S3H Working Paper Series

Number 5: 2024

The Economic Cost of Inadequate Water and Sanitation in Pakistan

Kaneez Fatima

Muhammad Ali

Verda Salman

July 2024

School of Social Sciences and Humanities (S3H)
National University of Sciences and Technology (NUST)
Sector H-12, Islamabad, Pakistan

S3H Working Paper Series

Number 5: 2024

The Economic Cost of Inadequate Water and Sanitation in Pakistan

Kaneez Fatima
Graduate, School of Social Sciences and Humanities, NUST
E-mail: kfatima475@gmail.com

Muhammad Ali
Associate Professor, School of Social Sciences and Humanities, NUST
E-mail: alishuja@s3h.nust.edu.pk

Verda Salman
Associate Professor, School of Social Sciences and Humanities, NUST
E-mail: verda.salman@s3h.nust.edu.pk

July 2024

School of Social Sciences and Humanities (S3H)
National University of Sciences and Technology (NUST)
Sector H-12, Islamabad, Pakistan

Table of Contents

List of Acronyms

ARIs	Acute Respiratory Infections
GDP	Gross Domestic Product
KWSB	Karachi Water and Sewage Board
MDGs	Millenium Development Goals
PDHS	Pakistan Demographic and Health Survey
PKR	Pakistani Rupee
PSLM	Pakistan Social and Living Standards Measurement Survey
SDG	Sustainable Development Goals
USD	U.S. Dollar
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation

Abstract

While the state of sanitation in Pakistan has improved from 2013 to 2018, a significant proportion of its population is still surviving with either a limited, unimproved, or no toilet facility at all. This translates into considerable adverse consequences ranging from morbidity to mortality. Even so, research regarding inadequate sanitation in Pakistan remains limited. Hence, the present research fills this gap calculating the economic cost of inadequate sanitation in Pakistan using cost benefit analysis. The results show that cumulative economic impact of health, water, welfare, tourism, and drainage user costs, PKR 910.40 billion (USD 4.96 billion), which accounts for 1.91 percent of Pakistan's GDP. Of this, the health-related costs account for the highest burden, followed by the other welfare costs, water-related costs, tourism-related costs, and finally, the drainage user cost. Even though these figures present an alarming situation, it is possible to mitigate the economic cost through water, sanitation-, and hygiene-related interventions. More specifically, they can cumulatively generate economic gains amounting to PKR 1890.65 billion (USD 2.64 billion), which exceed the economic losses by PKR 980.26 billion (USD 5.34 billion).

Keywords: Sanitation, Water, Health, Welfare, Tourism, Drainage, Intervention, Economic Cost, Economic Benefit, Sanitation Market, WASH, Environment

1. Introduction

Under the 2030 Agenda for Sustainable Development, goal 6 guarantees the availability and sustainable management of water and sanitation services for everyone. More specifically, it targets safe management of drinking water and sanitation services, basic handwashing services, safe treatment of wastewater, and inter alia, good ambient water quality. To satisfy the sustainable development goals (SDG) standard for safe drinking water services, improved water sources; including packaged or delivered water, piped water, boreholes or tube wells, protected springs, protected dug wells, and rainwater; should be uncontaminated, easily accessible on premises, and readily available when required. The SDG standard for improved sanitation services comprises those that are not only private but also safely dispose excreta in situ or remove and treat them off-site. Basic hygiene services, lastly, should ensure the availability of a handwashing facility with soap and water at home to meet the SDG standard for hygiene (WHO & UNICEF, 2021).

Identifying and understanding the problems associated with the aforesaid factors is of utmost importance today because in the vicious circle of poverty and disease, inadequate water and sanitation services are, inter alia, their causes as well as their effects. The unavailability, inaccessibility, or fragility of water and sanitation services in terms of quality, efficiency, and structure thus induce an exponential rise in diseases and infections, especially the waterborne ones. The sequelae associated with the ineffectiveness and inefficiency of water and sanitation systems also exacerbate poverty and impede economic development, which is why water and sanitation systems coverage is especially crucial for highly populated and underprivileged areas. While the provision of adequate WASH facilities may not result in immediate improvement towards nutritional aspects, they still comprise significant direct benefits in terms of economic development, time savings, security, dignity, and equity (Ferreira et al., 2021).

Adequate water and sanitation have thus been promoted as the “heart of public health,” especially in developing countries (Abramovsky et al., 2023). In Pakistan, however, only 51 percent of the population has access to safely managed water supplies. The inequalities between the level of water services available to the rich and poor, additionally, remain even more pronounced – while at least basic drinking water services cover 98 percent of the richest population, they only cover 78 percent of the poorest population (United Nations Children’s Fund & World Health Organisation, 2023). In addition to that, even though 71 percent of Pakistan’s population now has access to at least basic sanitation services, 7 percent, 12 percent, and 11 percent of the population still engages in open defecation, utilizes unimproved sanitation services, and accesses only limited sanitation facilities, respectively. There are, however, significant inequalities between the richest and poorest people of the country. Open defecation, for instance, is practiced by less than 1 percent of the richest population but 45 percent of the poorest population. 97 percent of the richest but only 30 percent of the poorest population, similarly, has access to at least basic sanitation services. (United Nations Children's Fund & World Health Organisation, 2023).

Pakistan has thus been ranked third among the economies with inadequate water and sanitation services according to the International Monetary Fund (IMF), with 2.1 million individuals without access to safe water. This has adversely affected a range of sectors in the country, perhaps the most important of which is the public health sector due to the exponential rise in the incidence of waterborne diseases. Advocating the aforesaid, statistics show that in 2017, diarrhoea, alone, resulted in 2.5 million deaths in Pakistan. Inadequate water and sanitation further annually account for 50 percent of the disease burden and 40 percent of the mortality rate in Pakistan (Qamar et al., 2022).

1.1. Research Objectives

The Even though some effort has been made in favour of these agendas, progress remains meagre, particularly among most of the developing nations, including Pakistan, as is evident from the aforementioned statistics. The present study will thus explore this gap in research through the following objectives:

i. To determine the economic cost of poor water management in Pakistan
ii. To determine the magnitude of economic benefit that may result from sanitation, hygiene, and water-related interventions
iii. To determine the size of Pakistan's potential sanitation market

The results of this research will contribute towards determining the costs that poor water and sanitation imposes on the economy and the economic benefits that may be incurred through different mitigation interventions. In doing so, it may be of significance to the government in employing targeted programmes to help curtail the effect of inadequate water and sanitation.

This research is henceforth divided into six chapters. Firstly, the literature review summarises the existing research on the impact of poor water and sanitation. It additionally elaborates on the literature gap that this study aims to explore. Next, the conceptual framework explains the channels through which faecal bacteria are spread. Moving on, chapter four entails details about the methodology employed to construct the cost estimation models of this research. It is followed by a discussion of the results after which the conclusion summarises and concludes the research. Finally, this dissertation ends with several policy recommendations in light of the results.

2. Literature Review

WASH facilities are most effectively standardised and compared through service ladders, which categorise them into different levels; the unimproved the service, the lower the level assigned while the improved the service, the higher the level assigned (WHO & UNICEF, 2021). This study considers three service ladders – the drinking water ladder, sanitation ladder, and hygiene ladder, the definitions and understanding of which are paramount. They are thus henceforth defined and discussed.

The drinking water ladder comprises five service levels, ranging from the lowest to the highest level of service: surface water i.e., lakes, ponds, rivers, dams, streams, irrigation canals or canals; unimproved i.e., uncovered springs or dug wells; limited i.e., improved sources for which households require 30 minutes to make a round trip, including queuing; basic i.e., improved sources for which households require less than 30 minutes to make a round trip, including queuing; and safely managed i.e., improved sources that are located on premises, available when required, and free from faecal and chemical pollutants – which also serves as the global indicator for SDG target 6.1. In this context, it is worth noting that improved water sources include packaged or delivered water, piped water, boreholes or tube wells, protected springs, protected dug wells, and rainwater (WHO & UNICEF, 2021).

The sanitation ladder, similarly, constitutes five service levels: open defecation i.e., disposing excreta or solid waste in bushes, fields, forests, open water bodies, and other public places; unimproved i.e., using pit latrines without a platform or slab, bucket latrines or hanging latrines; limited i.e., using improved services that are shared with other households; basic i.e., using improved services that are not shared with other households; and safely managed i.e., using improved services that are not only private but also safely dispose excreta in situ or remove and treat them off-site – which also serves as the global indicator for SDG 6.2. It is noteworthy to mention that any sanitation service that effectively separates human waste from the surface environment, either on-site or off-site in treatment plants (WHO & UNICEF, 2021).

The service ladder for hygiene, lastly, comprises three levels: no facility i.e., no handwashing service at home; limited i.e., availability of a handwashing service that may be lacking soap and/or water at home; and basic i.e., availability of a handwashing service with soap and water at home – which serves as the SDG standard for hygiene (WHO & UNICEF, 2021).

Identifying and understanding these factors is of utmost importance today because in the vicious circle of poverty and disease, inadequate water and sanitation services are, inter alia, the causes as well as the effects of these issues. The unavailability, inaccessibility, or fragility of water and sanitation services in terms of quality, efficiency, and structure induce an exponential rise in diseases and infections, especially the waterborne ones. The sequelae associated with the ineffectiveness and inefficiency of water and sanitation systems also exacerbate poverty and impede economic development, which is why water and sanitation systems coverage is especially crucial for highly populated and underprivileged areas. While the provision of adequate WASH facilities may not result in immediate improvement towards nutritional aspects, they still comprise significant direct benefits, including economic development, time savings, security, dignity, and equity (Ferreira et al., 2021).

2.1. Health-Related Impacts of Inadequate WASH

Inadequate water and sanitation pose a threat to numerous sectors of an economy, the most important of which may be the health sector (Hasan & Richardson, 2017). Sanitation, in fact, is often promoted as the "heart of public health," especially in developing countries – a notion that follows the effectiveness of various water and sanitation programmes in alleviating economic losses from WASH-related diseases among developed countries during the early 19th century. Such public health interventions are thus often portrayed as agents of behavioural change, incentivizing the investment and adoption of health technologies (Abramovsky et al., 2023; Alsan & Goldin, 2019).

Despite the aforesaid, poor water, sanitation, and hygiene, remain overlooked as causes of adverse neonatal and maternal health conditions, which is alarming considering that approximately 1.9 billion people and 1.2 billion people around the world lack access to basic sanitation services and drinking water services, respectively (Cameron et al., 2021). In the low- and middle-income countries, for instance, approximately 85 percent of the population remains without access to proper sanitation, resulting in several adverse consequences on child health, morbidity, human capital, and mental stress (Abramovsky et al., 2023).

The most common diseases attributable to inadequate water, sanitation, and hygiene include diarrhoea, malaria, trachoma, protein energy malnutrition and inter alia, lower respiratory infections (Brouwer et al., 2023; Kumar et al., 2022). Water, sanitation, and hygiene deficits not only contribute towards ill health but, through that, also contribute towards a significant economic burden, especially in the developing part of the world, where the rate of mortality from inadequate service quality is considerably higher than from inaccessible care, which alone costs \$1.4 trillion to \$1.6 trillion annually (Chaitkin et al., 2022).

The literature thus frequently emphasizes upon the estimation of the global burden of these diseases to identify areas that improve public health, as well as track changes in the relative importance of the diseases. This is especially important for countries with a growing population, because poor sanitation only aggravates numerous health problems such as typhoid fever, diarrhoea, and malaria all of which occur due to the consumption of contaminated water and food, increasing the economic burden due to higher costs of the health sector (Brouwer et al., 2023; Kumar et al., 2022).

2.1.1. Diarrheoa

Diarrhoeal infections occur when faecal pathogens are transmitted to humans via water or soil due to poor water, sanitation, and hygiene, leading to malnutrition and stunted mental and physical growth (Prüss-Ustün et al., 2019). In quantitative terms, as much as 88 percent of diarrhoeal diseases are associated with inadequate WASH services (World Bank, 2006). Infections accompanying substandard sanitation, drinking, and hygiene hence fall under the most recurrent causes of poor health in developing economies (Bartram et al., 2005; WHO, 2004; World Bank, 2006).

Despite being a worldwide concern, diarrhoea's severest and most frequent episodes occur in South Asia and South Africa, where individuals in underprivileged areas remain at a higher risk of infection. Younger children in South Asia are especially more susceptible to the disease than older cohorts, with those under two years of age forming a greater proportion of the associated deaths. Pakistan, for example, has the highest rate of diarrhoeal diseases, with approximately 40 percent of deaths and 50 percent of diseases associated with poor drinking water quality due to the amalgamation of municipal sewage at different sections of the water distribution network (Hasan & Richardson, 2017; Kumar et al., 2022). Bangladesh, in addition to the former, also falls victim to a substandard health status because of unimproved sanitation. It is, however, noteworthy that even children in areas with inadequate water and sanitation facilities in Bangladesh are less exposed to diarrhoeal infections than the children in economically privileged areas in Pakistan and Nepal (Hasan & Richardson, 2017).

