Translating national climate policies to resilience actions at the subnational level in low resource settings: Lessons from Ghana's health systems.

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Introduction

The World Bank estimates that climate change could drag more than one hundred million people back into extreme poverty by 2030, with a substantial part of this reversal attributable to negative impacts on health (1). These health impacts include both the consequences of heatwaves(2) as well as the consequences of other extreme weather events, including impacts on mental health (3–5) and changing patterns of communicable diseases(6,7), resulting in increasing pressure on primary healthcare systems(8). Despite global recognition of the impacts of climate change and health, the *2021 WHO health and climate change global survey* reported that majority of countries' climate change and health plans are witnessing low to moderate implementation(9).Bottlenecks to implementation include insufficient funding and budgets, research and evidence, prioritization, multisectoral collaboration, a lack of engagement of health actors in in-country processes (9,10), and the lack of mainstreaming of climate action to health systems policies and standards, known as "thick mainstreaming" (11) The *2022 report of the Lancet Countdown on Health and Climate Change* argues that adopting the "Health Centered Approach" to climate change policy presents an opportunity for a low carbon and resilient future. The report further suggests that the first step to achieve this ambition is to develop context-specific responses to strengthening health systems, which is essential for protecting populations from the negative impacts of climate change (12).

Climate change will disproportionately impact the Global South (13). For example, extreme weather events caused damage across the globe with an approximate value of US$253 billion in 2021, particularly in countries with low Human Development Index (12) In Africa, extreme weather events affected 19 million people and caused 4,000 deaths in 2022 (14). In Ghana, hydrometeorological events have affected over sixteen million people and caused four hundred deaths in the last 50 years(15). Secondly, climate change is shrinking Ghana's forest and transition

zones (16), with future projections suggesting that climate change will widen health(care) inequities and intensify pressure on Ghana's health budget due to increased climate-sensitive diseases and extreme climate events (17).

The government of Ghana initiated action to enhance the adaptation of its health system to climate change in 2010. These efforts culminated in the implementation of a pilot climate change and health project which was implemented by the Ministry of Health (MOH), with support from its development partners, from 2010 to 2015. This pilot aimed to develop systems and response mechanisms to mainstream climate change risk management into the health sector (18). Furthermore, the Ministry mainstreamed change adaptation into the Health Sector's Medium-term Development Plans (HMDP) for the years 2010-2013 and 2014-2017 (19,20). Subsequently, Ghana developed a National Climate Change Policy led by an inter-ministerial National Climate Change Committee, which estimated the cost of adaptation actions, and recommended budget allocations by its health ministry for climate action (21). In 2020, Ghana's ministry of health updated its healthcare waste management policy to enhance sustainable waste management by healthcare facilities (22).

Since 2010, Ghana's national-level climate change policy documents underscore the need for action on climate change and health. The National Climate Change Adaptation Strategy 2010-2020 (23) envisaged decentralized planning, implementation, and monitoring at the sub-national level through broad intersectoral collaboration. Specific to health systems, it emphasizes the need to build health workers' capacity, upgrade existing healthcare facilities, promote modern information management systems, and strengthen rapid disaster response teams to cope with climate change health-related challenges. Ghana's National Climate Change Master Action

Programs for Implementation 2015-2020 dedicated policy action six to climate change and health and developed a mechanism for mainstreaming climate action into health systems and increase the number of functional Community-Based Health Planning and Services (CHPS) to scale up existing interventions for effective management of associated risk and effects of climate change. The plan incorporated fixed implementation timelines alongside monitoring and evaluation plans (24).

Amidst the increasing threats of climate change to health systems in Ghana and the lack of data on health system vulnerabilities (25), this study aims to examine how Ghana's national-level climate-resilient health systems agenda has translated to building climate-resilient PHCs and to identify existing barriers to further mainstreaming. The study also aims to inform health systems policymakers, researchers, and local government authorities on how to improve PHC systems adaptation and further the national agenda for health systems adaptation to climate change.

