymously.

Furthermore, the conducted study ensured that accurate and reliable data was collected and analyzed to endeavor on the credibility of the study.

CHAPTER 5: FINDINGS AND ANALYSIS

5.1 Thematic Analysis

Thematic analysis, as outlined by Sovacool et al. (2023), was used to identify patterns in semi-structured interviews with 16 key stakeholders from healthcare, government, NGOs, and academia due to their expertise in flood management, public health, and disaster response. The analysis began with reading and segmenting the transcripts, followed by initial coding, and the formation of sub-themes and themes, guided by the Ecosocial theory. The focus was on understanding the effects of climate-induced floods and the socioeconomic and sociodemographic factors influencing vulnerability, providing a rich, qualitative context to the findings.

Figure 4: Major Themes

5.1.2 Climate-Induced Floods and Disease Incidence

Climate change has intensified floods and disease outbreaks, as noted by Filho et al. 2022. The findings from the interviews strongly suggested that the effects of climate change, particularly the increase in flood prevalence, negatively impact mental health, increase stress, and displace

both human and livestock populations(Pillay & van den Bergh, 2016). This damage to ecosystems worsens human health, with severe flooding linked to epidemics like malaria, dengue, and chikungunya in Asia (R. Ahmad & Javed, 2022).

Contribution of climate change in increasing challenges was evident in the 2022 floods in Pakistan, which brought diseases, public health crises, and displacement, among several other issues(OCHA Services, 2023). Interviewees noted that these floods disrupted healthcare delivery, vaccination campaigns, and increased maternal and child health issues (Muhammad & Noor, 2023). Inadequate flood policies reveal critical gaps in response strategies. An NGO representative stated that,

> *"Climate change does not just bring diseases; it affects economies and causes major displacements, as seen with the floods in 2022. Many people from Sindh have moved to Karachi, creating social issues, like ethnic tensions and inadequate living conditions. Privacy is a luxury in these settlements."*

Post-floods, there was a rise in diseases such as respiratory infections, watery diarrhea, dengue, malaria, typhoid, scabies, and dermatitis, as well as concerns about leishmaniasis and leptospirosis(Burke et al., 2023). A public health official discussed,

> *"We observed a significant rise in infectious and zoonotic diseases such as diarrhea, malaria, dengue, and leptospirosis after floods, primarily due to contaminated water and stagnant floodwaters. Respiratory infections and tuberculosis also increased due to overcrowding and poor living conditions. Contaminated water further raises the risk of Hepatitis B. These diseases pose major challenges in flood recovery efforts, exacerbated by damaged infrastructure and limited healthcare access."*

Floods damaged health infrastructure, disrupted services, and exacerbated disease prevalence. Effective public health interventions, improved water sanitation, and better infrastructure are urgently needed.

5.1.3 Water, Sanitation, and Hygiene (WASH) Needs

Climate change disrupts the hydrologic cycle, leading to poor WASH access and increased vulnerability to floods and droughts (Abrams et al., 2021). All of the interviewees discussed that

they observed a complete devastation of WASH services during the 2022 floods, leading to a rise in waterborne diseases such as diarrhea, cholera, and typhoid, especially in rural Sindh and Punjab. Poor hygiene and limited water supply further exacerbated health issues. Interviewees discussed that they noticed practices like open defecation. Failing purification centers and polluted water further worsened the situation. An NGO representative stated that,

> *I conducted a study one year after the September 2022 floods, and by September 2023, some areas still had stagnant water. Imagine, after two monsoon seasons, mosquitoes were thriving, and people, including children, were living near and even drinking from those water sources. Livestock like buffaloes and goats were also drinking that contaminated water. The problem in Sindh is that the ground doesn't absorb water well, which is a significant threat.*

Interviewees told that there were also cultural challenges and issues with funding faced by NGOs. Some WASH campaigns included constructing basic facilities and engaging religious leaders as advocacy tools. Measures for protecting water resources have been reinforced, such as placing latrines at least 10 meters away from any water source, as recommended by Sphere standards. However, some of these plans faced dissatisfaction, highlighting issues with systems in disaster response.

Interviewees stressed that there is a need to address sanitation and hygiene needs, particularly in the flood-affected areas, by setting up temporary toilets and filtration plants. These steps are crucial to prevent infections and ensure the availability of safe drinking water. However, efforts are constrained by low budget allocations, poor political will, and administrative bottlenecks. Additionally, the outbreak of the Lumpy Skin Disease Virus (LSDV) in cattle and other livestock highlights the necessity of enhancing existing sanitation measures.

5.1.4 Challenges in Disease Prevention during and after Floods

Poor sanitation and hygiene during floods posed significant challenges to disease prevention, including outbreaks of typhoid fever, diarrhea, and cholera(Abdi & Lohrasbi, 2020). When people were asked, they reported that disease risks in these areas were due to large population displacement and lack of safe shelter, which prevented the development of disease-

preventive environment. Public health officials and epidemiologists revealed that these floods increased disease vulnerability and heightened mortality rates by up to 50% just within a year (Alderman et al., 2012).

Respondents reported that stagnant water increased the breeding of disease-carrying mosquitoes, such as those causing dengue and malaria. Water and poor sanitation were associated with respiratory diseases and dog bites, respectively. Additionally, crowds created by stagnant water limited access to vaccination services, leading to outbreaks of easily preventable diseases like measles. To address these challenges, several steps were deemed crucial: implementing efficient and highly effective flood control measures, introducing effective disease control strategies, building a well-trained workforce with optimal infrastructure and necessary resources for the health sector, and establishing proper training programs. Community mobilization and health promotion, targeting hygiene, immunization, and disease control, are also essential. Cross-cutting responses from health, water and sanitation, disaster response, and the environment are needed. Drills, simulations, and evaluation models were employed for preparation and response.

Disaster reporting also revealed conflicts, particularly between the disaster and health departments, especially during floods. Interruptions in healthcare, vaccine distribution, and antenatal care exacerbated the issue, and often, civil society or relief agencies provided the necessary support. This situation highlighted the importance of integrating the operational activities of disaster management and public health properly.

5.1.5 Socio-economic and Socio-demographic Vulnerabilities

Disaster vulnerability was of significant correlation with poverty, this entailing that flooding was probable to affect vulnerable households' low ability to prevent or mitigate such disasters(Nor Diana & Nurul Atikah, 2023). The existing socio-economic and socio-demographic conditions in Pakistan thereby augmented the hazards relating to climate change-induced floods as well as related diseases. Housing and employment opportunities were scarce, and many people could not afford to move out of poverty-stricken regions or even towns and because of poor healthcare and emergency services, conditions became even worse. Prevention measures were partially understood because health education was not enough; people did not know how to prevent diseases such as malaria through using mosquito nets or chlorinating drinking water. In addition, there was no adequate provision for serving nutritionally and mentally healthful diets and foods,

notably for expectant mothers and kids. One interviewee from an organization for disabled people noted that,

> *"People with disabilities, the elderly, and the transgender community were extremely vulnerable during 2022 floods. They often faced severe neglect and lack of accessibility in evacuation and relief efforts. The disabled and elderly, for instance, were frequently left behind or mishandled due to the lack of proper training and facilities. Similarly, the transgender community faced significant discrimination, making it even harder for them to receive the support they needed. These groups are often ignored in emergency responses, leading to exacerbated suffering and health issues."*

Interviewees shared that the first ones affected where the poor, disabled, children, the elderly, and pregnant women groups in the community. Possible determinants included socio-demographic factors including; household size, education, livelihood diversification and access to emergency response (Kissi et al., 2015). Poor housing conditions, like mud huts, were prone to flooding, while mobility and health issues increased the vulnerability of the elderly and disabled. Transgender individuals faced discrimination and exclusion from assistance, while children suffered from malnutrition due to inadequate resources and socio-economic challenges.

5.1.6 Challenges in Health Surveillance and Infrastructure in Flood-Affected Areas

Respondents said that conditions for health surveillance across the affected regions were inadequate. Some districts lacked basic amenities such as infrastructure, water, and proper sewerage systems, which resulted in many health-related complications. Flooding affected the ability of health facilities to deliver care and function, and restricted health risk monitoring and access to care, presenting a significant threat to the stability of health centers during the floods (Saha, 2023). Hospitals, clinics, and other healthcare infrastructure were scarce, making it arduous to procure data and learn about diseases present in such places. For example, there were cases of acute watery diarrhea due to pathogens such as Salmonella and E. coli. Patients needed to be referred to other districts due to a lack of proper facilities to handle and treat these diseases, not to mention proper documentation.

Interviewees also determined the need for frequent evaluation of the various health risks associated with floods because impacts such as disruptions in health facilities, safe water, sanitation, and transportation made the vulnerable community more fragile.(Tiwari et al., 2022). Poor sewage and drainage affected the health surveillance system in the flood-affected districts, significantly weakening it. This problem interfered with obtaining accurate information about the health status of the population. For example, diseases such as acute watery diarrhea, which were commonly linked to contaminated water, were either not reported at all or poorly handled in areas with weak health systems. There were no local medical resources to deal with the influx of patients, who sought treatment in other districts, thereby distorting the data and undermining positive public health outcomes. Additionally, inadequate reporting mechanisms resulted in a gap between the data collected and the existing health situation. The study unveiled that while significant amounts of data were generated annually regarding disaster impacts and health, little of this information was applied within disaster planning to enhance disaster response.

5.1.7 General Animal Management

Managing animals during floods posed issues that required significant input and preparation to prevent floods from affecting livestock. Due to polluted water, livestock became sick and injured, and without shelter, the animals faced hunger and cold (M. Rahman et al., 2020).

Interviewees explained the situation on the ground; floods were disastrous, having a significant impact on animal management, whereby animals struggled to receive adequate feed and medical attention. This led to problems such as rabies, which particularly affected children. Families living in rural areas where people prioritized their livestock over everything because it is the only source of their livelihood, further increased health risks for the animals. Such conditions triggered the breeding of disease-carrying agents, thereby increasing the occurrence of both human and animal diseases. Floods caused destruction of infrastructure, deterioration of living space and sanitation, and restricted the availability of food and medicine, leading to high death rates among animals.

A livestock expert mentioned that stressed and hungry animals driven out of their shelters had become a nuisance, posing a threat of spreading rabies. Floodwater mixed with animal feces, combined with unhygienic practices, led to deteriorated health, especially where people came into close contact with animals and non-potable water sources, such as in Sindh. Poor diet, low hygiene

standards, and severe diseases had negative implications on the general well-being of the victims, leading to deaths. Addressing these problems required activities in disaster preparedness and protective provisions for animals, as well as preventive measures aimed at promoting people's health.

5.1.8 Multi-Sectoral Collaboration and One Health Approach

Interviewees discussed that there is nearly complete lack of a One Health approach in disaster response, which implies the interconnection of human, animal, and environmental health systems. This strategy is useful in dealing with risks associated with changes in ecosystems in less developed countries' rural areas; however, it lacks coordination.

One interviewee indicated that there was some level of awareness in urban areas, but it was poorly implemented and understood in rural areas due to challenges such as bureaucracy and embezzlement of funds, among others. Because of these dynamics, and to improve disaster response, it is paramount for NGOs, communities, and the government to work together closely.

All interviewees agreed that it is evident that there is a need to adopt multi-sectoral approaches in disaster management, but this is problematic, especially in flood responses. Some recent attempts to overcome these difficulties include the establishment of the National Emergency Operations Center, which was meant to enhance cooperation and coordination among different stakeholders.

Initiatives such as PDMAs and NDMA were established to harmonize responses through consolidation from various actors. However, issues like slow district operations and resource procurement persisted. Disaster management could be enhanced by prepositioned stocks, adequate personnel, and detailed operational guides.

Despite attempts to improve coordination with entities like the NDRCC and the National Disaster Response Coordination Committee, gaps remained. The live dashboard created with the Ministry of Health was a step forward, allowing real-time monitoring of disease outbreaks and improving the treatment of climate-related health risks.

5.1.9 Education and Awareness

Prominent cultural issues and widespread hygiene illiteracy contributed significantly to the spread of diseases, leading to increased cases. In Pakistan, the reception and implementation of

humanitarian aid varied. While Sindh and Punjab were relatively receptive, access and acceptability in KP and Balochistan often posed challenges. In these remote areas, collaborating with local NGOs and maintaining a low profile were frequently necessary.

Other factors affecting health included cultural problems, poverty, and a lack of awareness about health issues beyond disasters and climate change. In some rural populations, extreme poverty led to overcrowding and poor hygiene, with some people living in ditches and in close contact with animals.

Despite preventive guidelines from NDMA and WHO for managing infectious and zoonotic diseases during floods, community attitudes and the use of resources remained problematic. To optimize outcomes, increased community participation through education and local leadership was essential. Improved focus on distribution and tracking of aid, support for livelihood diversification, and addressing infrastructure and health system issues were crucial. In order to build lasting resilience among affected communities it is important to change social behaviors along with involving partners in providing social support. This will help manage vulnerability of people effectively.

5.1.10 NGOs vs Government

Interviews tried to shed light on the differences that exist between NGOs and government agencies in disaster response. They discussed that humanitarian non-governmental organizations (NGOs) such as Concern Worldwide usually perform well in terms of timely response and physical actions. They are able to quickly mobilize and reach areas that require their services, especially rural areas that might otherwise be overlooked. They can easily assemble funds and respond without the hindrances of office or other administrative procedures, which can lead to slow responses.

On the other hand, government agencies are well structured with ample resources and a solid foundation but often face one major stumbling block: bureaucracy and protocol. The distribution of aid can therefore be tedious, mainly due to policy measures and logistics issues. For instance, during floods, the government often receives criticism for the slow response to distribute non-essential commodities like blankets and tents. However, governments are better positioned to coordinate, as they operate on a larger scale and focus on long-term operations, such as providing permanent shelters.

"NGOs can't replace the government. While NGOs like Concern Worldwide acted quickly and prioritized on-ground rescue operations, the government, bogged down by formalities, often faced delays. NGOs bypassed formalities to deliver immediate aid, while the government, despite having more resources, distributed aid slowly and focused more on urban areas. Despite these delays, the government eventually provided substantial support, including the construction of durable homes. However, the government's tendency toward bureaucratic red tape and delays in permissions often hindered timely disaster response efforts."

Interviews revealed that NGOs are good at short-term, ad hoc forms of assistance, namely humanitarian or disaster intervention, whereas government agencies are better suited for a broad continuum of interventions involving large-scale and long-term disbursement. Each sector has its advantages and disadvantages; NGOs, in particular, step in when the government has not adequately addressed certain issues. Although the government may lag in some aspects of flood vulnerabilities, NGOs such as Al-Khidmat have been actively involved in sectors like WASH (water, sanitation, and hygiene) and infrastructural support. These NGOs have been successful in addressing urgent crises and complementing the government's efforts.

Still, NGOs lack effective methods to educate local people on avoiding diseases transmitted through floods. In cases where diseases require integrated management by multiple services, issues such as duplication of services and neglect of cases. NGOs often address diseases like diarrhoea and dysentery only after they have affected populations, rather than focusing on prevention. Additionally, NGOs may lack the capacity to provide preventive services and health promotion, such as immunization, which is typically managed by the public sector. These challenges highlight the need for an integrated approach to disaster response and health promotion.