It is thus imperative to establish whether improved sanitation contributes alleviates the disease burden that exists otherwise. With reference to that, the literature concludes that a 50 percent increase in the sewage cover in Brazil solely lead to a 22 percent decline in the prevalence of diarrhoeal infections among minors under 3 years of age (Barreto et al., 2007). Similarly, another research analyzing the impact of increased distribution of sewage on diarrhoea estimated a 30 and 60 percent decline in its incidence and prevalence, respectively (Norman et al., 2010).

2.1.2. Acute Respiratory Infections (ARIs)

Acute respiratory infections (ARIs) occur because of malnutrition and inadequate micronutrient levels from diarrhoeal episodes, which compromise the immune system, making human hosts more vulnerable to respiratory pathogens. Severe malnutrition is thus linked to an elevated risk of death from acute respiratory infections (Ashraf et al., 2020; Swarthout et al., 2020). The World Bank (2006) further advocates that 50 percent of the incidence of ARIs is associated to malnutrition.

Inadequate sanitation, in addition to the aforesaid, can lead to respiratory infections through the consumption of contaminated water and food, due to which harmful particles may colonize the human respiratory tract. The nexus between respiratory infections and improved water quality, however, requires further research (Ashraf et al., 2020). Diarrhoea and ARIs, nevertheless, are the most prevalent reasons for hospitalization, mortality, and other long-term health problems among children in low- and middle-income economies (WHO, 2004; Windi et al., 2021).

Multiple studies throughout the literature further advocate the aforementioned nexus between inadequate WASH and ARIs. Upon analyzing two substantial child studies in the low-income settings of Ghana and Brazil, it was concluded that a higher risk of diarrhoea among malnourished children also makes them more vulnerable to ARIs, with 26 percent of the incidence directly associated with diarrhoea (Schmidt et al., 2009). Similarly, research quantifying the likelihood of ARIs manifesting between two groups of Indian and Nepali children in the same week and otherwise, concluded that the incidence of ARIs for both the cohorts was directly linked to that of diarrhoea (Walker, Perin, et al., 2013).

These infections thus constitute a major public health concern associated with poor sanitation. Being the cause of an alarming 70 percent of the morbidities among under-five children in the developing part of the world, ARIs present a far greater threat to the economically disadvantaged countries than those otherwise. They are also regarded as some of the primary factors causing mortality in several developing countries, accounting for an annual figure of 4.2 million deaths, 1.6 million of which comprise children under 5 years of age (Selvaraj et al., 2014; WHO, 2004).

ARIs have been categorised as “major child killers” and despite measures being taken to control them, they contribute towards almost half of the death toll among children in South Asia (Zaidi et al., 2004). Being one of the countries with the highest rate of childhood mortality due to ARIs, Bangladesh provides a fitting example in this case, with statistics showing that in 2013, 39.8 per 1000 under-five children were suffering from ARIs in Bangladesh. While multiple factors contribute towards these alarming figures, a nexus between the sanitary environment of households, determined by the toilet type in use, and the incidence of ARIs in Bangladesh has in fact been established (Nguyen, 2015; Sultana et al., 2019). These results can also be extended to other countries in South Asia such as Pakistan, which harboured the highest prevalence rate of

ARIs of 15.9 percent, with the children in poorer households considerably more vulnerable to ARIs due to the prevalence of poor sanitation services on account of residential crowding (Hasan & Richardson, 2017).

2.1.3. Malaria

Malaria, in addition to the acute respiratory infections, shares an intricate relationship with inadequate WASH. It occurs because of malnutrition and inadequate micronutrient levels from diarrhoeal episodes, which compromise the immune system, making human hosts more vulnerable to the disease. Severe malnutrition is thus linked to as much as 50 percent to 80 percent of the incidence of malaria (Ashraf et al., 2020; Prüss-Ustün et al., 2019; Swarthout et al., 2020; World Bank, 2006). The nexus between inadequate WASH and malaria is, however, not limited to the aforesaid as poor water, sanitation, and hygiene services raise the level of vector breeding, leading to an increased risk of malaria transmission (Messenger et al., 2023).

Advocating the aforesaid, the literature estimates that the lack of water resource management resulted in 355,000 global deaths due to WASH-attributable malaria in 2016. There is, however, an opportunity to reduce this substantial disease burden attributable to water, sanitation, and hygiene. In principle, all the disease burden estimated may be averted through appropriate interventions, depending on the health outcome in question and the selected alternative exposure scenario (Prüss-Ustün et al., 2019).

Environmental management strategies for malaria prevention typically encompass actions involving the management of water resources, such as the installation, cleaning, and maintenance of drainage systems, the systematic removal of stagnant water sources, and the strategic placement of communities away from locations where disease-carrying vectors breed (Prüss-Ustün et al., 2019).

2.2. Water-Related Impacts of Inadequate WASH

Safe and clean drinking water is a basic human need that ensures survival and improves consumer welfare. Drinking microbiologically clean water is thus a key indicator of human health, especially for children of growing ages. To achieve this, it is pertinent to improve the WASH facilities, including safe drinking water, enhanced sanitation facilities, and increased handwashing with soap. This will not only improve child health but also enhance their ability to learn and improve school attendance, thus reducing attention deficits and early dropouts (Alam & Mukarrom, 2022).

Adequate WASH facilities in households, as well as schools, has therefore been especially emphasized throughout the literature. A considerable number of households and schools in developing countries, however, neglect the provision of proper WASH services; in fact, only 51 percent of schools in low- and middle-income countries have access to adequate water facilities and 45 percent have access to adequate sanitation facilities. It is therefore not surprising that 1.5 to 2 million children under five years of age, most of whom attend schools, die annually from WASH-related illnesses while many others become susceptible to morbidity. This is because while young children lack complete immunity against bacteria such as the pathogenic E.coli, they still spend a considerable part of their day in school facilities. There is thus a direct nexus between water quality and health, which makes students of schools without adequate WASH facilities at a higher risk of mortality and morbidity (Alam & Mukarrom, 2022).

Between 2000 and 2020, a considerable proportion of the global population accessed safely managed drinking water facilities; however, 2 billion people in 2020 still lacked these services, including 1.2 billion people with basic facilities, 282 million people with limited facilities, 367 million people with unimproved facilities, and 122 million people drinking surface water. The current rate of progress of global coverage of safely managed drinking water facilities may thus not be enough to cater to the entire population, with only 81 percent of the population projected to have access to safely managed drinking water services by 2030 if the situation does not improve (WHO & UNICEF, 2021).

The coverage of safely managed drinking water services varies widely across SDG regions and countries. While most of the high-income countries may achieve universal coverage by 2030, the lower-middle-income countries are either progressing too slowly or even regressing in terms of safely managed drinking water services. North Africa, West Asia, Central Asia, and South Asia, for instance, are only expected to reach 96 percent coverage by 2030. Another kind of variation may additionally occur within countries as national estimates conceal the difference between urban and rural coverage (WHO & UNICEF, 2021).

In Pakistan, only 36 percent of the population have access to safely managed water services. The disparities between the level of drinking water services between urban and rural areas in the country, however, are relatively less significant; approximately 70 percent people in rural areas and 69 percent people in urban areas have drinking water accessible on premises, approximately 79 percent people in rural areas and 80 percent people in urban areas have water available when needed, and approximately 35 percent people in rural areas and 41 percent people in urban areas have water that is free from contamination (WHO & UNICEF, 2021). It is, however, notable that disparities in the quality of water not only between urban and rural areas but also among different urban environments do exist (Kumar et al., 2022). Water facilities that are accessible on premises may thus be unavailable or contaminated when needed (WHO & UNICEF, 2021).

Inadequate, unavailable, or contaminated water services thus impose significant costs on consumers and economies. Advocating the aforesaid, a case study from Karachi, Pakistan, elaborates that 1.91 million cubic meters of wastewater regularly remains untreated, due to which households are required to either treat the water prior to consumption or purchase bottled water – both of which add to the costs of living (Kumar et al., 2022).

2.3. Welfare-Related Impacts of Inadequate WASH

Despite the global coverage of safely managed sanitation services improving significantly from 47 percent in 2015 to 54 percent in 2020, 3.6 billion people around the world still lack these facilities. Even more alarming is the fact that out of this, 1.7 billion people were even deprived of basic sanitation services, which included 580 million with limited services, 616 million with unimproved services, and 494 million practicing open defecation. The current rate of progress may thus not be sufficient to cater to the entire global population, with only 67 percent of the population expected to have access to safely managed sanitation services by 2030 (WHO & UNICEF, 2021).

Interventions targeted at increasing the access of households to better sanitation facilities certainly cultivate massive benefits in terms of health; however, it is not the only sector that reaps the advantages of an improved sanitary environment. In fact, the positive effects of such interventions on households go beyond those initially fathomed by the scientists, including certain social and economic dimensions (Woersem et al., 2011). Research into the factors that promote the instalment of better sanitation facilities and instill improved sanitation practices among individuals and households has only recently begun to gain importance in the scientific community.

There exists a wide disparity between the objective of interventions targeting inadequate sanitation and the reasons that actually motivate households to make use of improved toilet types. While the former aims to reduce the prevalent health concerns, the latter is primarily concerned with the social aspect of using a private sanitation facility. This social dimension includes factors such as the need for privacy, avoidance of embarrassing and awkward situations, the desire to appear modern, the need for convenience, avoidance of the dangers and discomforts of bushes, and lastly, the need for social acceptance or to establish a social status (Jenkins & Curtis, 2005; Jenkins & Scott, 2007).

The provision of improved sanitation facilities, additionally, has wide-ranging benefits for the female gender in particular. Inadequate WASH facilities impede menstrual hygiene management and thus impose severe consequences for females in terms of their reproductive health and school performance. The literature especially emphasizes on proper water, sanitation, and hygiene facilities as a prerequisite for adolescent females to access basic education. 550 million females in the world, however, are deprived of such services and 335 million go to schools without access to soap or water. This leads to an increase in urinary and tract infections, as well as a rise in school absenteeism and school dropout rates. The evidence, therefore, suggests that improvements in school hygiene facilities result in favourable effects on the health and well-being of students, promote equal access to learning opportunities, and yield positive educational outcomes (Mahon & Fernandes, 2010; Melaku et al., 2023). This may not only lead to huge productivity gains but also help to curtail the frequency of infections associated with inadequate sanitation among children as educated mothers, being more aware of the consequences of child exposure to ARIs and diarrhoea, may take better prevention measures (Mukhtar et al., 2011).

Improved sanitation further comprises significant economic implications, including a decrease in the costs of the healthcare system due to a fall in the incidence of infectious diseases with the prevalence of better sanitation practices. There are additionally fewer productivity losses via work or school absenteeism, whether directly because of being infected with a disease or indirectly due to the obligation of taking care of a sick relative. Lastly, the economic benefits also include convenience time savings, which is defined by the time saved from being able to avoid waiting in lines at shared sanitation facilities or walking to a suitable site for open defecation (WHO, 2007).

Advocating the aforesaid, statistics show that the prevention of sanitation and water-borne infections may potentially save an annual figure of approximately $7 billion in the health system. If the value of reduced mortality figures, based on discounted future earnings, was also included, it would lead to further savings of $3.6 billion every year (Hutton et al., 2004). Pertaining to the developing part of the world in specific, the significance of the costs of sanitation-related diseases may be judged by the fact that during one time period almost half of the beds in hospitals are reserved by patients of diarrheal infections alone (UNDP, 2006). Costs associated with inadequate sanitation and hygiene, for example, account for 5.6 percent of the annual GDP of the Lao People's Democratic Republic (Hutton et al., 2009). Other studies focusing on the effect of interventions in countries like Ghana and Pakistan also suggest the existence of a relationship between improved sanitary environment and annual reductions in the cost to GDP, reducing the value of these expenses by as much as 8 to 9 percent per year (World Bank, 2008). Analysing the cost-benefit ratios accompanying the MDGs related to sanitation thus confer that every dollar spent in favour of it may generate approximately 10 dollars' worth of economic benefit, whereby the enhanced productivity owing to the avoidance of illnesses remains the primary contributor (Cairncross & Valdmanis, 2006).

2.4. Wider Economics Benefits of WASH Interventions

In the wake of this water quality crisis, the efficient and effective management of water resources is highly significant. The previously mentioned notion is advocated by the development hypothesis asserting that improvements in water, sanitation, and hygiene (WASH) have the most prominent and sustainable effect on health. It is achieved when there is a balance of three elements: increased access to hardware, such as water and sanitation infrastructure and hygiene products; necessary behavioural changes for sustained advancements in water and sanitation service and hygiene practices; and improved empowering policies and institutional environment (USAID, 2014).

