Review

Wash Implementation in Climate Change Induced Emergency

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WASH Implementation in Climate Change Induced Emergency

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Abstract: Emergencies and disasters are basic aspects of everyday life. They are the results of societies' economic and social structures, the interactions between states and societies, and the maintenance of the relationships among the decision-makers. Emergency-affected individuals frequently experience exhaustion, stress, malnourishment, and other illnesses, including injuries. Water, sanitation, and hygiene (WASH) measures aim to protect health by reducing the exposure of disease-causing pathogens and promoting well-being. This review explores climate change's implications on WASH interventions in emergency contexts. Climate change has significantly increased the frequency and severity of natural disasters, including floods, droughts, and hurricanes, and amplified the emergencies by increasing flood events, drought intensification, and enhanced hurricane severity. Climate change has impacted WASH in emergencies by increasing the demand for WASH service due to displacement, water scarcity, and contamination and undermined sanitation infrastructure and hygiene behaviors. Strategies to develop climate-resilient wash infrastructure include designing climate-resilient infrastructure, Integrating Climate Risk Assessments in WASH Planning, and sustainable water management practices.

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1. Introduction

Emergencies and disasters are basic aspects of everyday life. They are the results of societies' economic and social structures, the interactions between states and communities, and the maintenance of the relationships among the decision-makers. The catastrophe results from the fact that some people or groups are compelled to relocate to regions because they are vulnerable to the effects of natural or anthropogenic disasters such as conflict, volcanic eruption, drought, flood, or hurricanes [1]. Emergency-affected individuals frequently experience exhaustion, stress, malnourishment, and other illnesses, including injuries. Those affected by disasters are particularly susceptible to illness because of these factors as well as unhygienic living situations such as poor sanitation, and insufficient water supply. People frequently flee their houses in disaster situations in quest of safer environments. In many cases, the new environment's water, sanitation, and hygiene conditions may be insufficient. In other cases, people may be left in their homes, but the physical and social infrastructure—such as the systems for water, sanitation, and health care—may be destroyed or damaged. Natural disasters can trigger infectious disease epidemics when they cause significant population displacement and exacerbate synergic risk factors (changes in the environment, human situations, and vulnerability to existing infections) for disease transmission [2]. Water, sanitation, and hygiene (WASH) measures aim to protect health by reducing the exposure of disease-causing pathogens and promoting well-being [3]. Access to clean water and sanitary facilities is a human right[4] that is applicable in both emergencies and times of peace, according to the United Nations social infrastructure—such as the systems for water, sanitation, and health care—may be destroyed or damaged.

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WASH interventions are critically needed during natural disasters, conflicts, and displacements since they form a crucial part in the prevention and dignification of humans. Safe water and sanitation access primarily reduces the vulnerability to diseases such as cholera and diarrhea caused by water, mainly spread during humanitarian crises[5–7]. Evidence indicates that WASH programs can be effective in disease reduction, as various studies demonstrate that interventions reduce childhood diarrhea and increase water quality[8,9]. However, existing literature also identifies that much of the current evidence lacks high quality about the efficacy of these interventions, underlining a need for more robust research to inform best practices[5,8]. This paper aims to explore the implications of climate change on WASH interventions in emergency contexts.

2. Role of Climate Change in Amplifying Emergencies

Climate change has significantly increased the frequency and severity of natural disasters, including floods, droughts, and hurricanes. This escalation is primarily driven by rising global temperatures and altered weather patterns, which intensify the impacts of these events. The following sections outline the key mechanisms through which climate change exacerbates these natural disasters.

2.1. Increased Flooding Events

Floods and droughts have detrimental impacts on various sectors including water, agriculture, energy, infrastructure, and ecosystem health [10]. Climate change leads to heavier rainfall and more intense storms, resulting in increased flooding risks[11] The frequency of flood events is projected to rise, with compound flood and drought occurrences expected to double under 1.5°C warming scenarios[12]. Urban areas face heightened pollution risks from flooding, exacerbated by climate change, which can lead to significant ecological damage.[13]

2.2. Drought Intensification

Rising temperatures contribute to prolonged drought conditions, reducing snowpack and altering hydrological cycles [13,14]. The variability of drought events is increasing, with droughts expected to occur later in the season, complicating water resource management. [12]

2.3. Enhanced Hurricane Severity

Climate change is linked to the increased destructive power of hurricanes, characterized by stronger winds and higher rainfall [13]. Urban areas that are heavily developed are particularly vulnerable to the impacts of hurricanes, leading to significant economic and environmental consequences. [11]

While the evidence strongly supports the notion that climate change exacerbates natural disasters, some argue that improved disaster preparedness and response strategies can mitigate these impacts. Enhanced resilience measures may help communities adapt to the increasing frequency and severity of such events.

