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The Changing Climate Is Changing Safe Drinking Water, Impacting Health: A Case in the Southwestern Coastal Region of Bangladesh (SWCRB)

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Abstract: This study focuses on investigating the impact of climate change on the availability of safe drinking water and human health in the Southwest Coastal Region of Bangladesh (SWCRB). Additionally, it explores local adaptation approaches aimed at addressing these challenges. The research employed a combination of qualitative and quantitative methods to gather data. Qualitative data were collected through various means such as case studies, workshops, focus group discussions (FGDs), interviews, and key informant interviews (KIIs). The study specifically collected qualitative data from 12 unions in the Shyamnagar Upazila. On the other hand, through the quantitative method, we collected respondents' answers through a closed-ended questionnaire survey from 320 respondents from nine unions in the first phase of this study. In the next phase, we also collected data from the three most vulnerable unions of Shyamnagar Upazila, namely Poddo Pukur, Gabura, and Burigoalini, where 1579 respondents answered questions regarding safe drinking water and health conditions due to climate change. The findings of the study indicate that local communities in the region acknowledge the significant impact of sea-level rise (SLR) on freshwater sources and overall well-being, primarily due to increased salinity. Over 70% of the respondents identified gastrointestinal issues, hypertension, diarrhea, malnutrition, and skin diseases as major waterborne health risks arising from salinity and lack of access to safe water. Among the vulnerable groups, women and children were found to be particularly susceptible to waterborne diseases related to salinity. While the study highlights the presence of certain adaptation measures against health-related problems, such as community clinics and health centers at the upazila level, as well as seeking healthcare from local and paramedical doctors, it notes that these measures are insufficient. In terms of safe drinking water, communities have adopted various adaptation strategies, including pond excavation to remove saline water (partially making it potable), implementing pond sand filters, rainwater harvesting, and obtaining potable water from alternative sources. However, these efforts alone do not fully address the challenges associated with ensuring safe drinking water.

Keywords: climate change; salinity; safe drinking water; health hazard; adaptation; Southwestern Coastal Region Bangladesh (SWCRB)

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1. Introduction

Due to an intensified greenhouse effect, global warming is expected to have a significant impact on the hydrological cycle, resulting in rising sea levels, an increased frequency of floods, and prolonged droughts [1]. This ongoing process of climate change and sea-level rise (CCSLR) poses a significant challenge for accessing clean water in coastal regions of Bangladesh [2]. Many individuals in these areas rely on impure saline water for drinking

and domestic purposes, posing a considerable risk to their health. Shockingly, approximately 97% of the country's population depends on groundwater as their primary source of drinking water [3], exposing 35 to 77 million coastal inhabitants to the grave danger of consuming contaminated water [3,4]. Additionally, freshwater salinization in coastal aquifers has led to a severe drinking water crisis, affecting 35 million people [5]. Climate change is just one of the factors contributing to the impending challenges faced by water resources and management in the coming years and decades [6]. Water scarcity is mainly attributed to a combination of natural and anthropogenic factors. However, the risks associated with climate change are particularly alarming, threatening the preservation of water reserves. Safe drinking water is a crucial requirement to ensure public health, quality of life, and food safety, aligning with the United Nations Sustainable Development Goals (SDGs) [7]. The impact of climate change and sea-level rise (CCSLR) on global water resources has resulted in increased strain on human populations, leading to a rise in regional water crises and significant implications for overall well-being [1,8]. Bangladesh, being a low-lying deltaic country, is particularly vulnerable to the adverse effects of climate change, exposing its large coastal population to various hazards [9–11]. In this context, Bangladesh faces numerous health risks, exacerbated by the increasing salinity of clean water and the complex challenges related to soil in coastal areas. These factors contribute to the overall complexities of the situation [9–11].

The demand, availability, and quality of water are critical global concerns. Over the past 40 years, water usage has been steadily increasing at a rate of approximately 1% per year. This trend is expected to continue until 2050, driven by factors such as population growth, socio-economic development, and evolving consumption patterns. The majority of this increase in water demand is concentrated in middle- and lower-income countries, particularly in emerging economies [12]. Unfortunately, water scarcity is becoming a pervasive issue due to a combination of local physical water stress and the widespread pollution of freshwater sources. Climate change exacerbates the problem by causing shifts in water availability. Regions that currently enjoy abundant water resources, such as Central Africa, East Asia, and parts of South America, will experience increased seasonal water scarcity. At the same time, regions already facing water scarcity, like the SWCRB, will face even greater challenges. Currently, approximately 10% of the global population resides in countries with high or critical water stress. Water quality issues are prevalent across low-, middle-, and high-income countries. However, comprehensive water quality data remain scarce, largely due to insufficient monitoring and reporting capacities. This data gap is particularly pronounced in many of the least developed countries in Asia and Africa [12,13].

Groundwater sources in South Asia and most of the African region are highly vulnerable to impacts from climate change, and a decline in the freshwater supply is predicted [12]. Over 844 million people worldwide currently confront drinking water hardships, and they have no easy ways of acquiring good-quality drinking water [13]. In the year 2050, more than half (57%) of the world's population will be living in areas that experience water scarcity for at least one month each year [14]. The declining trend in drinking water quality due to climate change leads to an increase in risky situations related to potential health effects [15,16]. Observational and climate projection data suggest considerable impacts of climate change on freshwater resources [17], which in turn will contribute to wide-ranging social and environmental consequences, such as negative influences on crop production, energy generation, human health, and ecosystems [9,18,19].

Bangladesh is a low-lying delta; its southwestern region is flat and much lower than other segments of the landscape. The bare, coastal area stretches out roughly 1.5 m to 5 m higher than the mean sea level [20,21] and is susceptible to the consequences of climate change, such as sea-level rise, flooding, and seawater intrusion. Alongside regular and natural cycles, such as river saltiness and interaction with ground water, flowing flood and storm flood immersion, and water logging, saltwater interruption, precipitation, and evapotranspiration are significant reasons for saltiness proliferation and saline front

extension in the Bengal Delta [20,22]. Climate change is also likely to impact different aspects of the quantity and quality of water, including sediments, nutrients, dissolved organic carbon, pathogens, pesticides, salt, and thermal pollution [23]. Damage to the water supply system due to extreme climate events, such as storms and floods, may result in water usage from unimproved sources, causing increases in waterborne diseases [24,25]. Water-related disease refers to any death, disability, illness, or disorder that is caused directly or indirectly by the condition or changes in the quantity or quality of waters [9,26].

The Safe Drinking Water Foundation (SDWF) states that 80% of every type of sickness is rooted from insecure drinking water and the sprawl of waterborne illnesses [27,28]. Thus, climate change impacts human health in direct and indirect ways that interact with social dynamics to produce adverse health outcomes [29].

Direct risks include health impacts from heatwaves and extreme weather conditions, including storms, floods, and drought. Climate change will affect the provision of health and other services, since it affects the national economy and infrastructure [30]. These risks are unevenly distributed across the world, with less developed countries and specific population groups, such as the poor and marginalized, people with disabilities, the elderly, women, and young children, being at the highest risk [29]. Indirect mechanisms for health risks include a complex interaction of ecological and biological systems affecting pathogen growth rates, the range and activity of disease vectors (such as mosquitoes), water flows and quality, and crop yields [31]. Several infectious diseases, including vector-borne diseases, are associated with changing climatic conditions, such as temperature, rainfall, humidity, and sea level rise [32].

The health risks from increased water salinity are directly and indirectly related to consumption due to changes in water quality and the creation of favorable conditions for vectors [33]. Due to the absence of safe freshwater owing to higher salinity, people may use contaminated water for drinking, which can also lead to diarrhea and waterborne diseases, such as cholera [34]. Health problems reported in coastal Bangladesh that may relate to high salinity drinking water include hypertension, preterm delivery due to pre-eclampsia, acute respiratory infections, and skin diseases [35,36]. Studies in similar settings have also reported a positive correlation between higher salinity and skin diseases and malnutrition [37]. Among the reported health problems, the potential risk of increasing blood pressure by drinking saline water has been a growing concern for large populations in low-lying coastal areas, especially in low-income countries [33].

Climate change is the reason behind various natural disasters, and there seems to be a major statistical disproportion and discrepancy in terms of how these disasters will impact males, females, and children. In contrast to men, women and children are 14 times more vulnerable in terms of post-disaster casualties [38]. A good example is the cyclone flood that took place in Bangladesh in 1991, where the number of female casualties was five times higher than men [39]. In the Asian Tsunami of 2004, there were three times more women who died in contrast to men [40]. Furthermore, the Caritas Development Institute (CDI) and the Bangladeshi government stated that, besides drinking it, saline water could also enter the body through bathing, diet, and occupational means, such as farming, which has potential negative effects on health [41]. Some of the diseases associated with saline water include hypertension, skin diseases, miscarriages, digestive diseases such as diarrhea, and acute respiratory infections [34].

The direct effects of climate change and extreme temperature environments correlate with maternal and newborn health physiology. Research suggests that preterm birth, low birth weight in infants, PTSD (post-traumatic stress disorder), and postpartum depression may be caused by extreme weather incidents [42–44]. Certain threats to perinatal and maternal health are associated with unmet nutritional needs, physical labor, and infections that may lead to high blood pressure and diabetes, ultimately causing concern during pregnancy [45,46].

However, the widespread presence of higher salinity concentrations has various adverse effects. Studies have shown that higher salinity concentrations can contribute

to the development of illnesses such as hypertension and pre-eclampsia. Additionally, it has been linked to skin diseases, acute respiratory infections, and diarrhea. Moreover, activities like cooking and bathing and occupations such as shrimp farming in Bangladesh can facilitate the transmission of mosquito-borne diseases [20].

Preventing hypertension becomes challenging in populations already exposed to high salinity levels, as reducing salt intake becomes difficult [46,47]. Therefore, there is a pressing need for global research and collaborative efforts to address water salinity and effectively combat the rising prevalence of high blood pressure. By exploring innovative solutions and implementing preventive measures, we can make significant progress in mitigating the health risks associated with water salinity on a global scale.

The objectives of this investigation were to:

i. Analyze the social sensitivity of water quality and its significance on the standard of living, e.g., the accessibility of drinking water and health consequences;
ii. Identify people's water habits, as well as determine general health, maternal health, and child health impacts and risks through people's experiences;
iii. Understand the extent of salinity exposure for the inhabitants living in SWCRB and the potential threats;
iv. Learn locals' perceptions on water shortage, their susceptibilities, and adjustment approaches regarding their health.

These analyses mean to explore the connection between drinking water salinity and related health emergencies, more explicitly in relation to women, children, and general health in Southwestern Coastal areas of Bangladesh (SWCRB). Additionally, we further surveyed two basic elements in future general health provisioning and water resource supervision: ground water salinity and populace susceptibility.

2. Materials and Methods

Study Area: The Ganges Delta, also referred to as the Ganges–Brahmaputra Delta, the Sundarbans Delta, or the Bengal Delta, is a significant river delta located in Eastern South Asia. It primarily covers the Bengal region, which includes Bangladesh and the Indian state of West Bengal. Renowned as the world's largest river delta, it spans across a vast area. The delta serves as the final destination for the convergence of various river systems, primarily the Brahmaputra river and the Ganges river, before emptying into the Bay of Bengal. It stretches from the Hooghly River in the west to the Meghna River in the east, encompassing a wide expanse of land [20,21,48,49] (Figure 1A).

Shyamnagar Upazila: An Upazila of the Satkhira district, Shyamnagar Upazila is 1968.24 sq. km, including 1622.65 sq. km of forest, and located between 21°36′ and 22°24′ in northern latitudes and between 89°00′ and 89°19′ in eastern longitudes [48]. It is bound by Kaliganj (Satkhira) and Assasuni Upazila in the north, the Bay of Bengal in the south, Koyra and Assasuni Upazila in the east, and the West Bengal state of India on the west. There are 12 unions that belong to the upazila: Atulia, Bhurulia, Burigoalini, Gabura, Ishwaripur, Koikhali, Kashimari, Munshiganj, Nurnagar, Padmopukur, and Ramjannagar. The Gabura, Podmapukur, and Buri Goalini Unions are mostly coastal regions and natural-disaster-affected areas in Shyamnagar Upazila. Furthermore, Shyamnagar Upazila is important for different natural climates [49] (Figure 1B).

According to the 2011 Bangladesh census, Shyamnagar had a population of 318,254, where males constituted 48.21% of the population and females constituted 51.79% [50]. The main economic activities of the people are shrimp farming, agriculture, and fishing. Due to its geographic location, this southwestern region suffers from frequent flooding, erosion, and river flooding, but above all, sea level rise, hurricanes, and storms. People in this area have been suffering from drinking water shortages since Cyclone Aila in 2009 [51]. High storm surges during cyclones inundate almost all areas, and almost all contaminated freshwater sources become salinized. Again in 2020, Cyclone Amphan flooded 21 villages of Shyamnagar and Asashuni Upazilas and devastated the areas. After the cyclone, 57 km of embankment was damaged, which again led to the intrusion of salinity into fresh water [52].

People are suffering from a chronic shortage of drinking water, as they depend heavily on surface and ground water for drinking and other purposes. Freshwater aquifers are rarely available, geological conditions are not suitable for groundwater development, and shallow tube wells are not viable for domestic water supply in the region [51,53]. The study seeks to assess the impact of safe drinking water and health on women, children, and the overall population in Gabura, Burigoalini, and Poddo Pukur Unions of Shyamnagar Upazila of Satkhira District and to discover opportunities and challenges. Unions are selected by monitoring existing water scarcity and health conditions through a retrospective survey.