5.1.11 Policy and response gaps:

From a policy perspective, current government programs addressing health risks associated with floods are often inadequate or delayed. While medical teams do provide essential care for disaster victims, prevention measures are rarely implemented, with most focus placed on managing acute conditions rather than preventing them(Waseem & Rana, 2023).

A disaster management official pointed out another significant shortcoming, that is the lack of specific and institutionalized mechanisms at the district level. Although national and provincial levels have operational systems, the absence of local authorities hampers effective community training and stewardship during spontaneous calamities. Establishing district-level entities, similar to WHO offices, could enhance local capacity to manage the effects of increasingly frequent disasters. A disaster management official quoted,

Floods, exacerbated by climate change, increase the incidence of infectious and zoonotic diseases in Pakistan. This issue is often attributed to low political will and poor governance, which lead to ineffective water resource management and inadequate flood control measures. For instance, prioritizing agricultural land over constructing robust flood management structures results in suboptimal flood water management. Consequently, disease outbreaks are poorly managed due to the lack of comprehensive and operationally relevant policies.

A policy such as Infectious Disease Act got put into action, but it is not proving to be as efficient and effective as it should to halt the spread of the zoonotic diseases caused by floods, because of the lack of resources and improper training of frontline workers. To improve the efficiency of the workers adequate resources and training is mandatory.

5.2 Qualitative Content Analysis

In order to analyze qualitative content to reveal contrast, patterns across and within the categories and codes, Qualitative Content Analysis(QCA) is extensively used in social research (Komor & Grzyb, 2023). Policy documents relevant to disease transmission, climate change and floods were assessed using this method. This was done on the basis of already identified themes and research problems. Floods, public health, socioeconomic, sociodemographic factors and one health interventions were among the selected themes. This method helped a lot in evaluating how policies discussed each theme and provided the idea how these policies can be applied regarding disease transmission and floods. The table below shows which policies which policies discuss the relevant themes:

Table 1: Qualitative Content Analysis of National Policies

Theme	Category	National Climate Change Policy 2012	Disaster Risk Reduction Policy of 2013	National Health Vision of Pakistan 2016-2025	National Water Policy 2018	National Environmental Policy 2005
Impact of Climate-Induced Floods on Public Health	**Health Consequences of Floods**	*Yes*	*No*	*Yes*	*No*	*Implicitly*
	Healthcare System Response	*Somewhat*	*Somewhat*	*Yes*	*No*	*No*
	Environmental Health Risks	*Yes*	*No*	*Yes*	*No*	*Yes*
Incorporation of Socio-economic and Socio-demographic Factors	**Economic Vulnerability**	*Yes*	*Somewhat*	*Yes*	*Implicitly*	*Yes*
	Social Inequities	*Yes*	*No*	*Yes*	*Implicitly*	*Yes*
	Demographic Vulnerability	*Yes*	*No*	*Yes*	*Implicitly*	*Yes*
Integration of One Health Approach	**Human-Animal-Environment Interface**	*No*	*No*	*Yes*	*No*	*Implicitly*
	Cross-Sectoral Collaboration	*Implicitly*	*Implicitly*	*Yes*	*Implicitly*	*Yes*
Policy Recommendations for Flood Management and Health	**Disaster Risk Reduction**	*Yes*	*Yes*	*Somewhat*	*Yes*	*Yes*

	Health Policy Integration	*Yes*	*Somewhat*	*Yes*	*No*	*Yes*
Coordination and Implementation Strategies	**Interagency Coordination**	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
	Implementation Challenges	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*

5.2.1 Impact of Climate-Induced Floods on Public Health

National Climate Change Policy 2012 comprehensively discusses the adverse effects of climate change on human health along with the increasing events of floods. It talks about vector-borne diseases, mental health issues and water borne diseases along with multisectoral interventions. It stresses on insufficient clean water leading to diarrheal diseases, further highlights the risks of increasing motility and injuries. It also discusses depression among people as noted in Nowshera post floods in 2010.

Disaster Risk Reduction Policy 2013 does not explicitly highlight health effects of climate induced floods ut rather focuses on structural and economic implications of disasters. It mentions community risk management and monetary losses due to past floods.

National Health Vision Pakistan 2016-2025 implicitly highlights public health but does not discuss health issues related to floods categorically. Limited clean water, urbanization and increasing health issues during disasters in general is the main argument in this document. It stresses on the betterment of healthcare capacity during emergencies including floods but lacks emphasis on flood's effects on healthcare infrastructure.

National Water Policy 2018 does talk about flood control frameworks community management and early warning systems and mentions flood hazards but does not talk about its impact on public health. It emphasises on provision of clean water and sanitation but its main focus is on water management and flood risks.

National Environmental Policy 2005 addresses general environmental issues related to public health effects but lacks specific discussion on floods. It promotes waste and water

management, hygiene, and public awareness to reduce health risks during floods, indirectly related to flood health impacts.

5.2.2 Incorporation of Socio-economic and Socio-demographic Factors

National Climate Change Policy 2012 emphasizes that poverty and inequalities are crucial socio-economic determinants. Poor people are more affected due to limited resources and dependence on vulnerable industries. It highlights gender disparities, with rural women at greater risk due to social discrimination. The policy also addresses population growth and its impact on poverty, stressing the importance of integrating poverty dimensions into economic decision-making and enhancing community engagement in climate risk management.

National Disaster Risk Reduction Policy 2013 acknowledges the importance of socio-economic and socio-demographic factors in disaster risk management but provides limited detail. It highlights the need to consider these factors in disaster planning, including literacy levels among vulnerable groups and incorporating socio-economic characteristics into land use models. Capacity building should align with community socio-economic conditions.

National Health Vision 2016-2025 Pakistan covers a range of socio-economic and socio-demographic determinants of health, such as illiteracy, employment, gender, and food insecurity. It links urbanization and environmental degradation to health risks, highlighting how poverty and low literacy affect mental health and overall health outcomes.

National Water Policy 2018, while not extensively covering socio-economic and socio-demographic risks, it addresses water deficit issues impacting food and energy security. It notes social tensions from water shortages and supports equitable water distribution to reduce social disparities, though it does not focus deeply on socio-economic issues.

National Environmental Policy 2005 incorporates socio-economic and socio-demographic factors related to environmental problems and poverty. It highlights the severe impact of environmental issues on the poor and recommends grassroots-level interventions. Gender issues are also considered, with a focus on the differential exposure of women to environmental problems. It advocates for developing a National Resettlement Policy to address the socio-economic effects of displacement due to environmental changes or disasters.

5.2.3 Integration of One Health Approach

National Climate Change Policy 2012 policy is one-dimensional and does not include the One Health approach or address animal health. It focuses on the health consequences of climate change for humans but overlooks the interdependence of human, animal, and environmental health. The potential for reducing and mitigating health effects through a One Health perspective is not realized.

National Disaster Risk Reduction Policy 2013 omits the One Health approach and does not consider animal health. The policy addresses disaster prevention and management but fails to integrate the combined effects on human, animal, and environmental health, missing the broader range of health threats provoked by disasters.

National Health Vision Pakistan 2016-2025 incorporates a cross-sectoral approach with key initiatives like "One Health" and "Health in All Policies." It includes activities such as advocacy, planning, and evidence-based decision-making aimed at achieving SDGs. The goal is to enhance core capacities for sustainable development and public health security through strengthened coordination, surveillance, and response mechanisms.

National Water Policy 2018 discusses the impacts of climate change on water availability, crop production, and environmental sustainability. Although these topics intersect with the One Health approach, the policy does not specifically address them in the context of One Health. It focuses on water resource management and environmental measures without explicitly linking them to One Health.

National Environmental Policy 2005 does not explicitly mention the One Health approach but incorporates its principles. The policy addresses environmental health aspects in medical and health care courses, occupational health, waste management, and public health promotion, reflecting a comprehensive view of health effects related to environmental factors.

5.2.4 Policy Recommendations for Flood Management and Health

National Climate Change Policy 2012 recommends hazardous location analysis, building flood-resistant homes, and wastewater treatment to prevent diseases like cholera. It includes multipronged flood mitigation measures such as constructing dams, escape channels, and early

warning systems. The policy also emphasizes community-based flood preparedness and ensuring the protection of endangered persons in evacuation measures.

National Disaster Risk Reduction Policy 2013 does not provide a specific list of recommendations but suggests integrating flood management with health plans. It highlights the importance of community awareness, updating disaster management plans, financial preparedness, and building capacity for managing flood and health emergencies.

National Health Vision Pakistan 2016-2025 offers general guidelines on development on disaster preparedness in healthcare centres and management of health during floods. It talks about the enhancement of the intersectoral collaboration, restoration of health financing systems and mobilization of resources for health interventions related to floods.

National Water Policy 2018 recommends flood management preparedness, forecasting and involvement of communities during prevention and response. This policy emphasises on increasing water storage supplies, constructing flood protection infrastructure and maintenance of natural barriers.

National Environmental Policy 2005 recommends community stewardship of environment, enhancement of drainage systems and proper handling of waste. It stresses on evaluation of risks, improvement of flood control and community preparedness for mitigation of health effects in not only urban but also rural areas too.

5.2.5 Coordination and Implementation Strategies

National Climate Change Policy 2012 suggests enhancement of efficient strategies and coordination for climate change and disaster management. It highlights the need for acknowledging the departmental roles, enough funding for DRRM frameworks, capacity building, enhancement of monitoring and evaluation tools and involvement of communities in early warning systems. It has also encouraged public private partnerships and emphasized the need of strong legal frameworks because they are necessary for good implementation and multisectoral intervention in climate hazard management.

National Disaster Risk Reduction Policy 2013 highlights the need for efficient coordination among federal, provincial, and district disaster management authorities. It supports multi-level planning to align local needs with national and provincial plans, integrates flood management with

health goals, and promotes stakeholder participation through communication and feedback mechanisms. A joint monitoring and evaluation program with provincial governments aims to assess DRR effectiveness and enhance civil-military relations and local resource mobilization.

National Health Vision 2016-2025 focuses on cross-sectoral coordination with health, education, agriculture, and environment. It includes creating disease surveillance systems, effective monitoring and evaluation tied to SDG reporting, and ongoing professional development for health workers. The vision aims to build a responsive health system that addresses emerging health issues and improves overall health outcomes.

National Water Policy 2018 recommends enhanced inter-provincial cooperation, balanced resource allocation, and strengthening of water sector institutions through training and infrastructure development. It emphasizes community involvement and public-private partnerships, data acquisition for water resource assessment, and adherence to Integrated Water Resources Management principles. Legal frameworks for land-use planning and flood zoning are suggested to manage flood risks and build community resilience.

National Environmental Policy 2005 outlines coordination strategies for environmental management, including formulation of an Action Plan by the Ministry of Environment. Provincial and local governments are encouraged to develop region-specific programs, with a National Environment Policy Implementation Committee overseeing policy execution. Stakeholder involvement and periodic evaluation by various committees are key to managing environmental issues effectively.

5.3 GIS Mapping

5.3.1 Geographical hotspots affected by 2022 floods

Data Preparation involved the compilation of the floodwater raster data primarily from NASA, supplemented with district and river boundary shapefiles to enhance analysis efficiency. These data layers were carefully integrated, with spatial layers merged using geospatial techniques to identify flood-affected areas. Flood zonation of the involved districts was then conducted based on reports from the District Disaster Management Authorities (DDMAs). Districts were

categorized into three levels—severely, moderately, and least affected—facilitating the identification of hotspots within flood-prone areas.

Geospatial Analysis involved determination of the spatial extent and distribution of effected areas, so, for that flood water raster data with district and river boundary shapefiles were overlaid. In order to attain a clear graphical representation of flooding, in relation to hydrologic units and administrative regions, these layers were combined by using GIS tools. Patterns of high flood density and risk were revealed by the resulting flood map which highlighted areas most exposed to floods. Districts were classified into three categories: severely, moderately and less effected districts on the basis of ground reports and special analysis which led to flood zonation. Such categorization is very effective in directing response efforts to the most severely effected areas.

Results revealed that coastal areas near the Arabian sea were particularly effected. GIS analysis further revealed that Sindh, Balochistan, KPK and Punjab were effected during 2022 floods. The flood map categorizes districts into three levels of severity: red for severely affected, orange for moderately affected, and yellow for less affected. This visual tool illustrates the impact and vulnerability of these regions, with the most severe flooding occurring in districts close to river boundaries or within floodplains.

Sindh was the worst affected, particularly along the Indus River, resulting in significant loss and damage. Balochistan also faced heavy flooding, especially in its southern and central districts, highlighting the vulnerability of these areas to such disasters(GOP, 2022). While Punjab was not as severely impacted as Sindh and Balochistan, districts near the Indus River experienced considerable flooding. Khyber Pakhtunkhwa saw severe flooding in some districts, though the overall damage was less than in Sindh and Balochistan. The flood map provides a spatial reference for the extent of flooding across districts and river boundaries, clearly depicting geographical patterns that align with known flood-prone areas.

Geographical Patterns showed that, the flood data revealed a clear geographical distribution of flood intensity, with districts bordering rivers, particularly the Indus, experiencing the most severe flooding. This aligns with the typical behaviour of river systems during flood events. Low-lying areas, due to their geographic altitude, also faced significant flooding concerns.

The map clearly depicts these patterns, corroborating previous findings that regions near rivers or with lower altitudes are more susceptible to extensive flood damage.

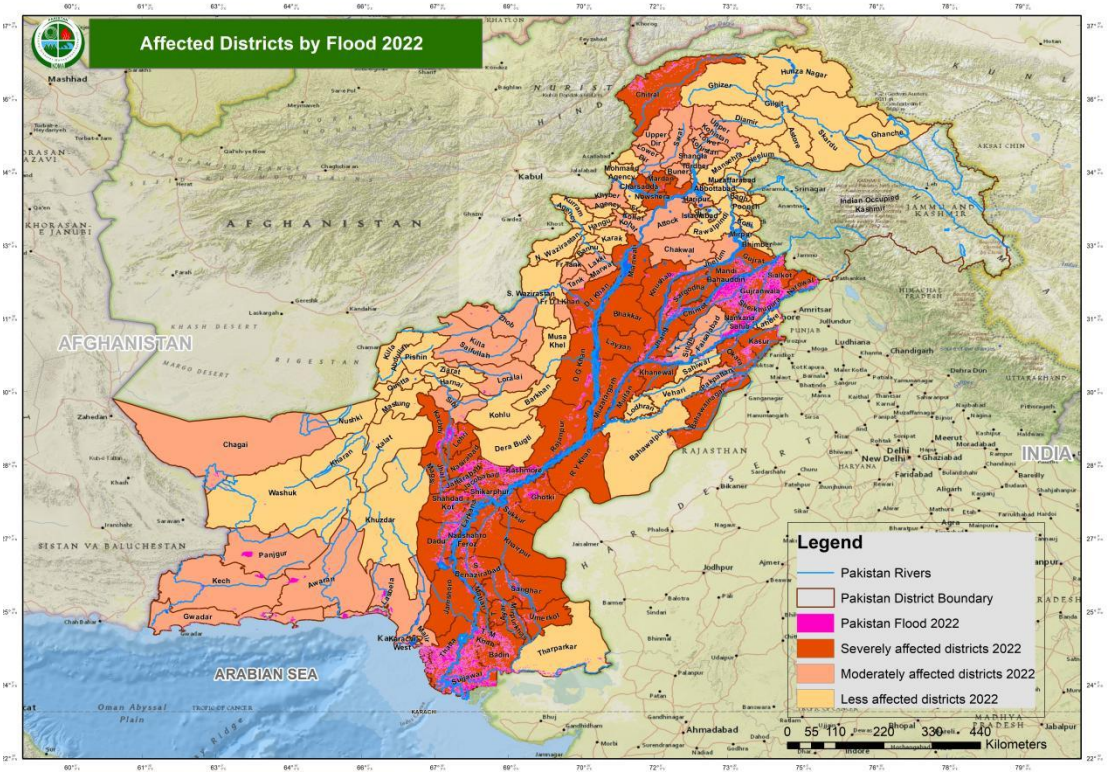

Figure 5: Map of Flood Affected Districts during 2022 Floods in Pakistan. Source: NEOC, NDMA

Implications: Geospatial analysis is crucial for efficient disaster management and response, as it provides essential information for resource distribution and planning(Thomas, 2023). By identifying the worst flood-affected areas, responders can prioritize quick interventions where they are most needed. This analysis highlights the importance of focusing resources on specific local, district, or regional levels that are most impacted by intense floods, thereby improving flood management efforts and community preparedness. The 2022 flood analysis revealed critical insights into the distribution of flood impacts across districts and river boundaries, using satellite imagery combined with shapefiles. This approach not only pinpointed the hardest-hit areas but also supports policy formulation for effective disaster response, ensuring resources are directed to the most vulnerable regions during and after floods.

