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Exploring the Interconnection between Climate Change and Public Health in Humanitarian Crises- A Case Study of Syria

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Abstract

The intersection of climate change and public health is increasingly critical in humanitarian settings. Syria exemplifies a complex context where prolonged conflict, environmental degradation, and climate-related shocks converge to severely impact health systems and vulnerable populations. To examine how climate change exacerbates public health challenges during humanitarian crises in Syria, with a focus on systemic vulnerabilities, health outcomes, and potential adaptation strategies. This analysis synthesizes findings from literature, field data, and case studies in Syria to assess the compounded effects of climate change on public health. It applies to a systems-thinking framework to explore health infrastructure, governance, and community-level resilience. Climate change intensifies public health risks by increasing water scarcity, food insecurity, disease outbreaks, and heat-related illnesses. Vulnerable populations, including children, women, and the elderly, face disproportionate health burdens. Conflict-related infrastructure damage and fragmented health systems further hinder effective response. Mental health impacts are profound and under-addressed. Addressing the climate-health-humanitarian nexus in Syria requires integrated strategies that strengthen local health systems, invest in resilient infrastructure, and incorporate climate risk into health planning. Collaborative, multi-sectoral action is essential to mitigate future crises and protect public health in conflict-affected, climate-vulnerable regions.

Keywords: *Adaptation Strategies, Climate Change, Health Systems, Humanitarian Crisis, Public Health, Syria.*

Introduction

Climate change represents one of the most pressing global health threats of the 21st century, intensifying the frequency and severity of humanitarian crises [1]. In vulnerable regions already affected by conflict, poverty, or fragile health systems, the intersection of climate change and public health can result in compounded challenges [16]. Syria exemplifies such a context, where years of civil war, environmental degradation, and climate-induced stressors have converged to create one of the most complex humanitarian crises in recent history [17].

This paper explores how climate change exacerbates public health vulnerabilities in Syria's humanitarian context. It examines the pathways through which climate-induced hazards such as extreme heat, water scarcity, and food insecurity interact with ongoing conflict and institutional breakdown to worsen health outcomes [19]. By integrating a systems-thinking approach and analysing case-specific data, the study aims to understand the compounded effects on health infrastructure, disease burden, and community resilience. Special attention is given to the most vulnerable groups, including children, the elderly, and internally displaced persons (IDPs), who face disproportionate risks [12].

The paper underscores the urgent need to embed climate resilience into health planning

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and humanitarian action [15]. It argues that only by recognizing and responding to the climate-health-humanitarian nexus can sustainable and equitable solutions be developed to address the evolving challenges in Syria and similar fragile settings.

Methods

This study adopts a mixed-methods approach, utilizing:

1. Literature review of peer-reviewed articles, humanitarian reports, and climate data sources [9, 11].
2. Case studies (e.g., Aleppo and Idlib) to provide ground-level insight [2, 6].
3. Synthesis of secondary data (e.g., WHO, IPCC, UNICEF) using a systems-thinking framework [18].
4. Spatial and temporal assessments through available observation points, GIS references, and community-level assessments in NWS Syria [21].

Results

The main findings show:

1. Increased disease burden linked to water and air pollution, malnutrition, heat stress, and conflict-related trauma [22].
2. Disruption of health services through conflict and climate-induced degradation [8].
3. Chronic vulnerabilities among children, women, the elderly, and displaced communities [12].
4. Mental health crisis due to war and ecological stressors [15].
5. Breakdown of infrastructure (e.g., water chlorination, electricity, waste systems) [17].
6. Efforts made by local NGOs and international actors to mitigate these issues remain fragmented and underfunded.

Discussion

Climate change amplifies existing vulnerabilities in humanitarian settings [23]. Public health systems in Syria are structurally weakened, and insufficient adaptation policies exacerbate this [21]. Vulnerable populations bear a disproportionate burden due to limited access to essential services. Mental health, though less visible, poses a profound challenge that requires greater policy attention. Resilience-building and integration of climate considerations into humanitarian health responses are crucial [26].

Background on Climate Change

Climate change (CC) is directly or indirectly attributed to human activity that alters the composition of the global atmosphere and leads to changes in climate on a given time scale [10]. Scientific reports assert that continuing CC will undoubtedly lead to global-scale crises with profound effects on public health. These crises include permafrost thawing, glacier melting leading to flooding, coastal towns' flooding because of sea-level rise, and severe flooding in rivers and lakes' watersheds leading to habitat destruction and displacement of human habitats [10].

CC, through extreme weather events (heat waves, floods, storms, droughts) and chronic climate events (long-lasting droughts, rising average temperature), exacerbates existing health challenges related to water and food insecurity, vector-borne infectious diseases, population displacement, and mental health issues. Moreover, the indirect effects of CC compromise human security and economic growth, further increasing vulnerability, especially of poorer populations who are least responsible for greenhouse gas emissions [11]. Humanitarian organisations are increasingly aware that CC is a game-changer for vulnerable communities and humanitarian action.

Overview of Public Health in Syria

The population of Syria is estimated at 17.5 million, with significant demographic diversity across urban and rural regions. Pre-crisis, the epidemiological pattern of disease included a dual burden of communicable and non-

communicable diseases, alongside a substantial trauma burden related to traffic accidents, workplace injuries, and limited occupational safety enforcement [2, 6]. Syria had begun making progress in reducing infectious diseases through widespread vaccination programs, improved sanitation infrastructure, and expansion of maternal and child health services. Simultaneously, lifestyle changes, urbanization, and increased tobacco use have led to a rise in chronic conditions such as cardiovascular disease, diabetes, and cancer [11]. Trauma-related health issues, both accidental and violence-related, already formed a key part of the country's health profile before the onset of conflict.