2.4. Severe Impact on Displaced Population

The most vulnerable people of climate change-induced displacement are children, populations from the Global South that are marginalized, and populations suffering from socio-economic and political inequalities. The factor that makes them vulnerable include not having full legal frameworks, insufficient data on the displaced, and compounded effects from multiple climate hazards like floods, droughts, and rising sea levels with rising temperatures [15–19]. Besides, the children, who have been rendered homeless by climate change, are particularly susceptible to exploitation and interruption of essential services, including educational and health services[17]. Regarding this, socio-economic inequalities limit the potential for adaptation, thus rendering the said groups very vulnerable to the adverse impacts of climate change[18]. The lack of effective

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intervention strategies and recognition worsens their plight, and urgent policy responses are required to protect the rights and well-being of climate migrants. [18,19]

3. Impacts of Climate Change on WASH in Emergencies

3.1. Increasing Demand for WASH Services Due to Displacement

Climate-induced displacement puts extreme pressure on the already constrained WASH infrastructure in both camps and host communities, exacerbating vulnerabilities and health risks. In cases of greatly increased populations of displaced persons with already limited resources, deficiencies in access to safe water and sanitation facilities are extremely common; dire situations have recently worsened in countries like Bangladesh and Uganda amid various climate change impacts faced by refugees and host communities alike.

3.2. Increased Demand on Water Resources

Displacement sees an increase in demand for water resources. In most of the Rohingya camps, Seasonal variability, such as monsoon periods, even further complicates the supply with critical water shortages and contamination threats. [20]

3.3. Poor WASH Infrastructure

Inadequate WASH facilities at the campsite present health hazards. Communal latrines are a source of discomfort and humiliation among users [21]. Adverse weather conditions have downed structures intended for WASH. This has been witnessed in Nigeria, where cholera broke out due to the inefficiency of WASH services in the displacement camp [22].

3.4. Host Community Strain

For instance, California witnessed an influx of displaced people which increased the strain on infrastructure challenges for house and water services. Refugee integration into national development planning, as recently done in Uganda, calls for sustainable WASH solutions able to take into consideration both refugees and the host communities.

On the other hand, some believe that forcibly displaced persons would engender resilience in camps and host communities, hence innovative solutions for better resource management. This would have provided a clearer view of the potential for collaborative approaches to better enhance WASH infrastructure in light of the climate challenge.

3.5. Climate-Induced Water Scarcity and Contamination

Flooding and droughts are the key events that bring about changes in water chemistry, adding pollutants to the water, hence affecting the quality and safety of water sources. Droughts can result in increased concentrations of NOM that may be recalcitrant to the conventional treatment technologies, while floods import high molecular weight, UV-absorbing NOM, which is more tractable during treatment. These two extremes, when changed over suddenly, heighten water quality concerns. Studies have revealed that the probability of exceeding the threshold for water quality is likely higher during the transition from drought to flood [23]. Other long-term impacts include degraded aquatic ecosystems, heightened pathogenic loads, and manifest difficulties in managing water due to highly variable water quality parameters and complicating the treatment process. These affect human health and ecological balances adversely. [24–26]

3.6. Sanitation and Hygiene Challenges in Changing Climates

Climate change significantly exacerbates sanitation and hygiene issues, more so in low- and middle-income countries, where there is further risk to vulnerable groups, such as women and people with disabilities. In addition, disruption in the availability and quality of water due to extreme

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weather events, such as floods and droughts, leads to increased reliance on unsafe water sources, thereby increasing the incidence of waterborne diseases [27,28]. For example, in countries such as Zambia, anticipated climate projections show an increase in heavy rainfall events, possibly leading to cholera outbreaks, while at the same time, increased aridity threatens access to safe drinking water [28]. Moreover, lack of climate risk awareness among communities contributes to these issues, with women among those least likely to know how to effectively manage WASH during climate disasters [29]. The sanitation sector is similarly affected by insufficient incorporation within climate policies, which constrains its resilience and adaptation approaches [30]. Consequently, tackling these interconnected issues requires specific interventions that emphasize inclusive and sustainable Water, Sanitation, and Hygiene (WASH) solutions [31].

4. Challenges in Implementing WASH Interventions Amid Climate Change

4.1. Resource Constraints and Logistical Barriers

Water poverty and health crises are extremely aggravated by the limited funding, manpower, and access to clean water sources in the climate-affected regions. It is extrapolated that with climate change, there will be an exponential surge in the shortage of water and a rise in competition due to constraints in resources particularly for developing countries, which usually have poorly developed governance and management systems[32].

For instance, in Sub-Saharan Africa, the urgent need for clean water access become paramount with the emergence of cholera and other water-borne diseases that happen due to poor conditions of sanitation and water supply[32,33].

Furthermore, social inequalities and climate interlinkage make sustainable development goals difficult to achieve because a lack of funding hinders the development of the necessary infrastructure[34]. Hence these challenges could be overcome through multilevel approach such as improved financing, good governance and civil participation to equitably distribute clean water[33]

4.2. Infrastructure Vulnerabilities in Extreme Weather

Conventional Wash infrastructure is increasingly failing due to extreme events induced by climate change as shown in various studies depicting vulnerabilities. For instance, sanitation systems in informal settlements, like those in Kibera, Kenya, often collapse during heavy rainfall events, releasing fecal matter and pathogens into living environments, with resilience largely dependent on the type and design of the infrastructure [35]. In the same way, The water sector in Jordan also faces significant impacts from extreme events like flooding and droughts, as infrastructure failures compromise public health, food security, and social stability [36].