5.3.2 Geographical hotspots susceptible to diseases during 2022 floods

Data Preparation involved disease data from the National Institute of Health (NIH) for all provinces of Pakistan, except Punjab, and from the District Health Information System (DHIS) for Punjab, was collected for the flood-prone months of June to October 2022. This data highlighted the epidemiological patterns of infectious and zoonotic diseases during the extreme weather events of the 2022 floods. Several key shapefiles were integrated into the GIS framework to map the effects of these floods. District boundary shapefiles provided the necessary geographical context, river boundary shapefiles depicted the river systems and their flood margins, and flood extent shapefiles were obtained from NASA.

Analysis Techniques: Data Integration was the first process in the geospatial analysis where the disease data was combined with the geographic boundaries. Georeferencing of datasets of diseases with district boundary shapefiles was done to view diseases district wise. River boundary layers have enabled the evaluation of the relationship between disease rates and the rivers in the affected areas as well as flood extent to show how flooding may have impacted disease incidences during the year 2022.

Overlay Analysis was used to combine the layers of the district boundaries, the river boundaries and flood extent data on the disease dataset. This enabled definition of districts that had high incidence of the disease and were also vulnerable to floods; making a distinction between higher risk districts.

Choropleth Mapping was used to display the disease vulnerability districts wise. Colour coding was attributed to districts, where districts were shaded according to the disease index, making it easier to compare the levels of disease and the level of risk that comes with them which is important especially for public health measures.

Data Visualization was the last step. Therefore detailed maps which combined the data on disease prevalence, flood extent and the river boundaries using ArcGIS cartography tools were produced. These maps helped in locating districts most affected by diseases and those that received severe flooding; in essence, these maps helped to locate the most appropriate areas in which public health interventions during floods should be directed.

Results revealed Disease Susceptibility Hotspots, geospatial studies made it possible to identify tendencies of disease incidence in 2022 floods; Punjab and KPK are ranked as the most affected provinces. From the choropleth map, high disease incidence was observed in these areas thus implying that there was a relationship between the two – exposure to flood and occurrence of disease. The analysis underlined the necessity of increasing special attention to the furthering of public health for the inhabitants of these districts.

Geographical Patterns were further revealed by showing spatial distribution of disease risk especially in KPK and Punjab where geographical and environmental factors that rendered the regions more susceptible to Infections and Zoonoses in flood months were identified. Sindh and Balochistan provinces were also affected by flood, but there was scarcity of data for these provinces thereby limiting the conclusion of this study. However, those presented a clear implication that health officials should give first priority to districts, which experienced severe flood incidence and were already saddled with high disease incidence rates.

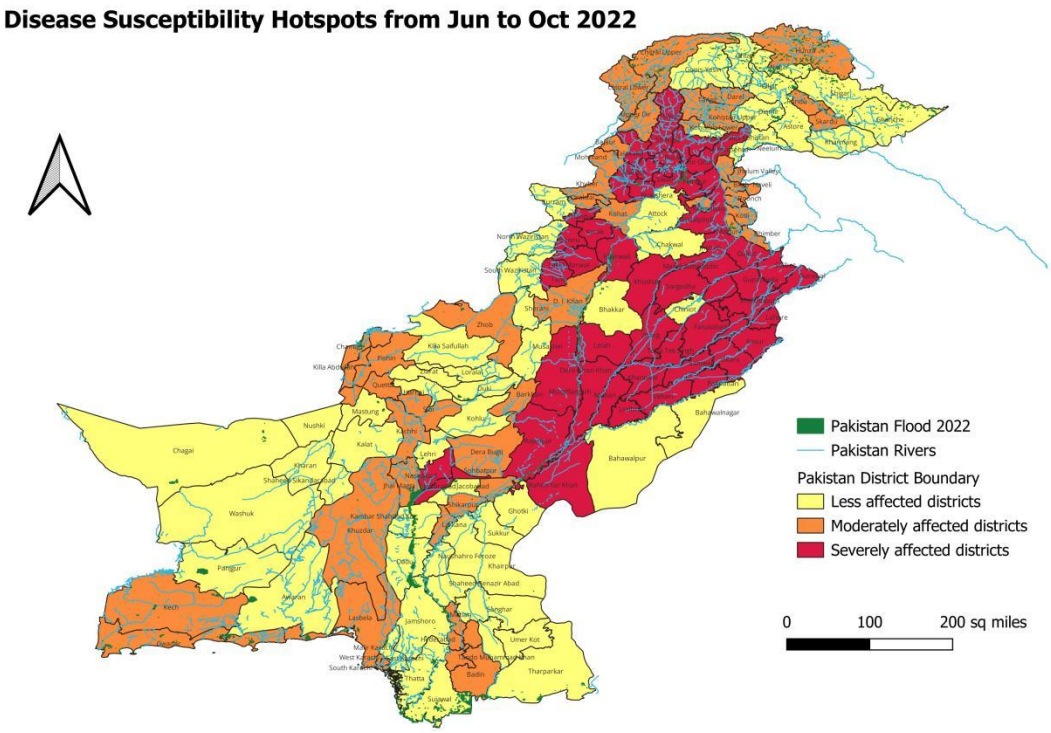

Figure 6: Disease Susceptible Districts during 2022 floods in Pakistan

Implications: Important implication of disease vulnerability mapping using geospatial analysis is on healthcare especially in case of disaster response and humanitarian aid planning(Ortiz, 2019). Pakistan has high infectious disease incidence during floods, which demands control of health risks through certain measures (Raza et al., 2023a). These outcomes help the public health concern to redirect the funds and offer the relevant assistance to the needy areas based on the short term and long-term goals in terms of health improvement(Yasobant et al., 2018). However, this should also be considered as limitation to the data as specified by the respondents in some severely affected districts may not have reported accurately. Still, such challenges did not hinder the effectiveness of ArcGIS cartography in evaluating disease hotspots that occurred during the floods in 2022 in Pakistan, with the choropleth map showing an excellent visual representation of the areas most affected or likely to experience new outbreaks in the future. The outcomes of this evaluation assist the hospitals as well as the public health organizations to make the right decisions for patients and the community at large. Further, issues of data bias and properly incorporating all forms of data into reporting will be critical in advancing the causes of health and disaster management in planning.

5.3.3 Geospatial association between flood intensity and disease outbreaks during 2022 Floods

The disease and flood maps obtained from the floods that occurred in 2022 in Pakistan clearly show a relationship between the level of diseases and the extent of floods in Punjab and Khyber Pakhtunkhwa (KPK). The data of infectious and zoonotic diseases was then overlaid with the maps showing the extent of flood and river boundary for the districts that showed higher rates of disease incidence during flood period. This correlation pointed out certain territories that deemed to be at a higher risk and under great public health threats. The maps show that areas with high flood rates also had increased risks in diseases; therefore, there is a need to increase the effort and devise strategies of handling floods and disease outbreaks in these areas. However, situation on the ground was a little different since it was quite evident that Sindh and Balochistan were highly impacted by floods and diseases, so, data underreporting is a crucial issue for disease surveillance.

CHAPTER 6: DISCUSSION

This chapter provides the findings generated in the course of the thematic analysis of the semi-structured interviews, the qualitative content analysis of the national policy documents released by the government sectors and ministries, as well as the mapping of the flood affected and disease affected areas in 2022. It also discusses the possibilities and limits of managing climate change related disasters like floods, diseases and public health within the framework of Ecosocial theory proposed by Nancy Krieger and One Health approach.

Some of the key themes that came out of the interviews showed various dimensions of vulnerability to communities during climate-induced floods and risk of new infectious and zoonotic diseases were apparent: These themes are associated with social factors, micro and macro level causation factors and health systems accessibility (Short & Mollborn, 2015). From Krieger's Ecosocial theory, it is clear that disease distribution is a function of factors like socio-economic status, a reality that is determined by history and politics. Through interviews, the author confirmed that floods impact was concentrated among the poorer populations, therefore, they were comparatively at a higher risk of getting diseases. By applying the Ecosocial theory formulated by Krieger one can best comprehend the link between sociocultural factors and health behavior (Bhatia et al., 2024).

Issues such as illness, malnutrition, diseases, and lack of necessities such as utensils and clothing affect vulnerable communities including children and the elderly because of poor access to healthcare and poor lifestyle (Das et al., 2023). This is in concordance with Krieger's somatization theory of social injustice; therefore, these groups are marginalized in terms of health. Nancy Krieger has been one of the leading researchers in race/ethnicity and social class factors of health disparities and effects on healthcare(McLafferty & Chakrabarti, 2009).

Another important variable but which came out of the interview is the poor health facilities which is one of the variables that define the high rates of diseases during floods. Almost all affected healthcare facilities either sustained significant damage or became inaccessible, preventing patients from receiving adequate or timely treatment(Alied et al., 2024). The nation's vulnerability to flood disasters is also evident in the significant economic losses and extensive damages caused

by floods (Malik et al., 2023). Krieger's ecosocial theory emphasizes the interactions among biological, social, and ecosystem factors in health disparities(Krieger, 2011). In this context, the damaged infrastructure represents a breakdown in addressing the social determinants of health, leaving some of the impacted populations even more exposed.

The interviews also highlighted aquatic habitats, such as stagnant waters and geographical locations near rivers, as key features contributing to the concentration of disease vectors like mosquitoes and the increased frequency of waterborne diseases(Qamar et al., 2022). Based on the analysis of the extant literature, Krieger's theory underscores the importance of ecological contexts in generating health inequalities(Krieger, 2012). The floods in Pakistan have had far-reaching ramifications, disrupting vaccination campaigns, medicine supply chains, and access to healthcare(I. Ali & Hamid, 2022). The deteriorating environmental conditions in the flood-hit districts not only increase immediate health risks but also challenge the broader strategies required for long-term disease prevention(T. Quinn et al., 2023).

Analysis of national policy documents revealed that country has serious gaps in its national policies to respond to climate change, floods and public health. Even though these policies recognize these problems, but do not fully mainstream the One Health approach, which entails the interconnection of human, animal and environmental (Braam et al., 2023). It means that the systemic injustice is not only a social or political issues, but it can also have biological impacts on people's lives, a phenomenon that has been described as "embodied harm" (Lappé, 2021). This study also showed the divergence of climate change, disaster management and health policies. This fragmentation also makes it difficult to come up with integrated approaches to deal with the diverse issues attributed to climate change such as floods and disease outbreak(Abdullah et al., 2024).

Global One Health concept represents an awareness of integrated cross-disciplinary collaborative approach to such a problem; however, the unity is not strong and there no reference of it in the policies(Yopa et al., 2023). Another emerging issue from the qualitative content analysis is the need to pay more attention to vulnerable groups and animals due to health risks associated with floods. Legislation and policies are rarely designed to accommodate concerns with these minority groups, and this is contrary to One Health or Krieger's Ecosocial analysis. These

frameworks as mentioned earlier state that it is necessary to close gaps where inequalities or ecological perspectives in health exist but the present policies fail to demonstrate it.

An analysis of the flood-affected areas and disease-prone areas as of 2022 floods facilitated the creation of a GIS mapping analysis of vulnerable regions prone to both infectious and zoonotic diseases. Vulnerability and risks of floods can be identified by using remote sensing and GIS tools for mapping the flood prone areas and diseases prone areas (Sajjad et al., 2020; I. Ahmed et al., 2024; Murad & Khashoggi, 2020). In the classification of the provinces, the maps revealed Punjab and Khyber Pakhtunkhwa (KPK) provinces as the most affected since a large number of diseases occurred in the flood period. Swat River Basin in the eastern Hindukush Mountains of Pakistan has been identified as very vulnerable area concerning floods and according to the twenty six percent of that area regarding flood vulnerability the SRB is considered as one of the most vulnerable areas in the country (Z. U. Rahman et al., 2023).

Flood affected areas were also identified in Southern Punjab & Northern Sindh particularly in Jacobabad district which was severely affected by the flood (A. Munir et al., 2022). The choropleth map that has been created on ArcGIS using cartographic tools helped in discerning spatial difference and several district level vulnerability maps pointed towards Punjab and KPK as high-risk areas. These findings provide support for Krieger's Ecosocial theory that posits that place and environment matter to health. It is further noted that distribution of diseases in these areas depends on flood extent and social factors such as access to health care and income levels. Studying disease vulnerability hotspots is crucial for promoting health. The One Health model advocates for population-specific prevention strategies at the human-animal-environment interface. In the identified hotspots, composite public health strategies are needed to address the root causes of disease spread, including improvements in healthcare facilities, surveillance systems, and environmental conditions.

Combining Nancy Krieger's ecosocial theory with the One Health approach provides a robust theoretical foundation for analyzing the relationship between climate-induced floods, communicable diseases, and public health. Krieger's socioecological view of health focuses on the social and ecological contexts of health, while the One Health approach emphasizes interdisciplinary strategies to address health-related challenges. Both frameworks highlight the importance of considering social determinants that increase susceptibility to infections directly

linked to climate change. The themes emerging from this study underline the importance of addressing socioeconomic disparities as determinants of disease outcomes, echoing McQueen's call for policies and interventions that reduce social disparities.

The knowledge gaps identified through the qualitative analysis underscore the need to mainstream the One Health approach at the national level. More effective prevention of health threats requires improved intersectoral collaboration and the recognition of cross-cutting human-animal-environmental health mechanisms in responding to the effects of climate change-induced floods.

The findings from GIS mapping highlight the potential for improving disaster risk management in densely populated and disease-prone areas. According to the ecosocial theory, improving social and environmental conditions is essential to reducing health inequalities. The One Health approach, which emphasizes collaboration between medical professionals, veterinarians, and ecologists, advocates for interventions that are both medically effective and socially and environmentally responsible. Moreover, the importance of the One Health concept and public-private partnerships in eliminating zoonotic diseases in Pakistan is highlighted in a recent review (Yasmeen et al., 2022b). The implications of these developments for disease vulnerability during climate-induced floods are discussed in the critical context of both Nancy Krieger's ecosocial theory and the One Health approach. Interventions that incorporate social determinants, ecological perspectives, and interdisciplinary approaches can effectively protect high-risk groups from future climate-related health threats.