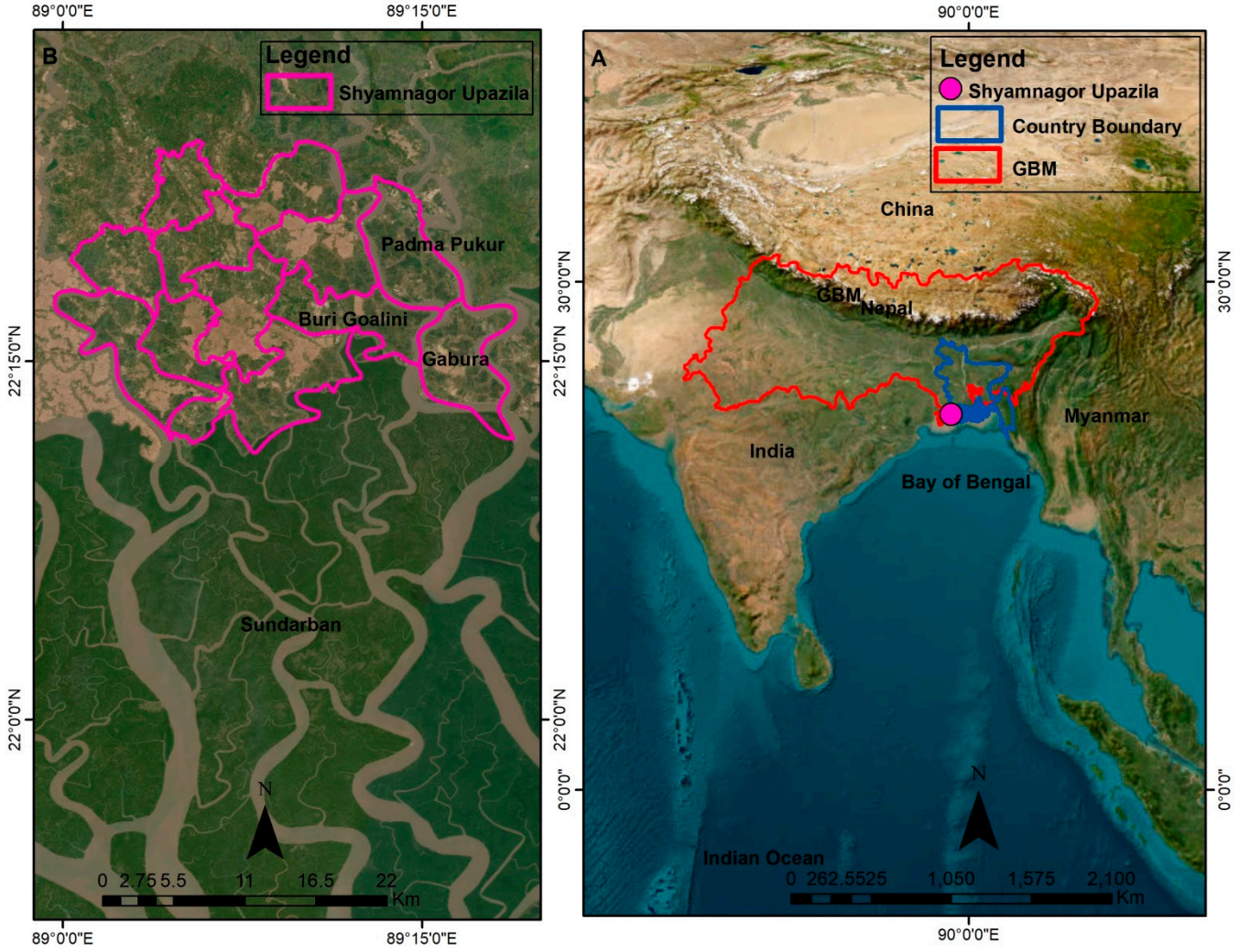

Figure 1. (**A**). Shyamnagar Upazila, Bangladesh Shyamnagar Upazila, Bangladesh adjacent to the Bay of Bengal and the Ganges–Brahmaputra-Meghna (GBM) river basin and Sundarbans. (**B**) Study areas of the Gabura, Burigoalini, and Poddo Pukur Unions in Shyamnagar Upazila; Union Council (or Union Porishod or Union) is the smallest rural administrative and local government unit in Bangladesh.

The 12 unions situated in Shyamnagar Upazila were chosen as the specific fields of research. In the first stage in this research, 320 persons were selected to complete a set of questionnaires as a quantitative research approach (overall research consisted of 128 to 152 questionnaires on people from 9 out of 12 unions, whereas salinity, health, and safe drinking water were considered as one of the sub-chapters). After that, we realized that health and safe drinking water were two of the major problems in this SWCRB. Later, we selected 3 of the 12 unions (Gabura, Burigoalini, and Poddo Pukur) situated in Shyamnagar Upazila as the particular domains of research, based on the accessibility of pure water and

health impacts of climate change. Moreover, to learn the status of safe drinking water, child health, general health, and women's health, we gave priority to three unions because these three unions were close to Bay of Bengal and were the most vulnerable (unions are the smallest rural administrative and local government units in Bangladesh). From these three unions (Gabura, Burigoalini and Poddo Pukur), 1579 household people were selected to complete a set of questionnaires regarding general health, women's health, child health, and safe drinking water as a quantitative research approach. Moreover, for qualitative research approaches like case studies, workshops, FGDs, interviews, and KIIs, we selected all 12 unions of Shyamnagar Upazila.

2.1. Quantitative Method

A questionnaire survey was successfully conducted that was based on respondents' real-life encounters with climate change, SLR (sea level rise), pure water insufficiency, and health impacts. In order to meet the target of the survey, the questionnaire focused on issues that were associated with people's points of view on climate change, SLR, and its effects on various sectors, such as the reason behind the inadequacy of pure drinking water, the source path as well as supply of water, the range of diseases caused by water, access to medical services, and anticipated coping measures.

2.2. Questionnaire Survey

A household survey involving 320 participants was conducted using structured, closed-ended questionnaires to gather data on risks, hazards, social vulnerability, and health impacts. In addition, the survey specifically focused on aspects such as general health, child health, and maternal health. The survey encompassed 1579 households from three unions within the Shaymnagar sub-district (see Table 1 for details).

Table 1. The details of quantitative sample size distribution.

Sample Size Distribution							
Type of Respondents	**Union Coverage**	**N = Total Population**	**E = Admissible Error in the Estimate**	**Sample Size = n**	**Female**	**Male**	**Percent of Them Youth**
Social vulnerability and Health Impact	09	242,392	5.5% admissible error margin	320	98	222	25.5%
Health Impact (General Health)	03	79,579	4% admissible error margin	915	631	248	20%
Health Impact (Women's and Maternal health)	03	79,579	5% admissible error margin	420	420	00	42%
Child Health	03	79,579	5% admissible error margin	244	104	140	0%
Total	12			1899	1253	610	

The data collection for the household survey involved the use of a structured, closed-ended questionnaire. The questionnaire was administered to household heads, and in some cases, interviews were conducted with other household members, depending on the respondents' willingness to participate. The questionnaire aimed to gather information on issues such as the lack of safe drinking water, salinity, and their impact on community health at the household level. The sample size of respondents was determined proportionally based on the population size in each respective area, using a simple random sampling technique, also known as purposive sampling [54]. The households were selected systematically using random sampling procedures. To ensure inclusivity and account for participants who might be interested in taking part in the study, an additional sampling method called snowball sampling was employed, which is a form of non-probability sampling. In this approach,

researchers reached out to a member of the union porishod (local government body) and a journalist from a local newspaper to help identify potential participants for interviews. The initial participants then assisted in recommending other suitable participants for the research, forming a snowball effect [55]. The questionnaire, which focused on safe drinking water and health impact, was designed to be brief and took approximately 10 min to complete.

It should be mentioned here that we carefully selected three unions, namely Gabura, Burigoalini, and Poddo Pukur, situated in the Shyamnagar Upazila, to serve as our primary research areas. These selections were based on two key factors: the accessibility of pure water and the health impact of climate change. Additionally, we prioritized these three unions in order to assess the status of safe drinking water, child health, general health, and women's health due to their proximity to the Bay of Bengal and their vulnerability as the smallest rural administrative and local government units in Bangladesh. In total, we identified 1579 individuals from households within these three unions as potential respondents for our survey questionnaires. Our research followed a quantitative approach, employing survey questionnaires to gather data on various indicators. These indicators included the source of water for drinking, water demand for drinking and cooking per household per day, distance of safe drinking water from households, challenges faced by respondents, general health conditions, diseases affecting women, and diseases affecting children. By focusing on these specific unions and collecting data through our survey questionnaires, we aimed to gain a comprehensive understanding of the overall health situation, particularly regarding safe drinking water, general health, women's health, and child health in the selected areas.

To achieve our objective, we employed a semi-structured, close-ended questionnaire divided into three segments. In the initial segment, the questions were designed to gather factual information about the respondents' socioeconomic characteristics. The second segment focused on their observations and awareness regarding the scarcity of drinking water. In the final segment, we explored the impact of drinking water scarcity on the respondents' health and their adoption of various practices and approaches to ensure safe drinking water and maintain good health. This segment also assessed the health impact on the respondents themselves. The questionnaire survey was conducted between July 2017 and December 2019 in three unions located in the Shymnagar upazilas of the Satkhira district in the southwestern coast of Bangladesh. Additionally, qualitative methods such as focus group discussions (FGDs), case studies, interviews (both in-depth and key informant), participant observation, and workshops were employed in 12 unions. However, starting from 2019, due to the COVID-19 pandemic, data collection had to be adapted. We utilized online platforms such as Zoom, Messenger, Skype, and other similar sources to collect data remotely. The respondents provided information regarding their socioeconomic features, including gender, age, education, occupation, and income. They also shared their observations regarding the impact of drinking water scarcity on their daily lives and health consequences. To analyze the collected data and present them effectively, we utilized Excel, statistical software, and SPSS. These tools enabled us to generate tables and figures that effectively represented the data obtained from the study.

2.3. Quantitative Sample Size Determination

In this study, a representative sampling approach was used. The sample was considered at a 95% confidence level, with an accuracy rate or amount of admissible error margin of $\pm$ 5%, as we had an exact beneficiary count. Samples were represented equally for each district and distributed proportionately in accordance with population size. The following sampling approach and statistical formula has been applied for the sample design:

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{z^2 \cdot p \cdot q + (N-1)e^2} \quad (1)$$

where:

n = Sample size;
N = Targeted population size;
e = Admissible error in the estimate;
p = Proportion of defectiveness or success for the indicator;
$q = 1 - p$;
z = Standard normal variable at the given level of significance.

To ensure a representative sample size from each union, sample sizes of equal proportion were selected. Sample size distribution through stratified random sampling is represented in Table 1.

2.4. Qualitative Method

FGD: Focus group discussion was analyzed after the conversation, and this process played an important role in understanding the research on climate change, salinity, lack of fresh water, health impact, and adaptation status. Focus groups gave a clear concept of the research and informed people about the different changes over time. The focus group discussions and meetings were held at convenient places like schools, youth clubs, and community organizations where the concerned respondents were able to discuss issues and express their ideas and concerns independently. A recorder was used by the author to write out the discussion, and at the same time, we obtain the participants' consent to record the discussion and explained to them the purpose of the research [56–58]. They were well-informed that participation was completely voluntary and that they also had the right to refuse to answer any questions, if needed. The participating members of the community established a respectful appreciation by providing their valuable contributions to this research. All members were encouraged to talk freely and ask questions at any time during the session, and each participant's consent was recorded using a predetermined format [59]. The study coordinated 26 (twenty-six) focus group discussions with various gatherings of pre-chosen respondents of a homogenous nature with semi-structured guidelines and the utilization of participatory tactics. Guidelines were prepared for each group of respondents to purposely draw out specific information related to the research objective. Each FGD consisted of 8–12 participants including women, men, youth, elders, doctors, teachers, stakeholders from government and non-government organizations, farmers, honey collectors, members of the UDMC (Union Disaster Management Committee), members of the WDMC (Ward Disaster Management Committee), poets, NGO practitioners, members of civil society, journalists, people with disabilities, etc. [56,58]. The data collected through focus groups can also be compared with other qualitative methods. Focus groups provide first-hand data which gave us new ideas that were helpful as well as necessary for the research [60].

Interviews: During the initial stages of this study, we conducted interviews using an open inquiry approach, incorporating a testing question at the end [61]. Some practical recommendations for interviews were taken from Bryman [58]. Additionally, closed-ended questionnaires were distributed to 1579 + 320 respondents to assess the impact of salinity on safe drinking water, health, and the overall situation in the SWCRB (Southwest Coastal Region Bangladesh). Given the significant role of leading queries in qualitative research, we carefully designed our investigation questions to cover various aspects, such as general inquiries about climate change, salinity, health, and safe drinking water, among others. This approach allowed us to gain valuable insights from the perceptions of the participants involved in providing information. Furthermore, as it became evident that the informants were well-versed in climate change issues, the familiarity within the field proved beneficial to the research, eliminating the need for extensive query clarifications.

However, a random sample was not attempted; rather, the research team interviewed as many people as possible to ensure a wide-ranging sample of voices, experiences, and perspectives [58,62]. In many cases, people were invited to participate based on their experiences with health issues, with the impact of salinity on water and soil, and local adaptation,

and interviews were opened during the study period for any interested individuals in the SWCRB community. To gather data, interviews were conducted over various time frames: 6-month periods (July/August/September/October/November/December), during the study period from 2017 to 2019, according to the convenient timing of the researchers (us) and the interviewers. The interviews averaged 30 min in duration and consisted of semi-structured, open-ended questions, conducted in a free-flowing conversational format to allow for participant elaboration, the personalization of answers, and emergent themes [63]. This illustrates the essential stages of the technique, which include questions (the same health-related quantitative survey questions used earlier in this study are considered here). Informants were first contacted by telephone, Facebook Messenger, and Skype; after that, we conducted the interview at a convenient time for them. Study information was clarified and verbal consent was obtained to participate during the interview.