The National Health Information Centre, operating under the Ministry of Health, served as the hub for data management and surveillance. It provided regular health bulletins and maintained a centralised epidemiological reporting system. This system, although limited in transparency and reliant on vertical chains of reporting, allowed for a relatively structured health monitoring framework compared to many neighbouring states. Data collectors were employed by the Ministry and affiliated agencies, ensuring the routine collection of morbidity and mortality statistics. These datasets, despite their limitations, enabled planning for immunization campaigns, outbreak response, and health workforce deployment [21].

Before the war, Syria's health system was regarded as one of the strongest in the Middle East [6, 12]. The public sector provided subsidised health services, particularly in primary and secondary care. Health infrastructure included a dense network of primary health centres, general hospitals, and specialized referral institutions in larger cities such as Damascus, Aleppo, Homs, and Latakia. The private health sector was also expanding rapidly, catering to wealthier urban populations and offering services such as specialised surgeries, advanced diagnostics, and elective care. Public health coverage was relatively robust compared to the regional average, and Syria was making incremental gains toward universal health coverage [15].

Despite these strengths, persistent inequities remained. Rural populations, particularly in the northeast and southern governorates, had weaker access to health facilities and trained staff [16]. Disparities were also observed among vulnerable groups, including refugees, seasonal agricultural workers, and marginalised ethnic minorities. Preventive care and continuity of care were uneven, with maternal health and chronic disease management lagging behind international standards.

The onset of war in 2011 shattered this fragile progress. The health system is fragmented into two broad structures: one under the control of the Ministry of Health in government-held areas, and another emerging in opposition-controlled territories through NGOs, local councils, and alternative governance structures [21]. Both systems struggled with dire shortages of supplies, an exodus of trained medical professionals, and attacks on health facilities that eroded trust and functionality. The politicization of aid further complicated service delivery, with assistance often distributed along political and territorial lines rather than based on humanitarian need [18].

Over time, what had once been a relatively integrated national health system became a patchwork of disconnected, resource-strapped networks. International humanitarian agencies stepped in to fill gaps, but coordination was inconsistent and heavily constrained by access restrictions, insecurity, and fluctuating donor commitments [14]. This fragmentation not only undermined service delivery but also crippled national health governance, leaving millions without reliable access to essential care.

The destruction of health facilities and infrastructure further widened gaps in access. More than 50% of hospitals and primary healthcare centres have been reported as either

entirely destroyed or partially damaged since the beginning of the conflict [19]. Essential health services such as maternal care, vaccinations, and surgical capacity have become highly inconsistent, and this has had intergenerational consequences for maternal and child health outcomes. Additionally, the outflow of health professionals, many of whom fled violence or emigrated to pursue safer livelihoods abroad, has left severe shortages of qualified doctors, nurses, and technicians. This "brain drain" effect means that even where facilities exist, they often lack the staff needed to operate at full capacity [22].

Public health in Syria today exists in a state of chronic crisis management, marked by collapsing infrastructure, fragmented governance, and overreliance on international humanitarian assistance. The erosion of preventive care programs, including immunization and communicable disease control, has created fertile ground for outbreaks of measles, polio, and cholera [17]. Chronic conditions, once increasingly manageable pre-crisis, are now underdiagnosed and undertreated, contributing to long-term health deterioration. Without a stable health governance framework, the population's health is likely to remain precarious for the foreseeable future.

Humanitarian Crises in Syria

Syria's civil war, now in its second decade, remains one of the most devastating humanitarian crises in modern history. The conflict has displaced more than half the population, with nearly 6 million seeking refuge abroad and another 6.7 million internally displaced [2, 12]. Beyond the immediate violence, the crisis has systematically dismantled essential health, water, and food systems. Hospitals have been bombed, medical workers targeted, and medicines rendered scarce due to disrupted supply chains [6]. These acts are not collateral consequences but represent a broader strategy of war, where denial of health services has been used as a weapon of control.

The COVID-19 pandemic further exposed the fragility of what remains of the health system. Overcrowded camps and besieged urban settlements lacked testing capacity, ventilators, and vaccination coverage. International humanitarian agencies attempted to intervene, but access restrictions, politicization of aid, and donor fatigue limited their effectiveness [15]. The compounded effect of conflict, pandemic, and institutional breakdown has created a near-permanent state of emergency.

Climate change has added a profound new dimension to the crisis. Prolonged droughts have undermined agriculture in the northeast, exacerbating food insecurity in a region already dependent on aid. Flash floods have damaged informal displacement camps, while heatwaves have worsened health risks for children, the elderly, and people with chronic conditions. These shocks interact with existing vulnerabilities: displaced families dependent on fragile humanitarian pipelines often face a cycle of repeated loss, where each climate-related hazard deepens displacement, erodes resilience, and heightens dependency on external aid [17, 21].

In this sense, Syria illustrates the *climate–conflict–health nexus*: conflict generates immediate destruction, climate hazards amplify existing fragility, and both combine to create chronic humanitarian need. The Syrian case also underscores a wider lesson for humanitarian actors responses cannot remain siloed between conflict relief and climate adaptation; both must be integrated to address cascading risks.