6.1 Limitations

Several limitations were encountered in this study. There was poor data representation, particularly from highly affected districts. Disease data from most provinces were collected from NIH, but data from Punjab were obtained from DHIS, potentially causing disparities in data quality and adequacy. Underreporting during the flood period might also impact the identified disease hotspots. The study used data from June to October 2022, the flood months, but diseases can take time to manifest. Thus, the study may not have captured epidemics occurring after the floods or long-term health effects. The GIS analysis used flood extent, river boundary, and district boundary shapefiles, along with a flood extent image from NASA. The quality of these data and the resolution of shapefiles may have affected the vulnerability maps' detail. The thematic and

qualitative content analysis, while rigorous, involves interpretive bias inherent to qualitative research. The absence of comprehensive public policies to combat climate change, floods, and public health limits the ability to evaluate existing policies' effectiveness in minimizing flood-related health impacts. Although the One Health approach was used theoretically, its sparse application in policy and public health interventions is a significant gap.

CHAPTER 7: CONCLUSIONS AND FUTURE RECOMMENDATION

The study of the relationship between climate-induced floods and the spread of infectious and zoonotic diseases in Pakistan clearly shows that it is a complex relationship and necessitates integrated, dynamic health approaches to address such natural disasters. This research has established that climate change, especially through floods, enhances the occurrence of both infectious and zoonotic diseases, particularly in the flood-prone areas of Punjab and Khyber Pakhtunkhwa. GIS mapping also reveals flood-disease interaction hot zones, demonstrating that targeted preventive measures should be implemented in these regions.

The communities exposed to flooding are characterized by poverty, low income, limited resources, poor education, low literacy levels, inadequate infrastructure, and insufficient healthcare. These conditions not only contribute to immediate public health consequences during floods but also impact the long-term health of vulnerable communities. Addressing these factors and integrating them into flood management and health policies can significantly enhance community resilience and reduce disease incidence.

There is evidence of gaps in the alignment of policies and procedures related to disaster management and health sector responses. Given the advancement of global warming, there is a need to promote the One Health concept, which emphasizes the interconnectedness of human, animal, and environmental health. Improved organization and coordination among government stakeholders and local communities are required to effectively respond to both flooding and disease outbreaks.

Therefore, addressing the dual risks of climate-induced flooding and infectious diseases calls for a multi-sectoral approach that integrates climate change policies, measures, and public health interventions. By triangulating the study's results through geospatial and policy analysis, interviews, and a focus on vulnerable populations, this research provides valuable practical implications for enhancing health and disaster management in Pakistan.

Recommendations for future research and practice include improving health/disease surveillance during natural disasters with real-time reporting and standardized data formats to refine vulnerability measures. Future research should use large sample sizes and assess disease

incidence at various times to capture long-term flood effects on health. Employing higher-resolution GIS techniques, such as remote sensing and AI, can improve vulnerability mapping accuracy. Including environmental, social, and economic factors in GIS analysis provides a broader understanding of disease causes during climate events. Strengthening the connection between climate change, disaster, and public health policies would improve inter-sectoral coordination and health outcomes. Translating the One Health approach into real policy and intervention strategies is essential, emphasizing cross-sectoral collaboration, strengthening public health systems, and involving marginalized groups in disease prevention. Enhancing community resilience in identified disease vulnerability areas through interventions targeting health inequalities, education, and economic productivity is important. Increasing public awareness and preventive measures against flood-related health risks, tailored to specific social classes or demographics, is also crucial.

REFERENCES

Abdi, M., & Lohrasbi, V. (2020). Challenges and successes in the prevention and control of infectious diseases after March and April 2019 floods in Iran. *Infection Control and Hospital Epidemiology*, *41*(1), 130–131. https://doi.org/10.1017/ice.2019.311

Abdullah, M. A., Shaikh, B. T., Sikander, A., & Sarwar, B. (2024). Public Health and Health System's Responsiveness During the 2022 Floods in Pakistan: What Needs to Be Done? *Disaster Medicine and Public Health Preparedness*, *17*, e567. https://doi.org/DOI: 10.1017/dmp.2023.224

Abebe, E., Gugsa, G., & Ahmed, M. (2020). Review on Major Food-Borne Zoonotic Bacterial Pathogens. *Journal of Tropical Medicine*. https://doi.org/10.1155/2020/4674235

Abrams, A., Carden, K., Teta, C., & Wågsæther, K. (2021). Water, Sanitation, and Hygiene Vulnerability Among Rural Areas and Small Towns in South Africa: Exploring the Role of Climate Change, Marginalization, and Inequality. *Water*, *13*(20), 2810. https://doi.org/10.3390/w13202810

Adelekan, I. (2010). Vulnerability Assessment of an Urban Flood in Nigeria: Abeokuta Flood 2007. *Natural Hazards*. https://doi.org/10.1007/s11069-010-9564-z

Aguirre, A. A. (2017). Changing patterns of emerging zoonotic diseases in wildlife, domestic animals, and humans linked to biodiversity loss and globalization. *ILAR Journal*, *58*(3), 315–318. https://doi.org/10.1093/ilar/ilx035

Ahern, M., Kovats, S., Wilkinson, P., Few, R., & Matthies, F. (2005). Global Health Impacts of Floods: Epidemiologic Evidence. *Epidemiologic Reviews*. https://doi.org/10.1093/epirev/mxi004

Ahmad, D., & Afzal, M. (2022). Flood hazards and agricultural production risks management practices in flood-prone areas of Punjab, Pakistan. *Environmental Science and Pollution Research International*, *29*(14), 20768–20783. https://doi.org/10.1007/s11356-021-17182-2

Ahmad, D., Kanwal, M., & Afzal, M. (2023). Climate change effects on riverbank erosion Bait

community flood-prone area of Punjab, Pakistan: an application of livelihood vulnerability index. *Environment, Development and Sustainability*, *25*(9), 9387–9415. https://doi.org/10.1007/s10668-022-02440-1

Ahmad, R., & Javed, T. (2022). Chikungunya Outbreak in Pakistan; Optimal Control, and Management Prevention. *The Journal of Microbiology and Molecular Genetics*. https://doi.org/10.52700/jmmg.v3i3.71

Ahmed, H., Ali, S., Afzal, M. S., Khan, A. A., Raza, H., Shah, Z. H., & Simsek, S. (2017). Why more research needs to be done on echinococcosis in Pakistan. *Infectious Diseases of Poverty*, *6*(1), 90. https://doi.org/10.1186/s40249-017-0309-z

Ahmed, I., Das (Pan), N., Debnath, J., Bhowmik, M., & Bhattacharjee, S. (2024). Flood hazard zonation using GIS-based multi-parametric Analytical Hierarchy Process. *Geosystems and Geoenvironment*, *3*(2), 100250. https://doi.org/https://doi.org/10.1016/j.geogeo.2023.100250

Albrecht, G., Higginbotham, N., Connor, L., & Freeman, S. (2008). Social and cultural perspectives on eco-health. In S. Quah (Ed.), *International Encyclopedia of Public Health* (pp. 57–63). Academic Press. https://doi.org/10.1016/B978-012373960-5.00512-8

Alderman, K., Turner, L. R., & Tong, S. (2012). Floods and human health: A systematic review. *Environment International*, *47*, 37–47. https://doi.org/https://doi.org/10.1016/j.envint.2012.06.003

Ali, I., & Hamid, S. (2022). Implications of COVID-19 and "super floods" for routine vaccination in Pakistan: The reemergence of vaccine preventable-diseases such as polio and measles. *Human Vaccines & Immunotherapeutics*, *18*(7), 2154099. https://doi.org/10.1080/21645515.2022.2154099

Ali, M., Farhat, S. M., Saeed, R. F., Amraiz, D., Mehmood, S., & Akbar, S. (2021). Climate beast: A potential threat for repercussions of disease status in Pakistan. *Reviews on Environmental Health*, *36*(2), 177–183. https://doi.org/10.1515/reveh-2020-0108

Ali, S., Liu, Y., Ishaq, M., Shah, T., Abdullah, Ilyas, A., & Din, I. U. (2017). Climate Change and Its Impact on the Yield of Major Food Crops: Evidence from Pakistan. In *Foods* (Vol. 6, Issue 6). https://doi.org/10.3390/foods6060039

Ali, S., Metlo, M., Ahmed, Z., Ali, S., Ahmed, S., Zafar, N., Latif, N., & Jamal, N. (2023). Prevalence of Water Borne Diseases in Flood Affected Areas of District Khairpur Mirs, Pakistan. *Pakistan Journal of Medical & Health Sciences*, *17*(03), 599. https://doi.org/10.53350/pjmhs2023173599

Ali, S. U., Shabbir, N. Z., Ali, U., & Abbasi, A. (2023). *Rise in Skin Diseases, as the Torrential Flood Water Recedes Is a State of Humanitarian Emergency*. https://doi.org/10.22541/au.167347082.20148579/v1

Alied, M., Salam, A., Sediqi, S. M., Kwaah, P. A., Tran, L., & Huy, N. T. (2024). Disaster after disaster: the outbreak of infectious diseases in Pakistan in the wake of 2022 floods. *Annals of Medicine and Surgery (2012)*, *86*(2), 891–898. https://doi.org/10.1097/MS9.0000000000001597

Alifu, H., Hirabayashi, Y., Imada, Y., & Shiogama, H. (2022). Enhancement of river flooding due to global warming. *Scientific Reports*, *12*(1), 20687. https://doi.org/10.1038/s41598-022-25182-6

Altizer, S., Ostfeld, R. S., Johnson, P. T. J., Kutz, S., & Harvell, C. D. (2013). Climate Change and Infectious Diseases: From Evidence to a Predictive Framework. *Science*. https://doi.org/10.1126/science.1239401

Anas, A., Sathyendranath, S., Vijayakumar, S. K., Menon, N., George, G., Kulk, G., Raj, D., Krishna, K. S., Rajamohananpillai, R., Tharakan, B., Corso, J., Vengalil, J., & Platt, T. (2023). The Distribution of Fecal Contamination in an Urbanized Tropical Lake and Incidence of Acute Diarrheal Disease. *Acs Es&t Water*. https://doi.org/10.1021/acsestwater.2c00255

Anthony, R., & De Paula Vieira, A. (2022). One Health Animal Disaster Management: An Ethics of Care Approach. *Journal of Applied Animal Welfare Science*, *25*(2), 180–194. https://doi.org/10.1080/10888705.2022.2040360

Arbo, A., Sanabria, G., & Martínez, C. (2022). Influence of Climate Change on Vector-Borne Diseases. *Revista Del Instituto de Medicina Tropical*, *17*(2), 23–36. https://doi.org/10.18004/imt/2022.17.2.4

Arnell, N. W., & Gosling, S. N. (2016). The impacts of climate change on river flood risk at the

global scale. *Climatic Change*, *134*(3), 387–401. https://doi.org/10.1007/s10584-014-1084-5

Asaaga, F. A., Rahman, M., Kalegowda, S. D., Mathapati, J., Savanur, I., Srinivas, P. N., Seshadri, T., Narayanswamy, D., Kiran, S. K., Oommen, M. A., Young, J., & Purse, B. V. (2021). 'None of My Ancestors Ever Discussed This Disease Before!' How Disease Information Shapes Adaptive Capacity of Marginalised Rural Populations in India. *Plos Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0009265

Ashraf, I., Ahmad, S. R., Ashraf, U., & Khan, M. (2023). Community perspectives to improve flood management and socio-economic impacts of floods at Central Indus River, Pakistan. *International Journal of Disaster Risk Reduction*, *92*, 103718. https://doi.org/https://doi.org/10.1016/j.ijdrr.2023.103718

Ayala, R. G., & Estrugo, A. (2014). Assessing the Effects of Climate and Socioeconomic Factors on Vulnerability to Vector-Borne Diseases in Latin America. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2533567

Babanawo, D., Mattah, P. A. D., Agblorti, S. K. M., & Aheto, D. W. (2023). Perspectives on factors that influence local communities' vulnerability to coastal floods in Ketu South Municipality of Ghana. *International Journal of Disaster Risk Reduction*, *90*, 103646. https://doi.org/https://doi.org/10.1016/j.ijdrr.2023.103646

Bambra, C. (2022). Pandemic inequalities: emerging infectious diseases and health equity. *International Journal for Equity in Health*, *21*(1), 6. https://doi.org/10.1186/s12939-021-01611-2

Bank, U. V. partnering with the W. (2023). *Building resilience to extreme weather events in Pakistan*. https://www.unv.org/Success-stories/building-resilience-extreme-weather-events-pakistan

Baqir, M., Sobani, Z. A., Bhamani, A., Bham, N. S., Abid, S., Farook, J., & Beg, M. A. (2012). Infectious Diseases in the Aftermath of Monsoon Flooding in Pakistan. *Asian Pacific Journal of Tropical Biomedicine*. https://doi.org/10.1016/s2221-1691(11)60194-9

Bartlow, A. W., Manore, C., Xu, C., Kaufeld, K., Valle, S. Del, Ziemann, A., Fairchild, G., & Fair, J. M. (2019). Forecasting Zoonotic Infectious Disease Response to Climate Change:

Mosquito Vectors and a Changing Environment. *Veterinary Sciences*. https://doi.org/10.3390/vetsci6020040

Bassett, M. T., Chen, J. T., & Krieger, N. (2020). Variation in racial/ethnic disparities in COVID-19 mortality by age in the United States: A cross-sectional study. *PLOS Medicine*, *17*(10), 1–14. https://doi.org/10.1371/journal.pmed.1003402

Bett, B., Tumusiime, D., Lindahl, J., Roesel, K., & Delia, G. (2022). *The Role of Floods on Pathogen Dispersion BT - Nature-Based Solutions for Flood Mitigation: Environmental and Socio-Economic Aspects* (C. S. S. Ferreira, Z. Kalantari, T. Hartmann, & P. Pereira (eds.); pp. 139–157). Springer International Publishing. https://doi.org/10.1007/698_2021_761

Bhatia, K., Intezar, H., & Akhtar, P. (2024). Cultural Hierarchies in Health: Does Inherited Sociocultural Position (Biraderi) Shape Diet and Nutrition Among British Pakistani Children? Protocol for a Mixed-Methods Study. *Plos One*, *19*(6), e0305556. https://doi.org/10.1371/journal.pone.0305556

Bokhari, H., Shah, M. A., Asad, S., Akhtar, S., Akram, M., & Wren, B. W. (2013). Escherichia coli Pathotypes in Pakistan from Consecutive Floods in 2010 and 2011. *The American Journal of Tropical Medicine and Hygiene*, *88*(3), 519–525. https://doi.org/10.4269/ajtmh.12-0365

Bostan, N., Javed, S., Nabgha-E-Amen, Eqani, S. A. M. A. S., Tahir, F., & Bokhari, H. (2017). Dengue fever virus in Pakistan: effects of seasonal pattern and temperature change on distribution of vector and virus. *Reviews in Medical Virology*, *27*(1). https://doi.org/10.1002/rmv.1899

