Using Participatory Research to Understand the Health Impacts of Climate Change from the Perspectives of Communities and Health Systems: A Case Study from Battambang Province

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I. Introduction

Climate change is acknowledged as one of the most pressing environmental challenges, with far-reaching consequences for human health (1–3). The magnification of climate change phenomena, including rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events, has been linked to shifts in disease transmission dynamics, particularly in vulnerable populations such as those residing in rural areas (1–4). According to the World Health Organization (WHO), climate change is projected to cause approximately 250,000 additional deaths annually between 2030 and 2050 due to malnutrition, malaria, diarrhea, and heat stress (2). Vulnerable populations, including the elderly, children, and those with preexisting health conditions, are at heightened risk as climate-related events such as extreme weather, rising sea levels, and changing disease patterns disrupt health services and exacerbate existing health inequities. The health impacts of climate change manifest in several critical ways, including the increased incidence of vector-borne diseases, heat-related illnesses, food and water insecurity, and mental health challenges.

In Cambodia, the impacts of climate change on health are increasingly evident, underscoring the need for localized research. The country is characterized by a tropical climate and is highly vulnerable to climate-related hazards such as flooding, droughts, and rising temperatures. According to the Humanitarian Response Forum, between August and September 2023, a total of 40,942 families and 76 schools across 17 provinces in Cambodia were affected by severe flooding attributed to climate change (6). Among these, Battambang province suffered significant impacts, with 9 districts and 6,117 households impacted by floods, resulting in the evacuation of 1,920 households and tragically one reported fatality (6). This context of severe flooding highlights the urgent need to understand its effects on the livelihoods of villagers in Battambang, making it a critical site for this study. Rural areas, where socioeconomic disparities and limited access to healthcare services prevail, face acute consequences from infectious disease outbreaks exacerbated by climate change (7,8). Rural communities often lack the resources and infrastructure necessary to cope with the health impacts of climate change, leading to heightened vulnerability to

infectious diseases such as dengue fever, malaria, and diarrheal illnesses (9,10). The exacerbation of these diseases due to climate change places additional strain on an already overburdened healthcare system, threatening progress toward health-related Sustainable Development Goals (11,12).

Recognizing the critical link between climate change and public health, the Royal Government of Cambodia is committed to addressing climate-related health issues as a priority for social and economic development. In response, the *National Action Plan for Climate Change and Public Health* was introduced, aiming to strengthen public health infrastructure and reduce health vulnerabilities related to climate variability and extreme weather events (11). Despite these efforts, gaps remain in understanding how climate change is perceived by communities and how health systems are adapting. This research aimed to explore perceptions, experiences, and adaptation strategies related to climate change among rural communities and healthcare systems, with a focus on the effects of flooding on health. Understanding this will contribute to local and national efforts in formulating policies and strategies to mitigate the health impacts of climate change and enhance resilience among vulnerable populations.

II. Materials and Methods

A. Study Setting and Design

The study was conducted in Battambang province, Cambodia, from 20 to 22 December 2024. Battambang was selected as it is among the provinces most severely impacted by flooding in recent years. Three districts affected by flooding—Sanke, Thmor Kol, and Phnom Prek—were purposively recruited for this study. To narrow down, the communities surrounding three flood-affected health centers (Preak Loung, Ampil Pram Derm, and Pech Chenda) were selected for data collection due to high risk of flooding. Participatory research for action approach was employed to explore local perceptions and experiences related to flooding-induced climate change and healthcare system adaptation. Qualitative methods, including focus group discussions (FGDs), key informant interviews (KIIs), and direct observation, were utilized.

B. Participant and Site Recruitment

A purposive sampling method was used to recruit participants living nearby the three health centers impacted by flooding during 2023–2024. A total of 63 local residents were invited, including 50 villagers for FGDs and 13 key stakeholders for KIIs. Stakeholders comprised village chiefs, village health support group (VHSG) representatives, heads of health centers, operational district representatives, provincial

health department (PHD) staff for disaster health risk management, and members of the provincial disaster management committee. For FGDs, six homogenous groups (separated by gender) were arranged to minimize gender influence during discussions. Direct observations were conducted at three health centers to evaluate operational services during floods.