Collapse of Basic Services

The war has devastated essential infrastructure and public services. Water systems have been deliberately targeted or neglected, leaving millions without access to clean and safe drinking water [6]. Sewage

treatment plants and waste management systems have collapsed in many areas, contributing to outbreaks of waterborne diseases such as cholera and typhoid. Hospitals and health facilities have been systematically bombed, with over 70% of Syria's health workforce displaced or killed. Medicines, once relatively accessible, are now scarce, and supply chains for insulin, antibiotics, chemotherapy drugs, and maternal health supplies have been disrupted. The COVID-19 pandemic further exposed these fragilities, overwhelming what remained of the health system and making even basic care inaccessible for large segments of the population.

Education systems have also collapsed, with schools destroyed, occupied by armed groups, or converted into shelters for displaced families. An entire generation of Syrian children faces the prospect of growing up without adequate education, creating long-term implications for human capital and stability.

Displacement and Refugee Burden

Internally displaced persons (IDPs) are among the most vulnerable groups. Families live in overcrowded camps or informal settlements with little protection from the elements. Tents offer limited insulation against freezing winters and scorching summers, conditions that climate change is intensifying. Refugee camps in Idlib and Aleppo governorates are particularly overcrowded, with poor sanitation, limited water supplies, and inadequate healthcare. Women and girls face heightened risks of gender-based violence, while children are exposed to child labour, early marriage, and recruitment by armed groups.

Host countries, particularly Turkey, Lebanon, and Jordan, have struggled to accommodate millions of Syrian refugees. Turkey hosts more than 3.5 million, the largest refugee population in the world, while Lebanon's refugee population constitutes nearly a quarter of its residents, straining already fragile political and economic systems. Host communities experience mounting tensions, competition over jobs and resources, and pressure on housing, education, and health services.

Climate Change as a Conflict Multiplier

The crisis is compounded by climate change, which acts as a "threat multiplier." Prolonged droughts in the years preceding the conflict devastated agricultural livelihoods, fueling rural-urban migration and social unrest. Since the conflict began, climate-related shocks have only worsened vulnerabilities. Prolonged droughts strain fragile food systems, reducing crop yields and increasing reliance on humanitarian food aid. Flash floods, increasingly common due to erratic rainfall patterns, have repeatedly damaged IDP camps, washing away tents, contaminating water supplies, and spreading disease. Heatwaves worsen health outcomes for populations living in poorly ventilated shelters and lacking access to cooling mechanisms.

Food insecurity has become chronic. According to the World Food Programme, over 12 million Syrians are now food insecure, with families surviving on reduced meals and nutritionally inadequate diets. Rising food prices driven by global shocks, the war in Ukraine, and disrupted domestic production have pushed families deeper into poverty. Climate-related crop failures exacerbate this, forcing greater reliance on imports and aid at a time of shrinking donor budgets.

Humanitarian Access and Aid Challenges

Humanitarian access remains a critical challenge. Insecurity, bureaucratic hurdles, and political manipulation frequently obstruct aid delivery. Cross-border aid into northwest Syria has been subject to contentious negotiations in the UN Security Council, with periodic threats of vetoes undermining the predictability of assistance. Within government-controlled

areas, humanitarian agencies face restrictions and surveillance, limiting their ability to reach populations impartially.

Funding shortfalls add another layer of difficulty. The Syria Humanitarian Response Plan is consistently underfunded, with health, WASH (water, sanitation, and hygiene), and protection sectors receiving less than half of the requested funding. Donor fatigue, competing global crises (such as Ukraine, Yemen, and climate disasters elsewhere), and political reluctance have all reduced international commitment. As a result, lifesaving interventions, including immunization campaigns, maternal health programs, and food assistance, are scaled back, leaving millions at risk.

Regional and Global Implications

The Syrian crisis has significant spillover effects beyond its borders. Neighbouring states struggle with economic and social pressures, and Europe continues to grapple with the political consequences of the 2015–2016 refugee influx. Protracted displacement has also created a "lost generation" of Syrians, raising concerns about future instability, radicalization, and long-term dependence on aid. Climate change threatens to further destabilize the region, as resource scarcity, migration pressures, and extreme weather events interact with existing political fragilities.

At the global level, Syria serves as a stark example of how conflict, climate change, and weak governance intersect to produce protracted humanitarian crises. It underscores the urgent need for integrated approaches that combine humanitarian assistance with climate adaptation, resilience-building, and long-term development strategies.

The humanitarian crisis in Syria is not only the result of conflict but also of the compounded pressures of climate change, poverty, and weak governance. Prolonged droughts, flash floods, and heatwaves exacerbate displacement, food insecurity, and health vulnerabilities, placing extraordinary pressure on already overstretched humanitarian systems. With over half the population displaced, essential services in ruins, and donor support dwindling, the crisis represents one of the greatest humanitarian and public health challenges of our time. Without sustained international engagement and investment in resilience, millions of Syrians will remain trapped in a cycle of conflict, displacement, and climate-driven vulnerability [2, 6, 12].

The Impact of Climate Change on Health

Climate change affects health by altering disease transmission, water systems, air quality, and food security [1]. Humanitarian health organizations must adapt by integrating climate-informed approaches into programs.