Braam, D. H. (2022). Zoonoses in the margins: environmental displacement and health outcomes in the Indus Delta. *International Journal for Equity in Health*, *21*(1), 1–13. https://doi.org/10.1186/s12939-022-01823-0

Braam, D. H., Chandio, R., Jephcott, F. L., Tasker, A., & Wood, J. L. N. (2021). Disaster displacement and zoonotic disease dynamics: The impact of structural and chronic drivers in Sindh, Pakistan. *PLOS Global Public Health*, *1*(12), e0000068. https://doi.org/10.1371/journal.pgph.0000068

Braam, D. H., Jephcott, F. L., & Wood, J. L. N. (2021a). Identifying the research gap of zoonotic

disease in displacement: a systematic review. *Global Health Research and Policy*, *6*(1), 25. https://doi.org/10.1186/s41256-021-00205-3

Braam, D. H., Jephcott, F. L., & Wood, J. L. N. (2021b). Identifying the research gap of zoonotic disease in displacement: a systematic review. *Global Health Research and Policy*, *6*(1). https://doi.org/10.1186/s41256-021-00205-3

Braam, D. H., Tasker, A., Parravani, E., & Saville, K. (2023). A fair share? Animal health actors and resources in One Health initiatives: A multisite case study in Ethiopia and Pakistan. *CABI One Health*. https://doi.org/10.1079/cabionehealth.2023.0015

Braveman, P., Egerter, S., & Williams, D. R. (2011). The social determinants of health: coming of age. *Annual Review of Public Health*, *32*, 381–398. https://doi.org/10.1146/annurev-publhealth-031210-101218

Burke, S., Saccoccia, L., Schmeier, S., Faizee, M., & Chertock, M. (2023). Pakistan: {How} floods threaten global security {\textbar} {PreventionWeb}. In *UNDRR Prevention Web*. https://www.preventionweb.net/news/how-floods-pakistan-threaten-global-security

Cao, B., Bai, C., Wu, K., La, T., Su, Y., Che, L., Zhang, M., Lu, Y., Gao, P., Yang, J., Xue, Y., & Li, G. (2023). Tracing the future of epidemics: Coincident niche distribution of host animals and disease incidence revealed climate-correlated risk shifts of main zoonotic diseases in China. *Global Change Biology*, *29*(13), 3723–3746. https://doi.org/https://doi.org/10.1111/gcb.16708

CDC. (2019). *One Health | What We Do | NCEZID | CDC*. https://archive.cdc.gov/www_cdc_gov/ncezid/what-we-do/2018-highlights/one-health.html

Charak, A., Ravi, K., & Verma, A. (2024). Review of Various Climate Change Exacerbated Natural Hazards in India and Consequential Socioeconomic Vulnerabilities. *IDRiM Journal*, *13*(2), 142–177. https://doi.org/10.5595/001c.92642

Chitre, S. D., Crews, C. M., Tessema, M. T., Plėštytė-Būtienė, I., Coffee, M., & Richardson, E. T. (2024). The impact of anthropogenic climate change on pediatric viral diseases. *Pediatric Research*, *95*(2), 496–507. https://doi.org/10.1038/s41390-023-02929-z

CHOI, E. (2022). The Need for a One Health Approach to Health Care. *Korean Journal of Medical*

Ethics, *25*(1), 43–57. https://doi.org/10.35301/ksme.2022.25.1.43

Chowdhury, S., Aleem, M. A., Khan, M. S. I., Hossain, M. E., Ghosh, S., & Rahman, M. Z. (2021). Major zoonotic diseases of public health importance in Bangladesh. *Veterinary Medicine and Science*, *7*(4), 1199–1210. https://doi.org/https://doi.org/10.1002/vms3.465

Cissé, G. (2019). Food-borne and water-borne diseases under climate change in low- and middle-income countries: Further efforts needed for reducing environmental health exposure risks. *Acta Tropica*, *194*(March), 181–188. https://doi.org/10.1016/j.actatropica.2019.03.012

Coalson, J. E., Anderson, E. J., Santos, E. M., Garcia, V. M., Romine, J. K., Dominguez, B., Richard, D., Little, A. C., Hayden, M. H., & Ernst, K. C. (2021). The Complex Epidemiological Relationship Between Flooding Events and Human Outbreaks of Mosquito-Borne Diseases: A Scoping Review. *Environmental Health Perspectives*. https://doi.org/10.1289/ehp8887

Conde, E., & Gorman, D. M. (2009). Krieger's conceptualization and measurement of discrimination and internalized oppression in studies of adverse health outcomes. *GeoJournal*, *74*(2), 131–142. https://doi.org/10.1007/s10708-009-9262-0

Das, J. K., Siddiqui, F., Padhani, Z. A., Khan, M. H., Jabeen, S., Mirani, M., Mughal, S., Baloch, S., Sheikh, I., Khatoon, S., Muhammad, K., Gangwani, M., Nathani, K., Salam, R. A., & Bhutta, Z. A. (2023). Health behaviors and care seeking practices for childhood diarrhea and pneumonia in a rural district of Pakistan: A qualitative study. *PloS One*, *18*(5), e0285868. https://doi.org/10.1371/journal.pone.0285868

Deem, S. L., & Brenn-White, M. (2020). One Health—the Key to Preventing COVID-19 From Becoming the New Normal. *Molecular Frontiers Journal*. https://doi.org/10.1142/s2529732520400039

Deepak, S., Rajan, G., & Jairaj, P. G. (2020). Geospatial Approach for Assessment of Vulnerability to Flood in Local Self Governments. *Geoenvironmental Disasters*. https://doi.org/10.1186/s40677-020-00172-w

Ding, G., Li, X., Li, X., Zhang, B., Jiang, B., Liu, D., Xing, W., Liu, Q., Liu, X., & Hou, H. (2019). A Time-Trend Ecological Study for Identifying Flood-Sensitive Infectious Diseases in

Guangxi, China From 2005 to 2012. *Environmental Research*. https://doi.org/10.1016/j.envres.2019.108577

Durodola, O. S. (2019). The Impact of Climate Change Induced Extreme Events on Agriculture and Food Security: A Review on Nigeria. *Agricultural Sciences*, *10*(04), 487–498. https://doi.org/10.4236/as.2019.104038

Erkyihun, G. A., & Alemayehu, M. B. (2022). One Health Approach for the Control of Zoonotic Diseases. *Zoonoses (Ireland)*, *2*(1). https://doi.org/10.15212/ZOONOSES-2022-0037

Esmaeilnejad, M., Bazrafshan, E., & Ansari-Moghaddam, A. (2018). Effect of Climatic Changes on Spatial Distribution of Zoonoses: A Case Study From South Khorasan Province, Iran. *Health Scope*. https://doi.org/10.5812/jhealthscope.56045

Esteve-Gassent, M. D., León, A. A. P. de, Romero-Salas, D., Feria-Arroyo, T. P., Patino, R., Castro-Arellano, I., Gordillo-Pérez, G., Auclair, A. N. D., Goolsby, J. A., Rodríguez-Vivas, R. I., & Estrada-Franco, J. G. (2014). Pathogenic Landscape of Transboundary Zoonotic Diseases in the Mexicoâ€“US Border Along the Rio Grande. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2014.00177

Farah, N., Siddiqui, S., Afzal, S., Khan, M. I., & Afzal, A. (2023). Health Impacts Of Flood Disasters: An Evidence From Pakistan. *Journal of Positive School Psychology* , *2023*(4), 935–943. https://journalppw.com/index.php/jpsp/article/view/16462

Filho, W. L., Ternova, L., Parasnis, S. A., Kovaleva, M., & Nagy, G. J. (2022). Climate Change and Zoonoses: A Review of Concepts, Definitions, and Bibliometrics. *International Journal of Environmental Research and Public Health*, *19*. https://api.semanticscholar.org/CorpusID:245980439

GOP. (2022). Pakistan Monsoon Floods 2022 (Post-Disaster Needs Assessment). *Financial Tracking Service- UNOCHA, 2022. "Pakistan Floods Relief Plan." Https://Fts.Unocha.Org/Multiyear/2313/Summary ExecutIVe*, *September*, 1–7.

Ha, K. M. (2024). Reexamining the issue of wild animals in disaster management. *Journal of Applied Animal Research*, *52*(1). https://doi.org/10.1080/09712119.2023.2295459

Halima, I. E., & Shirakawa, H. (2022). Assessing the Disparities of the Population Exposed to

Flood Hazards in Nigeria. *Iop Conference Series Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/1016/1/012007

Hamidi, A. R., Jing, L., Shahab, M., Azam, K., Tariq, M. A. U. R., & Ng, A. W. M. (2022). Flood Exposure and Social Vulnerability Analysis in Rural Areas of Developing Countries: An Empirical Study of Charsadda District, Pakistan. *Water (Switzerland)*, *14*(7). https://doi.org/10.3390/w14071176

Hanage, W. P., Testa, C., Chen, J. T., Davis, L., Pechter, E., Seminario, P., Santillana, M., & Krieger, N. (2020). COVID-19: US federal accountability for entry, spread, and inequities-lessons for the future. *European Journal of Epidemiology*, *35*(11), 995–1006. https://doi.org/10.1007/s10654-020-00689-2

Hasan, S. M., Anisha, A. M., Adnin, R., Eliza, I. J., Tarin, I., Afroz, S., & Islam, A. B. M. A. Al. (2022). Revealing Influences of Socioeconomic Factors over Disease Outbreaks. *Proceedings of the 5th ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies*, 490–512. https://doi.org/10.1145/3530190.3534804

Hassall, R., Burthe, S. J., Schäfer, S., Hartemink, N., & Purse, B. V. (2023). Using Mechanistic Models to Highlight Research Priorities for Tick-Borne Zoonotic Diseases: Improving Our Understanding of the Ecology and Maintenance of Kyasanur Forest Disease in India. *Plos Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0011300

Hathaway, J., & Maibach, E. W. (2018). Health Implications of Climate Change: a Review of the Literature About the Perception of the Public and Health Professionals. *Current Environmental Health Reports*, *5*(1), 197–204. https://doi.org/10.1007/s40572-018-0190-3

Hayman, D. T. S., Adisasmito, W. B., Almuhairi, S., Behravesh, C. B., Bilivogui, P., Bukachi, S. A., Casas, N., Becerra, N. C., Charron, D. F., Chaudhary, A., Ciacci Zanella, J. R., Cunningham, A. A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G. F., Khaitsa, M., Machalaba, C., … Koopmans, M. (2023). Developing One Health surveillance systems. *One Health*, *17*(August). https://doi.org/10.1016/j.onehlt.2023.100617

Heath, S. E., & Linnabary, R. D. (2015). Challenges of managing animals in disasters in the U.S. *Animals*, *5*(2), 173–192. https://doi.org/10.3390/ani5020173

Hjerpe, M., & Glaas, E. (2011). Evolving Local Climate Adaptation Strategies: Incorporating Influences of Socio–economic Stress. *Mitigation and Adaptation Strategies for Global Change*. https://doi.org/10.1007/s11027-011-9337-3

Holloway, S. W. (2022). *Infectious Diseases*. https://doi.org/10.1201/9781003254591-ch_21

Horefti, E. (2023). The Importance of the One Health Concept in Combating Zoonoses. *Pathogens*, *12*(8). https://doi.org/10.3390/pathogens12080977

Hörman, A., Rimhanen-Finne, R., Maunula, L., Bonsdorff, C.-H. von, Torvela, N., Heikinheimo, A., & Hänninen, M. (2004). <i>Campylobacter</I> Spp. <i>, Giardia</I> Spp. <i>, Cryptosporidium</I> Spp., Noroviruses, and Indicator Organisms in Surface Water in Southwestern Finland, 2000-2001. *Applied and Environmental Microbiology*. https://doi.org/10.1128/aem.70.1.87-95.2004

Hossain, B., Shi, G., Ajiang, C., Sohel, M. S., & Yijun, L. (2023). Social vulnerability, impacts and adaptations strategies in the face of natural hazards: insight from riverine islands of Bangladesh. *BMC Public Health*, *23*(1), 1737. https://doi.org/10.1186/s12889-023-16497-8

Hossain, B., Sohel, M. S., & Ryakitimbo, C. M. (2020). Climate change induced extreme flood disaster in Bangladesh: Implications on people's livelihoods in the Char Village and their coping mechanisms. *Progress in Disaster Science*, *6*, 100079. https://doi.org/https://doi.org/10.1016/j.pdisas.2020.100079

Houghton, A., & Castillo-Salgado, C. (2017). Health Co-Benefits of Green Building Design Strategies and Community Resilience to Urban Flooding: A Systematic Review of the Evidence. *International Journal of Environmental Research and Public Health*, *14*(12). https://doi.org/10.3390/ijerph14121519

Index, G. H. S. (2021). Pakistan. In *GHS Index*. https://ghsindex.org/country/pakistan/

Iqbal, A., Sheikh, A., Ali, E., & Islam, Z. (2023). Impact of prolonged flooding in Pakistan: In the middle of unexpected health emergency. In *The International journal of health planning and management* (Vol. 38, Issue 2, pp. 536–540). https://doi.org/10.1002/hpm.3604

Iqbal, M., Fatmi, Z., & Khan, M. A. (2020). Brucellosis in Pakistan: a neglected zoonotic disease. *Journal of the Pakistan Medical Association*, *70*(9), 1625–1626.

https://doi.org/10.5455/JPMA.24139

Islam, M. M. M., Hofstra, N., & Islam, M. A. (2017). The Impact of Environmental Variables on Faecal Indicator Bacteria in the Betna River Basin, Bangladesh. *Environmental Processes*, *4*(2), 319–332. https://doi.org/10.1007/s40710-017-0239-6

Islam, M. T., Brooks, A. A., Kabir, M. M., Jahid, I. K., Islam, M., Goswami, D., Nair, G. B., Larson, C. P., Yukiko, W., & Luby, S. P. (2007). Faecal Contamination of Drinking Water Sources of Dhaka City During the 2004 Flood in Bangladesh and Use of Disinfectants for Water Treatment. *Journal of Applied Microbiology*. https://doi.org/10.1111/j.1365-2672.2006.03234.x

Jabeen, A., Ansari, J. A., Ikram, A., Khan, M. A., & Safdar, M. (2022). Impact of climate change on the epidemiology of vector-borne diseases in Pakistan. *Global Biosecurity*. https://doi.org/10.31646/gbio.163

Kain, M. P., Skinner, E. B., Hurk, A. F. van den, McCallum, H., & Mordecai, E. A. (2021). Physiology and Ecology Combine to Determine Host and Vector Importance for Ross River Virus. *Elife*. https://doi.org/10.7554/elife.67018

Kalawat, U., & Mohan, A. (2023). Endemic, emerging and re-emerging zoonotic diseases: The way forward! *Journal of Clinical and Scientific Research*, *12*(2). https://journals.lww.com/jcsr/fulltext/2023/12020/endemic,_emerging_and_re_emerging_zoonotic.1.aspx

Kanki, P. J. (2013). *Infectious Diseases, Introduction BT - Infectious Diseases: Selected Entries from the Encyclopedia of Sustainability Science and Technology* (P. Kanki & D. J. Grimes (eds.); pp. 1–6). Springer New York. https://doi.org/10.1007/978-1-4614-5719-0_1

Katoch, A. (2022). Disaster Risk Assessment and Operations Planning. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 39–46). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_4

Keenum, I., Medina, M. C., Garner, E., Pieper, K. J., Blair, M. F., Milligan, E., Pruden, A., Ramírez-Toro, G., & Rhoads, W. J. (2021). Source-to-Tap Assessment of Microbiological Water Quality in Small Rural Drinking Water Systems in Puerto Rico Six Months After

Hurricane Maria. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.0c08814

Keesing, F., & Ostfeld, R. S. (2021). Impacts of Biodiversity and Biodiversity Loss on Zoonotic Diseases. *Proceedings of the National Academy of Sciences*. https://doi.org/10.1073/pnas.2023540118

Khan, M., Cao, Z., Khan, A., Kausar, S., Xiao, J., & Ud-din, N. (2020). Knowledge, attitude and practices related to Brucellosis in the people of Khyber Pukhtun Khwa Province, Pakistan. *Authorea Preprints*, 3–6.