Out of these elements, the first one is especially emphasized throughout literature as key infrastructure choices significantly affect water resources (FODP, 2012). Its significance may be better understood through the example of Karachi's dire water problems that are becoming more challenging because of its growing population – while the Karachi Water and Sewage Board (KWSB) supplies 665 million gallons of water per day, the demand for water is approximately 820 to 1200 million gallons (Kumar et al., 2022). In this regard, valuing water is an important pre-requisite to ascertain whether infrastructure costs are even worth the investment. This may be done by taking into account the price charged for water or evaluating the direct and indirect benefits water offers to the general economy (FODP, 2012).

It is thus imperative to establish whether improved sanitation contributes towards alleviating the disease burden that exists otherwise. Although a significant portion of the literature was unable to extract its advantages independent of those collectively resulting from improved water, sanitation, and hygiene; one research conducted in Brazil did conclude a 22 percent decline in the prevalence of diarrhoeal infections among minors under 3 years of age, attributed solely to an increase in the sewage cover by over 50 percent (Barreto et al., 2007). Similarly, another research analyzing the impact of the distribution of sewage on diarrhoea estimated a 30 percent decline in its incidence and a 60 percent reduction in its prevalence in the vicinity due to improved sanitation (Norman et al., 2010).

These distressing figures can, however, be controlled by simply capitalizing on the inverse relationship between adequate sanitation and childhood mortality. The introduction of such interventions in the past has successfully resulted in the reduction of diarrhoea by 36 percent, which not only concludes it as effective but also solidifies the hypothesized link between sanitation, diarrhoea, and mortality (Thompson & Khan, 2003).

2.5. Conclusion of Literature Review

The effect of inadequate water and sanitation is the most prominent among individuals and households in developing countries. This impact occurs in the form of additional costs to the health, water, welfare, tourism, and drainage sectors. The provision of improved sanitation thus leads to significant improvements in the health sector, as well as other social and economic avenues. With the conclusion of the literature review, certain gaps in research became evident; highlighted in the following section, this study will contribute to the literature by exploring these gaps.

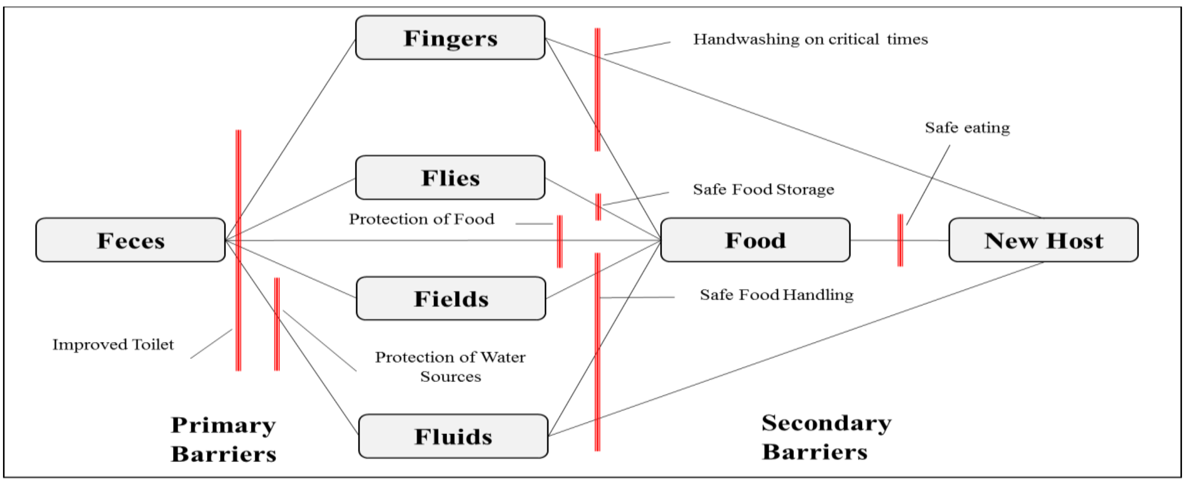
2.6. Literature Gap

The research concerning this avenue remains limited as the most recent relevant study was conducted by the World Bank in 2013 using data from 2006. This research will hence fill the aforesaid gap in the literature by analyzing the impact of inadequate water and sanitation on the health sector, water sector, welfare sector, tourism sector and drainage user cost for households in Pakistan and further calculating the economic benefit that may be derived from different mitigation interventions.

3. Conceptual Framework

This chapter illustrates and elaborates the different channels through which pathogens are transferred from excreta to a new host and the sanitation practices that can function as a barrier to halt the spread of harmful bacteria. Most of the health concerns originating as a result of poor sanitation are spread through a faecal-oral route of transmission that makes individuals vulnerable to a variety of health concerns such as malnutrition, diarrhoea, hepatitis, and ARIs. These transmission routes, along with the barriers that help to curtail them, are illustrated in Figure 3.1.

Figure 3.1 Faecal-Oral Routes of Disease Transmission (Gil et al., 2004)



The transmission route of pathogens from faeces to a host may be direct via food consumed, or indirect via four other faecal-oral channels, including transmission through fingers, flies, soil, and contaminated water. The routes involving fingers and contaminated water transpire in two ways – directly or through the consumption of food carrying faecal bacteria. Firstly, some bacteria may remain on hands and fingers after defecation, leading to harm. Secondly, water contamination can occur from numerous sources such as untreated wastewater and surface water flow carrying openly defecated waste, all of which makes water harmful for domestic use. The transmission of pathogens through flies and soil, however, occurs only indirectly by contamination of food consumed. Flies come into contact with human waste collected in heaps, from where they carry and spread dangerous microbes. These pathogens are passed onto eatables if flies come into direct contact with food substances, which become a cause of infections when consumed. Lastly, open defecation also contaminates the soil, which transfers faecal bacteria to crops.

As illustrated in Figure 3.1 Faecal-Oral Routes of Disease Transmission (Gil et al., 2004), providing adequate sanitation facilities is one of the primary barriers to block all faecal-oral transmission channels. An additional primary barrier is also required to fully disintegrate the route polluting water bodies; this includes the protection of water bodies by keeping water containers well-covered and out of reach of young children and animals, boiling water before use, and exposing water to sunlight for several hours in clear plastic containers. The model additionally includes numerous secondary barriers that protect new hosts from infection. Firstly, handwashing on critical times such as after defecation and before eating/handling of food is significant to prevent the spread of pathogens via fingers. Safe food storage and handling are also essential to eliminate direct transmission of faecal bacteria. Lastly, properly washing fruits and vegetables before consuming them raw also plays a significant role in protecting individuals from being the target of infections associated with inadequate sanitation (Gil et al., 2004).

4. Data and Methodology

4.1. Data Description

The cost-benefit analysis comprises various sources from which the required data was gathered, all of which are henceforth described.

4.1.1. Pakistan Demographic and Health Survey, 2017-18

The Pakistan Demographic and Health Survey (PDHS), 2017-18 serves as the foremost data source. It is a comprehensive national survey comprising information about child health, maternal, and population problems in Pakistan, of which this study uses the following variables:

percentage of under-five children, disease incidence and treatment, toilet types, water source and access, percentage of females aged 11 to 17 years, household size, and percentage distribution of rural and urban population according to age (NIPS, 2019).

4.1.2. Pakistan Social and Living Standards Measurement Survey, 2019-20

This research further relies on the 2019-2020 Pakistan Social and Living Standards Measurement Survey (PSLM), a district-level national economic survey with modules comprising health; disability; and housing, water supply, and sanitation, among others. Of the large variety of variables in the survey, the percentage of urban and rural households with inaccessible water supply, no connection to sanitation system, and any connection to sanitation system were of use for this study (Pakistan Bureau of Statistics, 2021).

4.1.3. Pakistan Labour Force Survey, 2020-21

This research further relies on the 2019-2020 Pakistan Social and Living Standards Measurement Survey (PSLM), a district-level national economic survey with modules comprising health; disability; and housing, water supply, and sanitation, among others. Of the large variety of variables in the survey, the percentage of urban and rural households with inaccessible water supply, no connection to sanitation system, and any connection to sanitation system were of use for this study (Pakistan Bureau of Statistics, 2021).

4.1.4. Other Secondary Data Sources

In addition to the above, this research also uses the Population and Household Census, 2017 (Pakistan Bureau of Statistics, 2017), the Pakistan Economic Survey, 2020-21 (Ministry of Finance, 2021), and published literature for other variables and statistics used in the cost estimation (See Appendix A for details about the secondary data sources).

4.2. Methodology

Adhering to the research questions mentioned above, this study adopts the estimation technique used by Hutton and Haller (2004) to calculate the overall, direct, and indirect costs of inadequate water management; the economic benefit resulting from sanitation-, hygiene-, and water-related interventions; and the size of Pakistan's potential sanitation market. The methodology pertaining to each of these categories; including the equations, inputs, and relationships used; is explained under the following sections.

4.2.1. Economic Cost of Poor Water Management

The economic cost of poor water management is calculated as the sum of health, water, welfare tourism, and drainage user costs, incurred as a result of inadequate sanitation. It may be categorised into direct and indirect economic costs, whereby the former includes health, water, tourism, and drainage user costs; and the latter includes health, water, and welfare costs. This may be summarized and represented by the following equations:

$$EC = \sum [H + W + X + T + D] \quad (4.1)$$

In Equation $EC = \sum [H + W + X + T + D]$ (4.1), EC = economic cost, H = health cost, W = water cost, X = welfare cost, T = tourism cost, and D = drainage user cost. This equation includes both direct and indirect economic costs, represented by Equation (1A) and Equation (1B), respectively. Even though both of them comprise several similar variables, the nature of these variables is different in each, as explained further in this chapter.

$$DEC = \sum [HD + WD + TD + DD] \quad (4.2)$$

In Equation $DEC = \sum [HD + WD + TD + DD]$ (4.2), *DEC* = direct economic cost, *HD* = direct health cost, *WD* = direct water cost, *TD* = direct tourism cost, and *DD* = drainage user cost. More particularly, *DEC* covers the cost of treatment of diseases incurred under health; the cost of drinking water treatment, bottled water consumption, and piped water consumption under water; the cost of lost tourism earnings and treatment of foreign tourists' illnesses under tourism; and finally, the user cost of drainage.

$$IEC = \sum [HI + WI + XI] \quad (4.3)$$

In Equation $IEC = \sum [HI + WI + XI]$ (4.3), *IEC* = indirect economic cost, *HI* = indirect health cost, *WI* = indirect water cost, and *XI* = indirect welfare cost. In contrast to nature of costs above, *IEC* comprises the cost of premature mortality and productivity losses due to diseases under health; the value of time lost in fetching water and drinking water treatment through boiling; and the value of time lost due to shared toilet facilities and open defecation, and welfare losses attributable to the lack of access to female toilets in schools and workplaces.

4.2.2. Health-Related Costs

Discussing the first component of the aforementioned economic cost, the health-related cost (*HC*) of poor water management is given as a sum of the cost of premature mortality (*P*), cost of treatment of diseases (*C*), and productivity loss attributable to diseases (*L*); it is noteworthy to mention that the diseases considered in this research include diarrhoea, acute respiratory infections (*ARIs*), and malaria, selected because of the significance of their relationship with inadequate sanitation. This information is represented by Equation $HC=$▯ $[P + C + L]$▯ (4.4) below:

$$HC = \sum [P + C + L] \quad (4.4)$$

Each

a. Cost of Premature Mortality

The cost of premature mortality (*P*) due to diarrhoea, ARIs, and malaria is given as the function of N_{U5} = children under five years old, *d* = percentage of deaths by case attributable to inadequate sanitation, and *HCA* = human capital approach value – which essentially sets a monetary value on any loss of wealth, equating it to a deprivation of economic activity caused by poor health, premature mortality, or disability. *HCA* thus incorporates the present value of expected future earnings to calculate the loss to society because of the aforementioned causes.

E
q
u

$$P = (N_{U5} \times d) \times HCA \quad (4.5)$$

b. Cost of Treatment of Diseases

a
t

The cost of treatment of diseases is calculated as the sum of the cost of treatment of diarrhoea pertaining to children under five years of age and adults over five years of age, and the cost of treatment of ARIs and malaria pertaining to children under five years of age. The following equation

i
o
n

$C= \sum[D_c + A_c + M_c]$ (4.6) represents the aforesaid.