C. Study Materials, Data Collection, and Procedure

A semi-structured questionnaire was employed for FGDs and KIIs. During direct observation, a checklist was used to capture issues and adaptation strategies. Three research volunteers were recruited to conduct interviews, take notes, and perform observations. All data collectors were training to ensur the research team's competence in fieldwork. FGDs employed open-ended questions to explore flood impacts on health, sanitation, income, and adaptation strategies. Sessions lasted 40–60 minutes and were audio-recorded. KIIs focused on six domains: health, food security, income, homestead damage, healthcare infrastructure, and government disaster management policies.

D. Data Management and Analysis

Audio recordings were transcribed verbatim in Khmer and translated into English. Transcripts were cross-verified against recordings for accuracy. Analysis of qualitative data was performed using open-source QualCoder version 3.5. Thematic content analysis was conducted through iterative coding by four independent researchers. Codes were generated inductively, and themes were finalized via consensus. Triangulation methods included cross-checking transcriptions, cross-coding, and expert validation.

E. Ethical Considerations

This study was approved by the National Ethics Committee for Health Research (NECHR), Cambodia's Ministry of Health, on 28 November 2024 (No. 424 NECHR). Written informed consent was obtained from all participants. Unique codes replaced names to ensure confidentiality.

III. Results

As a result, 63 participants were invited through purposive sampling. Of these, 13 participants (F: 23.0%) took part in the in-depth interviews, while 50 participants (F: 60%) participated in the focus group discussions. Table 1 presents the demographics of the study population. The mean age of the participants was 47.7 years (SD ± 8.4) for those involved in the in-depth interviews, and 42.5 years (SD ± 13.3) for those who participated in the focus group discussions.

In addition, most of the respondents acknowledged that climate change could lead to flooding, as well as increase the risk of other climate-related events, including storms, rising temperatures, and droughts, etc. Through the analysis, we identified three main themes: community perception of climate change, the impact of climate change on health, and adaptation strategies.

Table 1: Summary study population demographics information

	In-depth interview	Focus group discussion
	n = 13 (%)	n = 50 (%)
Gender		
Female	3 (23.0)	30 (60.0)
Male	10 (77.0)	20 (40.0)
Age		
Mean (SD) - years	47.7 (± 8.4)	42.5 (13.3)
Operational District (OD)		
Battambang	2 (15.4)	-
Sangke	2 (15.4)	14 (28.0)
Sampov Loun (Phnom Prek*)	5 (38.5)	19 (38.0)
Thmor Kol	4 (30.8)	17 (34.0)
Education		
≤ High school	4 (30.8)	-
Nursing Degree	4 (30.8)	-
Medical diploma	1 (7.7)	-
Diploma	1 (7.7)	-
Master degree	3 (23.1)	-
Occupation		
Health	7 (53.8)	-
Non-health related	6 (46.2)	-

*According to the Ministry of Health's Health Mapping, Phnom Prek district is managed under the Sampov Loun Operational District (OD) for health services.

A. Community Perceptions of Climate Change

When asked if they had heard the term *"climate change"*, most participants responded affirmatively. They defined climate change as rising global temperatures, shifting rainfall patterns, frequent flooding, and increased storms/strong winds. Most community members agreed that climate change is occurring in

their communities, citing deforestation, slash-and-burn agriculture, industrialization, and plastic usage as key drivers.

All of the respondents strongly believed that climate change is one of the cases that could lead to flooding in recent years. Respondents described that four types of flooding occurred in their home villages: rapid flooding, monsoon flooding, flash flooding, and flooding caused by blockages in the sewage system or poor drainage. In addition, the flooding lasted from 3 days to a month, which interfered with their livelihood. The male FGDs in Phnom Prek district noted, *"Prolonged heavy rain for 2–3 hours lead to flooding."* Flood duration varied by district: 10 days in Sanke and Thmor Kol (2023) versus 1–2 days in Phnom Prek.

B. Impacts of Climate Change-Induced Flooding

The result from FGDs and KIIs demonstrated that climate change-induced flooding significantly impacts communities, affecting their livelihoods, agriculture, food chain, health, healthcare systems, financial hardship, overall well-being and resilience.