Materials and Methods

Study Area

This study was conducted in the Upper East Region (UER) of Ghana. This region is prone to multiple extreme weather events(26,27), witnessing reduced access to water and food, and disruption of health services due to extreme weather events resulting in restricted access and provision of health services in resource deprived, hard-to-reach communities (17,28). The region has poor geographical access to health facilities and points of care (including diagnostics) (29,30), high poverty rates (31), intermittent outbreaks of climate-sensitive conditions like cerebral spinal meningitis (32), zoonotic diseases e.g. Anthrax(33,34), and endemic malaria(35). The UER has fifteen administrative districts that are coterminous with PHCs. PHCs are key implementation units of Ghana's health systems. A PHC is overseen by a District Health Management Team (DHMT) headed by a district director. Healthcare services are delivered through a network of Community

Based Planning and services (CHPS) with a mandate of close-to client services, health centers which are referral points for CHPS and a district hospital serving as the top referral facility within the PHC structure.

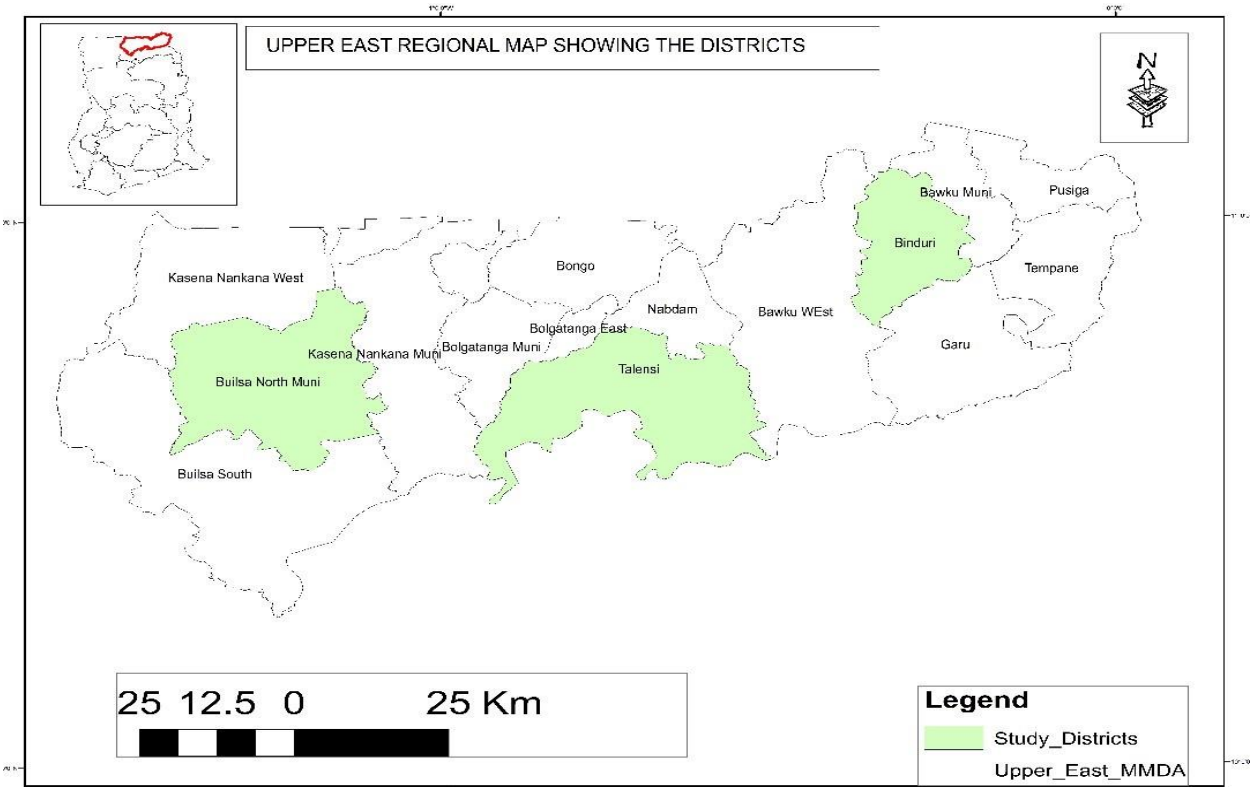

Fig 1. Map of the Upper East Region of Ghana showing study PHCs shaded in green ink. Source: Authors' construct.

Study Design

The study utilized mixed methods, involving vulnerability and impact assessment of PHCs and PHC facilities using WHO guidance and checklist, and Key informant interviews using adapted Consolidate Framework for Implementation Research Index (CFIR Index) interview guides to understand context-specific facilitators and barriers to mainstream climate change adaptation and mitigation into PHC operations.