R
E

$$C = \sum[D_c + A_c + M_c] \quad (4.6)$$

F

In Equation

$C= \sum[D_c + A_c + M_c]$ (4.6), C = cost of treatment of diseases, D_c = cost of treatment of diarrhoea, A_c = cost of treatment of ARIs, and M_c = cost of treatment of malaria. The formulae used to calculate each are mentioned in the following paragraphs.

_
R
e
f
1

The cost of treatment of diarrhoea is estimated separately for children under and adults over five years of age treated at medical facilities and traditional healers. This is given by Equation

6
3
0
2
4

$DC = \sum_Y \sum_X [(T_Y \times \alpha) \times (C_X + M_D) \times t_X \times N_V]$ (4.7) below, where D_C = cost of treatment of diarrhoea, Y = age group (under-five children or over-five adults), X = medical facility or traditional healer, T_Y = number of treated cases belonging to each age group, α = fraction of diarrhoeal cases attributable to inadequate sanitation, C_X = cost of treatment per case at medical facility and traditional healers, M_D = cost of diarrhoea medicine per case, t_X = percentage of cases treated at medical facilities and traditional healers, and N_V = number of consultation visits per case.

$$D_C = \sum_Y \sum_X [(T_Y \times \alpha) \times (C_X + M_D) \times t_X \times N_V] \quad (4.7)$$

The cost of treatment of ARIs (A_C) is calculated for children under five years of age treated at a medical facility. It is calculated as a function of the percentage of ARI cases treated at medical facilities (t_M), cost of ARI treatment at medical facilities (C_M), number of children under five years of age (N_{U5}), two-week ARI incidence (β), and percentage of malnutrition-related cases attributable to inadequate sanitation (α). Equation $AC = \{[(N_{U5} \times \beta) \times \alpha \times t_M] \times t_M \times C_M\}$ (4.8) aptly summarises this information, as shown below:

$$A_C = \{[(N_{U5} \times \beta) \times \alpha \times t_M] \times t_M \times C_M\} \quad (4.8)$$

Similar to the previous case of ARIs, the cost of treatment of malaria (M_C) is also calculated for under-five children treated at medical facilities. This research estimates it as a function of the number of children under five years of age (N_{U5}), malaria incidence (β), percentage of malnutrition-related cases attributable to inadequate sanitation (α), percentage of malaria cases treated at medical facilities (t_M), and cost of malaria treatment at medical facilities (C_M). The following formula, given as Equation $MC = \{[(N_{U5} \times \beta \times \alpha) \times t_M] \times C_M\}$ (4.9, represents the abovementioned information.

$$M_C = \{[(N_{U5} \times \beta \times \alpha) \times t_M] \times C_M\} \quad (4.9)$$

c. Value of Productivity Loss

The productivity losses pertaining to diarrhoea, ARIs, and malaria are calculated individually for under-five and over-five patients, as well as adult caretakers of the sick children. It may be given as the following equation:

$$L = \sum[L_D + L_A + L_M] \quad (4.10)$$

In Equation $L = \sum[L_D + L_A + L_M]$ (4.10), L = total productivity loss, L_D = productivity loss from diarrhoea, A_L = productivity loss from ARIs, and

M_L = productivity loss from malaria. The equations used to calculate each of these components are given and explained in the following sections.

The productivity loss arising from diarrhoea is calculated as the sum of the value of productivity loss due to diarrhoea among children under five years of age, the value of productivity loss due to diarrhoea among population over five years of age, and the loss of financial earnings of diarrhoea patients.

$$L_D = \sum\{N_{u5} \times \beta \times 52 \times \alpha^2[\rho + (l_{u5} \times w \times \mu \times \mu_{u5})]]\} + \{N_{o5} \times d_{o5} \times \alpha \times l_{o5} \times w \times \mu\} + \left\{\frac{GDP\ per\ capita}{360} \times N_{o5} \times d_{o5} \times \alpha \times l_{o5} \times e\right\} \quad (4.11)$$

Equation $LD = \sum\{N_{u5} \times \beta \times 52 \times \alpha^2[\rho + (l_{u5} \times w \times \mu \times \mu_{u5})]]\} + \{N_{o5} \times d_{o5} \times \alpha \times l_{o5} \times w \times \mu\} + \left\{\frac{GDP\ per\ capita}{360} \times N_{o5} \times d_{o5} \times \alpha \times l_{o5} \times e\right\}$ (4.11) quantifies these components, whereby N_{u5} = children under five years of age, N_{o5} = population over five years of age, β = two-week diarrhoea incidence, d_{o5} = estimated annual diarrhoea cases among population over five years of age, α = percentage of diarrhoea cases attributable to inadequate sanitation, ρ = time loss per case, l_{u5} = duration per case of diarrhoea among children under five years of age, l_{o5} = duration per case of diarrhoea among adults over five years of age, w = working hours per day, μ = value of welfare loss, μ_{U5} = welfare loss of child as a percentage of adult, and e = percentage of population employed.

The productivity losses arising due to ARIs (L_A) are calculated as the sum of the value of productivity loss from caring for children with ARIs and that of patients suffering from ARIs. Equations $LA = \sum\{[(N_{U5} \times \beta \times \frac{52}{2.5}) \times \alpha \times \rho \times \mu] + [(N_{U5} \times \beta \times \frac{52}{2.5}) \times \alpha \times l_A \times w \times \mu \times \mu_{U5}]]$ --- (4.12) and $LA = \left(N_{U5} \times \beta \times \frac{52}{2.5}\right) \times \alpha \times \mu \sum[\rho + (l_A \times w \times \mu_{U5})]$ (4.13) fractionate both these components, whereby β = two-week ARIs incidence, α = percentage of malnutrition cases attributable to inadequate sanitation, μ = value of welfare loss, ρ = time loss per case, l_A = duration of ARIs episode, w = working hours per day, and μ_{U5} = welfare loss of child as a percentage of adult.

$$L_A = \sum\{[(N_{U5} \times \beta \times \frac{52}{2.5}) \times \alpha \times \rho \times \mu] + [(N_{U5} \times \beta \times \frac{52}{2.5}) \times \alpha \times l_A \times w \times \mu \times \mu_{U5}]] \quad \text{--- (4.12)}$$

$$L_A = \left(N_{U5} \times \beta \times \frac{52}{2.5}\right) \times \alpha \times \mu \sum[\rho + (l_A \times w \times \mu_{U5})] \qquad (4.13)$$

The productivity losses pertaining to malaria are estimated as the sum of the financial earning loss of patients, value of productivity loss from caring for sick individuals, and that of patients suffering from malaria. Each of these components are calculated through the inputs included Equation $LM = \sum\{[\partial \times (N_{O5} \times \beta) \times l_M \times e \times \alpha] + [(N_M \times \alpha) \times \rho \times \mu] + [(N_M \times w \times l_M) \times \mu \times \mu_{U5}]\}$ (4.14) , mentioned below. They comprise: $\partial =$ average value of time per day, N_{O5} = population over five years of age, β = malaria incidence, l_M = duration of malaria episode, e = percentage of population employed, α = percentage of malnutrition cases attributable to inadequate sanitation, N_M = total number of malaria cases, ρ = time loss per case, μ = value of welfare loss, w = working hours per day, μ_{U5} = welfare loss of child as a percentage of adult.

$$L_M = \sum\{[\partial \times (N_{O5} \times \beta) \times l_M \times e \times \alpha] + [(N_M \times \alpha) \times \rho \times \mu] + [(N_M \times w \times l_M) \times \mu \times \mu_{U5}]\} \qquad (4.14)$$

In addition to the equations mentioned above, two of the inputs used in the estimation of cost of treatment of diseases, namely ρ = time loss per case and μ = value of welfare loss, require further calculations. Their construction and calculation are explained by the following equations:

$$\rho = \sum[(a \times h) + (c \times i)] \qquad (4.14)$$

$$\mu = \left[\frac{GDP_{PC}/_{360}}{w}\right] \times wl \qquad (4.15)$$

The first of these formulae, Equation $\rho = \sum[(a \times h) + (c \times i)]$ (4.14), calculates the time loss per case (ρ), where a = time loss of adults in accompanying children for healthcare, h = proportion of cases seeing healthcare provider, c = time loss of adults in caring for ill children, and l = duration of the disease episode.

E

q

u

a

t

i

o

n

4.2.3. Water-Related Costs

Moving on to the second component of the economic cost given by Equation (1), the water-related costs are calculated as the sum of the cost of treatment of drinking water (D_c), value of time lost in boiling water (B_t), cost of bottled water consumption (Y_c), cost of piped water consumption (P_c), and the cost of fetching water (F_c). The following equation $W=$ [$D_c + B_t + Y_c + P_c + F_c$] (4.16) represents and summarises this information.

$$W = \sum[D_c + B_t + Y_c + P_c + F_c] \qquad (4.16)$$

Each of the abovementioned components of water costs are individually estimated and then accumulated; the formulae constructed to calculate them are elaborately explained in the following sections.

a. Household Treatment of Drinking Water

The cost incurred by households due to the treatment of drinking water (D_c) is given as the sum of different treatment processes, including boiling (Bl_c), bleach/chlorine (Cl_c), strained through cloth (St_c), and ceramic, sand, or other filters (Ot_c). These inputs and components are summarised in Equation $Dc= \sum[Bl_c + Cl_c + St_c + Ot_c]$ (4.17), as shown below.

$$D_c = \sum[Bl_c + Cl_c + St_c + Ot_c] \qquad (4.17)$$

Water may be boiled for treatment through various tools, including wood, kerosene, natural gas, and other materials. This research thus calculates the associated cost as the sum of the cost of treatment of boiling water by wood, kerosene, natural gas, and other materials. Equation $Blc= \sum[w_c + k_c + n_c + o_c]$ (4.18) summarises this information, as shown below.

$$Bl_c = \sum[w_c + k_c + n_c + o_c] \qquad (4.18)$$

In Equation $xc= \left[(P_x \times A_x \times 360) \times \left(\frac{kg_x}{e}\right) \times p_x\right]$ (4.19) above, w_c = cost of boiling water using wood, k_c = cost of boiling water using kerosene, n_c = cost of boiling water using natural gas, and o_c = cost of boiling water using other materials. The general formula used to calculate each of these variables is given below as Equation $xc= \left[(P_x \times A_x \times 360) \times \left(\frac{kg_x}{e}\right) \times p_x\right]$ (4.19).

$$x_c = \left[(P_x \times A_x \times 360) \times \left(\frac{kg_x}{e}\right) \times p_x\right] \quad (4.19)$$

In Equation $xc= \left[(P_x \times A_x \times 360) \times \left(\frac{kg_x}{e}\right) \times p_x\right]$ (4.19), x_c constitutes the cost of boiling water for treatment using wood, kerosene, natural gas, or other materials, P_x = population using x, A_x = average litres of x used per person per day, kg_x = kilograms of x required to boil 1 litre of water, e = efficiency adjustment, and p_x = price of x per kilogram.

Water may also be treated through other means, one of which constitutes treatment using bleach or chlorine. This research calculates its cost of treatment using Equation $Clc= [(P_{cl} \times 4 \times 365) \times C_{cl}]$ (4.20), mentioned and explained below.

$$Cl_c = [(P_{cl} \times 4 \times 365) \times C_{cl}] \quad (4.20)$$

In Equation $Clc= [(P_{cl} \times 4 \times 365) \times C_{cl}]$ (4.20), Cl_c = cost of drinking water treatment using chlorine or bleach, P_{cl} = population using chlorine or bleach for drinking water treatment, and C_{cl} = cost to treat 1 litre of water using chlorine.

In addition to the aforementioned, water may also be treated through cloth straining, the cost estimation method of which is elaborated henceforth.

$$St_c = [(P_{st} \times 4 \times 365) \times C_{st}] \quad (4.21)$$

In Equation $Stc= [(P_{st} \times 4 \times 365) \times C_{st}]$ (4.21), St_c = cost of drinking water treatment using cloth straining, P_{st} = population using cloth straining for drinking water treatment, and C_{cl} = cost to treat 1 litre of water using the cloth straining method.