Khan, M., Shah, S. H., Khan, S. A., & Hayat, F. (2023). Post-flood infectious disease prevention and control: Current scenario in Pakistan. *Journal of Flood Risk Management*, *16*(1), e12867. https://doi.org/https://doi.org/10.1111/jfr3.12867

Kim, B.-J., Kim, S., Kang, J. S., Ko, S., Won, S., Kim, H., Kim, S. H., Kim, M.-S., Chong, S.-T., Klein, T. A., Lee, S.-H., & Chae, J. (2013). First Report for the Seasonal and Annual Prevalence of Flea-Borne<i>Bartonella</I>from Rodents and Soricomorphs in the Republic of Korea. *Vector-Borne and Zoonotic Diseases*. https://doi.org/10.1089/vbz.2012.1115

Kissi, A. E., Abbey, G. A., Agboka, K., & Egbendewe, A. Y. G. (2015). Quantitative Assessment of Vulnerability to Flood Hazards in Downstream Area of Mono Basin, South-Eastern Togo: Yoto District. *Journal of Geographic Information System*, *07*(06), 607–619. https://doi.org/10.4236/jgis.2015.76049

Komor, M., & Grzyb, K. (2023). Qualitative Content Analysis – A Research Method in Social Science. *Przegląd Badań Edukacyjnych*, *2*(43), 143–163. https://doi.org/10.12775/pbe.2023.032

Kondo, H., Seo, N., Yasuda, T., Hasizume, M., Koido, Y., Ninomiya, N., & Yamamoto, Y. (2002). Post-Flood — Infectious Diseases in Mozambique. *Prehospital and Disaster Medicine*. https://doi.org/10.1017/s1049023x00000340

Kouamé, P. K., Dongo, K., Fokou, G., Apkatou, B., Ouattara, A., & Bonfoh, B. (2022). *Assessing Transmission Patterns of Flood-Related Waterborne Diseases in Two Urban Municipalities of Côte D'Ivoire*. https://doi.org/10.21203/rs.3.rs-2048605/v1

Krieger, N. (1994). Epidemiology and the web of causation: has anyone seen the spider? *Social Science \& Medicine (1982)*, *39*(7), 887–903. https://doi.org/10.1016/0277-9536(94)90202-x

Krieger, N. (2001). Theories for social epidemiology in the 21st century: an ecosocial perspective. *International Journal of Epidemiology*, *30*(4), 668–677. https://doi.org/10.1093/ije/30.4.668

Krieger, N. (2011). 202Ecosocial Theory of Disease Distribution: Embodying Societal & Ecologic Context. In N. Krieger (Ed.), *Epidemiology and the People's Health: Theory and Context* (p. 0). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195383874.003.0007

Krieger, N. (2012). Methods for the scientific study of discrimination and health: an ecosocial approach. *American Journal of Public Health*, *102*(5), 936–944. https://doi.org/10.2105/AJPH.2011.300544

Kumar, A. (2022). Disaster Response Under ``One Health'' Approach: Contribution of Veterinary Public Health. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 245–261). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_21

Kurien, A. J., Roy, J., & Das, K. (2022). Flood Dermatoses: A Literature Review. *Ip Indian Journal of Clinical and Experimental Dermatology*. https://doi.org/10.18231/j.ijced.2022.045

Kurtzer, J., & Abdullah, H. F. (2022). *Pakistan's {Deadly} {Floods} {Pose} {Urgent} {Questions} on {Preparedness} and {Response}*. https://www.csis.org/analysis/pakistans-deadly-floods-pose-urgent-questions-preparedness-and-response

Lappé, M. (2021). You Are What Your Mother Endured: Intergenerational Epigenetics, Early Caregiving, and the Temporal Embedding of Adversity. *Medical Anthropology Quarterly*, *35*(4), 458–475. https://doi.org/10.1111/maq.12683

Lau, C. L., Watson, C., Lowry, J. H., David, M., Craig, S. B., Wynwood, S. J., Kama, M., & Nilles, E. J. (2016). Human Leptospirosis Infection in Fiji: An Eco-Epidemiological Approach to Identifying Risk Factors and Environmental Drivers for Transmission. *Plos Neglected Tropical Diseases*. https://doi.org/10.1371/journal.pntd.0004405

Lee, D., Ahmadul, H., Patz, J., & Block, P. (2021). Predicting social and health vulnerability to

floods in Bangladesh. *Natural Hazards and Earth System Sciences*, *21*(6), 1807–1823. https://doi.org/10.5194/nhess-21-1807-2021

Lin, N., Kopp, R. E., Horton, B. P., & Donnelly, J. P. (2016). Hurricane {Sandy}'s flood frequency increasing from year 1800 to 2100. *Proceedings of the National Academy of Sciences*, *113*(43), 12071–12075. https://doi.org/10.1073/pnas.1604386113

LINDSEY, R., & DAHLMAN, L. (2024). Climate {Change}: {Global} {Temperature} {\textbar} {NOAA} {Climate}.gov. In *NOAA Climate.gov*. http://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Liu, L., Xu, Z. X., Reynard, N. S., Hu, C. W., & Jones, R. G. (2013). Hydrological analysis for water level projections in {\textless}span style="font-variant:small-caps;"{\textgreater}{T}{\textless}/span{\textgreater} aihu {\textless}span style="font-variant:small-caps;"{\textgreater}{L}{\textless}/span{\textgreater} ake, . *Journal of Flood Risk Management*, *6*(1), 14–22. https://doi.org/10.1111/jfr3.12015

Lloyd Chikwiramakomo, Webster Gumindoga, Munyaradzi Davis Shekede, Tawanda Winmore Gara, & Talent Chuma. (2021). Modelling flood hazard in dry climates of southern Africa: a case of Beitbridge, Limpopo Basin, Zimbabwe. *Water SA*, *47*(4 October SE-Research paper). https://doi.org/10.17159/wsa/2021.v47.i4.3787

Lowe, D., Ebi, K. L., & Forsberg, B. (2013). Factors Increasing Vulnerability to Health Effects before, during and after Floods. In *International Journal of Environmental Research and Public Health* (Vol. 10, Issue 12, pp. 7015–7067). https://doi.org/10.3390/ijerph10127015

Magalhães, A. R., Codeço, C. T., Svenning, J.-C., Escobar, L. E., Van de Vuurst, P., & Gonçalves-Souza, T. (2023). Neglected tropical diseases risk correlates with poverty and early ecosystem destruction. *Infectious Diseases of Poverty*, *12*(1), 32. https://doi.org/10.1186/s40249-023-01084-1

Majeed, M. Z., Lu, L., Anwar, M. M., Tariq, A., Qin, S., El-Hefnawy, M. E., El-Sharnouby, M., Li, Q., & Alasmari, A. (2023). Prediction of Flash Flood Susceptibility Using Integrating Analytic Hierarchy Process (AHP) and Frequency Ratio (FR) Algorithms. *Frontiers in Environmental Science*. https://doi.org/10.3389/fenvs.2022.1037547

Majiwa, H., Bukachi, S. A., Omia, D. O., & Fèvre, E. M. (2022). *Knowledge of and Practices Around Zoonotic Diseases Amongst Actors in the Livestock Trade in the Lake Victoria Crescent Ecosystem in East Africa*. https://doi.org/10.21203/rs.3.rs-1992990/v1

Malik, I., Chuphal, D. S., Vegad, U., & Mishra, V. (2023). Was the extreme rainfall that caused the August 2022 flood in Pakistan predictable? *Environmental Research: Climate*, *2*(4), 041005. https://doi.org/10.1088/2752-5295/acfa1a

Manzoor, Z., Ehsan, M., Khan, M. B., Manzoor, A., Akhter, M. M., Sohail, M. T., Hussain, A., Shafi, A., Abu-Alam, T., & Abioui, M. (2022). Floods and flood management and its socio-economic impact on Pakistan: A review of the empirical literature. *Frontiers in Environmental Science*, *10*(December), 1–14. https://doi.org/10.3389/fenvs.2022.1021862

Mark, O., Jørgensen, C., Hammond, M., Khan, D. M., Tjener, R., Erichsen, A., & Helwigh, B. (2015). A New Methodology for Modelling of Health Risk From Urban Flooding Exemplified by Cholera – Case Dhaka, Bangladesh. *Journal of Flood Risk Management*. https://doi.org/10.1111/jfr3.12182

Mavrouli, M., Mavroulis, S., Lekkas, E., & Tsakris, A. (2022). Infectious Diseases Associated With Hydrometeorological Hazards in Europe: Disaster Risk Reduction in the Context of the Climate Crisis and the Ongoing COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*. https://doi.org/10.3390/ijerph191610206

McLafferty, S., & Chakrabarti, R. (2009). Locating Diversity: Race, Nativity and Place in Health Disparities Research. *Geojournal*, *74*(2), 107–113. https://doi.org/10.1007/s10708-009-9263-z

McMichael, A. J. (2015). Extreme Weather Events and Infectious Disease Outbreaks. *Virulence*. https://doi.org/10.4161/21505594.2014.975022

Meral, E. O. (2023). Extending {One} {Health} {To} {Animal} {Disaster} {Management}. In *Faunalytics*. https://faunalytics.org/extending-one-health-to-animal-disaster-management/

Mubarik Ali, & Norina Jabeen. (2022). Botulism a Major Risk in Animals After Flood in Pakistan; A Review. *Indus Journal of Agriculture and Biology*, *1*(1 SE-Articles), 1–7. https://doi.org/10.59075/ijab.v1i1.139

Muhammad, A., & Noor, S. (2023). Climate Change, COVID-19, and Flood disasters in Pakistan. *Journal of the Pakistan Medical Association*, *73*(8), 1754. https://doi.org/10.47391/JPMA.9231

Munir, A., Ghufran, M. A., Ali, S. M., Majeed, A., Batool, A., Khan, M. B. A. S., & Abbasi, G. H. (2022). Flood Susceptibility Assessment Using Frequency Ratio Modelling Approach in Northern Sindh and Southern Punjab, Pakistan. *Polish Journal of Environmental Studies*, *31*(4), 3249–3261. https://doi.org/10.15244/pjoes/145607

Munir, M., Saeed, A., Abubakar, M., Kanwal, S., & Berg, M. (2013). Molecular Characterization of Peste Des Petits Ruminants Viruses From Outbreaks Caused by Unrestricted Movements of Small Ruminants in Pakistan. *Transboundary and Emerging Diseases*. https://doi.org/10.1111/tbed.12089

Murad, A., & Khashoggi, B. (2020). Using GIS for Disease Mapping and Clustering in Jeddah, Saudi Arabia. *ISPRS International Journal of Geo-Information*, *9*, 328. https://doi.org/10.3390/ijgi9050328

Muzzamil, M., Naz, S., Mumtaz, H., & Omair, W. (2023). Pakistan's healthcare preparedness after the NIH warned of a new diphtheria strain and Covid-19 variation. *Journal of Taibah University Medical Sciences*, *18*. https://doi.org/10.1016/j.jtumed.2023.03.002

Nadeem, A., Ahsan, A., Tariq, R., & Basaria, A. (2023). The mental and maternal health of women in flood-affected areas in Pakistan: a call for action. *International Journal of Surgery: Global Health*, *6*, e135–e135. https://doi.org/10.1097/GH9.0000000000000135

Nadeem, A., Sahito, A. M., & Shahid, S. (2023). Flood Crisis in Pakistan: a mass destruction to economy and fragile health care systems. *Medicine, Conflict and Survival*, *39*(1), 81–85. https://doi.org/10.1080/13623699.2022.2157587

Narendr, A., Das, S., Shivamurthy, V., & Aithal, B. H. (2020). Adaptive Capacity Assessment for a Flood Vulnerable Region Through Land Use Modelling and Socio Economic and Physical Indicators. *Journal of Environmental Informatics Letters*. https://doi.org/10.3808/jeil.202000031

Nasir, M. M., Khan, A. B., & Farhan, S. H. (2023). Monsoon floods: A challenge to Pakistan's

already fragile healthcare infrastructure. *Journal of the Pakistan Medical Association*, *73*(8), 1765–1766. https://doi.org/10.47391/JPMA.7982

Nations, U. (2022). Biodiversity - our strongest natural defense against climate change. In *United Nations*. https://www.un.org/en/climatechange/science/climate-issues/biodiversity

Nor Diana, M. I., & Nurul Atikah, Z. (2023). Assessment of Household-Level Adaptation Strategy to Flood in East Coast Malaysia. *Iop Conference Series Earth and Environmental Science*, *1167*(1), 12044. https://doi.org/10.1088/1755-1315/1167/1/012044

OCHA. (2023). *Pakistan: 2022 {Monsoon} {Floods} - {Situation} {Report} {No}. 19 ({As} of 12 {August} 2023) {\textbar} {OCHA}*. https://www.unocha.org/publications/report/pakistan/pakistan-2022-monsoon-floods-situation-report-no-19-12-august-2023

OCHA Services. (2023). *Climate Crisis IN Pakistan Voices from the Ground*.

Ochani, S., Aaqil, S. I., Nazir, A., Athar, F. B., Ochani, K., & Ullah, K. (2022). Various health-related challenges amidst recent floods in Pakistan; strategies for future prevention and control. *Annals of Medicine and Surgery*, *82*, 104667. https://doi.org/https://doi.org/10.1016/j.amsu.2022.104667

Ochani, S., Aaqil, S. I., Nazir, A., Athar, F. B., & Ullah, K. (2022). Neonatal and child health crises due to recent floods in Pakistan. *Annals of Medicine and Surgery (2012)*, *84*, 104837. https://doi.org/10.1016/j.amsu.2022.104837

OIE), F. U. W. W. O. for A. H. (WOAH) (founded as. (2022). Working together for the health of humans, animals, plants and the environment. One Health Joint Plan of Action (2022–2026). In *Bulletin de l'OIE* (Vol. 2022, Issue 2). https://doi.org/10.20506/bull.2022.2.3324

Okaka, F. O., & Odhiambo, B. D. O. (2018). Relationship between Flooding and Out Break of Infectious Diseasesin Kenya: A Review of the Literature. *Journal of Environmental and Public Health*, *2018*, 5452938. https://doi.org/10.1155/2018/5452938

Ortiz, D. (2019). Geographic Information Systems (GIS) in humanitarian assistance: a meta-analysis. *Pathways*, *1*(2), 4.