As highlighted in Fig 2, the WHO operational framework for building climate -resilient health systems(36) recommends the mainstreaming of climate-resilient and environmental sustainability components into the six health systems building blocks of: leadership and governance, health

workforce, health information systems, essential medical products and technologies, service delivery, and climate financing. To enhance implementation and system -wide approaches, the WHO provided further guidance on measuring the climate-resilience of health system(37), building climate -resilient and environmentally sustainable healthcare facilities(38) and a checklist for assessing the climate resilient and environmental sustainability of healthcare facilities(39). The checklist supports health facility managers to conduct vulnerability and impact assessments, and planning on the workforce, energy, infrastructure, technology and products and Water sanitation hygiene and healthcare waste which are essential for functioning of healthcare facilities which are critical for optimal running of healthcare facilities.

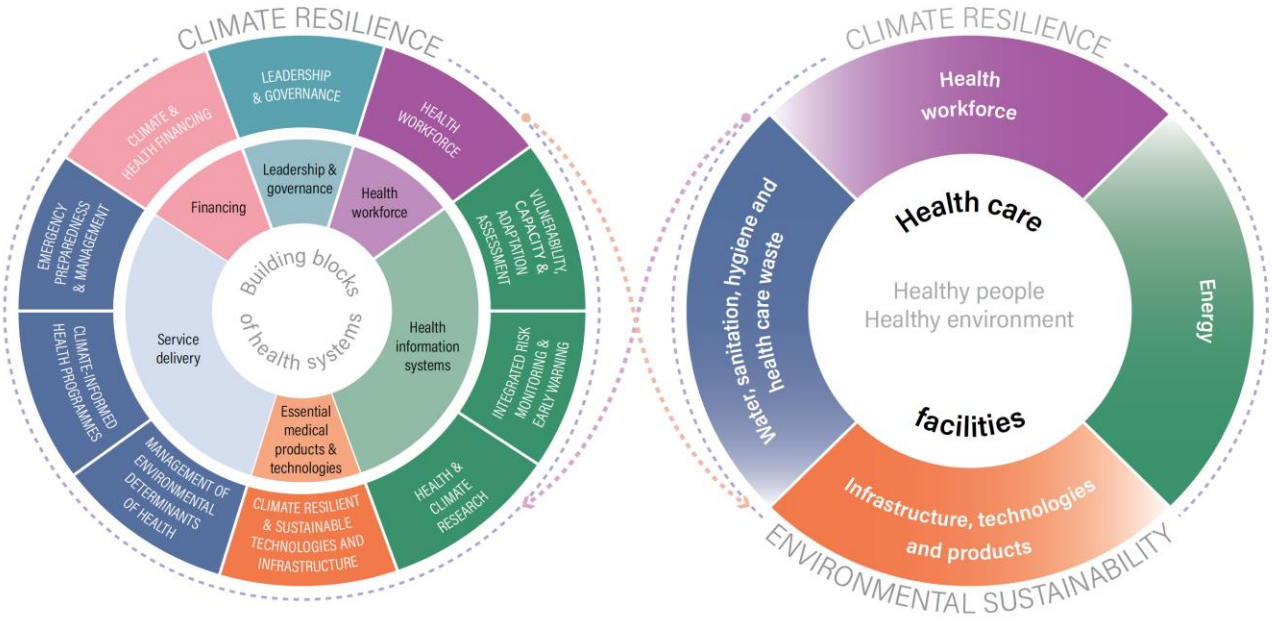

Figure 2: The WHO operational framework for building climate-resilient health systems Source: WHO guidelines for Climate-Resilient and Environmentally Sustainable Healthcare Facilities(38)

To explore context-specific facilitators to mainstreaming climate change adaptation and mitigation into PHC operations, we adapted open ended key-informant interview guides and Index dimensions of the CFIR Index(40), an adaptation of the CFIR(41). Index dimensions were

maintained, but questions were tailored to focus on PHC adaptation and mitigation using the WHO frameworks for building climate-resilient health systems as a benchmark (Supplementary material 1). Table 1 highlights the adaptations made to the CFIR Index dimension. The CFIR Index evaluates barriers and facilitators in the implementation of evidence-based practices. It comprises four dimensions and twenty-nine sub-dimensional items. The CFIR Index utilizes qualitative data with responses rated on a 5-point scale ranging from -2 (Barrier) to +2 (Facilitator). As part of the adaptation to CFIR Index, the study utilized thematic analysis instead of quantification of responses.