Finally, other materials such as ceramic may also be used for the treatment of drinking water. Due to the scope of this variable and limited data availability, however, its cost of treatment is taken as the average of that of the previous three methods. The following formula is used in the cost estimation of treatment through ceramic and other filters (Ot_c).

$$Ot_c = \left[\left(\frac{P_{ot}}{hh}\right) \times (C_{ot} \times 12)\right] \quad (4.22)$$

In equation $Otc= \left[\left(\frac{P_{ot}}{hh}\right) \times (C_{ot} \times 12)\right]$ (4.22), P_{ot} = population using ceramic and other filters for the treatment of drinking water, hh = household size, and C_{ot} = household average cost of treatment per month.

b. Value of Time Lost in Boiling Water

The value of time lost in boiling water (T_{BW}) is given as the function of P_t = total population, γ = percentage of population using drinking water treatment, t_{HH} = time lost per year per household, and μ = attributed welfare loss. Equation (3.3) below summaries the aforesaid variables.

$$T_{BW} = \left[\frac{P_t \times \gamma}{6.6} \times t_{HH} \times \mu\right] \tag{4.23}$$

c. Cost of Bottled Water Consumption

The cost of bottled water consumption rises because individuals perceive the drinking water quality as inadequate, and thus switch to bottled water to avoid susceptibility to water-borne diseases. The formula used in its calculation is given by Equation $Yc= \left[(DW_{pc} \times N_Y\right] \times 360$ (4.24) below.

$$Y_c = \left[(DW_{pc} \times N_Y\right] \times 360 \tag{4.24}$$

In Equation $Yc= \left[(DW_{pc} \times N_Y\right] \times 360$ (4.24), Y_c = cost of bottled water consumption, DW_{pc} = drinking water usage per person, and N_Y = number of people using bottled water.

d. Cost of Piped Water Production

Piped water is a preferrable alternative as households make a behavioural shift from unimproved water sources, such as unprotected dug well, unprotected spring, tanker truck/cart with small tank, and surface water, to improved water sources, including piped into dwelling/yard/plot, piped to neighbour, public tap/standpipe, tube well or borehole, protected dug well, protected spring, rainwater, and filtration plant.

$$P_c = \sum\left\{\frac{(P_{x,y} \times \rho_{x,y}) \times w_l}{1000} \times 365 \times \alpha\right\} \tag{4.25}$$

The piped water cost attributable to sanitation (P_c) is given by Equation $Pc= \sum\left\{\frac{(P_{x,y} \times \rho_{x,y}) \times w_l}{1000} \times 365 \times \alpha\right\}$ (4.25), where x = rural, y = urban, $P_{x,y}$ = population in rural or urban areas, $\rho_{x,y}$ = percentage of rural or urban population with piped water sources, w_l = daily water consumption – litres per person per day, and α = fraction of piped water production cost attributable to sanitation.

e. Cost of Fetching Water

In Pakistan, a considerable number of the households are deprived of a water source inside their houses; hence, they fetch water from one outside. This, however, prolongs the time spent doing water-related activities, such as fetching, purifying, and storing of water; and imposes a significant cost on the households, especially females and children, who often have to surrender work and education for fetching water. This study captures the cost of fetching water attributable to sanitation (F_c) through equation $Fc= \sum\{[(H_{x,y} \times d_{x,y}) \times t_{x,y}] \times \partial\}$ (4.26), whereby x = rural, y = urban, $H_{x,y}$ = total number of households in rural or urban areas, $d_{x,y}$ = percentage of households having inaccessible domestic water supply in rural or urban areas, $t_{x,y}$ = time taken to fetch water in rural and urban areas, and ∂ = average value of time per day.

$$F_c = \sum\{[(H_{x,y} \times d_{x,y}) \times t_{x,y}] \times \partial\} \qquad (4.26)$$

4.2.4. Other Welfare-Related Costs

The welfare-related costs (X) form the third component of the economic cost of poor sanitation and water management. They are calculated as the sum of the cost of using shared toilets (ST_c), cost of open defecation (OD_c), economic loss from lack of access to toilets in schools (SA_c), and economic loss from lack of access to toilets in workplaces (WA_c) – all of which is summarised by Equation $X=ST_c + OD_c + SA_c + WA_c$ (4.27) below.

$$X = ST_c + OD_c + SA_c + WA_c \qquad (4.27)$$

a. Economic Cost of Time Lost Using Shared Toilets

Even though all households generally prefer having private toilets, it is a rare commodity in many parts of Pakistan, including both urban and rural areas. Such households thus rely on shared toilets, due to which they incur significant losses in terms of time. This study uses Equation (4.1) to estimate the economic cost of time lost because of shared toilet facilities, where σ = access time for shared toilets per person per day, ∂_{c14} = value of time for children between 0 – 14 years of age per hour, C_{u14} = number of children between 0 – 14 years of age living in urban areas, s_u = percentage of households in urban areas using shared toilet facilities, ∂_{a15} = value of time for adults aged 15 years or older, A_{u15} = number of adults aged 15 years or older living in urban areas, C_{r14} = number of children between 0 – 14 years of age living in rural areas, s_r = percentage of households in rural areas using shared toilet facilities, and A_{r15} = number of adults aged 15 years or older living in rural areas.

$$ST_c = \sigma \times 365 \times \{[\partial_{c14} \times (C_{u14} \times s_u)] + [\partial_{a15} \times (A_{u15} \times s_u)] + [\partial_{c14} \times (C_{r14} \times s_r)] + [\partial_{a15} \times (A_{r15} \times s_r)]\} \quad (4.28)$$

b. Economic Cost of Time Lost Due to Open Defecation

Similar to the case of shared toilets discussed in the previous section, a significant proportion of the population in Pakistan also practices open defecation due to the unavailability of toilets. These households incur significant losses because of the time wasted in finding an appropriate place for open defecation, especially girls and women, who often have to wait until dark or early morning. This study estimates the economic cost of time lost due to open defecation using the following formula:

$$OD_c = \sigma \times 365 \times \{[\partial_{c14} \times (C_{u14} \times d_u)] + [\partial_{a15} \times (A_{u15} \times d_u)] + [\partial_{c14} \times (C_{r14} \times d_r)] + [\partial_{a15} \times (A_{r15} \times d_r)]\} \quad (2.29)$$

In Equation $ODc = \sigma \times 365 \times \{[\partial_{c14} \times (C_{u14} \times d_u)] + [\partial_{a15} \times (A_{u15} \times d_u)] + [\partial_{c14} \times (C_{r14} \times d_r)] + [\partial_{a15} \times (A_{r15} \times d_r)]\}$ (2.29) above, σ = time taken to access fields or spaces for open defecation per person per day, ∂_{c14} = value of time for children between 0 – 14 years of age per hour, C_{u14} = number of children between 0 – 14 years of age living in urban areas, d_u = percentage of households in urban areas without toilets or using open fields/spaces as toilets, ∂_{a15} = value of time for adults aged 15 years or older, A_{u15} = number of adults aged 15 years or older living in urban areas, C_{r14} = number of children between 0 – 14 years of age living in rural areas, d_r = percentage of households in rural areas without toilets or using open fields/spaces as toilets, and A_{r15} = number of adults aged 15 years or older living in rural areas.

c. Economic Loss from Lack of Access to Toilets in Schools

The economic loss that arises due to the lack of or inadequate sanitation in schools is calculated using Equation $SAc = \sum\left\{\frac{[(G_u \times \delta_s \times \gamma_u) \times a]}{360} \times \mu \times 360\right\} + \left\{\frac{[(G_r \times \delta_s \times \gamma_r) \times a]}{360} \times \mu \times 360\right\}$ (4.30), as given below, where G_u = number of girls between 11 – 17 years of age living in urban areas, δ_s = net attendance ratio of secondary education, γ_u = percentage of secondary schools in urban areas not having female toilets, a = average number of absences per year during menstrual periods for girls aged 11 – 17 years, μ = value of welfare loss from school absence per day, G_r = number of girls between 11 – 17 years of age living in rural areas, and γ_r = percentage of secondary schools in rural areas not having female toilets.

$$SA_c = \sum\left\{\frac{[(G_u \times \delta_s \times \gamma_u) \times a]}{360} \times \mu \times 360\right\} + \left\{\frac{[(G_r \times \delta_s \times \gamma_r) \times a]}{360} \times \mu \times 360\right\} \quad (4.30)$$

d. Economic Loss from Lack of Access to Toilets in Workplaces

Similar to the above, inadequate sanitation in workplaces also becomes a source of economic loss because women are either entirely restricted from work or adversely affected in terms of their job performance. This study estimates the economic loss due to the lack of access to toilets in workplaces using the following formula:

$$WA_c = \sum\{[(W_{u15} \times m \times a) \times \mu] + [(W_{r15} \times m \times a) \times \mu]\} \quad (4.31)$$

In Equation $WAc = \sum\{[(W_{u15} \times m \times a) \times \mu] + [(W_{r15} \times m \times a) \times \mu]\}$ (4.31), W_{u15} = number of women aged 15 years or older working in urban areas, W_{r15} = number of women aged 15 years or older working in rural areas, m = percentage of women absent during menstrual periods due to lack of sanitation, a = average number of absences per year during menstrual periods for women aged 15 years or older, and μ = value of welfare loss for an absent day.

4.2.5. Tourism-Related Costs

The tourism industry of Pakistan is additionally adversely affected due to inadequate sanitation and hygiene in the country. It constitutes the fourth component of the overall economic cost of poor sanitation and water management in the country. These tourism-related costs (T) are calculated as the sum of lost tourism earnings (E_t) and cost of international tourists' illnesses (I_t), as shown in Equation $T=$□$[E_t + I_t]$□ (4.32) below.

$$T = \sum[E_t + I_t] \quad (4.32)$$

a. Value of Lost Tourism Earnings

Lost tourism earnings basically estimate the difference between potential and actual tourism revenues because of inadequate sanitation in Pakistan, which is calculated using the following formula.

$$E_t = \sum\left\{\left[\left(F_A \times \frac{p}{o}\right) \times C_F\right] + \left[\left(D_A \times \frac{p}{o}\right) \times C_D\right] - [(F_A \times C_F) + (D_A \times C_D)]\right\} \quad (4.33)$$

In Equation $Et = \sum\left\{\left[\left(F_A \times \frac{p}{o}\right) \times C_F\right] + \left[\left(D_A \times \frac{p}{o}\right) \times C_D\right] - [(F_A \times C_F) + (D_A \times C_D)]\right\}$ (4.33), E_t = value of lost tourism earnings, F_A = actual number of foreign tourists, D_A = actual number of domestic tourists, C_F = average spending of foreign tourists per visit, C_D = average spending of domestic tourists per visit, p = percentage of potential tourism, and o = percentage of actual occupancy rate.

b. International Tourists' Illness

The cost of international tourists' illness is given as the sum of the opportunity cost of going on a vacation and treatment cost of international visitors. It is estimated using the inputs and variables identified in Equation $It = \{[\mu_t \times l \times (F \times i)] + [(F \times i) \times d \times c]\}$ (4.34), where I_t = cost of international tourists' illness, μ_t = welfare loss of tourists per day, l = average length of stay of foreign tourists, F = number of foreign tourists, i = percentage of foreign tourists getting sick, d = average duration of illness, and c = total treatment cost per case.

$$I_t = \{[\mu_t \times l \times (F \times i)] + [(F \times i) \times d \times c]\} \quad (4.34)$$

4.2.6. Drainage User Cost

Drainage user cost is the fifth and final component of the economic cost of poor sanitation and water management; it is estimated using the following equation.

$$D = \sum \left\{ \left[\left(\frac{HH_r}{a_r} \times f_r \right) \times u_r \right] + \left[\left(\frac{HH_u}{a_u} \times f_u \right) \times u_u \right] \right\} \quad (4.35)$$

In Equation $D = \sum \left\{ \left[\left(\frac{HH_r}{a_r} \times f_r \right) \times u_r \right] + \left[\left(\frac{HH_u}{a_u} \times f_u \right) \times u_u \right] \right\}$ (4.35), D = drainage user cost, HH_r = number of households in rural areas with any connection to sanitation system, a_r = average number of households in rural areas covered in one cleaning activity, f_r = frequency of cleaning activity in rural areas, u_r = user changes per main sewage line cleaning activity in rural areas, HH_u = number of households in urban areas with any connection to sanitation system, a_u = average number of households in urban areas covered in one cleaning activity, f_u = frequency of cleaning activity in urban areas, and u_u = user changes per main sewage line cleaning activity in urban areas.