Livelihood

From the interview, villagers revealed that flooding caused job insecurity and income loss. Flood damaged crops, livestock (chickens, ducks, pigs, cows), agricultural fields and infrastructures. During flooding, the strong water currents often led to the destruction of shelters, damage properties, leaving families displaced and vulnerable. The female FGDs stated, *"Floods impact our economics—no job, no income."*

Agriculture and Food chain

Among the three communities, agriculture was the main source of income and one of the most affected sectors during flooding. Farmlands were submerged, leading to crop failure and food shortages. Post-flood conditions often lead to an increase in insect and pest populations further threatening crops. Livestock was also lost or displaced, further reducing food security and financial stability for farming families. The male FGDs in Thmor Kol remarked, *"We rely on farming... floods destroy crops, reduce yields, and cut income."*

Health Issues

The villagers conferred that flood contributed to a significant risk in health issues comprising of diarrhea, fever, vector-borne diseases, skin diseases, and respiratory infections (flu, cough and pneumonia). Furthermore, they reported that they were more vulnerable to other physical health like injuries, snake/insect bite, and drowning.

We observed that villagers practiced common risk behaviours that exacerbate these health problems were using unclean water, unsafe drinking water, limited nutrition food, lacking personal hygiene, poor sanitation, and absence of safety signs in the affected area during flooding. Following the flooding, villagers were forced to use contaminated water for essential hygiene practices such as cleaning and showering. Consequently, some women reported experiencing a range of sexual and reproductive health issues, highlighting the direct impact of the compromised water quality on their well-being. A VHSG member in Phnom Prek reported, *"During floods, we observe more people sick with diarrhea, dengue, fever, and skin rashes due to unclean water."* Another women VHSG revealed that *"During flooding, I observed that most of women had virginal discharge due to lack of personal hygiene and I always informed them to visit health center for treatment."*