Examples include cholera outbreaks linked to warmer waters, increased asthma cases from dust storms, and malnutrition tied to crop failures. Humanitarian agencies face barriers: limited data, lack of technical expertise, and fragmented funding streams [10, 26].

Heatwaves and Health Risks

Heat waves are among the deadliest climate extremes. In Syria, exposure has already risen since 1910, and projections show further increases [10]. Heat exposure causes dehydration, kidney strain, cardiovascular stress, and death among vulnerable groups [26].

Children, the elderly, outdoor labourers, and IDPs in poorly ventilated tents are at the highest risk. Beyond physical health, heat amplifies mental stress, creating conditions of despair in already unstable communities.

Water Scarcity and Sanitation

Safe drinking water is a fundamental human right. The 7th SDG emphasises water and sanitation for all. In Syria, conflict destroyed much of the water infrastructure, reducing both access and quality [7]. Over half of the monitoring stations are now non-functional.

Households in southern Syria increasingly rely on unsafe sources. Few can afford proper

chlorination. Improper dosages of chlorine tablets expose 37% of households to cholera risk [18]. In Daraa, filtration is common, but quality remains inconsistent.

The combined effect of conflict and climate change has made water scarcity one of the greatest threats to public health [17].

Food Security and Nutrition

Globally, 825 million people face food insecurity [13]. In Syria, drought, conflict, and economic collapse intersect to create widespread hunger [9]. Poor intake drives malnutrition, which in turn weakens immunity and growth.

The interplay between food, care, and health reveals how climate stress worsens hunger cycles. In Syria, rising food prices, declining harvests, and disrupted supply chains leave millions food insecure. Yet international food aid is underfunded and politically manipulated [19].

Vulnerable Populations

Humanitarian crises amplify vulnerabilities, especially for those with fewer resources or less agency [3]. Syria's displaced populations face compounded risks: unsafe housing, poor nutrition, and climate-driven stressors like drought and flooding [12].

Children, women, elderly individuals, and those with disabilities face intersecting vulnerabilities. Fragile shelters often exclude accessibility measures, leaving people with disabilities stranded. Elderly individuals are neglected, as humanitarian aid tends to prioritize younger populations.

Climate stress deepens these divides by worsening poverty traps, where households must sell assets, reduce meals, or pull children from school to cope with climatic challenges. These dynamics perpetuate cycles of vulnerability and exclusion.

Children

Children represent one of the most profoundly affected groups in Syria. Exposure to violence, displacement, and environmental stressors has led to a multi-dimensional crisis. Nutritional deficiencies, particularly stunting and wasting, remain widespread, and recurrent cholera outbreaks have disproportionately affected children under five [4]. Education disruption compounds the problem, as loss of schooling erodes not only human capital but also access to basic health and nutrition programs traditionally delivered through schools. Conflict-related trauma has also had long-lasting mental health consequences, with children displaying chronic stress, anxiety, and behavioral disorders [5, 21]. Climate change multiplies these vulnerabilities: prolonged drought and heat stress reduce food availability, while floods and displacement undermine safe shelter and sanitation, leaving children more exposed to infectious disease.

Elderly

The elderly, often overlooked in humanitarian planning, face rising mortality and morbidity risks. Many lack the mobility to flee bombardments or relocate during floods, leaving them stranded in high-risk areas. Non-communicable diseases such as hypertension, diabetes, and chronic respiratory illnesses disproportionately affect older adults. Yet, continuity of care for these conditions has collapsed due to supply shortages and workforce depletion [3]. Climate-related hazards, extreme heat in particular pose additional risks, as older adults have reduced thermoregulation capacity and limited access to cooling infrastructure. Despite these vulnerabilities, elderly populations remain invisible in both humanitarian assessments and climate adaptation strategies, reflecting a systemic neglect that requires urgent rectification [10].

Women

Women face disproportionate impacts from both conflict and climate change [9]. In Syria,

they shoulder caregiving burdens and are first to sacrifice food and health for children [18].

Reproductive health services are scarce. Pregnant women suffer high rates of anemia and complications, worsened by malnutrition and stress. Early marriage, increasingly used as a coping strategy, exposes adolescent girls to early pregnancy and violence.

Water scarcity and camp conditions heighten risks of harassment and violence. Women walk long distances for water, often at risk of sexual violence [15].

Yet women are underrepresented in decision-making. Humanitarian planning must integrate a gender-sensitive climate lens, prioritizing reproductive health, protection, and women's leadership in adaptation.

Mental Health Implications

Mental health represents one of the least visible yet most profound impacts of Syria's crisis. Continuous exposure to conflict, displacement, and deprivation has generated a pervasive burden of trauma. Refugees and IDPs report high rates of post-traumatic stress disorder (PTSD), depression, and anxiety, with children and women disproportionately affected [2, 12]. The destruction of mental health infrastructure, compounded by the emigration of trained psychiatrists and psychologists, means services are grossly inadequate. Informal networks, including community and faith leaders, often provide the only available support.

Climate change acts as a secondary stressor, compounding the psychosocial toll of war. Droughts and crop failures intensify livelihood insecurity, contributing to despair among rural households. Repeated flooding and loss of shelter generate cycles of displacement, eroding a sense of safety and continuity. Extreme heat events exacerbate aggression, anxiety, and sleep disruption, further burdening already traumatised populations [23].