In-depth interviews (IDI): Eighty-seven in-depth interviews were conducted with selected respondents like doctors, physicians, teachers, community leaders, farmers, NGO representatives, and gender practitioners with IDI guidelines, prepared separately for each type of respondent [63], specifically to learn the status of safe drinking water and health. In the initial stage of our research, we reached out to high-ranking officials and scheduled interviews with them. For other participants, we utilized various means of communication such as telephone, Facebook Messenger, and Skype. Once we established contact, we coordinated the interview time based on their availability and convenience.

Key informant interviews (KII): A total of 22 key informant interviews (KIIs) were conducted with selected respondents, following separate KII guidelines prepared for each type of respondent. These guidelines focused on topics related to safe drinking water, health, and the adaptation process. To compile an initial list of potential key informants, we collaborated with the local administration [64], as well as members of the SWCRB community and researchers who had been actively involved in the region for over two years. The selection of key informants was based on their expertise, knowledge, and involvement in issues related to vulnerability and adaptation. In order to delve deeper into specific areas of interest, the quantitative survey questionnaires from our study were organized in a way that started with general topics and gradually moved towards more in-depth aspects. Each discussion session lasted between 30 and 40 min and was audio recorded to ensure accurate documentation. Additionally, a systematic approach was followed to guide the discussions based on the provided question list [65,66].

Participant observation: One key goal of this study was to understand [43] how SWCRB populations perceive their susceptibility to the jeopardy posed by salinity, safe drinking water at different scales, and how a shortage of safe drinking water impacts their daily lives. This was facilitated by identifying families' daily practices and people's life experiences in relation to shortages of safe drinking water, as well as better understanding the impacts on their quality of health.

Case studies: Case studies were used for in-depth investigation. They are an ideal methodology that can run a holistic investigation [66]. Since case studies span their focus on the analytic domain in a comprehensive sense, such an approach is optimal for carrying out qualitative research within a short duration of a study [58]. A case study helps to explore data in real-life environments. At the same time, it explains the complexities of water and health in real life. Case study samples tend to produce estimates with a great deal of variance, and therefore, we used purposive selection procedures. The case studies in our research were designed based on safe drinking water and women's health, child health, and questions on health issues. The individuals were briefed regarding the importance of our study during data collection and when concluding the study. They were also shown what was written and recorded during the case study, and their permission was obtained to use their case studies in our research. This research was facilitated with the knowledge of understanding the mechanism of shortages of safe drinking water, and health issues and to learn the adaptation process to those issues.

Workshop: The study was organized into nine workshops with high school students, college students, and mixed participants (local governments, government officials, journalists, and NGOs). Through the workshop meetings, we came to understand and sort out climate shocks, salinity, challenges, safe drinking water, health, and adaptation practices for the people in the SWCRB. Furthermore, the research was searching for the validation of qualitative and quantitative information through workshops [67,68]. Full participation of respondents who were interested in sharing their knowledge of how climate change affects general health, women's health and child health was encouraged in this research. Workshops are a rapid, and often enjoyable, research method that encourages communication among participants to produce quality feedback [69]. This research facilitated people sharing their ideas effectively and encouraged dialogue among participants [66]. Most of the respondents' names were not included in our research, as we used Respondent/Participant 1, 2, 3, 4 ... or A, B, C ... X, Y, Z because of qualitative research ethics [58]. This research was conducted through field work and interaction with the respondents, and each participant's consent was taken in writing or orally and recorded using a predetermined format.

3. Results

From the arguments, it is proven that climate change, sea level rise, and salinity impact safe drinking water and human health. Furthermore, the results, discussion, and analysis are provided below, according to the perceptions of the local people.

The Table 2 represents the respondents' perception on the rising salinity level in the study area due to climate change or sea level rise. The respondents of the study area were asked if the increase in salinity is due to climate change or sea level rise, and out of 320 respondents, 313 of the total respondents answered yes, while only 7 of the respondents answered no. Moreover, out of 1579 respondents, 1558 of the total respondents answered yes, while only 21 of respondents answered no. The respondents mentioned that saline water enters the coastal area due to sea level rise. Out of 320 respondents, 318 mentioned that salinity increased in the SWCRB and out of 1579 respondents, 1558 mentioned the same opinion.

The statistics in Table 2 focus on the different purposes of water; the mainstream response providers are extremely susceptible to the paucity of drinking water and health consequences in the SWCRB (N: 320). The age range of the response givers in vicinities susceptible to water shortage is between 15 and 80 years. Most of the response providers were certain to have undergone drinking water paucity directly, as this difficulty has been noticeable in the area for thirty years. Responses showed whether drinking water is adequate to fulfill necessities throughout the year, like for drinking, cooking, and irrigation. Out of the 320 respondents, 64%, 47%, and 41% replied negatively, indicating that people in the SWCRB suffer from salinity induced by sea-level rise (SLR), resulting in a year-round shortage of drinking, cooking, and irrigation water. In this case, the respondents were asked about the sufficiency of the water sources for different purposes, and only 36% of the total respondents said that they obtain sufficient drinking water from their water source, and more than half of the total respondents (64%) argued that they are not satisfied with their source of drinking water (Table 2).

Table 2 depicts the distance of safe drinking water sources from home. The numbers of respondents who had homestead or water sources within 500 m of their home were 8 (child health), 20 (general health), and 15 (women's health), and 47, 96, and 61 (child health, general health, women's health, respectively) of respondents had to travel 500 to 2000 m to collect safe drinking water. For most respondents, namely 156 (child health), 686 (general health), and 281 (women health), a safe water source was far from their homes, ranging from 2000 to 4000 m away. For general health (113), women's health (63), and child health (33), respondents had their water source very far from home, from 4000 to 6000 m away.

Table 2. Lack of safe drinking water for different purposes in households, distance of safe drinking water from households, water demand for drinking and cooking per household per day, source of water for drinking, challenges of the respondents (N = 1579 (child health (CH) = 244; women's health (WH) = 420; general health (GH) = 915) (N = means respondent).

Has the Salinity Increased in Your Area Due to CCSLR (N-320)	**Respondents**	**Has the Salinity Increased in Your Area Due to CCSLR (N-1579)**	**Single Response**
Yes	313	1558	Single response
NO	7	21	Single response
Different Purposes of Water Use	Yes	No	N-320
Drinking	36%	64%	Multiple Response
Cooking	53%	47%	Multiple Response
Irrigation	59%	41%	Multiple Response
Distance of safe drinking water from home	CH N-244 Single response	GH N-915 Single response	WH N-420 Single response
Homestead or near home within 500 m	8	20	15
Separate from homestead within 500 to 2000 m	47	96	61
Far from homestead within 2000 to 4000 m	156	686	281
Very far from home within 4000 to 60,000 m	33	113	63
Water demand for drinking and cooking per household per day	CH N-244 Single response	GH N-915 Single response	WH N-420 Single response
1 to 10 L	21	63	32
11 to 20 L	161	681	293
21 to 30 L	53	157	84
31 to 40 L	9	14	11
Source of water; (WH = 420, CH = 244, GH = 915; N = 1579)	Responses Count (WH + CH + GH) *	Percentage of Responses	Multiple Response
Deep tube well	40 + 21 + 82	9.5% + 8.6% + 9.0%	Multiple Response
Shallow tube well	159 + 111 + 368	37.9% + 45.5% + 40.2%	Multiple Response
Supply water	88 + 46 + 186	21% + 18.9% + 20.3%	Multiple Response
River	236 + 150 + 348	56.2% + 61.5% + 38.0%	Multiple Response
Pond	223 + 129 + 558	53.1% + 52.9% + 61.0%	Multiple Response
Rainwater	67 + 34 + 595	16% + 13.9% + 65.0%	Multiple Response
Pond Sand Filter	101 + 56 + 238	24% + 23% + 26.0%	Multiple Response
Challenges of the respondents	CH N-244 Single response	GH N-915 Single response	WH N-420 Single response
Poor social cohesion in the community	41	212	254
Lack of organizational support	71	361	267
Very poor economic conditions	198	798	388
Very far distances to safe drinking water sources	208	865	401

* The sources of water used by the respondents.

Table 2 shows the water demand for drinking and cooking per household per day. Out of 915 respondents from general health, 63 use 1 to 10 L of water per day. Out of 244 respondents from child health, 21 use 1 to 10 L of water per day. Additionally, out of 420 respondents from women's health, 32 use 1 to 10 L of water per day. Furthermore, 161 child health respondents, 681 general health respondents, and 293 women's health respondents use 11 to 20 L per day. In addition, 53 child health respondents, 157 general health respondents, and 84 women's health respondents use 21 to 30 L per day. Finally, only 9 child health respondents, 14 general health respondents, and 11 women's health respondents use 31 to 40 L of water per day, respectively.

Table 2 shows the source of water for different purposes. In this research, it has been perceived that deep tube wells, hand pumps, or shallow tube wells supplied water; rivers, ponds, and rainwater are used as sources of water in the study area. This table also shows that, out of the total 1579 respondents, more than half of the total households (56.2% + 61.5% + 38.0%) use river water for drinking, and the remaining respondents (16% + 13.9% + 65.0%) use rainwater. About (53.1% + 52.9% + 61.0%) of the total households have stated that they collect water for drinking from ponds, whereas (37.9% + 45.5% + 40.2%) use hand pumps or shallow tube wells, and supplied water (21% + 18.9% + 20.3%) for drinking. Furthermore, more than (24% + 23% + 26.0%) of total households collect water from pond sand filters for drinking and cooking purposes. From this Table 2, it is clear that very limited households use deep tube well (9.5% + 8.6% + 9.0%) water for drinking. It has already been perceived that pond water and rainwater are used by most respondents, and they are not satisfied with that.

One of the greatest challenges the respondents had to go through to collect safe drinking water was traveling to water sources that were very far from their home (Table 2). Among the 1579 respondents, 865, 401, and 208 people from general health, women's health, and child health, respectively, said that they had to travel a long distance to fetch drinking water. Most of the people in the study areas were economically poor. From general health (798), women's health (388), and child health (198), the respondents complained that they did not have safe drinking water due to their poor economic condition. Lack of organizational support and poor social cohesion in the community were also reasons behind the unavailability of safe drinking water to the respondents.

Household access to different types of toilet facilities is presented in Figure 2. It is observed that 68% of households have access to a slab with a ring, 23% to a sanitary latrine, 3% of households to a slab without a ring, 5% households to hanging latrines, and only 1% used open space for the discharge of human waste. Though there is positive progress towards the overall standard of living, with the percentage of households with no toilet (open space), the percentage of sanitary latrines has to be increased in the study area.

Generally, drinking water and waterborne diseases have an inter-relation, and drinking water with salinity has an adverse impact on people's health conditions. Figure 3 shows that, out of 915 respondents, 91.0% suffered from dysentery/diarrhea. Meanwhile Mosquito-borne disease (63%) was found to be the second highest disease among general health. Gastric and iron vitamin deficiency affected 57.8% and 54.9% of respondents, respectively. Malnutrition is one of the major problems found in the general population, at 55.4%. Colds and coughing (45.9%), weak Infectious diseases (44.3%), and cardiac diseases (26%) were the common types of diseases in the coastal area. Besides these, Respiratory disease, allergy and asthma problems (39.5%) and skin diseases (47%) were common because of water salinity.

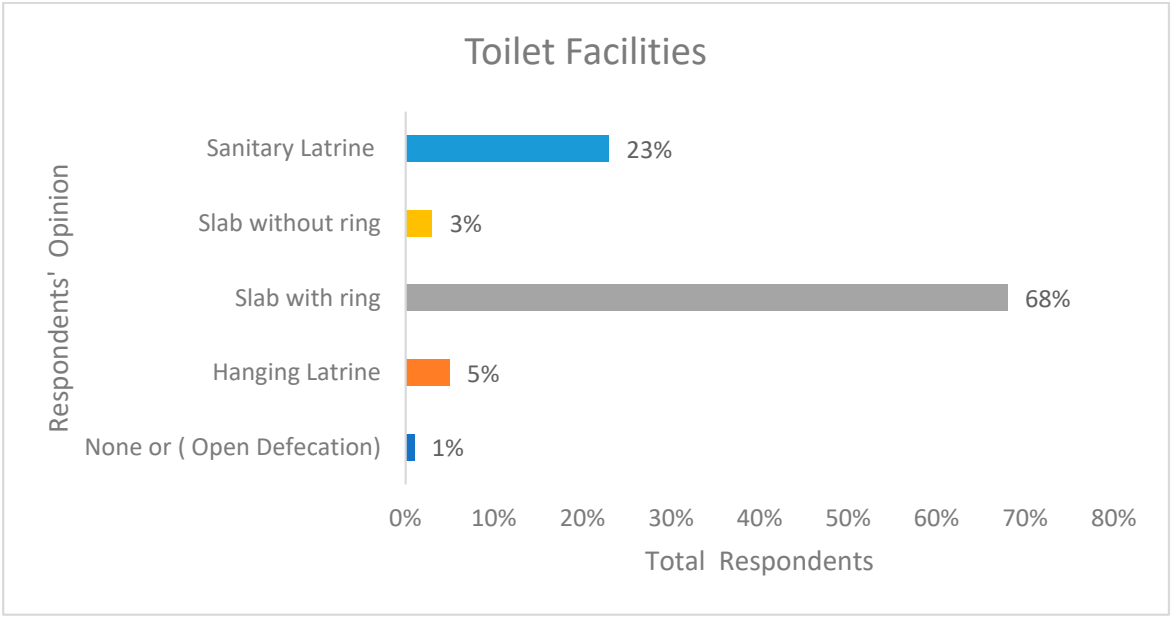

Figure 2. Toilet facilities of the respondents (N = 320).