4.2.7. Economic Benefit from Mitigation Interventions

The

Table

Interventions	Proportion of Mitigated Cost
Comprehensive sanitation and hygiene (γ)	• 45% of health impacts

	• 100% of water related impacts • 100% of welfare impacts • 100% of tourism impacts
Improved access to toilets (μ)	• 32% of health impacts • 100% of welfare impacts • 50% of tourism impact
Improved	• 45% of health impacts • 100% of welfare impacts • 50% of tourism impacts
Improved access to adequate quantity of water	• 25% of health impacts • 100% of welfare impacts • 50% of tourism impacts
Improved	• 39% of health impacts • 100% of household water treatment cost • 100% of bottled water costs • 100% of costs of hauling water from cleaner sources
Safe	• 32% of health impacts • 100% of household water treatment cost • 100% of bottled water costs • 100% of costs of hauling water from cleaner sources

a. Comprehensive Sanitation and Hygiene Interventions

The sanitation and hygiene interventions may be effective in mitigating health, water, welfare, and tourism-related economic losses. Equation $shb = \sum[h_b\gamma + w_b\gamma + x_b\gamma + t_b\gamma]$ (4.36) comprises these variables, where sh_b = cumulative economic benefits from sanitation and hygiene interventions, γ = percentage of associated costs mitigated from sanitation and hygiene interventions, h_b = economic benefit from mitigation in the health sector, w_b = economic benefit from mitigation in the water sector, x_b = economic benefit from mitigation in the welfare sector, and t_b = economic benefit from mitigation in the tourism sector.

$$sh_b = \sum[h_b\gamma + w_b\gamma + x_b\gamma + t_b\gamma] \quad (4.36)$$

b. Improved Access to Toilets

Enhancing

$tb = \sum[h_b\mu + w_b\mu + x_b\mu]$ (4.37) represents this information, where t_b = economic benefits from improved access to toilets, μ = percentage of associated costs mitigated from improved access to toilets, h_b = economic benefit from mitigation in the health sector, w_b = economic benefit from mitigation in the water sector, x_b = economic benefit from mitigation in the welfare sector.

$$t_b = \sum[h_b\mu + w_b\mu + x_b\mu] \quad (4.37)$$

c. Improved Hygiene Behaviour

Behavioural interventions (b_b) that attempt to improve people's attitude towards hygiene lead to economic benefits for the health (h_b) and welfare (x_b) sectors according to the percentage of the associated costs mitigated through this intervention (α), as shown in Equation $bb = \sum[h_b\alpha + x_b\alpha]$ (4.38) below.

$$b_b = \sum[h_b\alpha + x_b\alpha] \quad (4.38)$$

d. Improved Access to Adequate Quantity of Water

Interventions that target improved access to an adequate quantity of water are significant and result in economic benefits for the health, water, welfare, and tourism sectors. Under the water sector, however, it only mitigates the cost of fetching water. This study uses the following equation to calculate the associated economic benefits.

$$qn_b = \sum[h_b\alpha + f_b\alpha + t_b\alpha] \quad (4.39)$$

In Equation $qnb = \sum[h_b\alpha + f_b\alpha + t_b\alpha]$ (4.39), qn_b = economic benefits from improved access to adequate quantity of water, σ = percentage of the associated costs mitigated through the provision of an adequate quantity of water, h_b = cost mitigation in the health sector, f_b = cost mitigation of fetching water, and t_b = cost mitigation in the tourism sector.

e. Improved Access to Adequate Quality of Water

An improved access to adequate quality of water is equally important to alleviate the cost of poor sanitation and water management. Interventions targeting this area result in cost mitigation for the health (h_b) and water (w_b) sectors. Under the latter, however, this intervention specifically targets the cost of drinking water treatment (d_b), cost of bottled water consumption (bw_b), and cost of fetching water (f_b). Equation $qlb = \sum[h_b\upsilon + d_b\upsilon + bw_b\upsilon + f_b\upsilon]$ (4.40) below summarises this information, whereby υ = percentage of the associated costs mitigated through the provision of an adequate quality of water.

$$ql_b = \sum[h_b\upsilon + d_b\upsilon + bw_b\upsilon + f_b\upsilon] \quad (4.40)$$

f. Sewage Treatment Interventions

The interventions targeting sewage treatment include the safe confinement and disposal of faecal matter, and results in cost alleviation for the health sector, and certain parts of the water sector, including the cost of drinking water treatment, cost of bottled water consumption, and cost of fetching water. This study uses the following formula to calculate the economic gains from sewage treatment interventions.

$$s_b = \sum[h_b\varphi + d_b\varphi + bw_b\varphi + f_b\varphi] \quad (4.41)$$

In Equation

$sb = \sum[h_b\varphi + d_b\varphi + bw_b\varphi + f_b\varphi]$ (4.41), s_b = economic benefits from sewage treatment interventions, φ = percentage of the associated costs mitigated through sewage treatment interventions, h_b = economic benefit from the mitigation of health-related costs, d_b = economic benefit from cost mitigation of drinking water treatment, bw_b = economic benefit from cost mitigation of bottled water consumption, and f_b = economic benefit from cost mitigation of fetching water.

4.2.8. Potential Sanitation Market of Pakistan

This research estimates the potential sanitation market of Pakistan by first calculating the cost of construction of different types of toilets – including piped to sewer connections, piped to septic tanks, piped to pit latrines, and pit latrines with slab – through market research of the cost of materials used in toilet construction for the year 2020-21. This calculation is represented by Equation $CT = \sum(wc + p + b + c + s + l + t + w + x)$ (4.42).

$$C_T = \sum(wc + p + b + c + s + l + t + w + x) \quad (4.42)$$

In the equation above, C_T = Cost of toilet construction, p = cost of pipe to connect the main line, b = cost of blocks required for walls, c = cost of cement bags, s = cost of donkey carts of sand, l = cost of labour, t = cost of tank, w = cost of well construction, and x = cost of other materials.

The cost estimated is then adjusted for inflation for the years 2025 and 2030 according to the trend in inflation from 2006 to 2022, which is assumed to remain the same till 2030.

Moving forward, this study uses PSLM 2018-19 and PSLM 2019-20 to calculate the percentage change of households using piped to sewer connections, piped to septic tanks, piped to pit latrines, and pit latrines with slab. According to this, it next determines the percentage of households using the aforementioned types of toilets in the years 2021, 2025, and 2030. Using these figures, the number of households using different types of toilets in Pakistan is determined.

Finally, the potential sanitation market in Pakistan is calculated using the following equation for each type of toilet:

$$S_m = H_T \times C_T \quad (4.43)$$

In Equation $Sm= H_T \times C_T$ (4.43) above, S_m = sanitation market, N_T = number of households using each type of toilet, and C_T = cost of constructing each type of toilet.

5. Results and Discussion

5.1. Economic Cost of Poor Sanitation and Water Management

Pakistan's economy annually incurs a significant burden due to the poor management of water and sanitation in the country. The cumulative economic impact of health, water, welfare, tourism, and drainage user costs, as mentioned in Table 1, is PKR 910.40 billion (USD 4.96 billion), which accounts for 1.91 percent of Pakistan's GDP. Of this, the total direct economic cost amounts to PKR 292.68 billion (USD 1.60 billion), accounting for 0.62 percent of the GDP, while the total indirect economic cost amounts to PKR 646.33 billion (USD 3.52 billion), accounting for 1.36 percent of the GDP. Even though these figures present a sufficiently concerning scenario for Pakistan's economy, they do not highlight the performance or costs of each of the aforesaid sectors, individually – all of which are examined further.

The health sector, first of all, is associated with an aggregate loss of PKR 575.87 billion (USD 3.14 billion), which accounts for 1.21 percent of Pakistan's GDP. Under this sector, the cost of treatment of diseases is PKR 157.23 billion (USD 0.86 billion), the cost of premature mortality is PKR 240.29 billion (USD 1.31 billion), and the value of productivity loss is PKR 178.34 billion (USD 0.97 billion). In percentage terms, they account for 0.33 percent, 1.21 percent, and 0.38 percent of Pakistan's GDP, respectively.

It is further noteworthy to mention that diarrhoea constitutes the highest share of the total economic cost in all three categories under health – 11.63 percent of the cost of treatment, 14.44 percent of premature mortality, and 13.93 percent of the productivity loss. This is followed by ARIs, which comprises 4.56 percent of the cost of treatment, 11.82 percent of premature mortality, and 5.29 percent of the productivity loss. Malaria, lastly, comprises 1.08 percent of the cost of treatment, 0.13 of premature mortality, and 0.37 percent of the productivity loss. Having analysed the health sector, this research next pursues a breakdown of the equally important water sector.

Table 5.1 The Overall Economic Impact of Poor Water Management in Pakistan

Variables	Overall Economic Impact			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Health	**575.87**	**3.14**	**1.21**	**63.25**
Direct	157.233	0.86	0.33	53.72
Indirect	418.63	2.28	0.88	64.77
Water	**93.33**	**0.51**	**0.20**	**10.25**
Direct	87.18	0.48	0.18	29.79
Indirect	34.77	0.19	0.07	5.38
Other Welfare	**192.92**	**1.05**	**0.41**	**21.19**
Tourism	**47.14**	**0.26**	**0.10**	**5.18**
Drainage User Cost	**1.13**	**0.006**	**0.002**	**0.12**
Total Economic Impact	**910.40**	4.96	**1.91**	**-**

Table 5.2 Health-Related Economic Impact of Poor Water Management in Pakistan

Variables	Economic Impact: Health			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Direct Costs	**157.23**	**0.86**	**0.33**	**53.72**
Cost of Treatment: Diarrhoea	105.84	0.58	0.22	11.63
Cost of Treatment: ARIs	41.53	0.23	0.09	4.56
Cost of Treatment: Malaria	9.86	0.05	0.02	1.08
Indirect Costs	**418.63**	**2.28**	**0.88**	**64.77**
Premature Mortality: Diarrhoea	131.46	0.72	0.27	14.44
Premature Mortality: ARIs	107.61	0.59	0.23	11.82
Premature Mortality: Malaria	1.22	0.006	0.002	0.13
Productivity Loss: Diarrhoea	126.85	0.69	0.27	13.93
Productivity Loss: ARIs	48.12	0.26	0.10	5.29
Productivity Loss: Malaria	3.37	0.02	0.01	0.37

Total Health Cost	**575.87**	**3.14**	**1.21**	**63.25**

The water sector of Pakistan is associated with a cumulative cost of PKR 93.34 billion (USD 0.51 billion), which accounts for 0.20 percent of Pakistan's GDP.

Of this, the cost of treatment of drinking water constitutes PKR 31.80 billion (USD 0.17 billion) or 0.07 percent of the GDP, cost of bottled water PKR 39.14 billion (USD 0.21 billion) or 0.08 percent of the GDP, and cost of piped water production PKR 16.23 billion (USD 0.09 billion) or 0.03 percent of the GDP – all of which cumulatively form the direct cost of the water sector i.e., PKR 87.18 billion (USD 0.48 billion) or 0.18 percent of Pakistan's GDP.

The indirect cost, although lower than the direct cost, reserves equal significance. It comprises the value of time lost in boiling water, which accounts for PKR 31.19 billion (USD 0.17 billion) or 0.07 percent of the GDP, and the value of time lost in fetching water, which accounts for PKR 3.58 billion (USD 0.02 billion) or 0.01 percent of the GDP. It is further notable that the bottled water consumption constitutes the highest share of 13.37 percent among all types of water costs, followed closely by that of the treatment of drinking water i.e., 10.87 percent – both of which arise only because the water is deemed unfit for usage otherwise. The cost of piped water production, value of time lost in boiling water, and the value of time lost in fetching water constitute a share of 5.55 percent, 4.83 percent, and 0.55 percent of the total economic cost, respectively. Poor sanitation and water management, while directly related to only health and water, has wide ranging effects on the welfare of people as well, the associated costs of which are henceforth discussed.

Table 5.3 Water-Related Economic Impact of Poor Water Management in Pakistan

Variables	Economic Impact: Water			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Direct Costs	**87.18**	**0.48**	**0.18**	**29.79**
Treatment of Drinking Water	31.80	0.17	0.07	10.87
Bottled Water Consumption	39.14	0.21	0.08	13.37
Piped Water Consumption	16.23	0.09	0.03	5.55
Indirect Costs	**34.77**	**0.19**	**0.07**	**5.38**
Value of Time Lost in Boiling Water	31.19	0.17	0.07	4.83
Fetching Water	3.58	0.02	0.01	0.55
Total Water Cost	**93.34**	**0.51**	**0.20**	**10.25**

The welfare sector, as mentioned in Table 4, constitutes an annual loss of PKR 192.92 billion (USD 1.05 billion), which accounts for 0.41 percent of Pakistan's GDP. Even though this sector is associated with a lower aggregate cost than the health and water sectors, it reserves its own significance considering the education- and productivity-related variables included under it that share an indirect nexus with poor sanitation and water management. Under this sector, the value of households' economic loss because of the time taken to access shared toilets is PKR 35.62 billion (USD 0.19 billion) and that due to the time taken to access areas for open defecation is PKR 154.88 billion (USD 0.84 billion), which constitute 0.07 and 0.33 percent of Pakistan's GDP, respectively. In addition to the above, the economic loss due to the lack of female toilets in schools is PKR 1.47 billion (USD 0.008 billion) and that due to the lack of female toilets in workplaces is PKR 0.95 billion (USD 0.005 billion); in percentage terms, they account for 0.003 and 0.002 percent of the GDP, respectively. With the analysis of the welfare sector, this research next pursues one that combines aspects of both, welfare and health i.e., tourism.