What emerges is not simply an epidemic of trauma but a structural crisis in mental health: lack of services, weak community coping mechanisms, and chronic exposure to stressors create conditions for intergenerational transmission of psychological harm. Addressing this requires humanitarian health actors to elevate mental health to the same priority level as communicable diseases and malnutrition, embedding psychosocial support into all levels of humanitarian planning.

Health System Challenges

The health system has faced galactic escalations of needs, sector-wide destruction and collapse, and a corresponding decline in human resources, financial and material resources, and control. Health system access has deteriorated, affecting all population groups. People's choices regarding health providers, services, and practices have also changed. However, as might be expected in a complex disaster, some humanitarian needs were still being met. There was evidence of former systems being replicated in new forms and quickly attuning to the transformed environment [14, 21]. The scope of collapse in the Syrian health system was unparalleled in recent decades. Hospitals and primary care facilities that had once provided a comprehensive network of services were reduced to shells, often stripped of equipment, devoid of staff, and unable to provide even the most basic emergency services. The destruction was not just physical but systemic loss of governance, breakdown of referral pathways, collapse of medical education pipelines, and evaporation of donor funding streams.

Health workers were subject to siege and shelling, killed and abducted, restricted in movement, and had their loyalties tested. Facilities were destroyed, repurposed, and blocked or relieved. However, through violence and 'catch and release' health systems powered onward, resurfacing, adapting, replicating, and continuing to function [22]. Communities organized clandestine clinics in basements, mobile medical units emerged in conflict areas,

and NGOs stepped in to fill the gaps. Science produced new weapons, and old weapons were invented anew. As far back as 4000 BCE, health was used as a weapon in the siege of Jerusalem with a disposition of disease-bearing rodents. That obscure and scandalous event has repeated itself from the wars of Troy to blistering agent attacks in World War I and the 2014 CW Munitions Attacks in Ghouta. The use of chemical and biological agents throughout history reminds us of the vulnerability of civilian health during times of war. Global Health has faced accusations of being used as an integrating mechanism for pre-war health systems by belligerents or being unctuously ignored. The Syrian health system has demonstrated resilience in certain areas despite overwhelming odds, but the constant cycle of destruction and patchwork recovery has left an enduring fragility that will take decades to heal [27].

Infrastructure Damage

Water and sanitation infrastructure is a prerequisite for the delivery of safe drinking water and public health. Urban infrastructure systems are physically complex and economically expensive; when damaged or destroyed, they can take a long time to repair. Structural destruction of water infrastructure causes the population to turn to unsafe alternative water sources, jeopardising health from waterborne diseases [17, 18]. In Syria, the deliberate targeting of infrastructure water stations, pipelines, sewage treatment facilities became a weapon of war, depriving entire communities of life-sustaining resources.

In Syria, the early years of the conflict left more than 90% of prewar water infrastructure functional, most together with their treating systems. Since then, infrastructure destruction has been rampant. In 2020, two million displaced and marginalised people in northwestern Syria turned to unregulated and untreated sources of water. Widespread sewage leakage and the collapse of solid waste collection risked becoming the main cause of disease outbreaks, accelerating death rates, malnutrition, and displacement [18, 19]. These conditions bred cholera, dysentery, hepatitis A, and other waterborne diseases that spread quickly in crowded camps and informal settlements. Breakdowns in infrastructure and the widespread use of infectious receptors in the population necessitate monitoring of water and the delivery of health services.

Chlorination of water with chlorine gas or powder is the simplest and most effective way to disinfect water. It is applicable to break the transmission of other enteric, vector-borne, or respiratory pathogens. Functional chlorinated water stations are essential in humanitarian settings [21]. However, the destruction of chlorination stations, coupled with restrictions on the import of chlorine under the guise of "dual-use" material controls, has crippled adequate water and sanitation interventions. This infrastructure devastation not only affects public health but also undermines trust in humanitarian responses. Without safe water and waste management, even the most robust health systems cannot function effectively [28].

Resource Allocation

Humanitarian medical organizations are not standalone entities but rather part of a larger ecosystem of interconnected communities proposed by the Goodman Model: the funders, sectoral NGOs, implementers, governments, local NGOs, beneficiaries, and the military. In the humanitarian ecosystem, each player faces its own respective resource allocation dilemmas. Still, organisations must utilise their networks and engage in the design of a well-governed global strategy to enhance climate change resilience in humanitarian-oriented systems [20, 23]. Effective resource allocation is not only a matter of distributing financial resources but also of ensuring equitable distribution of human resources, medicines, equipment, and infrastructure across geographies.

All humanitarian ecosystem players must consider adapting their governance and ethics frameworks according to the Health Systems Thinking Framework, which can be used by all sectors (funders, HMAN organizations, governments, etc.) to promote multi-level governance and the mechanism to strengthen collaboration and partnerships among players [26]. The resource allocation optimization solution must also provide the transparency and accountability needed to build and maintain funding players' trust. Significantly, allocation decisions are often influenced by political priorities and donor preferences, which may not align with the most urgent health needs on the ground. For instance, while some donors prioritise high-visibility interventions such as trauma care, less visible but equally essential services such as mental health support, maternal care, or chronic disease management remain underfunded. Without reforming allocation frameworks, the humanitarian ecosystem risks perpetuating cycles of inequity [29].