In addition, growing numbers of extreme weather events have called for a shift in focus from centralized to decentralized, point-of-use water treatment technologies, as traditional centralized methods are found to be no longer sufficient to ensure a reliable supply of water under these events [37]. These findings, taken together, depict a clear imperative for resilient infrastructure that can adapt to the increasing severity of climate-related challenges.

4.4. Health and Hygiene Risks

The rate of waterborne diseases is significantly increased among vulnerable populations, including children and the elderly, due to insufficient access to safe water, sanitation, and good hygiene practices. In economically challenged countries—for example, in the Democratic Republic of Congo—there is a lack of improved sanitation and hygiene facilities that contribute much to the spread of diseases like cholera and diarrhea, diseases that mostly affect children below the age of five years [38]. Correspondingly, in India, citizens residing in rural regions experience a greater prevalence of waterborne illnesses, attributed to their dependence on unrefined water sources coupled with inadequate awareness regarding hygiene practices [39].Worldwide, Children populations are especially vulnerable to water-associated diseases, with diarrhea identified as a

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predominant factor contributing to morbidity and mortality, thereby underscoring the critical necessity for enhanced sanitation and hygiene measures to address these health challenges[40]. Moreover, health disparities are seen in Ecuador, wherein Indigenous communities have notably higher mortality rates related to waterborne diseases, thereby underpinning the really important link between health equity and access to clean water[41]. In general, improving water, sanitation, and hygiene (WaSH) services is essential for alleviating the incidence of waterborne diseases in these at-risk populations [42].

5. Strategies for Climate-Resilient WASH Interventions

5.1. Designing Climate-Resilient Infrastructure

The impacts of extreme weather events on urban populations can be relieved by designing innovative water and sanitation infrastructure that increasingly contributes to resilience and adaptability. In this regard, research tends to indicate the integration of blue-green infrastructure for effectively managing stormwater as a means of reducing surface runoff during extreme rainfall events[43]. During heavy rainfalls, piped sewers, septic systems, and other resilient sanitation in informal settlements have performed with the most potential compared to traditional latrine use; this has underlined the importance of better infrastructure design and maintenance[44]. The adoption of a systems thinking approach provides a broad understanding of urban water management to develop multi-faceted strategies that improve the resilience of water-related infrastructures to climate extremes[45,46]. Combined, these state-of-the-art methods underscore urgent action and the development of long-term strategies toward sustainable urban environments that have a resistant capacity against challenges thrown by changing climate.[47]

5.2. Integrating Climate Risk Assessments in WASH Planning

Local resilience to climate change impacts can be better enhanced with risk assessments and adaptive management plans that are suited to climate forecasts. Such assessments would allow local governments to find their particular vulnerabilities and effectively allocate resources, as seen in the analysis of the local adaptation plans in South Korea, where there were marked disparities in climate risks and budget allocations[48]. Further, with the availability of different information sources, such as OpenStreetMap, detailed risk assessments are possible for many industries that would otherwise not be seen or considered in traditional ways of evaluation[49]. Adaptive management incorporates flexibility, which is essential to handle the uncertainties of climate change; it promotes better decision-making and involvement of stakeholders, especially in urban infrastructure planning[50]. Examples are found in the development of tools such as the Climate Risk Monitoring Dashboard, which engenders dialogue amongst policymakers through proactive risk management, yielding resultant adaptation strategies that are much better informed and far more effective[51]

5.3. Sustainable Water Management Practices

Freshwater protection through sustainable practice offers enormous environmental and economic benefits. Environmentally, freshwater ecosystems are part of a high level of biodiversity-for example, 7% of all water-related species survive in freshwater habitats, which are essential to native ecological cycles and deliver essential ecosystem services. These entail resource-directed measures and source-directed controls in the sustainable management of threats emanating from urbanization, pollution, and climate change that help preserve these important habitats. Economically, investments in water treatment technologies ensure profitable returns while improving water conservation; such is the clearest linkage between sustainability and economic viability. The work of [52]presents examples of agricultural and energy sustainability as crop rotation and utilizing renewable energy resources enable resources to continue being replenished over long periods so that the needs of future generations can be met[53]. In general, the integration of

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environmental sustainability into water management protects ecosystems while providing economic resilience and growth[54].

Conclusion

Climate change has dramatically increased the frequency and severity of natural disasters, including floods, droughts, and hurricanes, and amplified the emergencies by increasing flood events, intensified drought, and enhanced hurricane severity. Climate change has impacted WASH in emergencies by increasing the demand for WASH service due to displacement, water scarcity, and contamination and undermined sanitation infrastructure and hygiene behaviors. Strategies to develop climate-resilient wash infrastructure include designing climate-resilient infrastructure, Integrating Climate Risk Assessments in WASH Planning, and sustainable water management practices.

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Abbreviations

WASH - water sanitation and hygiene
NOM- Natural organic matters
UN- United Nations

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