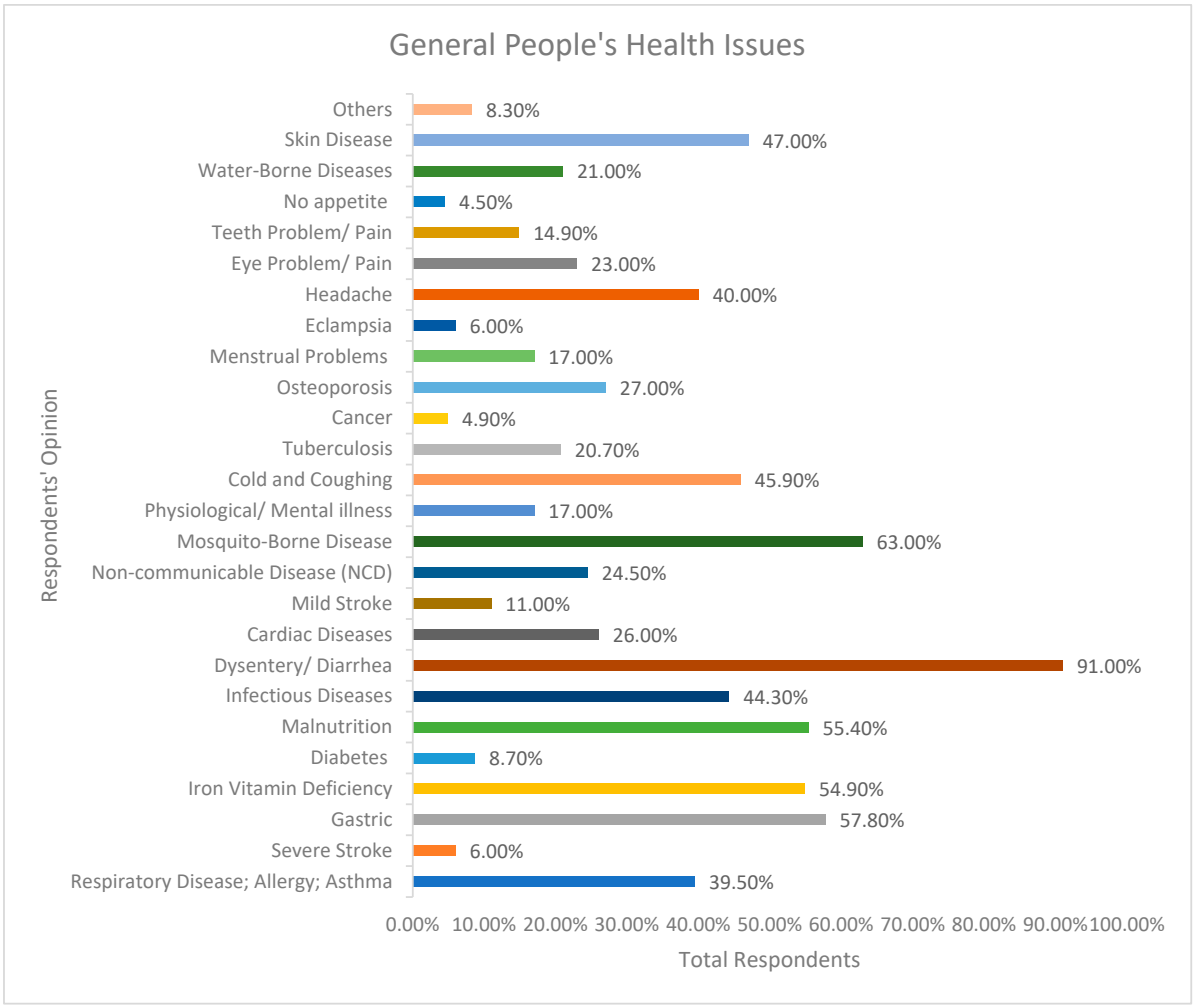

Figure 3. General health (N = GH = 915) (N = means respondent).

There are many health issues surrounding women during times of disasters due to the taboo in regard to menstruation, as well as practices of normal behavior. Since women have specific nutritional needs, they tend to suffer more from nutritional deficiencies. Figure 4 shows that, out of 420 respondents, women are most vulnerable to urinary tract infections, at 56.9%. Meanwhile, sugar and albumin contents in urine were at 40% and 43.8%, respectively. Malnutrition is one of the major problems for women's and maternal health, at 54.5%. Vaginal bleeding (39.5%) and PV bleeding (38.8%) also show alarming numbers for women's and maternal health. About 44.3% and 52.9% of women suffered from anemia and cardiovascular diseases, respectively, every year. More than 36% of the total respondents suffered from leucorrhea and vaginitis problems, breast tumors 30.2%, nipple problems 32.9%, jaundice 32.90%, and severe general weakness 30. 2%. More than 28.60% of the total female respondents faced eclampsia, fever 22.9%, delayed and obstructed pregnancy 24.80%, and early puberty 28.3% types from diseases. Several female respondents also encountered premature deliveries or early born baby 17.1%, the production of breast milk without having a baby 6.7%, infant mortality 17.2%, and other diseases 13.3%.

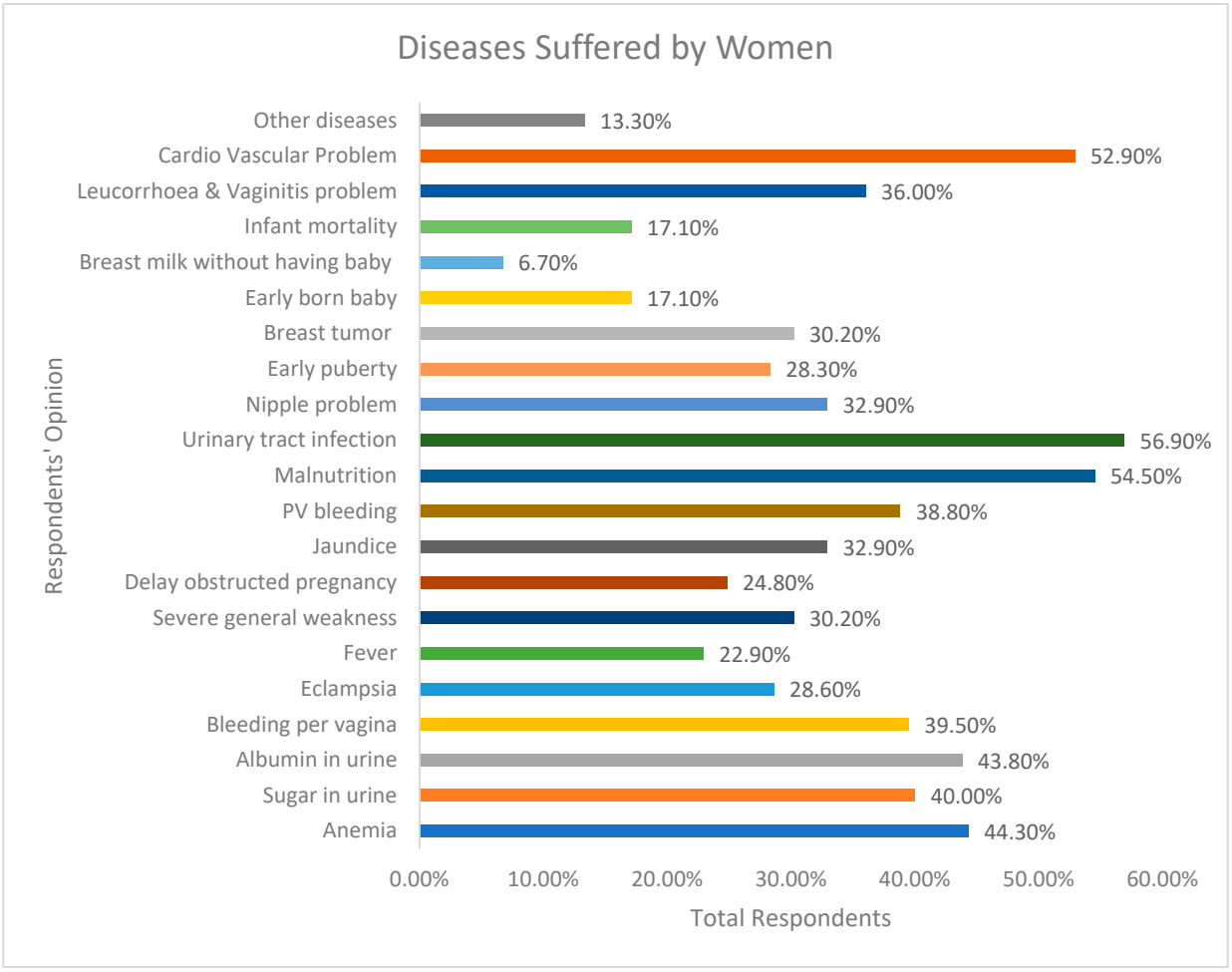

Figure 4. Diseases suffered by women (N = WH = 420, N = mean of respondent).

Children are the most vulnerable to climate change, both during and after disaster. Figure 5 depicts that, out of 244 respondents, most children suffered from malnutrition (52.9%), water-borne diseases (44.7%), and coughs or colds (37.3%). Infectious diseases (37.7%), food poisoning (17.2%), helminthiasis (11.9%), conjugative eye problems (7%), and hepatitis A, B, and other diseases (16.4%) are also very common.

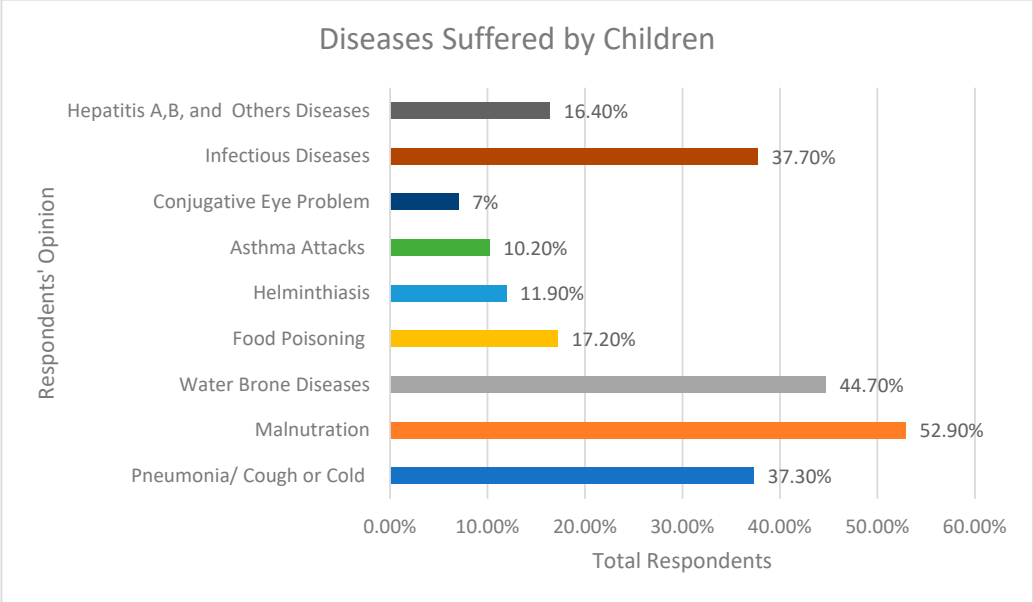

Figure 5. Diseases suffered by children ((N = CH =244) N = means respondent).

The most common adaptation strategies practiced by the respondents of the study areas were rainwater harvesting (general health (40.55%), women's health (15.95%), and child health (16.80%)), implementing pond sand filters (general, women's, and child health, 14.75%, 24.05%, and 16.39%, respectively), limited or balanced used of water (general, women's, and child health, 12.89%, 13.10%, and 21.31%, respectively), and storing water in advance (8.19%, 15.95%, and 15.57% for general, women's, and child health, respectively). There are other methods, such as maintaining personal hygiene and sanitation, personal water filters, installing a piped water supply, purchasing portable water, periodical medical checks, temporary migration during dry periods, and monitoring the spread of diseases by watching TV or reading newspapers (Figure 6).

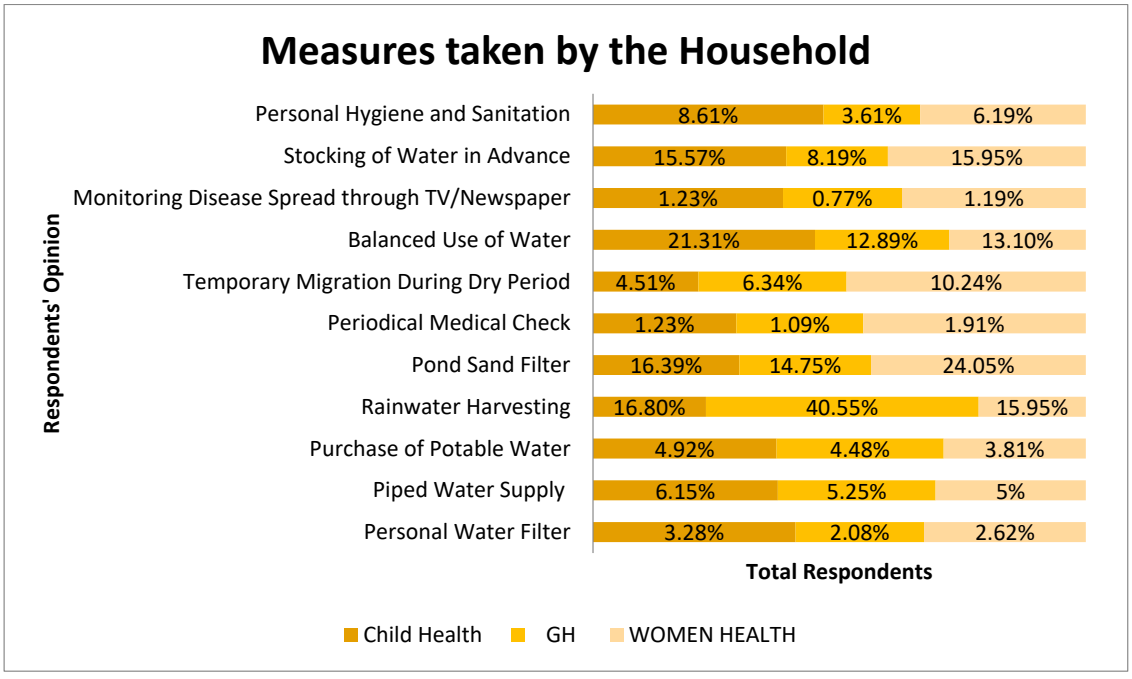

Figure 6. Measures taken by households for safe drinking water and health (CH = 244, WH = 420, GH = 915) (N = means respondents).