Adaptation Strategies

Climate change exacerbates existing environmental health hazards and creates new risks as it is linked to a wide range of health issues. Humanitarian organisations increasingly acknowledge this climate-humanitarian-health nexus, while most of their climate change-related work has focused on greenhouse gas emissions assessments, adaptation/mitigation strategies, and the health risks of climate-related disasters in the broader development context [11]. The health effects of climate change include direct impacts such as heat-related illnesses and injuries from extreme weather events, as well as indirect impacts through changes in food systems, vector-borne diseases, displacement, and economic collapse.

Humanitarian organisations have dedicated climate change adaptation funding, which is expected to grow. However, climate change adaptation is not included in a range of humanitarian financing tools, and there are concerns that this funding faces competition from other priorities amongst funding [26]. There is little supportive evidence on the climate-health impacts of humanitarian work. Although many public health coalitions, individual academics, and NGOs communicate on climate change and health in general, this area is a key gap in humanitarian communications. The absence of a systematic approach to climate-health adaptation within humanitarian strategies highlights the urgent need for integrated approaches that cut across sectors such as WASH, nutrition, mental health, and education. Strengthening early warning systems, enhancing community preparedness, and embedding climate literacy into humanitarian health programs are essential steps toward sustainable adaptation.

Public Health Interventions

In remote locations, it is essential to develop enhanced health system management models that include stakeholders from outside the health system. The urgent implementation of public health assessments is warranted [22]. Rapid needs assessments and epidemiological surveillance systems must be designed to work under conditions of limited infrastructure, insecurity, and shifting population dynamics.

Previous experiences from newer public health system implementers can provide off-the-shelf protection plans, including but not limited to enhanced disease surveillance and response. Additional support should include training and equipment provision for immediate application in field ambulances and Emergency Medical Teams [21, 23]. A nimble integration of disparate emergency and static response components is necessary to assist health systems in absorbing those in need of peace. This requires not only coordination among humanitarian organizations but also partnerships with local actors who understand the social, cultural, and political contexts. Such interventions should also integrate mental

health and psychosocial support, maternal and child health services, and chronic disease management into emergency responses. Public health interventions in crises must evolve beyond reactive measures to proactive, community-driven strategies that can withstand recurring shocks.

Community Resilience Building

The existing health system resilience in the face of crisis is defined as the ability of the health system to anticipate, absorb, accommodate, and recover from the effects of crises [14, 21]. Resilience aims to reduce risks from hazards and mitigate them through robust systems to keep people safe. Community resilience is also defined as the ability of a community to come together and cope with a disaster from a physical, social, emotional, and economic point of view [19].

The five major characteristics of a resilient system are: (i) flexibility; (ii) learning; (iii) foresight; (iv) network; and (v) robustness [10, 20, 26]. The health system is based on a strong foundation for addressing health needs, providing good-quality provision of health services; human resources for health; supplies and infrastructure; and adequate financing and funding for health care. Building resilience requires investing not only in infrastructure but also in social capital, community solidarity, and local leadership. Communities that are actively involved in planning, monitoring, and evaluating health interventions demonstrate stronger resilience in times of crisis. Programs that engage women, youth, and marginalized groups in resilience-building efforts often produce more inclusive and sustainable outcomes. In Syria, grassroots initiatives such as women-led health cooperatives and youth volunteer networks have shown that community ownership can significantly enhance the effectiveness of humanitarian responses.

International Response and Aid

At the UN Climate Change Conference COP26, world leaders declared the dire consequences of not taking urgent and adequate climate action [24]. Climate change is likely to increase the number of people forced to flee their homes due to the dangerous combination of rising sea levels, heatwaves, and natural disasters [25]. Humanitarian assistance is critical, and there is an urgent need to prepare more systematically. Stakeholders providing humanitarian aid are increasingly aware of the impacts of climate change on vulnerable communities.

National and international humanitarian assistance is provided through a diverse group of actors, including United Nations agencies, local and international non-governmental organizations, bilateral humanitarian aid agencies, corporations, and foundations [14]. Climate change exacerbates existing health challenges, including increasing disease burden, food and water insecurity, and mental health issues associated with poverty and conflict [25]. COVID-19 is further complicating health challenges. Climate change negatively impacts health systems, as it compromises human security and economic growth, which act as determinants of health [11, 24].

Disadvantaged and marginalised people are likely to experience the adverse effects of climate change disproportionately. Climate change has transitioned from being an environmental issue to an issue with growing consequences for human health, human rights, equity, and social justice [26]. The demand for external humanitarian assistance could double by 2050. However, there is still an optimistic time within which to mitigate the worst effects of climate change on vulnerable populations. The needs are urgent, as are calls for external support from humanitarian actors. Climate change is already recognised as a serious threat to global security and stability, with implications for regional and global migration

[25]. The international community must urgently prioritize coordinated funding mechanisms, improve accountability, and strengthen partnerships with local actors to ensure humanitarian aid remains effective in increasingly complex emergencies.

Role of NGOs

As organizations providing assistance or protection to vulnerable communities, non-governmental organizations (NGOs) must familiarize themselves with the links between climate change and health [9, 16]. This includes the health impacts of climate change in general, as well as those focusing on humanitarian crisis in particular. For organizations wishing to acquire more information and strengthen their own understanding and capacities, consultations can be organized.