Table 1. CFIR Index Dimensions vs Adapted Themes

	CFIR Index Dimensions	Study Adaptations	No.	Index Sub-dimensions
1	Perceptions of the intervention	Perceptions of suitability of WHO framework for PHC	4	Framework source, effectiveness, relative advantage, testability, adaptability, complexity, and cost.
2	Perceptions of the system and community	Perceptions of PHC systems and stakeholders	4	Clients' needs and resources, peer pressure, network and connectivity, external policy, and incentives
3	Perception of the programme	Perceptions of PHC programming attributes and culture	14	Structural characteristics, networks and communication, culture, implementation climate, tension for change, compatibility, relative priority, organizational incentive, goals and feedback, learning climate, readiness for implementation, leadership engagement resource availability, access to knowledge and information
4	Perceptions of the clinicians who will use the intervention	Perceptions of PHC managers' identification with WHO framework	4	Knowledge and beliefs about the WHO framework, self-efficacy, motivation, identification with framework

Sampling

Multi-stage sampling (42) was adopted for field research because PHCs are standardized (43) and are guided by the same policies and standards. PHCs are subnational or district health systems modelled around three-tier healthcare facility levels comprising Community-Based Health Planning and Services (CHPS), health centers, district hospitals, and a District Health Management

Team (DHMT) which is headed by a district director of health services who is responsible for healthcare services in the District/PHC.(44,45).

The current study utilized the pre-existing health systems clustering(46) of East [which is the Bawku Area and Kusasi speaking group and consists of six districts (Bawku Municipal, Bawku West, Binduri, Garu, Tempane and Pusiga]; Central [which is the Grune speaking group and consists of five Districts [Bolgatanga Municipal, Bolgatanga East, Talensi, Nabdam and Bongo]; and West [which is the Kasena-Nankana and Builli speaking areas and contains four Districts [Kasena-Nankana West, Kasena-Nankane Municipal, Builsa North and South] (46). Binduri, Talensi, and Builsa North Districts, were randomly selected from the East, Central, and West clusters, respectively.

Study Participants

All members of the District Health Management Team (DHMT) and all PHC facility managers in the study districts were invited to participate in vulnerability assessments of PHC systems and PHC healthcare facilities, respectively. Between the 31st of October and the 25th of November 2022, District Directors of Health Services (DDHS) of each PHC were purposively sampled for interviews on facilitators and barriers to mainstreaming climate change adaptation and mitigation into PHC operations. After interviewing the directors, they recommended experienced PHC facility managers for further interviews. Participation eligibility was based on their in-depth knowledge of the operations of PHCs and health sector policies and guidelines(47).

Quantitative Data Collection

The current study utilized the World Health Organization frameworks for building and assessing climate-resilient health systems (37,48,49) to assess the climate resilience of PHC systems and healthcare facilities (CHPS, health centers/clinics, district hospitals). The WHO frameworks were

chosen because they provide tools for the systemwide assessment of PHCs (50) and are recommended for use by the Ghana government (24).

PHC system

The study adapted the suggested checklist within the WHO framework for measuring the climate resilience of health systems (37) by removing questions targeting national health systems and restricting the checklist to short-term risk (less than ten years). The restriction to short term was because PHC managers typically implemented interventions that were guided by health system policies that have a typical cycle of five to ten years. A "remarks´ column was also created for participants to provide further context around their answers (supplementary material 1). District Health Management Team (DHMT) members of the participating PHCs or Districts underwent a district-based half-day orientation on the framework. After orientation, each DHMT member assessed their respective PHCs individually. Participants answered the questions in the checklist using a 3-level scale: (3) Unprepared; unable to respond or unavailable, (2) incomplete or basic preparation or in progress, and (1) prepared; achieved or completed as prescribed by the WHO.