Figure 7 shows healthcare facilities accessible for the inhabitants in the study area. Most of the respondents receive the most medical care from community clinics, where the general people, woman's health, and child health are 42.95%, 32.38%, and 28.28%, respectively. The next most available healthcare option is the local doctor (21.53%, 18.81%, and 23.77%, respectively), and then the upazila health center (9.63%, 16.90%, and 11.06%, respectively). Other available healthcare services are hospitals outside the study area, private clinics, Zila/District health centers, paramedical doctors, homeopathy, and Ayurvedic practitioners/physicians.

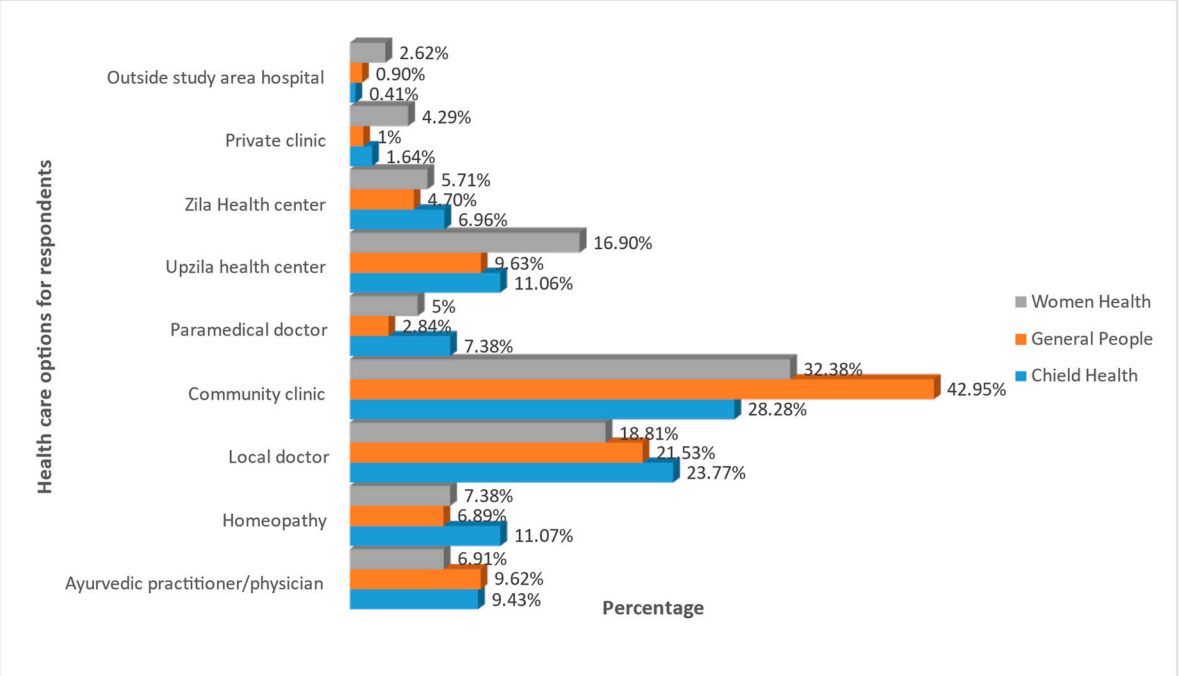

Figure 7. Healthcare options for respondents (N = 1579, CH = 244, WH = 420, GH = 915) (N = means respondent).

4. The Findings Obtained through Various Research Methods, Including KIIs, FGDs, Workshops, and Case Studies, Provided Valuable Insights into the Research Topic

The combination of key informant interviews, focus group discussions, workshops, and case studies allowed us to gather comprehensive and diverse findings. These different research methods provided a well-rounded perspective on the research topic, enhancing the overall quality and reliability of the results. The utilization of key informant interviews (KIIs) allowed us to learn the expertise and perspectives of individuals who possess in-depth knowledge and experience in the subject matter. Their insights provided a nuanced understanding of the research topic, offering unique perspectives that enriched our analysis.

The southwestern belt region of the Shyamnagar Upazila of the Shatkhira district undergoes harsh weather conditions during the summer. In recent years, despite the significant rise in rainwater and demand for potable water, the shortage is becoming severe due to salinity.

One of the key informants (KII), who is a Union Porishod member, mentioned that this climatic circumstance has arisen from several factors, including the drying up of natural water sources and the inability of water bodies (managed by both the government and private entities) to meet demand. This type of long-lasting problem with potable water is impacting the daily lives of the local people. Since there is insufficient potable water to meet the year-long demand, despite having massive water bodies everywhere, there is a need for additional smaller units of potable water. Thus, to meet the lack of potable water,

people are traveling miles and miles to obtain water. However, some drink the muddy saline water from ponds to quench their thirst.

Key informant 161, age 53 from the Poddapukur Union, mentioned that, due to excess salinity, people tend to collect rainwater for 2–3 months during the year. For the rest of the year, they try to collect water from ponds, though they find themselves in a precarious situation due to the salinity of the river during dry spells. During the dry season, the tube wells fail to provide water, and both the soil surface and subsurface remain without water. Even down to 1200 feet, potable water is not found, since the sea level is higher, and the salinity has penetrated deep into the soil. Thus, the inhabitants have to buy water for one paisa per liter, 6 km away.

Key informant 162, age 44 from the Burogoalini Union, mentioned that some people are unable to install deep tube wells and, hence, must obtain water from different natural sources. Among these natural sources, rainwater is the most prominent. Again, the village members collect cooking water from ponds and sometimes try to buy water from tube wells. They purchase 30 L of water per day; however, despite having money, this benefit is not available throughout the year, and poor people are not buying water because they are drinking water from ponds and rivers. In the Gabura Union, 3000 families undergo a severe water crisis during the summer, and the situation will worsen as there is no option to store rainwater and potable water, and there are not enough PSFs in the village. Moreover, for domestic cooking, the main sources of water are usually ponds and rainwater.

Through conducting in-depth interviews, valuable information was obtained from the respondents, shedding light on the challenges faced by the coastal belt inhabitants during cyclones Aila and Amphan. These cyclones brought about a severe scarcity of potable water, forcing the affected population to resort to drinking saline water. As a result, they fell prey to various waterborne diseases. Both males and females experienced skin ailments as a common consequence of consuming saline water. Furthermore, the scarcity of adequate sanitation facilities exacerbated the situation. Tidal waves caused the toilets to overflow with water, leading to unsanitary conditions and further health risks. This lack of proper sanitation facilities added to the overall difficulties faced by the coastal belt residents during these cyclones. The insights gathered from these in-depth interviews highlight the immediate and long-term health consequences faced by the affected population. The challenges related to water scarcity, consumption of saline water, and insufficient sanitation facilities expose the vulnerability of coastal communities during natural disasters. These findings underscore the urgent need for comprehensive interventions and support to mitigate the adverse health impacts of cyclones and improve the resilience of these communities in the face of future disasters.

One of the key informants (KII), who is from a local NGO, mentioned that the people in a neighborhood are frequently ill from food- and water-related problems. Among them, dysentery, cholera, typhoid, paratyphoid, and hepatitis were mentioned be key informants A and E. Besides these, air-borne illnesses, such as chicken pox, smallpox, tuberculosis, and pneumonia, are prominent. Moreover, insect-transmitted diseases, such as Dengue fever, Yellow fever, and Black fever are also present. Due to the shifting of climate change, increases in stomach gases, malnutrition, and different lung problems are occurring; among them, asthma, tuberculosis, bronchitis, and pneumonia are common. Furthermore, high blood pressure is a major concern in the SWCRB, and an increased chance of high blood pressure has been observed in people from consuming high saline water. Women also suffer many health-related issues due to water salinity, such as hypertension, pre-eclampsia, and respiratory infections, which can be seen in maternal health.

One of the key informants (KII), who is a member of the union disaster management committee (UDMC), mentioned that people are taking measures to deal with water shortage at the community level. Different prevailing adjustments and approaches are adopted by individuals, as well as community members, to battle drinking water paucity. At the personal level, subjected to socioeconomic circumstances, one respondent applies methods that are controllable for a single domestic setting, while at the public level, individuals have

responsibilities and derive advantages from the steps they employ jointly. For instance, ponds with smaller dimensions with sand filters and rainwater harvesting settings are regarded as the best option for safe drinking water, employed by family units. Larger ponds with sand filters and increased rainwater harvesting options are employed at the community level, and are currently the major bases for safe drinking water sustained at the community level. Respondent 164, age 42 from the Gabura Union, mentioned that only a handful of individuals have the capacity to purchase cleansed water from water treatment plants or shops; most inhabitants cannot afford such privileges.

One of the key informants (KII), who is vice chairman of the Shyamnagor Upazila, mentioned that, at the community level, the utilization of pond sand separation was the best frequent exercise in adequate water shortage zones. Pond sand filters are endorsed by the government and local government, NGOs, and native NGOs to deliver a source of safe drinking water through the collaboration of community members, but this is rare in remote areas. Different measures are taken, such as the installation of rainwater-harvesting systems in all administrative and nongovernment institutions, offices, schools, and colleges. Additionally, solar-power-driven deep tube wells with overhead tanks that provide piped water to households and common community outlets are installed, as a piped water supply is the most preferred alternative for communities in modest drinking water paucity regions.

According to key informant 163, a 46-year-old teacher at BG School and College, stated that the impact of increased salinity on children (aged 5–6 years) in the area is evident through a range of health issues. These include itching, cold, cough, fever, loose motion, worm infections, waterborne illnesses, and dysentery. The prevalence of these ailments highlights the adverse effects of salinity on the health of young children. Local doctors in the area have also expressed concerns about the overall health condition of children, emphasizing that malnutrition is a common problem leading to growth issues. This indicates that the health challenges faced by children extend beyond the immediate effects of salinity. In addition to children, adults in the community experience a variety of health problems. These include fevers, headaches, gastric problems, dysentery, physical debilities, loose motion, eye problems, ear problems, and itching. These health issues have a significant impact on the well-being and quality of life of the adult population in the area. Pregnant women face specific deficiencies in essential nutrients such as iron, calcium, and vitamin B complex. These deficiencies persist even after six months of childbirth, despite regular vitamin intake. The lack of modern medical equipment further hampers access to proper checkups and treatment for these women. Another health concern arises during the flood season, when people are forced to use unhygienic toilets, leading to further health hazards. These unsanitary conditions aggravate the risk of waterborne diseases and pose additional challenges to the community's overall health and hygiene. These findings highlight the profound impact of salinity and other environmental factors on the health of the local population. Addressing these health challenges requires comprehensive interventions, including improved access to healthcare facilities, nutrition support, and initiatives to enhance sanitation and hygiene practices in the area.

Key informant 164, age 48 from the Ramjannagar Union, who is a local female facilitator, mentioned that women use more water for different purposes every day, and since the water is saline, women can easily become sick with different diseases. This happens from the lack of awareness among women. Problems like skin irritation, scabs, soreness, worms, etc., occur more frequently in women. Local salinity levels lead to dysentery, problems related to physical growth, headache, gastric infections, physical disability, and eye and ear problems. Saline water also leads to grey hair, as men suffer from hair loss and an increase in grey hairs. Girls experience menstruation at an early age, even at around 10 years of age in grades 4 and 5 and gradually become weak. Women also suffer from breast tumors, which turn into breast cancer. Among 40-year-old women, breast pain is a common complaint. Women produce breast milk, even without bearing children. Women aged 25–35 suffer from anemia, and their hands and feet experience numbness, and there is hardly any fish to supply blood and calcium production. Consequently, physically disabled children are born,

and children do not receive their mothers' milk, as the mothers themselves are deprived of nutrition that cannot support lactation. Most children's physical development and weight gain are not proportionate with their height because of malnutrition. Children are affected by diarrhea, vomiting, and become ill due to drinking saline water. Saline water, along with a shortage of food, causes children and mothers to become ill and their health to deteriorate. Respondent 164 also stated that sea level rise and natural calamities caused houses to drift away during Amphan. She concludes by saying that saline water enters the ponds, and an acute shortage of water is experienced due to increases in salinity.

Key informant 165, a 27-year-old resident of the Gabura Union, shared that due to their impoverished circumstances, they are forced to collect water from ponds after rainfall and store it for drinking purposes, often storing it for up to 3 months. Another resident from the same union, referred to as Respondent 165, aged 38, also collects water during the monsoon season. However, they face the issue of beetles infesting the stored water over time, leading them to discard it. Moving to key informant 166, a 59-year-old resident of Ward No. 8 in the Ishwaripur Union, they primarily rely on a deep tube well as their source of drinking water. Additionally, key informant 167, aged 45, a resident of Ward No. 4 in Kolbari Village, expressed concerns about the salinity issue. They mentioned that due to the high salinity levels, they have to rely on water from rivers and ponds for both drinking and cooking purposes.