Oruganti, P., Root, E., Ndlovu, V., Mbhungele, P., Van Wyk, I., & Berrian, A. M. (2023). Gender and zoonotic pathogen exposure pathways in a resource-limited community, Mpumalanga, South Africa: A qualitative analysis. *PLOS Global Public Health*, *3*(6), e0001167. https://doi.org/10.1371/journal.pgph.0001167

Patel, K. S., Dahariya, N. S., Chakradhari, S., Sahu, P. K., Rajhans, K. P., Ramteke, S., Lata, L., & Huber, M. (2015). Sewage Pollution in Central India. *American Journal of Analytical Chemistry*. https://doi.org/10.4236/ajac.2015.610075

Paterson, D. L., Wright, H. B., & Harris, P. N. A. (2018). Health Risks of Flood Disasters. *Clinical Infectious Diseases*. https://doi.org/10.1093/cid/ciy227

Paz, S. (2024). Climate change: A driver of increasing vector-borne disease transmission in non-endemic areas. *PLoS Medicine*, *21*(4), e1004382. https://doi.org/10.1371/journal.pmed.1004382

PDNA. (2022). PAKISTAN FLOODS 2022 Post-Disaster Needs Assessment. *Financial Tracking Service- UNOCHA, 2022. "Pakistan Floods Relief Plan." Https://Fts.Unocha.Org/Multiyear/2313/Summary ExecutIVe*, *September*, 1–72.

Pedro, J. P. B., Oliveira, C. A. da S., Lima, S. C. R. B. de, & Sperling, M. von. (2020). A Review of Sanitation Technologies for Flood-Prone Areas. *Journal of Water Sanitation and Hygiene for Development*. https://doi.org/10.2166/washdev.2020.019

Philson, C. S., Gray, L., Pedroncelli, L., & Ota, W. (2021). Mitigating Climate Change's Impact on Tick-Borne Zoonotic Disease Emergence. *Journal of Science Policy & Governance*. https://doi.org/10.38126/jspg190109

Pillay, C., & van den Bergh, J. (2016). Human health impacts of climate change as a catalyst for public engagement. *International Journal of Climate Change Strategies and Management*, *8*(5), 578–596. https://doi.org/10.1108/IJCCSM-06-2015-0084

Price, L. (2014). Critical Realist versus Mainstream Interdisciplinarity. *Journal of Critical Realism*, *13*(1), 52–76. https://doi.org/10.1179/1476743013Z.00000000019

Qamar, K., Nchasi, G., Mirha, H. T., Siddiqui, J. A., Jahangir, K., Shaeen, S. K., Islam, Z., & Essar, M. Y. (2022). Water sanitation problem in Pakistan: A review on disease prevalence, strategies

for treatment and prevention. *Annals of Medicine and Surgery (2012)*, *82*, 104709. https://doi.org/10.1016/j.amsu.2022.104709

Qi, M., Huang, H., Liu, L., & Chen, X. (2022). An Integrated Approach for Urban Pluvial Flood Risk Assessment at Catchment Level. *Water*. https://doi.org/10.3390/w14132000

Quinn, S. C., & Kumar, S. (2014). Health Inequalities and Infectious Disease Epidemics: A Challenge for Global Health Security. *Biosecurity and Bioterrorism Biodefense Strategy Practice and Science*. https://doi.org/10.1089/bsp.2014.0032

Quinn, T., Heath, S., Adger, W. N., Abu, M., Butler, C., Codjoe, S. N. A., Horvath, C., Martinez-Juarez, P., Morrissey, K., Murphy, C., & Smith, R. (2023). Health and wellbeing implications of adaptation to flood risk. *Ambio*, *52*(5), 952–962. https://doi.org/10.1007/s13280-023-01834-3

Quintanilla, N. (2022). Outbreaks of Vector-Borne Infectious Disease Following a Natural Disaster. *Georgetown Medical Review*. https://doi.org/10.52504/001c.38768

Rahman, M., Bejo, S. K., Zakaria, Z., Hassan, L., & Roslan, M. A. (2020). Seroprevalence and Distribution of Leptospiral Serovars in Livestock (Cattle, Goats, and Sheep) in Flood-Prone Kelantan, Malaysia. *Journal of Veterinary Research*, *65*(1), 53–58. https://doi.org/10.2478/jvetres-2021-0003

Rahman, Z. U., Ullah, W., Bai, S., Ullah, S., Jan, M. A., Khan, M., & Tayyab, M. (2023). GIS-based flood susceptibility mapping using bivariate statistical model in Swat River Basin, Eastern Hindukush region, Pakistan . In *Frontiers in Environmental Science* (Vol. 11). https://www.frontiersin.org/articles/10.3389/fenvs.2023.1178540

Raja, M. S., Şanlı, O., Razzak, A., Janjua, L., Malik, F. A., Raja, M. S., Şanlı, O., Razzak, A., Janjua, L., & Malik, F. A. (2023). Health Impacts of Flooding and Risk Management: Recommended Policies for Pakistan's Local Government During Monsoon Rains and Flood 2022. In *https://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-6684-8103-5.ch007*. https://www.igi-global.com/gateway/chapter/www.igi-global.com/gateway/chapter/320845

Rana, I. A., Khan, M. M., Lodhi, R. H., Altaf, S., Nawaz, A., & Najam, F. A. (2023).

Multidimensional poverty vis-à-vis climate change vulnerability: Empirical evidence from flood-prone rural communities of Charsadda and Nowshera districts in Pakistan. *World Development Sustainability*, *2*, 100064. https://doi.org/https://doi.org/10.1016/j.wds.2023.100064

Raza, M., Fatima, A., Habiba, U., & Shah, H. H. (2023a). Public health implications of severe floods in Pakistan: assessing the devastating impact on health and the economy. *Frontiers in Environmental Science*, *11*(July), 2021–2024. https://doi.org/10.3389/fenvs.2023.1091998

Raza, M., Fatima, A., Habiba, U., & Shah, H. H. (2023b). Public health implications of severe floods in Pakistan: assessing the devastating impact on health and the economy . In *Frontiers in Environmental Science* (Vol. 11). https://www.frontiersin.org/articles/10.3389/fenvs.2023.1091998

Razgūnaitė, M., Radzijevskaja, J., Sabūnas, V., Karvelienė, B., & Paulauskas, A. (2019). Vector-Borne Zoonotic Pathogens in Cats. *Biologija*. https://doi.org/10.6001/biologija.v65i2.4030

Riaz, A., & Javed, T. (2022). Chikungunya Outbreak in Pakistan; Optimal Control, and Management Prevention. *The Journal of Microbiology and Molecular Genetics*, *3*(3), 67–69. https://doi.org/10.52700/jmmg.v3i3.71

Richard, M., Knauf, S., Lawrence, P., Mather, A. E., Munster, V. J., Müller, M. A., Smith, D. J., & Kuiken, T. (2016). Factors determining human-to-human transmissibility of zoonotic pathogens via contact. *Current Opinion in Virology*, *22*, 7–12. https://api.semanticscholar.org/CorpusID:3385453

Roy, H. E., Tricarico, E., Hassall, R., Johns, C. A., Roy, K. A., Scalera, R., Smith, K. G., & Purse, B. V. (2023). The role of invasive alien species in the emergence and spread of zoonoses. *Biological Invasions*, *25*(4), 1249–1264. https://doi.org/10.1007/s10530-022-02978-1

Rözer, V., Mehryar, S., & Surminski, S. (2022). From managing risk to increasing resilience: a review on the development of urban flood resilience, its assessment and the implications for decision making. *Environmental Research Letters*, *17*(12). https://doi.org/10.1088/1748-9326/aca8bc

Rupasinghe, R., Chomel, B. B., & Martínez-López, B. (2022). Climate change and zoonoses: A

review of the current status, knowledge gaps, and future trends. *Acta Tropica*, *226*(October 2021). https://doi.org/10.1016/j.actatropica.2021.106225

Saeed, U., & Piracha, Z. Z. (2016). Viral outbreaks and communicable health hazards due to devastating floods in {Pakistan}. *World Journal of Virology*, *5*(2), 82–84. https://doi.org/10.5501/wjv.v5.i2.82

Saha, J. (2023). The Pattern of Morbidity and Access to Healthcare Service in the Riverine Flood-Prone Villages of Assam, India. *The Open Public Health Journal*, *16*(1). https://doi.org/10.2174/0118749445269914231023070506

Sajjad, A., Lu, J., Chen, X., Chisenga, C., Saleem, N., & Hassan, H. U. (2020). Operational Monitoring and Damage Assessment of Riverine Flood-2014 in the Lower Chenab Plain, Punjab, Pakistan, Using Remote Sensing and GIS Techniques. *Remote Sensing*. https://doi.org/10.3390/rs12040714

Salman, M., Abbas, R. Z., & Mohsin, H. M. (2023). Impact of Climate Change on Ticks and Ticks-Borne Zoonotic Diseases. *International Journal of Agriculture and Biosciences*, *3*(March), 28–33. https://doi.org/10.47278/book.oht/2023.73

Sarkar, S. (2022). Pakistan floods pose serious health challenges. *BMJ*, *378*, o2141. https://doi.org/10.1136/bmj.o2141

Schwartz, B., Harris, J. B., Khan, A. I., LaRocque, R. C., Sack, D. A., Malek, M. A., Faruque, A. S. G., Qadri, F., Calderwood, S. B., Luby, S. P., & Ryan, E. T. (2006). Diarrheal Epidemics in Dhaka, Bangladesh, During Three Consecutive Floods: 1988, 1998, and 2004. *American Journal of Tropical Medicine and Hygiene*. https://doi.org/10.4269/ajtmh.2006.74.1067

Scott, K. A., Qureshi, M. H., Cox, P. B., Marshall, C. M., Bellaire, B. C., Wilcox, M., Stuart, B. A. R., & Njardarson, J. T. (2020). A Structural Analysis of the FDA Green Book-Approved Veterinary Drugs and Roles in Human Medicine. *Journal of Medicinal Chemistry*, *63*(24), 15449–15482. https://doi.org/10.1021/acs.jmedchem.0c01502

Selter, F., & Salloch, S. (2023). Whose health and which health? Two theoretical flaws in the One Health paradigm. *Bioethics*, *37*(7), 674–682. https://doi.org/10.1111/bioe.13192

Shabbir, M. A., Naveed, M., Asif, M. F., Shahid, A., Ain, N.-, Mahmood, S., Laila, U.-, & Iftikhar,

M. J. (2022). Dissemination of Water-Mediated Infections due to Torrential Rainfalls Leading to Havoc Floods: A Dreadful Curve for Pakistan. *Prehospital and Disaster Medicine*, *37*(6), 856–857. https://doi.org/DOI: 10.1017/S1049023X22001443

Shaikh, O. A., Rahim, M., Essarani, M., Nadeem, S., Ochani, S., Hasibuzzaman, M. Al, & Ullah, K. (2023a). Dreadful infectious disease outbreaks threaten flood-ravaged pakistan: short communication. *Annals of Medicine & Surgery*, *85*(6), 3237–3238. https://doi.org/10.1097/ms9.0000000000000754

Shaikh, O. A., Rahim, M., Essarani, M., Nadeem, S., Ochani, S., Hasibuzzaman, M. Al, & Ullah, K. (2023b). Dreadful infectious disease outbreaks threaten flood-ravaged pakistan: short communication. *Annals of Medicine and Surgery*, *85*(6). https://journals.lww.com/annals-of-medicine-and-surgery/fulltext/2023/06000/dreadful_infectious_disease_outbreaks_threaten.159.aspx

Shaikh, T. G., Waseem, S., Ahmed, S. H., Elsayed, M., & Hasan, M. M. (2022). Infectious Disease Surveillance System in Pakistan: Challenges and Way Forward. *Tropical Medicine and Health*. https://doi.org/10.1186/s41182-022-00439-y

Shaista Bibi Jadoon, Fizza BiBi, Azra Bibi, Dr Tahir Jadoon, H. R. (2023). *Health Impacts of the 2023 Flood in Pakistan : A Comprehensive Case Study on Skin-related Ailments and Waterborne Diseases*. *10*(2), 7–9.

Shankar, A., Jagajeedas, D., Radhakrishnan, M. P., Paul, M., Narendrakumar, L., Suryaletha, K., Akhila, V. S., Nair, S. B., & Thomas, S. (2020). Elucidation of Health Risks Using Metataxonomic and Antibiotic Resistance Profiles of Microbes in Flood Affected Waterbodies, Kerala 2018. *Journal of Flood Risk Management*. https://doi.org/10.1111/jfr3.12673

Sharma, S. N., Kumawat, R., & Singh, S. K. (2022). Risk Assessment and Impact of Floods on the Transmission of Vector Borne Diseases. *Journal of Communicable Diseases*, *54*(3), 15–21. https://doi.org/10.24321/0019.5138.202284

Short, S. E., & Mollborn, S. (2015). Social Determinants and Health Behaviors: Conceptual Frames and Empirical Advances. *Current Opinion in Psychology*, *5*, 78–84.

https://doi.org/10.1016/j.copsyc.2015.05.002

Sips, G. J., Limaheluw, J., de Roda Husman, A. M., & Bousema, T. (2023). [Climate change and infectious diseases]. *Nederlands tijdschrift voor geneeskunde*, *167*.

Somani, R. (2023). Global Warming in Pakistan and Its Impact on Public Health as Viewed Through a Health Equity Lens. *International Journal of Social Determinants of Health and Health Services*, *53*(2), 154–157. https://doi.org/10.1177/27551938231154467

Sovacool, B. K., Iskandarova, M., & Hall, J. (2023). Industrializing theories: A thematic analysis of conceptual frameworks and typologies for industrial sociotechnical change in a low-carbon future. *Energy Research & Social Science*, *97*, 102954. https://doi.org/https://doi.org/10.1016/j.erss.2023.102954

Subedi, D., Chandran, D., Niraula, A., Paudel, S., Acharya, K., & Dhama, K. (2022). Global climate change, floods, and associated zoonotic disease outbreaks: A mini-review insight. *The Indian Veterinary Journal*, *99*, 26–32.