PHC facilities

The WHO checklist for assessing climate resilience and environmentally sustainable healthcare facilities in the context of climate change was used for assessments (49). First, a hazard identification template was administered to PHC facilities managers to determine which climate hazards they had observed their health facility have been exposed to between September 2021 and September 2022. After analyzing and determining healthcare facility-specific hazards, the responding managers were invited to participate in a two-day district-based orientation and vulnerability assessment of their respective healthcare facilities. All risks were evaluated based on three options: (3), Unprepared or high risk, (2) Incomplete preparation or medium risk and (1) Prepared or low risk as recommended by the WHO checklist. The WHO checklist focuses on the

healthcare facility components of Health Workforce; Water, Sanitation, Hygiene and Healthcare waste; Energy; and Infrastructure, Technology, products, and processes.

Qualitative Data Collection

Key-Informant Interviews

The current study adapted the Consolidated Framework for Implementation Research (CFIR) Index (40) interview guides to explore PHC managers' views on facilitators and barriers to mainstreaming the WHO frameworks for climate change adaptation and mitigation into PHC operations. The guides were based on questions exploring the suitability of the WHO framework for PHC, PHC systems and stakeholders, PHC programming culture and PHC managers identification with WHO framework (supplementary material 2). At the beginning of the interviews, a PowerPoint presentation was used to refresh participants on the relevant WHO frameworks (37,48–50).

Data Analysis

Quantitative Data Analysis

The vulnerability of each PHC system was determined by calculating the average score of the individual assessments of all participating DHMT members. Based on the average score, we classified the level of climate resilience into 3 (unprepared), 2 (incomplete preparation) or 1 (prepared). Similarly, the average score from each health facility checklist was used to classify the level of vulnerability into three options: (3), Unprepared or high risk, (2) Incomplete preparation or medium risk and (1) Prepared or low risk. Even though the WHO checklist does not provide consolidated scoring like similar indexes (51) , the study adopted the average score per assessment to help participants get a clearer understanding of the overall preparedness or vulnerability of their respective PHCs and healthcare facilities.

Qualitative Data Analysis

The analysis of qualitative data involved the verbatim transcription of eighteen audio recordings of key informant interviews. Transcriptions were coded by thoroughly reading data, identifying issues, reflecting on their meanings, and capturing them as codes. We developed a codebook containing descriptions of the issues and the context, considering the breadth, depth, and nuance. Finally, emerging themes were identified from the codes (52).

Ethical Considerations

This study underwent scientific and ethical review and received approval from the Navrongo Health Research Center Internal Review Board, Ghana, on the 9th of September 2022 (Approval ID: NHRCIRB 478). Participant recruitment and data collection was from the 9th of September 2022 to the 8th of November 2022. Participation was voluntary. Before participating in this study, participants read a participant information brief that spelled out the purpose of the study, methods, time requirements, inclusion criteria , responsibility of participant , benefits and risk and confidentiality Additionally, participant were allowed time to seek clarification and they were informed of their unfettered freedom to discontinue participation in the study at any stage of the interview. Participants who agreed to participate signed a written consent form.

Results

Study Participants

Table 2 presents the categories of study Participants. Sixty-five PHC facility managers (97%) participated in vulnerability assessments (Binduri 19, Builsa North, 21 and Talensi, 25) and 27 District Health Management Team members (82%) participated in vulnerability assessments of their respective PHCs (Binduri 8, Builsa North, 10 and Talensi, 9). Eighteen PHC and district health facility managers participated in interviews (1 District Director of Health Services and 5 PHC facility managers per district).

Table 2. Overview of participating PHC and facility managers per District

Quantitative Data										
	Binduri		Builsa North		Talensi		Total		%	
Type of Facility (HCF)	**P**	**NP**	**P**	**NP**	**P**	**NP**	**P**	**NP**	**P**	**NP**
CHPS	14	0	18	0	18	1	50	1	98	2
Health center/Clinic	5	0	2	1	6	0	13	1	93	7
Hospitals	0	0	1	0	1	0	2	0	100	0
Sub-total (HCF)	19	0	21	1	25	1	65	2	97	3
% sub-total (HCF)	100	0	96	4	96	4	97	3	n/a	n/a
DHMT	8	3	10	1	9	2	27	6	82	18
Total	27	3	31	2	34	3	92	8	n/a	n/a
Qualitative Data										
	Binduri		Builsa North		Talensi		Total			
District Director of Health Services	1	n/a	1	n/a	1	n/a	3	n/a	n/a	n/a
Hospital Medical Director	0	n/a	1	n/a	0	n/a	1	n/a	n/a	n/a
Hospital Administrator	0	n/a	0	n/a	1	n/a	1	n/a	n/a	n/a
Health center Manager	3	n/a	2	n/a	2	n/a	7	n/a	n/a	n/a
CHPS Manager (In-charge)	2	n/a	2	n/a	2	n/a	6	n/a	n/a	n/a
Total	**6**	n/a	**6**	n/a	**6**	n/a	**18**	n/a	n/a	n/a