During our visits to places like Shyamnagar Upazila and its neighboring areas such as Henchi, Debaloy, Kalinchi, and Golakhali, we were deeply struck by the distressing situation regarding the availability of potable water. It was evident that numerous individuals, including men, women, and children, were facing desperate circumstances, as they had to travel long distances to procure water for their families. One particular incident that caught our attention in this research involved a young girl in the eighth grade, who shared with us her daily routine of traveling four kilometers from her village of Ishwaripur to a pond owned by Mr. Y in Debaloy village. This dedicated journey to fetch water occurred twice a day, once in the morning and then again after school. Tragically, this arduous task was compromising her ability to focus on her studies. Her mother, X, explained that due to the long-distance journey for water, her daughter's education was being adversely affected. With her mother busy with domestic chores and the husband working outside the village, the family had no choice but to rely on their daughter to secure water for their daily needs. Moreover, during interactions with key informants, we discovered that the water situation was dire in the nearby villages of Gomantoli and Chunar Bridge. A 45-year-old key informant from Gomantoli village described the challenges she faced as she had to walk three kilometers to access water. Similarly, another key informant, aged 38, residing near Chunar Bridge, expressed the same difficulties. Both of them shared that their local water sources had dried up, forcing them to collect water from Debaloy village. Adding to their plight, the water available from the tube wells in their areas was excessively saline and contained high levels of iron, rendering it unsuitable for consumption. Consequently, these individuals were compelled to wait in long queues, sometimes until midnight, to collect water from Debaloy village. This predicament not only resulted in inconvenience but also posed a serious security risk, especially for women who had to wait in the dark hours of the night. The observations and accounts gathered during this research visit shed light on the alarming situation faced by the residents of these villages. The scarcity of potable water and the associated hardships have not only impacted their daily lives but have also had adverse effects on crucial aspects such as education and personal security. Urgent measures need to be taken to address this pressing issue and ensure that these communities have access to a reliable and safe water supply.

4.1. Focus Group Discussions (FGD) and Workshops

The incorporation of focus group discussions (FGDs) enabled us to foster a dynamic and interactive environment for participants to share their thoughts and opinions. The collective wisdom generated from these group discussions highlighted common trends,

identified divergent viewpoints, and exposed underlying factors that influenced the research topic. Furthermore, conducting workshops provided a platform for collaboration and knowledge exchange among diverse respondents and stakeholders. Through active engagement, participants were able to contribute their expertise, challenge assumptions, and collectively explore innovative solutions. The workshop approach proved particularly effective in fostering creativity and generating actionable ideas.

During the focus group discussion, respondents 167, 168, 169, 170, 171, and others informed us that there is an acute paucity of potable water due to salinity. They tend to collect rainwater for 2–3 months during the year and try to collect water from ponds the remaining months, though during dry spells, they find themselves in a precarious situation due to the salinity in the river water. During most of the dry season, the tube wells fail to provide water, and the surface and subsurface soil remain without water. Thus, potable water is not found, even down to 1200 feet deep since the sea level is higher here and the salinity has penetrated deep into the soil. Thus, the inhabitants must endure chronic water scarcity.

Through workshops, we came to know that an RO (reverse osmosis) plant has been used for the desalination of salty water in ward number 4 of Burogoalini. Among the 688 families in the ward, 400 have cards that enable them to obtain water at 33 paisa per liter. However, for the ones without cards, it is 50 paisa per liter. Nevertheless, 10–15% of families continue to purchase water at 50 paisa per liter. From the workshop discussion, it was also found that, despite the 2300 people from 688 families, only 100 people can fetch water regularly. The rest are collecting water from the pond sand filter set up by NGOs and the government. Those who live in remote areas fetch water from places that are 5–9 km away through pond sand filters. Since a 25 L jar of water is worth 35 taka, it is unattainable for the common people; in addition, during a dry spell, water becomes scarce. A former UP (Union Porishod) member informed us that the situation is the same in Chandipur, Golakhali, near the Sudarban coast, in Henchi, and in hundreds of villages in the coastal region. The Upazila Assistant Engineer informed us that 70% of the inhabitants in the region drink saline water to meet their yearly water demand.

4.2. Case Study/Short Case Study

Case studies played a crucial role in providing real-life examples and illustrating the practical implications of safe drinking water and health. By closely examining specific instances or scenarios, we were able to draw meaningful conclusions and extract valuable lessons that can be applied in a broader context.

1. In Borkupot village, we encountered a widow who shared with us the challenges she faces in accessing water. She explained that her only son, H, and daughter-in-law, R, work during the day, leaving her and her grandchild, F, to go to Atlia Union Porishod to collect water. Unfortunately, their efforts were in vain as the water supply to the pipe connected to a water source two kilometers away had been disrupted. Consequently, they returned empty-handed, unable to meet their water needs. Another respondent, who was over 60 years of age and identified as respondent 168, echoed a similar struggle. She informed us that due to her husband's paralysis, she resided with her foster son. When her daughter-in-law fell ill, she took on the responsibility of fetching water for their five-member family. Despite walking for an hour at noon, she was unable to obtain any water as the source had run dry. To manage their needs, she had to rely on borrowing water from her neighbor, who had preserved rainwater. The situation extended beyond Borkupot village, as inhabitants of neighboring villages such as Napitkhali, Chandnimukha, and Talbaria in the upazila also faced difficulties in accessing potable water. While water sources were available near their homes, they were forced to travel long distances to fetch clean water. The aftermath of cyclone Aila had rendered the local water bodies saline, further exacerbating the issue of scarcity. Even the most basic laborers had to purchase water due to the impact of the cyclone on the water sources in their vicinity. These

accounts illustrate the widespread challenges faced by individuals and communities in acquiring safe water for their daily needs. The disruption of water supply, the contamination of local sources, and the resulting need to travel long distances or purchase water have put a significant burden on the affected population. It is evident that immediate attention and comprehensive solutions are required to address this pressing issue and ensure access to clean water for all residents in the region.

2. According to our interactions with various respondents, the water crisis in the region is a pressing issue affecting numerous villages. Respondent 169, a 43-year-old teacher from Kupot village, highlighted that the residents are forced to purchase a 40 L drum of water for 50 taka to meet their daily water needs. Similarly, Respondents 170 and 171, two women from Durgabati village, shared that despite their husbands' efforts to support the family, they still have to buy water for cooking purposes due to the absence of a reliable potable water source. The scarcity of water has had a significant impact on the inhabitants of the region, particularly in Ward numbers 4, 5, 7, 8, and 9 of the Nurnagar Union. The increased salinity in these areas has affected approximately 200 families, leading to a lack of potable water sources and insufficient facilities for water preservation and reformation. Respondent 172 from the Romjannogor Union emphasized the vulnerability of the coastal belt to natural catastrophes caused by climate change. The embankment breach during cyclone Amphan resulted in the intrusion of saltwater into 3000 ponds, rendering them unsuitable for cooking and domestic use. Respondent 173 from Shaper Dune Village shared her struggles of fetching water with a pitcher but returning empty-handed. She relied on those who had collected rainwater for her water supply. Many respondents, including Respondents 174 from Henchi village, 175 and 176 from Choto Kupot Duno village, 177 from Boro Kupot village, 178 from Atulia, and 179 from Kashipur, expressed similar concerns. Despite having ponds in almost every household, these ponds are not suitable for obtaining potable water. The long distances they have to travel, often 3 to 6 km, to fetch water for cooking purposes has had a negative impact on the education of their children.
   The water crisis in the region has worsened following cyclone Aila. Although submerged water was lifted and purified for supply, only a small percentage, approximately 5% of the population, had access to this service. Limited communication infrastructure and financial constraints have left a major portion of the population deprived of purified water. Deep and shallow tube wells have proven ineffective, and the water bodies that were once free of salinity now contain muddy water, exacerbating the water crisis for three to four months. Due to reliance on other natural water sources apart from rainwater, the local residents face acute cooking water shortages for approximately five months each year. These accounts collectively paint a grim picture of the water scarcity issue faced by the region's residents. It is clear that immediate attention and comprehensive solutions are necessary to address this critical situation, ensuring access to clean and reliable water sources for all individuals and communities in the affected areas.

3. In relation to the types of latrines used in households, respondents 180 (33 years old), 181 (48 years old), and 182 (35 years old) from the Gabura Union provided us with insights. They shared that due to limited financial means, the local inhabitants are unable to construct standard latrines. As a result, they resort to open defecation, under the open sky. Some individuals have latrines constructed with hard clay, while others utilize slab rings for their latrine structures. It is important to note that these types of latrines are susceptible to submersion during high tide and resurfacing during low tide.

4. In the past six months, there has been a concerning rise in illness attributed to polluted water and waterborne diseases, as reported by several respondents. Respondent 184, a 43-year-old individual from Ward No. 9 of the Gabura Union, highlighted the adverse effects following cyclone Amphan. The increase in germs, likely due to

water and soil salinity, has resulted in various health issues among the population. Diarrhea, jaundice, cholera, abscesses, and body soreness were among the ailments experienced. Respondent 185, a 52-year-old from Dumuria Village in the Gabura Union, connected the surge in illnesses to climate change. The changing weather patterns have significantly impacted the well-being of the community, with children being particularly vulnerable. Pneumonia, measles, pox, colds, fevers, and other illnesses have become prevalent among children. Pregnant women are also affected, suffering from anemia, nutritional imbalances, headaches, vomiting, and related symptoms. Furthermore, waterborne diseases, allergies, skin problems, abscesses, and diarrhea have seen an alarming increase. Another respondent, aged 49 and hailing from the same Gabura Union, shared her personal experience of encountering various skin problems in recent weeks, both for herself and her daughter. This suggests that skin issues are becoming more widespread in the community. These accounts collectively emphasize the detrimental impact of polluted water and waterborne diseases on the health of the local population. The consequences of climate change, coupled with salinity issues, have intensified the occurrence of illnesses and health complications. Urgent measures are needed to address these challenges, ensuring access to clean and safe water sources and implementing health interventions to mitigate the spread of water-related diseases and skin problems in the affected areas.

5. Respondent 187, a 40-year-old individual from the Romjan Nagar Union, shed light on the profound impact of climate change on the living standards and employment opportunities in coastal areas. The adverse effects of salinity have resulted in a myriad of waterborne diseases, significantly affecting the health of the community. Inhabitants of the neighborhood endure ailments such as scabies, diarrhea, dysentery, abdominal pain, fever, and kidney problems due to the consumption of saline water. Furthermore, a high prevalence of high blood pressure is observed among the local population as a direct consequence of saltwater intake. The stagnation of saline water in marshes and channels, where lotus plants thrive, exacerbates the situation, as decaying lotus plants emit a foul odor, leading to a surge in mosquito populations. Even the neighboring Sundarbans region is plagued by mosquito infestations. The mosquito bites often result in malaria, a disease that is challenging to cure. Additionally, women in the community experience various health issues related to the uterus, along with itching, soreness, and scabies, all attributed to the salinity problem. Disturbingly, children in the region are reaching puberty at an alarmingly early age. Previously, it would typically take 12–13 years to reach adolescence, but now it is occurring as early as 6 years. The local population firmly attributes these drastic changes in puberty to climate change and the prevalence of salinity in the region. This account highlights the severe health implications faced by the community due to climate change and salinity. The interconnectedness of these factors underscores the urgent need for mitigation and adaptation measures to address the adverse consequences on people's health and well-being. Efforts should focus on improving access to clean and safe water sources, implementing mosquito control measures, and providing healthcare services to combat the waterborne diseases and related health issues prevalent in the region.
6. The impact of water-related issues on mental health is a significant concern in the community. Respondent 188, a 39-year-old individual from the Ishwaripur Union, highlighted the higher incidence of (pre)eclampsia and gestational hypertension among expectant mothers in their area. These conditions are believed to be linked to the contamination of drinking water with salinity, particularly during dry spells and seasonal variations. The respondent also emphasized the significant association between sodium intake from the saline water and the occurrence of (pre)eclampsia and gestational hypertension. It has been observed that young women in the area face an elevated risk of hypertension due to saline water consumption. Respondent 189, aged 37, shared the challenges faced by her three-year-old son, F, who frequently falls ill. Both she and her son frequently experience severe bouts of diarrhea and

require medical appointments with local doctors. Additionally, bathing in the pond water during the summer causes her to get scabies. These accounts highlight the detrimental effects of contaminated water on physical health, particularly among expectant mothers and young children. The persistent health issues faced by the community members not only cause physical discomfort but also have implications for mental well-being. The stress and anxiety associated with these health challenges can take a toll on the mental health of individuals and their families. Addressing these water-related health issues requires a multi-faceted approach. It is crucial to implement measures to ensure the availability of clean and safe drinking water to mitigate the risks of (pre)eclampsia, gestational hypertension, diarrhea, and other waterborne illnesses. Additionally, promoting awareness about proper hygiene practices, such as handwashing and maintaining personal and environmental cleanliness, can significantly contribute to improving overall health and well-being in the community. Accessible healthcare services, including regular check-ups and treatments, are essential for managing and preventing water-related health problems. Efforts should also be directed towards long-term solutions, such as improving water infrastructure, implementing water treatment systems, and conducting regular quality checks to ensure the safety of drinking water sources. By addressing these issues comprehensively, the community can mitigate the adverse impacts on both physical and mental health, leading to an improved overall quality of life.
Example: In low-income countries, hypertensive disorders in pregnancy pose a significant threat to women of child-bearing age, leading to death and disabilities. However, the underlying causes and mechanisms of these disorders remain poorly understood, hindering effective prevention strategies. While excessive salt intake is known to increase the risk of hypertension, the health impacts of water salinity are less explored. This epidemiological study aimed to investigate the association between high salinity in drinking water and the risk of (pre)eclampsia and gestational hypertension among pregnant women in a rural coastal community in Dacope, Bangladesh. The study focused on a community where both surface and groundwater sources were severely affected by salinity, exacerbated by the impacts of sea-level rise and climate change. Through a population-based case–control design, the study collected data from 202 cases of (pre)eclampsia and gestational hypertension, along with 1006 controls. The findings revealed that women in Dacope were exposed to remarkably high levels of sodium in their drinking water, and this exposure was significantly associated with an increased risk of (pre)eclampsia and gestational hypertension.