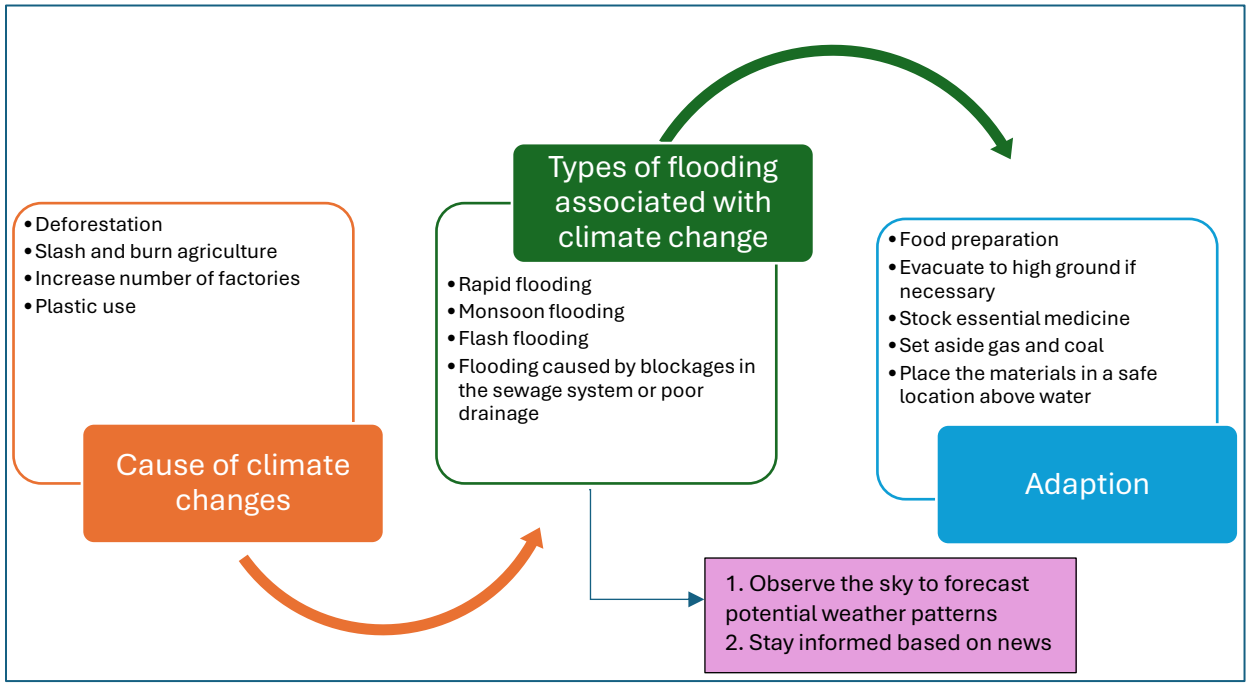
Healthcare System

The finding from FGDs, KIIs with health officers, and direct observation at health centers highlighted that flooding had a significant impact on the healthcare system, leading to service disruptions, reduced accessibility, and infrastructure damage. Health facilities experienced interruptions in service delivery due to physical barriers such as flooded roads and damaged infrastructure, limiting patient access to care. Additionally, flood-related damage to medical equipment and healthcare documents further constrained service capacity. Despite these challenges, essential outpatient department services, including vaccinations, antenatal care (ANC), and consultations, continued without major interruptions. However, emergency healthcare services, such as birth deliveries, were severely affected due to submerged facilities and resource limitations. Moreover, delays in health facility waste disposal posed contamination

risks, increasing the potential for secondary health hazards. "*We used to deliver babies during rapid flooding, which made it extremely difficult and high-risk for both us and the patients, as the entire area was flooded*." Prek Loung health center chief.

In all the health facilities we observed, there was an absence of an official contingency plan or a documented plan for any future actions, as well as a previous report on the impact of the flooding on their health facilities. Fortunately, there was a reporting mechanism in place for health facilities to communicate with higher-level: operational health districts as well as the provincial health department to report incidents, impacts, and needs. Simultaneously, information was shared with the provincial disaster management center and local authorities to facilitate cooperation, interventions, and evacuation if necessary due to the high risk of flooding. The report primarily utilizes the Telegram application for sharing information among the groups. *"We reported information to the operational health district via the Telegram application…there was also a dedicated Telegram group for sharing flooding-related updates in our province."* a staff from OD Sanke.

Figure 2: Describe the causality of flooding in relation to climate change and the adaptation strategies employed by communities



C. Adaptation Strategies

Local Preparation Before Flooding

Communities implemented various preparedness measures to mitigate the impact of climate change-induced flooding. Households stockpiled essential supplies, including charcoal, drinking water, insect repellents, lighters, and non-perishable food items, ensuring they had the necessary resources to sustain themselves during the flood. The experience shared by participants in focus group discussions during the flooding suggested a general lack of specific pre-emptive measures or tailored support for pregnant women and the elderly. It appeared that many individuals did not perceive any particular precautions being taken to address the heightened vulnerability of these groups.

Healthcare System Preparation Before Flooding

The healthcare system undertook systematic preparations to minimize disruptions in services. Health facilities ensured that essential medicines, injury kits, and snake bite vaccines were readily available. Emergency transport and ambulance services were arranged to facilitate timely evacuation and patient transfers. Additionally, healthcare centers allocated budgetary resources, relying on health center funds and community fundraising to support preparedness efforts.

Healthcare System Mitigation Strategies

Mitigation at a health center before and after flooding

To reduce the long-term health risks associated with flooding, the healthcare system employed mitigation strategies such as reinforcing infrastructure, securing medical supplies, and establishing emergency response teams. Community health workers, including VHSGs, played a crucial role in

disseminating health education, early warning alerts, and coordinating relief efforts. Healthcare facilities also adopted preventive measures such as elevating critical medical equipment and securing alternative power sources to maintain essential services during floods.

Actions Taken During Flooding

During flooding events, healthcare facilities and communities implemented immediate response measures to reduce health risks. Health centers ensured the continuous availability of essential medicines and emergency supplies. The outpatient services were relocated to high ground along the road to ensure the continuity of health services including consultation, basic treatment, vaccination, and ANC. In addition, mobile health teams were deployed to provide medical care in affected areas, prioritizing the distribution of injury kits, snake bite kits, and clean water. Ambulance and transport services were actively used to transfer critically ill patients to higher-level health facilities for advanced care.

"Even when our health center was flooded last year, we continued to provide health services to the villagers by relocating our outpatient department services to higher ground or along the road." Health center chief.

Post-Flooding Healthcare System Response

Mitigation at a health center after flooding

After the floodwaters receded, healthcare facilities focused on restoring services and mitigating post-flood health risks. Strategies included pouring soil over stagnant water to prevent vector-borne diseases, constructing sandbag barriers to control residual water flow, and lifting essential medical supplies and equipment to prevent contamination. VHSGs continued their role in community engagement, promoting hygiene practices and ensuring affected populations had access to healthcare services.