DHMT denotes District Health Management Team, CHPS denotes Community-Based Health Planning and Services, P= participated, NP= Not participated, n/a=not applicable

PHC systems

Table 3 presents an overview of the PHC systems' reported climate-resilience across the three districts. The average scores of ten components ranged from 2 (integrated risk and early warning systems, management of environmental determinants of health, climate informed programming) to 2.7 (health & climate change research), indicating that overall, PHCs were incompletely prepared (2.3) to respond to climate exposures.

Variations existed between the ten components. According to respondents, PHCs were unprepared in the components of the health and climate change research agenda (with average 2.6 Binduri, 2.9 Builsa North, 2.5 Talensi), climate health financing (average 2.5) and workforce (average 2.5).

PHCs were incompletely prepared in the component of integrated risk and early warning (2) management of environmental determinants of health (2), climate informed programing (2), emergency preparedness and management (2.2) and vulnerability and capacity assessment (2).

Table 3. Vulnerability of PHC systems across the participating regions, on a scale of 1-3

	District/PHC System			
Climate-resilience component	**Binduri**	**Builsa North**	**Talensi**	**Average**
Leadership & Governance	2.6	2.4	2.1	2.4
Workforce	2.5	2.4	2.6	2.5
Vulnerability & Capacity Assessment	2.1	2.3	2	2.1
Integrated Risk & early warning	2.1	2.1	1.9	2
Health & Climate change research agenda	2.6	2.9	2.5	2.7
Climate-resilient technology & Infrastructure	2	2.5	2.2	2.2
Management of Environmental determinants of health	1.8	2.2	2.1	2
Climate informed programing	1.8	2.2	2.1	2
Emergency preparedness & Management	2.2	2.4	2	2.2
Climate Health financing	2.1	2.8	2.6	2.5
Preparedness of DHMT	2.2	2.4	2.2	2.3
Color codes: Red=incomplete preparation or unable to respond, Yellow =Incomplete preparation, Green=prepared or able to respond, PHC=Primary Health Care				

PHC Facilities

Exposure/Observed Climate Hazards by PHC Facilities

Table 4 presents the type and number of observed impacts of climate hazards within PHC facilities between September 2021 and September 2022. Healthcare facilities in Builsa North and Talensi observed storms, heatwaves, floods, droughts, and wildfires while Binduri observed only storms, heatwaves, and floods. Of the 65 PHC facilities surveyed, 82% (n=53) were exposed to multiple climate hazards between September 2021 and September 2022.

As shown in Table 4, A total of 143 climate hazards was reported across all PHC facilities in one year, with an average of 2.2 hazards per facility, which was stable across area (Binduri: 2.1, Builsa North: 2.2, Talensi: 2.3. PHC facilities observed a total of forty-eight storm-related hazards (34%),

266 twenty-five heatwave-related hazards (25%), twenty-four flood-related hazards (17%), twenty-two
267 drought-related hazards (15%) and thirteen wildfire-related hazards (9%).

268 **Table 4. Type and number of hazard exposure of PHC facilities by District.**