Suk, J. E., Vaughan, E. C., Cook, R., & Semenza, J. C. (2020). Natural Disasters and Infectious Disease in Europe: A Literature Review to Identify Cascading Risk Pathways. *European Journal of Public Health*. https://doi.org/10.1093/eurpub/ckz111

Suman, M. (2022). Post-disaster Interventions Related to Livestock and Livelihood. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 87–98). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_9

Tabassum, S., Naeem, A., Nazir, A., Naeem, F., Gill, S., & Tabassum, S. (2023). Year-round dengue fever in Pakistan, highlighting the surge amidst ongoing flood havoc and the COVID-19 pandemic: a comprehensive review. *Annals of Medicine and Surgery*, *85*(4). https://journals.lww.com/annals-of-medicine-and-surgery/fulltext/2023/04000/year_round_dengue_fever_in_pakistan,_highlighting.48.aspx

Tajudeen, Y. A., Oladunjoye, I. O., Adebayo, A. O., & Adebisi, Y. A. (2021). The Need to Adopt Planetary Health Approach in Understanding the Potential Influence of Climate Change and Biodiversity Loss on Zoonotic Diseases Outbreaks. *Public Health in Practice*. https://doi.org/10.1016/j.puhip.2021.100095

Tall, J. A., & Gatton, M. L. (2020). Flooding and Arboviral Disease: Predicting Ross River Virus Disease Outbreaks Across Inland Regions of South-Eastern Australia. *Journal of Medical Entomology*, *57*(1), 241–251. https://doi.org/10.1093/jme/tjz120

Tate, E., Rahman, A., Emrich, C. T., & Sampson, C. (2021). Flood Exposure and Social Vulnerability in the United States. *Natural Hazards*. https://doi.org/10.1007/s11069-020-04470-2

Tempark, T., Lueangarun, S., Chatproedprai, S., & Wananukul, S. (2013). Flood-related Skin Diseases: A Literature Review. *International Journal of Dermatology*. https://doi.org/10.1111/ijd.12064

Thakur, D. (2022). Data Collection and Management. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 61–70). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_6

Thakur, R., & Dogra, P. K. (2022). Animal Welfare and Livestock-Related Responses During Disasters. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 115–127). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_11

Thakur, S. D. (2022). Early Warning Systems, Disease Management, and Biosecurity in Disasters. In S. Verma & H. T. Prem (Eds.), *Management of Animals in Disasters* (pp. 25–37). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-9392-2_3

Thomas, J. (2023). How geospatial technologies aid in effective disaster management. In *Innovation News Network*. https://www.innovationnewsnetwork.com/how-geospatial-technologies-aid-in-effective-disaster-management/38841/

Tiwari, A., Parveen, K., Singh, S. K., & Manar, M. (2022). Urban Flood Relief Management in COVID-19 Pandemic. *Indian Journal of Community Health*, *34*(2), 301–305. https://doi.org/10.47203/ijch.2022.v34i02.028

Tomori, O., & Oluwayelu, D. O. (2023). Domestic Animals as Potential Reservoirs of Zoonotic Viral Diseases. *Annual Review of Animal Biosciences*, *11*, 33–55. https://api.semanticscholar.org/CorpusID:256869133

Topluoglu, S., Taylan-Ozkan, A., & Alp, E. (2023). Impact of wars and natural disasters on

emerging and re-emerging infectious diseases. *Frontiers in Public Health*, *11*(September). https://doi.org/10.3389/fpubh.2023.1215929

Umair, M., Khan, M. H., Jabbar, A., Khan, S., Hamayun, M., & Khan, T. A. (2023). Post-Flood Outbreaks of Cholera in Pakistan; Endemic-to-Epidemic. *The Journal of Infection in Developing Countries*. https://doi.org/10.3855/jidc.17512

UN HABITAT. (2023). *Pakistan Un-Habitat Country Report 2023*. www.unhabitat.org.pk

UNICEF. (2023). *More than 10 million people, including children, living in Pakistan's flood-affected areas still lack access to safe drinking water - Pakistan | ReliefWeb*. https://reliefweb.int/report/pakistan/more-10-million-people-including-children-living-pakistans-flood-affected-areas-still-lack-access-safe-drinking-water

United Nations OCHA. (2023). *2022 Floods Response Plan Pakistan*. *12*(3), 1–2.

van Herten, J., Bovenkerk, B., & Verweij, M. (2019). One Health as a moral dilemma: Towards a socially responsible zoonotic disease control. *Zoonoses and Public Health*, *66*(1), 26–34. https://doi.org/https://doi.org/10.1111/zph.12536

Vasco, K., Graham, J. P., & Trueba, G. (2016). Detection of Zoonotic Enteropathogens in Children and Domestic Animals in a Semirural Community in Ecuador. *Applied and Environmental Microbiology*. https://doi.org/10.1128/aem.00795-16

Vikas. (2020). The Southwest Monsoon During COVID-19 Pandemic: A Potential Concern. *Asia Pacific Journal of Public Health*. https://doi.org/10.1177/1010539520944729

Warraich, H., Zaidi, A. K. M., & Patel, K. (2011). Floods in Pakistan: a public health crisis. *Bulletin of the World Health Organization*, *89*(3), 236–237. https://doi.org/10.2471/BLT.10.083386

Warsi, A., & Mansoor, N. (2023). Floods in Pakistan; are pregnant women at a greater risk? *Journal of the Pakistan Medical Association*, *73*(05), 1169. https://doi.org/10.47391/JPMA.7941

Waseem, H. Bin, & Rana, I. A. (2023). Floods in Pakistan: A state-of-the-art review. *Natural Hazards Research*, *3*(3), 359–373. https://doi.org/https://doi.org/10.1016/j.nhres.2023.06.005

WHO. (2023a). "It was just the perfect storm for malaria" – Pakistan responds to surge in cases following the 2022 floods. In *WHO*. https://www.who.int/news-room/feature-stories/detail/It-

was-just-the-perfect-storm-for-malaria-pakistan-responds-to-surge-in-cases-following-the-2022-floods

WHO. (2023b). *Climate change*. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

Williams, P. C. M., Bartlett, A. W., Howard-Jones, A., McMullan, B., Khatami, A., Britton, P. N., & Marais, B. J. (2021). Impact of climate change and biodiversity collapse on the global emergence and spread of infectious diseases. *Journal of Paediatrics and Child Health*, *57*(11), 1811–1818. https://doi.org/https://doi.org/10.1111/jpc.15681

World Bank Group. (2021). Climate Risk Country Profile: Uganda. *The World Bank Group*, 36. www.worldbank.org

Yasmeen, N., Jabbar, A., Shah, T., Fang, L., Aslam, B., Naseeb, I., Shakeel, F., Ahmad, H. I., Baloch, Z., & Liu, Y. (2022a). One Health Paradigm to Confront Zoonotic Health Threats: A Pakistan Prospective. *Frontiers in Microbiology*, *12*. https://doi.org/10.3389/fmicb.2021.719334

Yasmeen, N., Jabbar, A., Shah, T., Fang, L. X., Aslam, B., Naseeb, I., Shakeel, F., Ahmad, H. I., Baloch, Z., & Liu, Y. (2022b). One Health Paradigm to Confront Zoonotic Health Threats: A Pakistan Prospective. *Frontiers in Microbiology*, *12*(February), 1–11. https://doi.org/10.3389/fmicb.2021.719334

Yasobant, S., Vora, K. S., & Upadhyay, A. (2018). Geographic information system applications in public health: Advancing health research. *Healthcare Policy and Reform: Concepts, Methodologies, Tools, and Applications*, *2*(January 2019), 538–561. https://doi.org/10.4018/978-1-5225-6915-2.ch026

Yin, R. K. (2003). *Case Study Research: Design and Methods*. SAGE.

Yopa, D. S., Massom, D. M., Kiki, G. M., Sophie, R. W., Fasine, S., Thiam, O., Zinaba, L., & Ngangue, P. (2023). Barriers and enablers to the implementation of one health strategies in developing countries: a systematic review. In *Frontiers in public health* (Vol. 11, p. 1252428). https://doi.org/10.3389/fpubh.2023.1252428

Youde, J. (2023). *Pakistan's floods highlight the climate-health nexus | East Asia Forum*.

https://eastasiaforum.org/2023/02/17/pakistans-floods-highlight-the-climate-health-nexus/

Zahoor, M. A., Zahoor, M. K., BakerSiddique, A., Shafique, M., Nawaz, Z., Yasmin, A., Qamar, M. F., & Shahid, M. A. (2018). *Welfare of Pet Birds and Potential Zoonoses*. https://doi.org/10.5772/intechopen.72282

Zambrano, L. D., Lévy, K., Menezes, N. P., & Freeman, M. C. (2014). Human Diarrhea Infections Associated With Domestic Animal Husbandry: A Systematic Review and Meta-Analysis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. https://doi.org/10.1093/trstmh/tru056

Zellweger, R. M., Cano, J., Mangeas, M., Taglioni, F., Mercier, A., Despinoy, M., Menkès, C. E., Dupont-Rouzeyrol, M., Nikolay, B., & Teurlai, M. (2017). Socioeconomic and environmental determinants of dengue transmission in an urban setting: An ecological study in Nouméa, New Caledonia. *PLoS Neglected Tropical Diseases*, *11*(4), 1–18. https://doi.org/10.1371/journal.pntd.0005471

Zucca, P., Scagliarini, A., Ramma, Y., & Khan, A. S. (2022). Zoonoses—Diseases Naturally Transmitted From Animals to Humans. *Frontiers for Young Minds*. https://doi.org/10.3389/frym.2022.833893

Appendix-A- Semi-Structured Interview Questions

Target Audience:

- Healthcare professionals (public health officials)
- Government officials (disaster management, public health, environmental policy)
- NGO representatives (disaster relief, water sanitation hygiene (WASH) programs)
- Academics/Researchers (environmental health, epidemiology, infectious diseases)

Background Information:

1. Briefly describe your area of expertise or role.
2. How long have you been working in this field/area of Pakistan?

Climate-Induced Floods and Disease Transmission in Pakistan

Target Audience: Healthcare professionals (public health officials)

- In your experience, have you observed an increase in infectious or zoonotic diseases following flood events in Pakistan? If so, can you elaborate on specific diseases and the challenges faced in managing them?
- What are the biggest obstacles in preventing the spread of diseases during and after floods in Pakistan?
- How can flood preparedness plans be improved to better address the risk of infectious disease outbreaks?

Target Audience: Government officials (disaster management, public health, environmental policy)

- From a policy perspective, how do you see climate-induced floods impacting the spread of infectious diseases in Pakistan?
- What current government initiatives are in place to address the health risks associated with floods?
- Are there any challenges in coordinating between different government departments (disaster management, public health) when responding to flood-related disease outbreaks?
- How can investments in flood resilience be tailored to also mitigate the risks of infectious disease outbreaks?

Target Audience: NGO representatives (disaster relief, water sanitation hygiene (WASH) programs)

- In your experience working on the ground during flood responses, what are the most pressing WASH-related needs that contribute to disease outbreaks?
- How can WASH programs be adapted to better address the challenges posed by climate-induced floods?
- What are the biggest challenges faced by NGOs in collaborating with local communities to prevent flood-related diseases?
- Have you observed any successful strategies implemented by NGOs to mitigate disease risks during floods?

Target Audience: Academics/Researchers (environmental health, epidemiology, infectious diseases)

- Based on your research, what are the established linkages between climate-induced floods and the transmission of specific infectious and zoonotic diseases in Pakistan?
- Are there any emerging infectious diseases that pose a particular threat in the context of floods?
- What are the critical gaps in our current understanding of flood-related disease transmission in Pakistan?
- What research recommendations do you have to improve our ability to predict, prevent, and control disease outbreaks following floods?

Additional Prompts:

- Can you share any specific examples from your experience that illustrate the relationship between floods and disease outbreaks?
- What are your thoughts on the long-term impact of climate change on flood patterns and disease transmission in Pakistan?
- Are there any international best practices or case studies from other flood-prone regions that could be applied in Pakistan?

Socioeconomic and Sociodemographic Vulnerability to Floods and Diseases in Pakistan

Target Audience: All (Healthcare professionals, Government officials, NGO representatives, Academics/Researchers)

- In your area of expertise, what socioeconomic and sociodemographic factors do you believe make communities in Pakistan more vulnerable to the impacts of climate-induced floods? (e.g., poverty, housing type, access to education)

- How do these factors intersect to exacerbate the risks associated with floods, such as displacement, property damage, and loss of livelihoods?

Target Audience: Healthcare professionals (doctors, public health officials) & Academics/Researchers (environmental health, epidemiology, infectious diseases)

- Can you elaborate on how specific socioeconomic and sociodemographic factors contribute to the increased incidence of infectious and zoonotic diseases following floods? (e.g., limited access to clean water and sanitation)
- Are there any vulnerable populations (children, elderly, pregnant women) who are disproportionately affected by flood-related diseases due to these factors?

Target Audience: Government officials (disaster management, public health, environmental policy) & NGO representatives (disaster relief, water sanitation hygiene (WASH) programs)

- Based on your experience, what targeted interventions or policies can be implemented to address the needs of vulnerable communities before, during, and after floods? (e.g., early warning systems, community outreach programs, WASH infrastructure development)
- How can existing social safety nets be strengthened to better support vulnerable populations during flood events and mitigate disease risks?

Additional Prompts:

- Can you share any specific examples from your work that illustrate the relationship between socioeconomic factors and flood vulnerability?
- How do you see climate change further impacting the socioeconomic landscape and increasing vulnerability to floods and diseases in Pakistan?
- Are there any successful initiatives or programs you've encountered that effectively address the needs of vulnerable communities in flood-prone areas?

General Animal Management

Target Audience: All Groups

- How do climate-induced floods impact animal populations and their potential role in disease transmission (e.g., displacing wildlife, creating breeding grounds for vectors)?

Target Audience: Healthcare Professionals and Academics/Researchers

- Are there specific animal management strategies that could be implemented to reduce the risk of infectious and zoonotic disease transmission during and after floods (e.g., vaccination programs for livestock)?

Target Audience: Government Officials (Disaster Management)

- How are animal control measures integrated into flood response plans to minimize public health risks and animal welfare concerns?
- Are there resources available to assist farmers and livestock owners in protecting their animals during floods?

Target Audience: NGO Representatives (Community Development)

- Does your organization provide any educational programs for communities on safe animal handling practices during and after floods to minimize disease risks?
- How can animal welfare concerns be better addressed in the context of flood response and recovery efforts?

Target Audience: Academics/Researchers

- What research is being conducted on the impact of climate-induced floods on animal behavior and disease transmission patterns?
- How can animal management practices be adapted to better address the challenges posed by climate change?

Appendix-B-Coding framework for Qualitative Content Analysis

Theme	Category	Codes
Impact of Climate-Induced Floods on Public Health	**Health Consequences of Floods**	Infectious diseases, Waterborne diseases, Vector-borne diseases, Zoonotic diseases, Displacement-related health issues, Mental health impacts, Malnutrition
	Healthcare System Response	Access to healthcare, Disruption of health services, Emergency health interventions, Disease surveillance
	Environmental Health Risks	Contaminated water sources, Waste management, Sanitation infrastructure, Exposure to hazardous materials
Incorporation of Socio-economic and Socio-demographic Factors	**Economic Vulnerability**	Income levels, Livelihood disruption, Resource access, Insurance coverage
	Social Inequities	Poverty, Education levels, Health literacy, Access to social services
	Demographic Vulnerability	Age, Gender, Ethnic and tribal groups, Pre-existing health conditions
Integration of One Health Approach	**Human-Animal-Environment Interface**	Zoonotic disease transmission, Animal health, Environmental changes, Habitat disruption
	Cross-Sectoral Collaboration	Coordination between health, agriculture, and environmental sectors, Multidisciplinary research, Policy alignment
Policy Recommendations for Flood Management and Health	**Disaster Risk Reduction**	Flood forecasting and early warning, Infrastructure resilience, Community preparedness programs, Evacuation plans
	Health Policy Integration	Inclusion of health in disaster planning, Strengthening public health systems, Disease prevention strategies

Coordination and Implementation Strategies	**Interagency Coordination**	Roles of government agencies, NGO involvement, Public-private partnerships, Emergency response protocols
	Implementation Challenges	Resource allocation, Political will, Capacity building, Monitoring and evaluation mechanisms

Table 2: Coding framework for Qualitative Content Analysis

Ameema

ORIGINALITY REPORT

Dr. Uma Laila
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