7. Respondent 189, a 52-year-old individual, shared that the majority of patients in their area are plagued by various symptoms including itching, blurred vision, body aches, and weakness. Respondent 190, aged 56, added that knee pain, pressure, breathing problems, allergies, pain, and gastric issues are the major concerns reported by most patients. These symptoms are directly attributed to the presence of salinity in the region's water sources. Furthermore, respondent 190 recounted their harrowing experience during cyclone Aila, describing how they were swept away by a tidal wave and their non-concrete, earth-built household drifted along with the water. The destruction and suffering endured on that day are indescribable. Their poultry and dairy livestock also perished as a result of the storm. Additionally, respondent 190, aged 38, from Koikhali Union, emphasized the significant impact of climate change on the physical and mental health of the local population. They highlighted the immense harm caused to households, land properties, and domestic animals and livestock due to climate change-related events. As a consequence, people in the community are growing increasingly concerned and experiencing mental breakdowns, depression, and anxiety related to their lives, families, and future. These accounts paint a stark picture of the physical and psychological toll inflicted by climate change and salinity in the community. The wide range of health symptoms experienced by residents underscores the urgent need for comprehensive measures to address

these challenges. It is imperative to prioritize the well-being of individuals and their mental health in the face of such adversity. Efforts should focus on providing access to medical care and treatment for the symptoms and ailments associated with salinity and climate change. Additionally, raising awareness about climate change and its impact on health can help individuals better cope with the challenges they face. Implementing preventive measures, such as building resilient infrastructure and promoting sustainable practices, can contribute to mitigating the harmful effects of climate change and safeguarding both physical and mental well-being.

8. A local doctor, aged 35, hailing from Union Jelakhali, Munshigonj, provided valuable insights into the health issues prevalent in the community. According to the doctor, teenage girls between the ages of 12 and 16 often suffer from white inflammation, with 80% of these cases stemming from nutritional deficiencies, particularly the lack of iron and calcium. Women in the area frequently experience depression due to irregular menstruation and are prone to anemia, headaches, and fever. The intrusion of saline water also contributes to an increase in allergies among the population. The use of saline water for daily showers has significant repercussions on skin health, resulting in soreness, scabies, eczema, and other dermatological issues. Furthermore, the doctor observed that women face challenges in conceiving due to the adverse effects of saline water, and young girls give birth at early ages, typically between 13 and 17 years. Unfortunately, the gravity of this problem often goes unrecognized by those affected. The prevalence of early marriages driven by poverty exacerbates the issue of infertility in the women. Moreover, deficiencies in essential nutrients such as iron, calcium, and protein are widespread, leading to high and low blood pressure, weight loss, and pervasive anemia among the population. These observations shed light on the multifaceted health challenges faced by the community, with a particular emphasis on women and young girls. The interconnected nature of nutritional deficiencies, mental health concerns, skin problems, and reproductive health underscores the need for comprehensive interventions to address these issues. Efforts should be directed towards promoting awareness about proper nutrition, especially among adolescent girls, to combat the prevalence of white inflammation and nutrient deficiencies. Accessible healthcare services, including regular check-ups and consultations, can help diagnose and manage conditions related to irregular menstruation, anemia, and mental health. Providing education and support regarding family planning, reproductive health, and the consequences of early marriages can contribute to addressing the issue of early pregnancies. In addition, initiatives to improve the availability of clean and fresh water sources, reducing reliance on saline water for daily use, can significantly alleviate the burden of skin problems and promote better overall health in the community. Collaborative efforts involving healthcare professionals, community leaders, and relevant stakeholders are essential to tackling these complex health challenges and fostering a healthier future for the community. Saline water has been found to be associated with an alarming rise in teenage pregnancies. In coastal communities where water sources have been affected by salinity, young girls are experiencing an early onset of puberty and engaging in early marriages due to the economic hardships faced by their families. The high sodium content in the saline water not only affects their physical health but also disrupts their hormonal balance, leading to increased fertility at a young age. This phenomenon is a concerning consequence of the adverse effects of saline water on the reproductive health of adolescent girls. Efforts are needed to address this issue by providing education, access to reproductive health services, and raising awareness about the impact of saline water on teenage pregnancies in these communities.

   Climate change has been observed to have a concerning relationship with underage marriages in various regions. As climate change exacerbates poverty, food insecurity, and resource scarcity, vulnerable communities, particularly in developing countries, are compelled to adopt coping mechanisms to survive. In such circumstances, early

marriages are seen as a strategy to alleviate economic hardships and ensure the security of young girls. Climate-induced events like droughts, floods, and natural disasters also contribute to the displacement of communities, disrupting social structures and traditional norms. This disruption, coupled with increased vulnerability, can lead to an increase in underage marriages as families seek to protect their daughters and ensure their well-being in uncertain environments. Addressing the root causes of climate change, implementing sustainable development practices, and empowering communities with education and economic opportunities are crucial steps in combating the concerning issue of underage marriages linked to climate change.

5. Discussion

Climate change will expose coastal residents to numerous dangers with escalated severity and recurrence, and being a low-lying deltaic nation, coastal Bangladesh is susceptible to multiple health perils [9] (Figures 3–5). Saltiness in clean water and soil is one of the many outcomes if climate change in coastal Bangladesh [10]. The upstream redirection and decrease in clean water streams in the Ganges delta (and deltas are usually lively coastal systems) is related to both land-based fluvial and coastal sea level rise [10]. Deltaic areas are extremely susceptible to influences from weather changes and anthropogenic events; importantly, the Ganges–Brahmaputra–Meghna (GBM) delta in Bangladesh has the largest deltaic population on the planet [11]. With increasingly pronounced CCSLR impacts, current water resource management is expected to be highly complex in the SWCRB [10] (Table 2). About 97% of Bangladesh's population uses groundwater as their main source of drinking water [70]; however, widespread contamination of groundwater with arsenic and salinity has significantly reduced the availability of safe drinking water from 97% to 74% [71], which puts 35 to 77 million residents at great health risk by drinking contaminated water [4]. Furthermore, 35 million inhabitants are confronting drinking water catastrophes, due to aquifer salinization along the coasts [5]. Inadequate water supply has direct adverse health consequences and prevents good sanitation and hygiene [72] (Figures 2–5; Table 3). Any change in water quantity or quality due to pathogens, toxins, and chemical pollution can lead to water-related health problems, such as diarrhea, typhoid, hepatitis, and arsenicosis. A range of 28–60 million residents of Bangladesh are currently drinking water that contains salt and arsenic above nationwide health standards [73]. After Cyclone Aila in 2009 and the recent Cyclone Amphan in 2020, people living in the Satkhira district experienced the greatest level of hardship due to safe drinking water shortages compared to previous years [74,75]. Thus, one of the greatest challenges that the respondents in the study areas had to experience was the lack of availability of drinkable water (Tables 2 and 3).

The declines in water supply from intense weather calamities, such as storms and deluge, may compel residents to utilize poor water sources, leading to rising numbers of waterborne illnesses [72]. Abnormal river flows during cyclones and floods, combined with reduced water flow during droughts and rising temperatures in the SWCRB, have a significant impact on water quality. These conditions contribute to low levels of dissolved oxygen and increased microbiological interference. Consequently, these changes have adverse effects on health [76]. Acidification, salinization, or system failure result in increased water-related illnesses [72]. Rainfall fluctuations also impact water supply and hence cause problems like rainwater harvesting failure due to extended dry periods [36]. Saltwater intrusion in coastal aquifers from climate-induced sea level rise has resulted in the reduced quality and quantity of freshwater in coastal aquifers [10]. Numerous people frequently drink contaminated water for various domestic purposes, endangering their health (Tables 2 and 3). For example, according to the Food and Agricultural Organization (FAO) and the World Health Organization (WHO), the recommended daily dietary salt intake is below 5 g/d. However, daily salt intake is up to 16 g/d in numerous coastal communities, with only 2 L of natural drinking water [77,78]. Total daily salt intake may vary depending on exposure, degree of pollution, household water use habits, and local environmental disturbances. Different types of salinity exposure have potential links to health

problems, including skin ailments, respiratory ailments, high blood pressure, diarrheal illnesses, and miscarriages among expecting women [79] (Figures 3–5, Table 3).

Table 3. Unions' risks, vulnerabilities, impacts, health hazards, and their adaptation and mitigation strategies.

Union	Risk and Vulnerabilities	Impacts		Adaptation and Mitigation
		General	Health Hazard	
Burogoalini Union	Potable water crisis: Cyclone Amphan caused the embankments to be broken down; more than 5000 of the ponds in the locality have been overwhelmed by the salinity intrusion, resulting in the spoiling of the ponds for potable water.	Post-Amphan, out of 42 filters (PSF), 15 ponds have been pumped out of water, and water has been made potable	Diarrhea, dysentery, malnutrition, Illness due to malnutrition, disabled children, gynecological problems, blood pressure, eclampsia, hypertension, and early puberty among girls	Two thousand families in the Union have to buy water for consumption
				Digging ponds in order to remove saline water to make them potable
				Making plants to implement the RO process
				Installing water drums/plants in order to resolve the potable water crisis
Gabura Union	Gabura Union is surrounded by water but not any to drink.	95% of the inhabitants of Gabura Union are at health risk	Due to lack of safe drinking water: diarrhea, dysentery, soreness, itching, malnutrition scabies, skin problems, anemia, nutritional imbalance, blood pressure, eclampsia, and hypertension occur	Installing water plants according to the RO process, installing family-unit-based rainwater-harvesting plants under the initiative of the government
	In the 3 villages of Gabura like Jelia Khali deep tube well water is drinkable but water is light saline. People from the rest of the 12 villages drink high saline water.	Almost 26–30 km from the nearest Upazila Health Complex at Shyamnagar from this union		
Koikhali Union	Ponds containing potable water are spoiling.	More than 1500 ponds, and embankments are being destroyed	More than 50% of respondents are suffering from malnutrition and waterborne diseases, skin, and allergy related illnesses	Among the filters (PSF), water from 43 ponds were removed
				Installing RO-based plants
				Installing water drums/plants
Kashimari Union	Eight villages in this union, Kathal Baria, Khotikata, Deol, Shankarkati, Gobindopur, and Bill Godara, are surrounded by water.	The Shyamanagr Upazila Health Complex is 12–15 kilometers away from the union	40% of inhabitants of Kashimari Union are under health risk; children's and women's health problems are common	Installing rainwater-harvesting plants
			In the absence of safe water, diarrhea, dysentery, soreness, itching, and malnutrition issues arise in the area	
Munshigonj Union	Potable water crisis: Cyclone Aila in 2009 and Amphan in 2020 caused the embankments to be broken down; more than 6000 of the ponds in the locality have been overwhelmed by the salinity intrusion, resulting in spoiling of ponds for potable water.	Domestic water ponds are getting spoiled due to salinity intrusion, as embankments have been destroyed	Diarrhea, dysentery, malnutrition, illnesses, disabled children, gynecological problems, and early puberty among girls	Installing rainwater-harvesting plants

Table 3. *Cont.*

Union	Risk and Vulnerabilities	Impacts		Adaptation and Mitigation
		General	Health Hazard	
Atulia Union	Domestic water ponds are being spoiled.	More than 3000 ponds affected as embankments have been destroyed due to the occurrence of natural disaster Amphan	More the 40% of respondents suffer from various health diseases and children's and women's health problems	Digging ponds by removing saline water from them to make the water drinkable
	Potable water crisis is prevalent.	Post-Amphan, there were 45 filters (PSF); now, water has been removed from 18 ponds to make the water potable; 3000 families in the union have to buy water for consumption		Installing water plants by means of RO
				Installing water drums/plants to resolve domestic water crisis
Nurnagar union	Potable water crisis is on the rise.	Domestic water ponds are being spoiled due to salinity intrusion, as embankments have been destroyed	Risk of health and number of children suffering from malnutrition is on the rise	Installing water drums/plants to resolve domestic water crisis
	Domestic water ponds are being spoiled.	36 filters (PSF); now from 11 ponds, water has been removed to make the water potable	50% of them are suffering from various health diseases, child and women health problems are common	Increase the service of the Community Clinics while increasing their numbers as well as, employing MBBS doctors
Poddapukur Union	Poddapukur Union is surrounded by water with hardly a drop to drink.	Gabura, Chandipur, deep tube well water is drinkable with salinity. People from rest of the 13 villages drink high saline water	Due to lack of safe drinking water: diarrhea, dysentery, soreness, itching, malnutrition is on the rise.	Install RO plants to introduce rainwater harvesting from government's initiative
		Shyamanagar Upazila Health complex is 26–30 kms away from the Union.	85% inhabitants are under health hazards due to water	
Shyamanagar Union	Domestic water ponds are becoming spoiled.	Domestic water ponds are getting spoiled due to salinity intrusion, as embankments have been destroyed	50% of the inhabitants are suffering from skin issues, allergies, and other health problems	Making water plants through the RO process
	Potable water crisis is prevalent.	Post-Aila, there were 59 filters (PSF); now, water has been removed from 12 ponds to make the water potable	Due to excessive use of pesticides, farmers are suffering from different diseases, their vision is becoming blurry, and malnutrition, immunity reduction, child pneumonia, asthma, and water borne diseases are on the rise	Installing water drums/plants to resolve the domestic water crisis

Sources: FGDs, workshops, interviews.

A study was conducted on the relevance of dietary salt intake, but epidemiological studies that assess health issues associated with saline water intake remain insufficient. A study conducted in Massachusetts, USA, examined children from two different high schools who were exposed to drinking water containing either 272 mg/L (high) or 20 mg/L (low) salt [80]. The researchers concluded that children exposed to high salt concentrations had higher systolic and diastolic blood pressures by 3–5 mmHg, after dietary salt intake was controlled. Another study in Chicago conducted a similar study and produced comparable results.