Table 5.4 Welfare-Related Economic Impact of Poor Water Management in Pakistan

Variables	Economic Impact: Other Welfare			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Shared Toilets	35.62	0.19	0.07	3.91
Open Defecation	154.88	0.84	0.33	17.01
School Access	1.47	0.008	0.003	0.16
Workplace Access	0.95	0.005	0.002	0.10

The tourism sector associates with health in terms of lost tourism earnings and the cost of international tourists' illness due to the state of sanitation and water management in Pakistan. The former constitutes a cost of PKR 46.90 billion (USD 0.26 billion), accounting for 0.10 percent of the GDP, while the latter constitutes a cost of PKR 0.24 billion (USD 0.001 billion), accounting for 0.001 percent of the GDP. Cumulatively, the tourism sector incurs an annual cost of PKR 47.14 billion (USD 0.26 billion), which forms 0.10 percent of the GDP. It is further noteworthy that while the cost of international tourists' illness comprises only 0.03 percent of the economic cost, lost tourism earnings constitute the majority share of the economic cost of 5.15 percent. With the conclusion of the tourism sector's analysis, this research next considers the user cost of drainage.

Table 5.5 Tourism-Related Economic Impact of Poor Water Management in Pakistan

Variables	Economic Impact: Tourism			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Tourism Earnings	46.90	0.26	0.10	5.15
International Tourist Illnesses	0.24	0.001	0.001	0.03

Total Tourism Cost	**47.14**	**0.26**	**0.10**	**5.18**

The user cost of drainage is slightly different from the sectors analysed earlier because it includes no further types. It primarily calculates the direct cost of utilising drainage services provided by the country, which amounts to PKR 1.13 billion (USD 0.006 billion) and forms 0.002 percent of Pakistan's GDP. This cost calculation concludes the analysis of the drainage sector, as well as that of the first part of the cost-benefit analysis model applied by this research i.e., economic cost of poor sanitation and water management. The next part, examined in the following section, calculates the economic benefit that results from sanitation-, water-, and hygiene-related interventions.

Table 5.6 User Cost of Drainage in Pakistan

Variables	Economic Impact: Drainage			
	Cost (Billion Rs)	Cost (Billion $)	Percentage of GDP (%)	Share of Impact (%)
Drainage User Cost	**1.13**	**0.006**	**0.002**	**0.12**

5.2. Economic Benefit from Water, Sanitation, and Hygiene (WASH) Interventions

After the analysis of economic losses resulting from different sectors, including health, water, welfare, tourism, and drainage, this research now addresses the relevant policy question about the possibility of alleviating these costs. Despite their sizeable nature, a certain proportion of the economic losses may be mitigated through water-, sanitation-, and hygiene-related interventions. These "economic gains" from mitigation interventions to improve sanitation and hygiene are henceforth calculated, as show in Table 7.

The water-, sanitation-, and hygiene-related interventions in Pakistan cumulatively generate economic gains amounting to PKR 1890.65 billion (USD 2.64 billion), which exceed the economic losses by PKR 980.26 billion (USD 5.34 billion). It is, however, important to note that this study considers the possibility of mitigating the economic cost of poor water and sanitation through multiple interventions, all of which may not be implemented simultaneously; the economic benefit from mitigation interventions thus exceeds the economic cost as the effect of all the interventions is calculated together.

If sanitation- and hygiene-related interventions are implemented, they may result in an economic benefit worth PKR 484.41 billion (USD 2.64 billion). This constitutes 1.02 percent of the GDP, the highest among all types of interventions, and 53 percent of the economic losses. Mitigations through improved access to toilets may further lead to economic gains amounting to PKR 347.45 billion (USD 1.89 billion), which accounts for 0.73 percent of Pakistan's GDP and

38 percent of the economic impact. Improved hygiene behaviour among the Pakistani population may, additionally, produce an economic benefit worth PKR 343.93 billion (USD 1.87 billion), constituting 0.72 percent of the GDP and 38 percent of the economic cost.

The mitigation interventions targeting the provision of adequate quantity and quality of water may result in economic gains amounting to PKR 327.54 billion (USD 1.78 billion) and PKR 205.41 billion (USD 1.12 billion), respectively. In this case, while the former constitutes 0.69 percent of Pakistan's GDP or 36 percent of the economic loss, the latter forms 0.43 percent of the GDP or 23 percent of the economic loss.

Lastly, mitigation interventions targeting the safe confinement and disposal of faecal matter or sewage treatment may generate economic benefits worth PKR 181.91 billion (USD 0.99 billion), comprising 0.38 percent of the GDP and 20 percent of economic cost. This analysis summarises the economic benefits for Pakistan resulting from water-, sanitation-, and hygiene-related interventions. Their per capita advantages for the population of Pakistan, however, may be an equally important indicator in this cost-benefit analysis.

The cumulative per capita benefits of mitigation interventions may amount to PKR 9.10 thousand (USD 50). Of this, the sanitation and hygiene interventions may lead to per capita gains worth PKR 2.33 thousand (USD 13) – which is the highest among all types of mitigation efforts. The per capita economic gains from the provision of improved access to toilets is PKR 1.67 thousand (USD 9). Mitigation through improved hygiene behaviour leads to per capita economic gains amounting to PKR 1.66 thousand (USD 9).

Table 5.7 Economic Benefit from Sanitation-, Hygiene-, and Water-Related Interventions

Type of Intervention	Intervention	Economic Benefit from Mitigation Interventions				
		Economic Benefit (Billion Rs)	Economic Benefit (Billion $)	Percentage of GDP (%)	Percentage of Economic Impact	Per Capita Gain (PKR)
Sanitation & Hygiene	Sanitation & Hygiene	484.41	2.64	1.02	53	2,332
	Improved Access to Toilets	347.45	1.89	0.73	38	1,673
	Improved Hygiene Behaviour	343.93	1.87	0.72	38	1,656
Adequate WASH, better health & toilet use/access	Improved Access to Adequate Quantity of Water	327.54	1.78	0.69	36	1,577
Water Free from Bacterial Contamination	Improved Access to Adequate Quality of Water	205.41	1.12	0.43	23	989

	Safe Confinement & Treatment of Faecal Matter	181.91	0.99	0.38	20	876
Total		1890.65	10.30	22.74	-	9,103

The per capita economic benefits from interventions targeting the provision of adequate quantity and quality of water are worth PKR 1.58 thousand (USD 9) and PKR 0.99 thousand (USD 5), respectively.

Finally, the per capita economic gains resulting from sewage treatment or safe confinement and disposal of faecal matter amount to PKR 0.88 thousand (USD 5). With this, the present study concludes an elaborate analysis of the economic advantages arising from water-, sanitation-, and hygiene-related mitigation interventions.

5.3. Sanitation Market

The overall sanitation market of Pakistan sharply increased from PKR 239.85 billion in 2019 to PKR 326.22 billion in 2020, and from there, to PKR 599.16 billion in 2022. Based on this trend, this study projects that the market for sanitation products will continue rising steadily; Pakistan is expected to demand PKR 1946.93 billion and PKR 7572.86 billion worth of sanitation products in 2025 and 2030, respectively.

It is, however, noteworthy that the highest increase in the sanitation market of Pakistan originates from that of the demand for flush to pit latrines. It increased gradually over the years – from PKR 56.20 billion in 2019 to PKR 79.91 billion in 2020, and finally, to PKR 161.58 billion in 2022. Based on this trend, the demand for flush to pit latrines is expected to reach PKR 660.46 billion in 2025 and PKR 3.84 trillion in 2030. This could possibly be because of the total shift of the users of pit latrines with slab to flush to pit latrines, as the demand for the former may be entirely eliminated after 2020.

Table 5.8 Potential Market of Sanitation Products in Pakistan

Types of Toilets	Sanitation Market in Pakistan				
	2018-19	2019-20	2021-22	2025	2030
Sewer Connections					
Billion Rs	68.92	95.83	184.94	682.62	3420.50
Billion $	0.38	0.52	1.01	3.72	18.64
Septic Tanks					
Billion Rs	105.80	142.28	254.40	763.26	2374.84
Billion $	0.58	0.78	1.39	4.16	12.94
Pit Latrines					
Billion Rs	56.20	79.91	161.58	660.46	3838.16
Billion $	0.31	0.44	0.88	3.70	20.92
Pit Latrines with Slab					
Billion Rs	8.92	8.19	-	-	-

Billion $	0.05	0.04	-	-	-
Total					
Billion Rs	**239.84**	**326.22**	**599.16**	**1946.93**	**7572.86**
Billion $	**1.31**	**1.78**	**3.27**	**11.48**	**52.50**

On the other hand, the demand for flush to septic tanks and flush to sewer connection has also steadily increased from 2018 to 2022 – from PKR 105.80 billion of the former and PKR 68.92 billion of the latter to PKR 254.40 billion and PKR 184.40 billion, respectively. Based on the trends observed, this research estimates that the sanitation market will rise to PKR 763.26 billion in 2025 and PKR 2374.83 billion in 2030 on account of septic tanks. Similarly, the market for sanitation products will rise to PKR 682.62 billion in 2025 and PKR 3420.49 billion in 2030 on account of sewer connections.

6. Conclusion and Policy Implications

6.1. Conclusion

The objective of this research was to quantify the economic cost associated with poor water management, the economic benefit associated with water-, sanitation-, and hygiene-related interventions, and the potential market for sanitation products in Pakistan. The cumulative economic impact of health, water, welfare, tourism, and drainage user costs, PKR 910.40 billion (USD 4.96 billion), which accounts for 1.91 percent of Pakistan's GDP. Of this, the health-related costs account for the highest burden, followed by the other welfare costs, water-related costs, tourism-related costs, and finally, the drainage user cost. Even though these figures present an alarming situation, it is possible to mitigate the economic cost through water, sanitation-, and hygiene-related interventions. More specifically, they can cumulatively generate economic gains amounting to PKR 1890.65 billion (USD 2.64 billion), which exceed the economic losses by PKR 980.26 billion (USD 5.34 billion). It is, however, important to note that this study considers the possibility of mitigating the economic cost of poor water and sanitation through multiple interventions, all of which may not be implemented simultaneously; the economic benefit from mitigation interventions thus exceeds the economic cost as the effect of all the interventions is calculated together. With these steady improvements towards adequate sanitation in Pakistan, the country is expected to demand PKR 1.95 trillion and PKR 7.57 trillion worth of sanitation products in 2025 and 2030, respectively. It is, however, noteworthy that the highest increase in the sanitation market of Pakistan originates from that of the demand for flush to pit latrines.

6.2. Policy Implications

Based on the above conclusion, this section draws some implications for policymaking in Pakistan. These are the following:

- Behaviour change campaigns to raise awareness
- Provision of improved sanitation and hygiene facilities in rural and urban areas – highest economic benefit equal to PKR 5903.96 billion (USD 32.14 billion)
- Provision of improved access to adequate quality of water – economic benefit equal to PKR 2110.25 billion (USD 11.50 billion)
- Provide safe confinement and treatment of fecal matter – PKR 2082.92 billion (USD 11.35 billion)
- Provision of improved access to adequate quantity of water – economic benefit equal to PKR 749.83 billion (USD 4.09 billion)

References

Abramovsky, L., Augsburg, B., Lührmann, M., Oteiza, F., & Rud, J. P. (2023). Community matters: Heterogeneous impacts of a sanitation intervention. *World Development*, *165*, 106197. https://doi.org/10.1016/j.worlddev.2023.106197

Alam, Md. Z., & Mukarrom, A. A. (2022). Hygiene, sanitation facility, and assessment of drinking water quality in the schools of Chattogram city, Bangladesh. *Global Health Journal*, *6*(4), 204–211. https://doi.org/10.1016/j.glohj.2022.12.003

Alsan, M., & Goldin, C. (2019). Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880–1920. *Journal of Political Economy*, *127*(2), 586–638. https://doi.org/10.1086/700766

Ashraf, S., Islam, M., Unicomb, L., Rahman, M., Winch, P. J., Arnold, B. F., Benjamin-Chung, J., Ram, P. K., Colford, J. M., & Luby, S. P. (2020). Effect of Improved Water Quality, Sanitation, Hygiene and Nutrition Interventions on Respiratory Illness in Young Children in Rural Bangladesh: A Multi-Arm Cluster-Randomized Controlled Trial. *The American Journal of Tropical Medicine and Hygiene*, *102*(5), 1124–1130. https://doi.org/10.4269/ajtmh.19-0769

Barreto, M. L., Genser, B., Strina, A., Teixeira, M. G., Assis, A. M. O., Rego, R. F., Teles, C. A., Prado, M. S., Matos, S. M. A., Santos, D. N., dos Santos, L. A., & Cairncross, S. (2007). Effect of city-wide sanitation programme on reduction in rate of childhood diarrhoea in northeast Brazil: Assessment by two cohort studies. *Lancet (London, England)*, *370*(9599), 1622–1628. https://doi.org/10.1016/S0140-6736(07)61638-9

Bartram, J., Lewis, K., Lenton, R., & Wright, A. (2005). Focusing on improved water and sanitation for health. *Lancet (London, England)*, *365*(9461), 810–812. https://doi.org/10.1016/S0140-6736(05)17991-4

Brouwer, R., Sharmin, D. F., Elliott, S., Liu, J., & Khan, M. R. (2023). Costs and benefits of improving water and sanitation in slums and non-slum neighborhoods in Dhaka, a fast-growing mega-city. *Ecological Economics*, *207*, 107763. https://doi.org/10.1016/j.ecolecon.2023.107763

Cairncross, S., & Valdmanis, V. (2006). Water Supply, Sanitation, and Hygiene Promotion. In D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, & P. Musgrove (Eds.), *Disease Control Priorities in Developing Countries* (2nd ed.). World Bank. http://www.ncbi.nlm.nih.gov/books/NBK11755/

Cameron, L., Chase, C., & Contreras Suarez, D. (2021). Relationship between water and sanitation and maternal health: Evidence from Indonesia. *World Development*, *147*, 105637. https://doi.org/10.1016/j.worlddev.2021.105637

Chaitkin, M., McCormick, S., Alvarez-Sala Torreano, J., Amongin, I., Gaya, S., Hanssen, O. N., Johnston, R., Slaymaker, T., Chase, C., Hutton, G., & Montgomery, M. (2022). Estimating the cost of achieving basic water, sanitation, hygiene, and waste management services in public health-care facilities in the 46 UN designated least-developed countries: A modelling study. *The Lancet Global Health*, *10*(6), e840–e849. https://doi.org/10.1016/S2214-109X(22)00099-7.