Coping Mechanisms and Resilience

Communities and healthcare systems exhibited resilience in coping with the impacts of flooding. Local adaptation strategies included strengthening emergency preparedness, enhancing health facility response capabilities, and improving coordination between local authorities and healthcare providers. Fundraising initiatives and budget reallocation enabled healthcare facilities to sustain operations during crises. The collective effort of communities, health workers, and local governments highlighted the importance of resilience in mitigating the adverse health effects of climate change-induced flooding.

IV. Discussion

The findings of this study reveal the complex interplay between climate change-induced flooding, community health, and healthcare system resilience in Battambang Province, Cambodia. Participants consistently identified climate change as a driver of extreme weather events, including prolonged and intensify risk of flooding, which aligns with global observations linking environmental degradation to heightened health risks (1,2). Communities reported direct health consequences such as waterborne diseases (e.g., diarrhea), vector-borne illnesses (e.g., dengue), respiratory infections, and sexual reproductive health, exacerbated by contaminated water sources and disrupted sanitation systems during floods. These outcomes mirror patterns observed in other low-resource, flood-prone regions, where climate shocks amplify existing socioeconomic and health inequities (2,3,4). Notably, the intersection of agricultural losses, livelihood disruptions, and mental health stressors—reported here as anxiety, displacement-related trauma, and financial hardship—underscores the cascading effects of climate disasters on both physical and psychosocial well-being (3,5,7).

The strain on healthcare infrastructure during flooding events reflects systemic vulnerabilities observed in rural settings globally (4,8). Health facilities in Battambang faced operational disruptions, including submerged roads, damaged equipment, and limited emergency care capacity, particularly for maternal health services (5,8). Such challenges highlight gaps in climate-resilient health infrastructure, a critical concern for Cambodia's rural provinces (8,10). Despite

these barriers, health workers demonstrated adaptability by maintaining essential services like vaccinations and antenatal care, echoing resilience strategies documented in similar contexts (7,11). However, the reliance on community fundraising and limited institutional budgets for disaster preparedness signals a need for sustainable financing mechanisms to bolster long-term resilience (8,12).

Adaptation strategies employed by communities and health systems emphasized localized preparedness, including household stockpiling of supplies, infrastructure reinforcement, and mobile health team deployments (9,13). These measures align with Cambodia's National Action Plan for Climate Change and Public Health, which prioritizes community engagement and decentralized responses (10,14). The pivotal role of Village Health Support Groups (VHSGs) in disseminating early warnings and health education further illustrates the effectiveness of participatory approaches in disaster management (11,15). Yet, systemic gaps persist, particularly in addressing structural drivers of vulnerability, such as inadequate drainage systems and fragmented inter-sectoral coordination (12,16).

This study's participatory methodology underscores the value of integrating community perspectives into climate-health research and policy design. By centering local knowledge, the findings challenge top-down adaptation frameworks and advocate for solutions rooted in grassroots experiences, such as improved early warning systems and livelihood diversification programs (13,17). Such approaches align with global calls to prioritize equity in climate adaptation, particularly for marginalized populations bearing the brunt of environmental crises (14,18).

Strengthening health infrastructure, scaling community-led preparedness initiatives, and addressing socioeconomic determinants of vulnerability must form the cornerstone of Cambodia's climate adaptation agenda (10,14,19). Investments in flood-resistant facilities, mobile health units, and intersectoral collaboration between health, environment, and disaster management agencies are urgently needed (8,10,16). Concurrently, social protection programs targeting economic instability—such as crop insurance and livelihood grants—could mitigate the cascading health impacts of climate-related income loss (17,20).

While this study provides critical insights into climate-health dynamics in Battambang, its focus on three flood-affected districts limits generalizability to other regions. Future research should employ mixed-methods and longitudinal designs to quantify health outcomes, evaluate adaptation efficacy, and explore regional variations in climate vulnerability (17,21). Additionally, deeper exploration of mental health impacts and gender-specific vulnerabilities could further refine interventions (7,19,21).

In conclusion, Battambang's experience illustrates the inextricable link between climate resilience and health equity in rural Cambodia. By leveraging participatory research and community-driven solutions, policymakers can design interventions that address both immediate health risks and systemic inequities (16,20). As climate change intensifies, such inclusive approaches will be vital to safeguarding vulnerable populations and advancing progress toward the Sustainable Development Goals (1,17,21).

Disclaimer

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