NGOs can be effective advocates, as many climate-sensitive health impacts are preventable through mitigation and adaptation actions [23]. NGO advocacy could focus on key health-relevant outcomes from GHG emissions and exposures with evidence of unjust distribution, including increased ill health in specific population subgroups or communities least responsible for emissions [26]. Inputs published by humanitarian NGOs to date show concurrence with concerns raised by public health colleagues regarding climate impacts on health and various scenarios of how health systems will reshape under high emissions trajectories.

Humanitarian voices are now called for to advocate for vulnerable people during high-level climate discourse. Humanitarian organisations have the proximity to witness suffering and preventable loss of life exacerbated by climate change [24]. Organisations can amplify the voices of those most affected, who often have the least responsibility for the cause. Such personal accounts and stories are much more powerful and engaging than information about outcomes-driven statistics, slow cumulative changes, or systems-oriented concepts. NGOs also play a critical role in piloting innovative approaches such as solar-powered health clinics, climate-smart agriculture projects, and community-based disease surveillance systems. These grassroots interventions often pave the way for larger systemic reforms.

Governmental Support

The Syrian government has undertaken several measures to support the health system in light of the anticipated impacts of climate change on public health [21]. These initiatives can be broadly organized into five categories. First, the government is currently developing an operational framework for assessing climate change impacts on water supply [22]. This framework will serve as a valuable resource for the implementation of large-scale adaptation/mitigation projects.

Second, Syria has explored options for diversifying its energy resources in response to climate risks. The government has completed assessments and is working on a green growth plan that incorporates renewable energy targets [23]. Third, the country has implemented a series of projects aimed at reducing heat wave impacts on vulnerable populations through early warning systems. Fourth, Syria recently launched a project on developing the national climate change adaptation communication and information system [21]. This system will support systematic monitoring and assessment of climate change impacts and adaptation efforts. Finally, there is scope for establishing a monitoring system to assess the speed of change in population health as a result of climate change impacts [25].

Although the health system has shown resilience to climate risks and has made commendable progress in several areas, it must work proactively as a whole to prepare for the imminent impacts of climate change on human health [26]. Climate change has amplified existing health risks and created potential for new health threats. Adaptation efforts against

climate change health impacts have hampered due to dogmas, policies, and practices that neglect and, in some cases, exacerbate vulnerability. Interestingly, fearing that they would repeat past mistakes, health actors that failed to get involved in climate action previously are now resisting involvement altogether. Nevertheless, taking the backseat risks being supplanted in climate health discussions. Conditions for constructive engagement in climate action should be explored to allow participation in the narrative and subsequent interventions (Jamal et al., 2019) [21]. Strengthening governmental leadership in this area will be crucial to long-term system sustainability.

Case Studies

The International Research Institute for Climate and Society (IRI) and humanitarian organizations: twenty years of a fruitful collaboration [18]. During the calendar year for which reports are being consolidated, the IRI has collaborated with the International Federation of Red Cross/Red Crescent Societies (IFRC) in multiple capacities to enhance responses to climate risks. These activities have included introduction of weather and climate forecast maps to understand better the impact of heavy rains and flooding on the outbreak of infectious diseases in cases such as in Central America and West Africa [19]; working with decision-makers in disaster management and public health to provide climate information that assists with the allocation of scarce resources; and enhancing preparedness to manage rainy season cholera outbreaks in West Africa [21].

Framework outcome: Humanitarian health organizations' capacities to prevent, control and manage climate risks. The majority of humanitarian health organizations' recognition of emerging climate risks to health and humanitarian action [22]. Although most humanitarian health organizations have climate action efforts in place, few of them are well defined with set targets and measurable indicators. Only a quarter of humanitarian health organizations are currently working with or are aware of existing efforts. National and international leaders' roles, trust and personal attributes are critical in promoting or hindering the consideration of climate during humanitarian action and decision-making [23].

Case Study 1: Aleppo

Aleppo is the largest city in Syria and the second-largest city in the country after the capital, Damascus [24]. It is part of the Aleppo Governorate and has been the capital of the Aleppo Governorate since Ottoman times. Aleppo was a center for commerce and trade. There is also a detailed description of the "rayas" in the surrounding rural area which are villages with mud brick houses piled one on top of another.

Due to the central location of Aleppo desired as a commercial trade center, it was besieged by the government forces and was severely damaged by bombing [25]. Agriculture and livestock breeding were the livelihood of more than half of the population in the rural area surrounding Aleppo. One of the water sources, the Aleppo aquifer, which was the main water reservoir of the city, was damaged by shelling and bombing and has not functioned since then. A Dead Sea and land-sea boundary zone were discovered additionally around the Aleppo aquifer. It is thought that the damage to the aquifer and the boundary caused by the combats is the main reason for illness among the population in Aleppo, including cancers, respiratory system diseases, and children's growth problems [20, 26].

Case Study 2: Idlib

Idlib governorate is a small, yet densely populated area located north of Aleppo and bordering Turkey. It is home to four million people, two million of whom are internally displaced people [11]. The governorate has experienced a protracted humanitarian crisis

since 2011. Escalating violence and military siege have further deteriorated access to health care [15]. Primary health care services provided by the Idlib Health Directorate are insufficient to meet basic needs. Health care for COVID-19, encompassing both preexisting and newly established facilities, comprises three levels: a general hospital offering secondary health care and a quarantine centre for COVID-19. However, services are still inadequate, and patients have to pay a high out-of-pocket expenditure [25].