Based on the results from epidemiological studies, a strong correlation between blood pressure and higher salt intake was found. A study known as the INTER-SALT study showed a positive correlation between high blood pressure and dietary salt intake [81], and statistical reports from that study suggest that sodium intakes greater than 1.8 g/day increase the risk of hypertension [82]. A review study conducted by [83] stated that individ-

uals who reduce their salt intake to 5–6 g/day can significantly lower their blood pressure and prevent numerous cardiovascular diseases and coronary heart diseases (Table 3).

Domestic water insufficiency is related to different health issues caused by contagious diseases [84]. In Bangladesh, 24% of all deaths are caused by water-related diseases [85]. Respondents in the study areas have been enduring hardships by being infected with diseases from consuming little water or highly salted water. People in the SWCRB are living with different waterborne diseases, such as skin diseases; fevers; peptic ulcers; pneumonia; eye, nose, ear, and throat infections; dysentery; vomiting; diarrhea; gastrointestinal diseases; and so on (Figures 3–5). Also, women face physical health issues while collecting water from remote sources and these problems are typically not included in the listed diseases [86]. Water contamination during the collection of water from remote sources is also linked to water access (Figure 5). However, these issues remain hidden from the public eye. Health hazards also occur from consuming unsafe water from sources with obnoxious tastes or odors (due to iron content, water salinity, chlorination) that are deemed to be pathogen free, and physical impacts (to musculoskeletal health) occur from fetching safe water and moving heavy containers over long distances [87]. In certain parts of the coastal areas in Bangladesh, people especially women and teenage girls travel as far as 5 km to 8 km to find fresh water [88] (Figures 3–5; Table 3).

The response providers in three unions were also asked about their everyday water needs (Table 2). Almost 70% of the survey takers in the three unions hinted at the need for 11–20 L of water every day for each family. To fulfill their drinking water requirements, the response providers fetch clean drinking water from remote locations. All response givers in the three unions gather drinking water from sites over 2 to 4 km away (Table 2). In severe cases, women from certain rural locations of southwestern coastal Bangladesh walk 6 to 12 km every day to meet the water requirements of three jars (one jar holding 12–15 L of water) for every household [89]. Over 67.23%, 74.97%, and 63.93% of the response providers in the three unions collect drinking water from 2 to 4 km away (Table 2). Research in coastal Bangladesh shows that people tend to choose unsafe water when they must travel more than 2km and collection time takes longer than 2 h [90]. Such circumstances are common in coastal Bangladesh, as many areas suffer from moderate to severe freshwater scarcity [91]. Furthermore, physical health problems from collecting and transporting safe water are likely to be severe but are not examined by systematic studies [88]. It has been observed that women, including pregnant and lactating mothers, adolescent girls, and children are usually responsible for collecting and transporting heavy containers of drinking water from distant sources [68]. In some areas of coastal Bangladesh, household members travel up to 5 km to collect drinking water, which poses additional health burdens, especially on women [88].

Female participants in the investigated region are inflicted with a certain gynecological ailment (the lowering of the uterus) triggered by transporting big jars of water on their hip over a long distance [92]. The statistics in Figures 4 and 5 focus on 92% of the response providers in the inadequacy zones who frequently struggle with diarrhea, particularly infants and children, from ingesting saline water (Figures 3–5; Table 3). They also struggle with dyspepsia, black spots on the skin, and so on. Since women have specific nutritional needs, they tend to suffer from nutritional deficiencies, which is especially true for breastfeeding or pregnant women. In certain regions in Southeast Asia, as many as 45–60% of women who reach reproductive age tend to be underweight. Moreover, 80% of all pregnant women are iron deficient [77] (Figure 5). A study found that adolescent women were found to have perinea rashes, as well as urinary tract infections when a flood took place in Bangladesh in 1998. This is because the women were unable to clean and dry their menstrual rags [93]. In a post-disaster scenario, breastfeeding, pregnant, and menstruating women are more prone to health issues [94]. A lack of sanitary materials and safe places for breastfeeding create a hazardous situation in a post-disaster world. All these health issues affect the respondents during disasters, with women who are pregnant and who have children being considered the most vulnerable and are now marginalized

in certain countries [95]. Therefore, their health may be complexly affected by climate change (Figures 2 and 4). Increased water saltiness is directly related to health, for example, hypertension and pre-eclampsia, skin illnesses, intense respiratory contamination, diarrheal infections, and transmission of mosquito-borne sicknesses [5] (Figures 3–5). In 2002, the World Health Organization (WHO) decided that the effects of exceptionally saline water on health needed to be examined [96]. Higher numbers of (pre-)eclampsia and gestational hypertension in pregnant women were seen in the southwestern shoreline of Bangladesh, in contrast to non-seaside regions, which was assumed to be brought about by saline pollution of drinking water, with some higher irregular impacts, especially in the dry season [97] (Figure 4).

The United Nations Framework Convention on Climate Change (UNFCCC) stated that women in poorer parts of the world have the highest risk of contracting a disease from climate change [98] (Figure 4). This is especially true in health-related issues, where climate change brings about gender inequalities in terms of receiving treatments. All genders, including adult males, females, as well as children, are all at risk [99]. Since women have specific dietary requirements during pregnancy, they are especially threatened (Figure 4).

More than 19 million children in Bangladesh are endangered by disastrous environmental impacts, such as floods and cyclones. As per the suggestions of UNICEF Executive Director Henrietta Fore, climate change is becoming an impactful factor in coastal areas of Bangladesh, where the poorest communities suffer in terms of taking care of their children with food, education, and proper housing. Among South Asian countries, Bangladesh is currently rated second for children being at high risk due to the adverse effects of climate change [100] (Figure 5) and ranks 15th on a global scale. Unplanned urbanization, increases in non-communicable and communicable diseases, as well as environmental deterioration have been seen as consequences of unplanned family migrations from rural areas to the cities due to the natural disasters they face because of climate change. Other diseases that are vector-borne, such as chikungunya fever and dengue fever, are huge threats in Bangladesh [100]. The Directorate General of Health Services of Bangladesh reported 26 fatalities and 10,148 total cases in 2018 alone. Christina Weslund, UNICEF's Bangladesh child protection specialist, said that 3.45 million children are forced into child labor due to climate change [100]. The southwest coastal areas of Bangladesh struggle economically and are prone to various climate change disasters. Climate change affects humans physically in both direct and indirect ways, establishing a communication channel with social dynamics that has negative effects on physical conditions.

The lack of clean water is highly responsible for residents contracting dysentery, especially in the summer season (Table 2). Warmer temperatures are also related to increased episodes of diarrheal malady [91]. Thus, poor hygienic systems and the inaccessibility of safe water are the underlying factors of these diseases [1,8] (Figure 3). Diarrhea caused by lack of safe drinking water is a concern for people who participated in the questionnaire survey, where more than 90% of the respondents are affected by this in three unions. In the Gebura Union, some respondents reported that cholera appeared due to salt intrusion caused by climate change, whereas a number of studies revealed that high density and saline water are the most common causes for the cholera germs spreading in the coastal regions [1,8]. (Figures 3–5).

Due to changes in drinkable water from vectors, the number of health-associated risks from saline drinking water is increasing. More specifically, changing climatic conditions will affect pathogen maturation and multiplication, vector species distribution and behavior (such as the mosquito), the lifecycle of disease agents (such as parasites), and aspects of human behavior that increase the risks of infection (such as crowding and displacement) [101]. The association between climate variables and vector-borne diseases differs geographically. Among the vector-borne diseases, dengue fever is positively associated with globalized climate variability [102], as well as local climate factors [103]. Furthermore, an important mosquito-borne disease, malaria, is associated with climate variables at the local level and

is responsible for 200 million cases per year; more than 400,000 malaria-related deaths were reported in 2017 alone [104] (Figures 3–5).

Saltwater intrusion and the expansion of brackish water bodies in coastal zones can increase the densities of salinity-tolerant mosquitoes. Recent findings suggest that malaria and dengue mosquito vectors possess the capacity to tolerate variations in salinity and undergo preimaginal development in brackish waters [105]. In coastal areas, the density of salinity-tolerant mosquitoes, like *Anopheles sundaicus*; the vector of malarial parasites; the vector of Japanese encephalitis virus, *Culex sitiens;* and Ross River virus, can grow as brackish and saline water bodies expand due to sea level rise. Moreover, freshwater mosquitoes, like *Aedes aegypti* and *Aedes albopictus*, vectors of dengue fever, and *Anopheles culicifacies* and *Anopheles stephensi*, the vectors of malarial parasites, can also adapt to saline water [105] (Figures 3–5). Salinity also prevents normal crop production [10,11], with saltwater intrusion in coastal areas resulting in reduced availability and productivity of agricultural land, leading to food insecurity [106]. The decrease in food production and food security is likely to exacerbate adverse health effects, especially for women and children (Table 2).

In addition to water salinity, in Western Australia, the salinity of dry land (not drinking water) has been linked to several human health problems, including increased respiratory illness from air-borne dust and risk of mosquito-borne diseases, such as Ross River. Viruses and increases in psychosocial health issues are consequences of salinity-induced environmental degradation [41].

Adaptation can reduce vulnerability to climate change, helping rural community members adapt to it and be prepared for unpredictability, reducing potential losses, and helping them cope with adverse situations [8]. Figure 6 demonstrates that 16.80%, 40.55%, and 15.99% of the response givers in the three unions recommended that rainwater harvesting is the best alternative to adapt to clean drinking water shortages, while pond sand filters were preferred by 16.39%, 14.75%, and 24.05% of the participants in the three unions. Furthermore, a quarter of the participants in the three unions hinted that buying potable water is a beneficial option for acquiring clean drinking water that will help prevent waterborne illnesses, but due to poverty, they cannot afford it.

Clinic locations in zilas and upazilas are scattered, and most community members are far away from these healthcare facilities. Based on the survey findings, Figure 7 shows the well-being service availabilities for the three unions. Because of the relatively short distances to community clinics, most of the participants (32.38%, 42.95%, and 28.28%) in the three unions use the healthcare facilities in the community clinics to recover from sicknesses. However, due to the distance from the upazila health complex, a lack of communication systems, and poverty, 18.81%, 21.53%, and 23.77% of the participants in the three unions seek health care from local doctors.

Rainwater harvesting (16.80%, 40.55%, and 15.95%) was the greatest adaptation mechanism for acquiring drinking water on a personal level. Many regions undergoing strenuous drinking water challenges have adopted pond sand filters as alternatives to deal with the absence of drinking water at the personal level, while regions with acute drinking water paucity have incorporated PSFs to obtain safe drinking water [107,108] (Figure 6) with help from government establishments (for instance, the DPHE) and NGOs (like Sushilan), and with the collaboration of patron agencies and international NGOs (for instance, Caritas and UNICEF) [70]. Some response providers from acute drinking water shortage zones balance water use to obtain safe drinking water with negligible salinity and arsenic levels. Moreover, some of the response givers from these areas utilize deep tube wells with overhead tanks fitted by the local NGO, the Iswaripur Development Foundation (IDF), with international collaboration from GIZ (German Development Cooperation) [8,100].

Adaptation plays a crucial role in reducing vulnerability to the impacts of climate change, particularly in relation to the lack of safe drinking water and its effects on health. Recognizing the challenges posed by climate change, communities and stakeholders can implement various adaptation measures to improve access to safe drinking water and

mitigate health risks. These measures may include the development and implementation of sustainable water management strategies, such as rainwater-harvesting systems, water purification technologies, and efficient water distribution systems. Additionally, enhancing community awareness and education regarding safe water practices and hygiene can contribute to preventing waterborne diseases and improving overall health outcomes. Strengthening healthcare systems and infrastructure in vulnerable areas can also enhance the capacity to respond to health issues associated with water scarcity and contamination. By prioritizing adaptation actions, communities can build resilience, reduce vulnerability, and ensure sustainable access to safe drinking water, ultimately safeguarding the health and well-being of their residents in the face of a changing climate.

6. Conclusions

In Bangladesh, the management of water resources has become a crucial issue due to the growing demand for water and the increasing competition over its alternative uses. Consequently, water scarcity is becoming a pressing concern in the country. The findings of this study revealed that climate change has a significant impact on the availability of safe water and contributes to health problems in the study area. Climate variability, such as salinity, droughts during the dry season, and floods during the wet season, greatly reduces access to clean drinking water and leads to a rise in waterborne diseases among more than half of the affected population. Moreover, the existing healthcare facilities and safe drinking water practices are inadequate to address the growing number of health issues, as evidenced by the insufficient number of health centers. As a result, families have to travel long distances to collect safe water. To address these challenges, the study identifies effective approaches for ensuring safe drinking water, including rainwater harvesting, pond sand filters, and sustainable water supplies. Implementing these measures can significantly reduce waterborne illnesses and improve overall health. The study emphasizes the importance of collaboration among various stakeholders, such as government organizations, non-governmental organizations, and local communities, to implement adaptation-specific activities aimed at providing safe drinking water and improving health outcomes. The increasing salinity intrusion and its ongoing trend pose a significant challenge to future freshwater availability. To ensure sustainable and safe drinking water, it is crucial to develop comprehensive strategies that consider all the aforementioned concerns at the local level. The government should identify potential water sources and enforce drinking water policies. Local water resource management and conservation strategies should also be implemented to ensure the availability of safe drinking water and minimize health risks. Additionally, community-based initiatives and capacity-building programs should be introduced to enhance local coping mechanisms and improve household and individual access to clean drinking water. These efforts will foster resilience and adaptability within the community and contribute to the achievement of Sustainable Development Goals (SDGs) among coastal communities in Bangladesh.

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