Type of Hazard Exposures of PHC Facilities by District/PHC																														
	Binduri								Builsa North								Talensi								Total(T)							
	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%
Storms	13	42	4	50	0	0	17	44	10	26	0	0	0	0	10	22	14	36	6	35	1	50	21	36	37	34	10	32	1	25	48	34
Heatwaves	12	39	3	38	0	0	15	38	9	24	1	17	1	50	11	24	6	15	4	24	0	0	10	17	27	25	8	26	1	25	36	25
Floods	6	19	1	13	0	0	7	18	7	18	2	33	1	50	10	22	5	13	1	6	1	50	7	12	18	17	4	13	2	50	24	17
Droughts	0	0	0	0	0	0	0	0	8	21	1	17	0	0	9	20	10	26	3	18	0	0	13	22	18	17	4	13	0	0	22	15
Wildfires	0	0	0	0	0	0	0	0	4	11	2	33	0	0	6	13	4	10	3	18	0	0	7	12	8	7	5	16	0	0	13	9
Total(T)	31	79	8	21	0	0	39	27	38	83	6	13	2	4	46	32	39	67	17	29	2	3	58	41	108	76	31	22	4	3	143	100
No. of PHC Facilities	14	n/a	5	n/a	0	n/a	19	n/a	18	n/a	2	n/a	1	n/a	21	n/a	18	n/a	6	n/a	1	n/a	25	n/a	50	n/a	13	n/a	2	n/a	65	n/a
Average Exposure	2.2	n/a	1.6	n/a	0.0	n/a	2.1	n/a	2.1	n/a	3.0	n/a	2.0	n/a	2.2	n/a	2.2	n/a	2.8	n/a	2.0	n/a	2.3	n/a	2.2	n/a	2.4	n/a	2	n/a	2.2	n/a
Exposure of PHC facilities to Hazards																																
	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%	CHPS	%	HC	%	H	%	T	%
1 hazard	2	100	0	0	0	0	2	11	5	83	1	17	0	0	6	29	3	75	1	25	0	0	4	16	10	83	2	17	0	0	12	18
2 hazards	10	67	5	33	0	0	15	79	5	71	1	14	1	14	7	33	9	90	0	0	1	10	10	40	24	75	6	19	2	6	32	49
3 hazards	2	100	0	0	0	0	2	11	6	100	0	0	0	0	6	29	5	56	4	44	0	0	9	36	13	76	4	24	0	0	17	26
4 hazards	0	0	0	0	0	0	0	0	2	100	0	0	0	0	2	10	1	50	1	50	0	0	2	8	3	75	1	25	0	0	4	6
TOTAL(T)	14	74	5	26	0	0	19	29	18	86	2	10	1	5	21	32	18	72	6	24	1	4	25	38	50	77	13	20	2	3	65	100
NB: HC denotes Health Center/Clinic, H; Hospital , T=Total, n/a=not applicable, CHPS=Community- Based Planning and Services, PHC=Primary Health Care																																

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270 ## Vulnerabilities of PHC Facilities

271 Figure 3 presents the degree to which the PHC facilities are prepared against, or vulnerable to, the
272 observed climate hazards. Overall, the healthcare facilities showed high vulnerability to climate
273 hazards with no facility being completely prepared or able to respond to any of the observed
274 hazards (i.e. Lower risk). Instead, 83% of PHC healthcare facilities are unprepared or unable to
275 respond (higher risk) to observed climate hazards(n=118), while 17% (had basic or incomplete
276 preparation(n=25) and hence had the capacity for only a low-level response to the impacts of
277 storms, heatwaves, floods, droughts and wildfires (Medium risk).

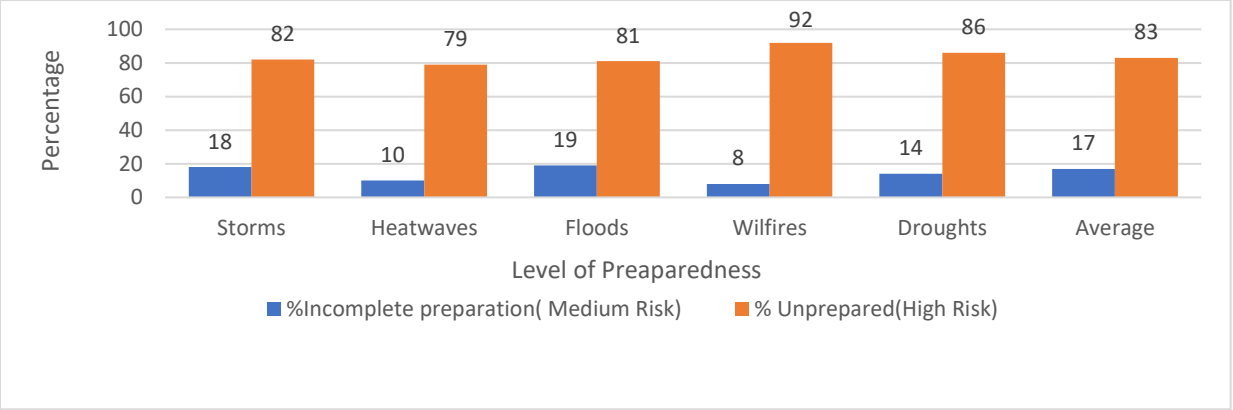

Fig. 3. Observed Climate hazards by Healthcare Facilities and level of preparedness.