Notably, primary health care services in Idlib have significantly improved since 2016. In March 2020, an outbreak of COVID-19 was reported in northwest Syria. Since then, health authorities and health partners have been working around the clock to prepare for and control the spread of the disease. The Idlib governorate is located in northwest Syria and has been the epicentre of the Syrian humanitarian crisis for years. Continued violence and a long-term military siege have affected every aspect of life and services in the area [22]. The Idlib case study illustrates the limits of humanitarian health response when access, funding, and infrastructure are constrained.

Policy Recommendations

Climate change poses an ever-growing threat to clean water, food security, and health, while increasing the frequency and severity of extreme weather events that may require a humanitarian response [11]. Despite this, humanitarian health actors have overlooked mainly the impacts of climate change. The Common Response Framework to Climate Change was undertaken to enhance the ability of humanitarian organizations to anticipate, prevent, prepare for, and manage climate-related health risks [23]. Effective policy recommendations must emphasize integrated approaches: cross-sectoral collaboration, long-term funding mechanisms, and embedding climate resilience into all levels of humanitarian programming. Without strong policy frameworks, even well-designed interventions risk fragmentation and inefficiency.

Sustainable Development Goals

The recently adopted 2030 Agenda for Sustainable Development presents a historic and unprecedented commitment by the global community to 1) end all forms of poverty; 2) ensure all people have access to basic services; and 3) promote sustainable, inclusive and equitable economic growth while combating climate change and environmental degradation [19]. Underlying these objectives are 17 Sustainable Development Goals (SDGs), which address issues ranging from social aspects such as poverty and education, to economic dimensions like income inequality, to environmental challenges including climate change and ecosystem degradation [24]. The SDGs provide a vital global framework that ties humanitarian health to climate resilience. Integrating humanitarian health response into the SDG framework ensures that immediate interventions align with long-term development goals.

Climate Action Plans

The effects of climate change are already being felt across all regions of the world [10], 20]. Its severity will undoubtedly increase with a significant, sustained drop-off in quality of life and a logical increase in humanitarian crises [22]. Medical futures are not predetermined instead, they are co-created over time and with expertise by diverse actors [21]. Climate change will need to be met with an understanding of how to take alternative, sustainable pathways to meet this challenge [26].

Action plans must include climate-smart health infrastructure, renewable energy integration in health facilities, and robust disease early warning systems. Embedding resilience thinking into health systems requires

strong political will, donor engagement, and community participation. For countries like Syria, which are already grappling with conflict, climate action plans must be conflict-sensitive, realistic, and context-specific.

Future Research Directions

Given all the available entries found in the literature, there are many avenues available to expand on this topic [14, 19]. This paragraph outlines various avenues for further exploration of the framework's interconnection between climate change and public health in humanitarian crises [20]. The growing number of research studies indicates an understanding of the need to integrate climate change and health to improve the preparedness and capacity of organisations working on humanitarian health issues [23]. However, there is still room for further exploration in different areas. Future research should focus on several key areas: the longitudinal health impacts of climate shocks, gender- and age-specific vulnerabilities, the integration of climate models with health surveillance data, and the evaluation of adaptation strategies. Building a robust evidence base will allow humanitarian actors to tailor interventions more effectively and advocate more persuasively for resources.

Conclusion

The Syrian crisis epitomises the convergence of conflict, climate change, and fragile governance as compounding determinants of public health emergencies. Years of civil war have dismantled a once relatively strong health system, leaving infrastructure fragmented, health workers displaced, and populations dependent on humanitarian aid. Against this backdrop, climate change acts as a risk multiplier, exacerbating water scarcity, food insecurity, the spread of communicable diseases, and psychosocial distress. The intersection of these forces has created a protracted humanitarian emergency, where fundamental health rights are undermined and resilience is eroded at both individual and community levels [1, 6].

This study underscores that health cannot be safeguarded in Syria, or in comparable conflict-affected contexts, without systematically embedding climate adaptation into humanitarian planning. Vulnerable populations, including children, women, the elderly, and displaced communities, face disproportionate risks that demand targeted interventions. For example, maternal and child health services must be climate- and conflict-sensitive, elderly populations require better integration into adaptation frameworks, and mental health must be elevated as a central pillar of humanitarian response rather than a secondary concern [10, 17].

A systems-thinking perspective reveals that the challenges are not discrete but interconnected. Water scarcity affects food security; food insecurity drives malnutrition and disease susceptibility; displacement amplifies mental health burdens; and climate extremes compound all. Humanitarian responses that remain siloed will therefore fall short. Instead, integrated strategies that bridge health, climate, and humanitarian sectors are required. This includes investment in resilient health infrastructure, protection of health workers, gender-sensitive programming, and anticipatory climate-risk management linked to humanitarian financing [11, 21].

Finally, the Syrian case has global resonance. It highlights that in the 21st century, humanitarian crises will increasingly be shaped by the dual forces of political conflict and climate disruption. Addressing one without the other risks perpetuating cycles of vulnerability. Policymakers, donors, and humanitarian actors must therefore embrace a paradigm shift: recognizing climate change not as an external backdrop but as a central driver of humanitarian health challenges. Only by adopting integrated, evidence-based, and equity-focused approaches can the international community prevent further

collapse of fragile health systems and foster resilience in Syria and beyond [12, 23].

Conflict of Interest

The author declares no conflict of interest.

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