Ferreira, D. C., Graziele, I., Marques, R. C., & Gonçalves, J. (2021). Investment in drinking water and sanitation infrastructure and its impact on waterborne diseases dissemination: The Brazilian case. *Science of The Total Environment*, *779*, 146279. https://doi.org/10.1016/j.scitotenv.2021.146279

FODP. (2012). *A Productive and Water Secure Pakistan: The Report of the Water Sector Task Force of the Friends of Democratic Pakistan* (pp. 85–93). Ministry of Water Resources. http://mowr.gov.pk/wp-content/uploads/2018/09/FoDP-WSTF-Report-Final-09-29-12.pdf\

Gil, A. I., Lanata, C. F., Kleinau, E., & Penny, M. (2004). *Strategic Report 11 Children's Feces Disposal Practices in Developing Countries and Interventions to Prevent Diarrheal Diseases*.

Hasan, M. M., & Richardson, A. (2017). How sustainable household environment and knowledge of healthy practices relate to childhood morbidity in South Asia: Analysis of survey data from Bangladesh, Nepal and Pakistan. *BMJ Open*, *7*(6), e015019. https://doi.org/10.1136/bmjopen-2016-015019

Hutton, G., & Haller, L. (2004). *Evaluation of the costs and benefits of water and sanitation improvements at the global level* (WHO/SDE/WSH/04.04). World Health Organization. https://apps.who.int/iris/handle/10665/68568

Hutton, G., Haller, L., & World Health Organization. Water, S. and H. T. (2004). *Evaluation of the costs and benefits of water and sanitation improvements at the global level / Guy Hutton and*

Laurence Haller. *WHO/SDE/WSH/04.04*. WHO IRIS. https://apps.who.int/iris/handle/10665/68568

Hutton, G., Larsen, B., Leebouapao, L., Rodriguez, U.-P. E., & Voladet, S. (2009). *Economic impacts of sanitation in Lao PDR: A five-country study conducted in Cambodia, Indonesia, Lao PDR, the Philippines, and Vietnam under the Economics of Sanitation Initiative (ESI)* (72198; pp. 1–49). The World Bank. http://documents.worldbank.org/curated/en/182721468266657037/Economic-impacts-of-sanitation-in-Lao-PDR-a-five-country-study-conducted-in-Cambodia-Indonesia-Lao-PDR-the-Philippines-and-Vietnam-under-the-Economics-of-Sanitation-Initiative-ESI

Hutton, G., Rodriguez, U.-P. E., Napitupulu, L., Thang, P. N., & Kov, P. (2008). *Economic Impacts of Sanitation in Southeast Asia* (Water and Sanitation Program). World Bank. https://www.wsp.org/sites/wsp/files/publications/Sanitation_Impact_Synthesis_2.pdf

Jenkins, M. W., & Curtis, V. (2005). Achieving the 'good life': Why some people want latrines in rural Benin. *Social Science & Medicine*, *61*(11), 2446–2459. https://doi.org/10.1016/j.socscimed.2005.04.036

Kumar, P., Arshad, F., Shaheen, S. K., Nadeem, A., Islam, Z., & Essar, M. Y. (2022). Water sanitation in Karachi and its impact on health. *Annals of Medicine and Surgery*, *77*, 103688. https://doi.org/10.1016/j.amsu.2022.103688

Mahon, T., & Fernandes, M. (2010). Menstrual hygiene in South Asia: A neglected issue for WASH (water, sanitation and hygiene) programmes. *Gender & Development*, *18*(1), 99–113. https://doi.org/10.1080/13552071003600083

Melaku, A., Addis, T., Mengistie, B., Kanno, G. G., Adane, M., Kelly-Quinn, M., Ketema, S., Hailu, T., Bedada, D., & Ambelu, A. (2023). Menstrual hygiene management practices and determinants among schoolgirls in Addis Ababa, Ethiopia: The urgency of tackling bottlenecks - Water and sanitation services. *Heliyon*, *9*(5), e15893. https://doi.org/10.1016/j.heliyon.2023.e15893

Messenger, L. A., Furnival-Adams, J., Chan, K., Pelloquin, B., Paris, L., & Rowland, M. (2023). Vector control for malaria prevention during humanitarian emergencies: A systematic review and meta-analysis. *The Lancet Global Health*, *11*(4), e534–e545. https://doi.org/10.1016/S2214-109X(23)00044-X

Ministry of Finance. (2021). *Pakistan Economic Survey 2020-21*. http://www.finance.gov.pk/survey_2021.html

Mukhtar, A., Izham, M. I. M., & Pathiyil, R. S. (2011). A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. *The Australasian Medical Journal*, *4*(9), 474–479. https://doi.org/10.4066/AMJ.2011.821

Nguyen, T.-L. (2015). *Pneumonia and Diarrhea Progress Report 2015: Sustainable Progress in the Post-2015 Era*. International Vaccine Access Center (IVAC), Johns Hopkins Bloomberg

School of Public Health. www.jhsph. edu/research/centers-and-institutes/ivac/resources/IVAC-2015-Pneumonia-DiarrheaProgress-Report.pdf

NIPS. (2019). *Pakistan Demographic and Health Survey 2017-18*. https://dhsprogram.com/publications/publication-fr354-dhs-final-reports.cfm

Norman, G., Pedley, S., & Takkouche, B. (2010). Effects of sewerage on diarrhoea and enteric infections: A systematic review and meta-analysis. *The Lancet. Infectious Diseases*, *10*(8), 536–544. https://doi.org/10.1016/S1473-3099(10)70123-7

Organization, W. H., & Programme, U. N. D. (2007). *Economic and health effects of increasing coverage of low cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target 10: Background document to the 'Human Development Report 2006'*. World Health Organization.

Pakistan Bureau of Statistics. (2017). *Population & Housing Census-2017*. http://www.pbs.gov.pk/content/block-wise-provisional-summary-results-6th-population-housing-census-2017-january-03-2018

Pakistan Bureau of Statistics. (2019). *Labour Force Survey 2018-19*. https://www.pbs.gov.pk/publication/labour-force-survey-2018-19-annual-report

Pakistan Bureau of Statistics. (2021). *Pakistan Social And Living Standards Measurement Survey (PSLM)*. https://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement-survey-pslm-2019-20-provincial-district

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., Gordon, B., Hunter, P. R., Medlicott, K., & Johnston, R. (2019). Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. *International Journal of Hygiene and Environmental Health*, *222*(5), 765–777. https://doi.org/10.1016/j.ijheh.2019.05.004

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*, *82*, 104709. https://doi.org/10.1016/j.amsu.2022.104709

Selvaraj, K., Chinnakali, P., Majumdar, A., & Krishnan, I. S. (2014). Acute respiratory infections among under-5 children in India: A situational analysis. *Journal of Natural Science, Biology, and Medicine*, *5*(1), 15–20. https://doi.org/10.4103/0976-9668.127275

Sultana, M., Sarker, A. R., Sheikh, N., Akram, R., Ali, N., Mahumud, R. A., & Alam, N. H. (2019). Prevalence, determinants and health care-seeking behavior of childhood acute respiratory tract infections in Bangladesh. *PLoS ONE*, *14*(1), e0210433. https://doi.org/10.1371/journal.pone.0210433

Swarthout, J., Ram, P. K., Arnold, C. D., Dentz, H. N., Arnold, B. F., Kalungu, S., Lin, A., Njenga, S. M., Stewart, C. P., Colford, J. M., Null, C., & Pickering, A. J. (2020). Effects of Individual and

Combined Water, Sanitation, Handwashing, and Nutritional Interventions on Child Respiratory Infections in Rural Kenya: A Cluster-Randomized Controlled Trial. *The American Journal of Tropical Medicine and Hygiene*, *102*(6), 1286–1295. https://doi.org/10.4269/ajtmh.19-0779

Thompson, T., & Khan, S. (2003). Situation analysis and epidemiology of infectious disease transmission: A South-East Asian regional perspective. *International Journal of Environmental Health Research*, *13*(sup1), S29–S36. https://doi.org/10.1080/0960312031000102787

Undp. (2006). *HDR 2006 - Beyond scarcity: Power, poverty and the global water crisis*. Human Development Report Office (HDRO), United Nations Development Programme (UNDP). https://ideas.repec.org/b/hdr/report/hdr2006.html

United Nations Children's Fund, & World Health Organisation. (2023). *Progress on household drinking-water, sanitation and hygiene 2000-2022: Special focus on gender*. https://www.who.int/publications/m/item/progress-on-household-drinking-water--sanitation-and-hygiene-2000-2022---special-focus-on-gender

USAID. (2014). *Water and development strategy: Implementation field guide* (PD-ACY-288; p. 41). United States Agency International Development (USAID). https://www.ircwash.org/resources/water-and-development-strategy-implementation-field-guide

WHO. (2004). *The global burden of disease: 2004 update*. World Health Organization. https://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/

Windi, R., Efendi, F., Qona'ah, A., Adnani, Q. E. S., Ramadhan, K., & Almutairi, W. M. (2021). Determinants of Acute Respiratory Infection Among Children Under-Five Years in Indonesia. *Journal of Pediatric Nursing*, *60*, e54–e59. https://doi.org/10.1016/j.pedn.2021.03.010

Woersem, B. V., Keen, M., & Someren, E. V. (2011). *WSSCC External Review 2005-2010—Final Report*. Water Supply and Sanitation Collaborative Council (WSSCC). https://www.wsscc.org/resources-feed/wsscc-external-review-2005-2010-final-report/

World Bank. (2006). *Pakistan—Strategic country environmental assessment: Main report* (36946; pp. 1=80). The World Bank. http://documents.worldbank.org/curated/en/132221468087836074/ Main-report.

World Health Organisation, & United Nations Children's Fund. (2021). *Progress on household drinking water, sanitation and hygiene 2000–2020: Five years into the SDGs* (p. 162). https://www.who.int/publications-detail-redirect/9789240030848

Zaidi, A. K. M., Awasthi, S., & deSilva, H. J. (2004). Burden of infectious diseases in South Asia. *BMJ (Clinical Research Ed.)*, *328*(7443), 811–815. https://doi.org/10.1136/bmj.328.7443.811

S^{3}H Working Paper

01: 2024 Development-induced Displacement and Dispossession: A Critical Discourse Analysis of the Construction of Dadhocha Dam in Rawalpindi by Arfa Saleem and Arslan Waheed (2024), 36 pp.

02: 2024 Gold of Chiniot: The Art of Chiniot Furniture Through Lens by Tehniat Iqbal and Muhammad Arif (2024), 20 pp.

03: 2024 Nature's Influence: Investigating the Relationship Between Nature Exposure and Pro-Environmental Behaviors in Islamabad, Pakistan by Wajeeha Ghaffar and Sheeba Tariq (2024), 20 pp.

04: 2024 Intercultural Communication Barriers of Afghan Refugees through the Lens of Stakeholders by Naba Aamir Azhar, Zoya Salman, Iman Khan, Raja Faizan Qamar and Joveria Hassan (2024), 22 pp.