Vulnerability of components of PHC Facilities

Table 5 presents the preparedness or vulnerability of PHC facilities and specific healthcare facility components of Workforce, WASH and healthcare waste, Energy, and Infrastructure, technology, and processes). Overall, 93% of CHPS were unable to respond (higher risk) to 100 out of 108 exposures (93%) while health centers were unable to respond (higher risk) to 18 out of the 31 exposures (58%). In contrast, all hospitals show basic or incomplete preparation (Medium risk). When examining the preparedness of individual components, CHPS and health centers were prepared (i.e. low risk) against 1 exposure in the component of WASH and healthcare waste. In the component of Infrastructure, technology, products and processes, health centers were able to respond(prepared) to 7% of exposures (n=2). In the component of energy systems, all hospitals show medium risk (low level of response) to their exposures(n=4), CHPS show a higher risk (unable to respond) to 89% of exposures (n=96), health centers have higher risk (unable to respond) to 48% of exposures(n=15). The workforce of all categories of PHC facilities are unable to respond to observed climate hazards or exposures.

Table 5. PHC Healthcare facility vulnerability/preparedness by component and Size

	CHPS								Health Center/Clinic								Hospital								Total							
	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%
Binduri	0	0	4	13	27	87	31	29	0	0	6	75	2	25	8	26	0	0	0	0	0	0	0	0	0	0	10	26	29	74	39	27
Builsa North	0	0	8	21	30	79	38	35	0	0	2	33	4	67	6	19	0	0	2	100	0	0	2	50	0	0	12	35	34	74	46	32
Talensi	1	3	6	15	32	82	39	36	1	6	9	53	7	41	17	55	0	0	1	50	1	50	2	50	2	3.4	16	40	40	69	58	41
Average	1	1	18	17	89	82	108	76	1	3	17	55	13	42	31	22	0	0	3	75	1	25	4	3	2	1.4	38	27	103	72	143	100
Energy																																
	CHPS								Health Center/Clinic								Hospital								Total							
	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%
Binduri	0	0	4	13	27	87	31	29	0	0	6	75	2	0	8	26	0	0	0	0	0	0	0	0	0	0	10	31	29	26	39	27
Builsa North	0	0	3	8.6	35	92	38	35	0	0	4	67	2	33	6	19	0	0	2	50	0	0	2	50	0	0	9	28	37	33	46	32
Talensi	0	0	5	15	34	87	39	36	0	0	6	35	11	65	17	55	0	0	2	50	0	0	2	50	0	0	13	41	45	41	58	41
Average	0	0	12	11	96	89	108	76	0	0	16	52	15	48	31	22	0	0	4	100	0	0	4	3	0	0	32	22	111	78	143	100
Infrastructure, Technology Products and Processes																																
	CHPS								Health Center/Clinic								Hospital								Total							
	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%
Binduri	0	0	3	9.7	28	90	31	29	1	13	1	13	6	75	8	25.8	0	0	0	0	0	0	0	0	1	50	4	18	34	29	39	27
Builsa North	0	0	6	16	32	84	38	35	0	0	2	33	4	67	6	19.4	0	0	0	0	2	##	2	50	0	0	8	36	38	32	46	32
Talensi	0	0	3	7.7	36	92	39	36	1	6	5	29	11	65	17	54.8	0	0	2	100	0	0	2	50	1	50	10	45	47	39	58	41
Average	0	0	12	11	96	89	108	76	2	6	8	26	21	68	31	21.7	0	0	2	50	2	50	4	3	2	1.7	22	18	119	83	143	100
PHC Facility Vulnerability(Preparedness)																																
	CHPS								Health Center/Clinic								Hospital								Total							
	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%	LR	%	MR	%	HR	%	T	%
Binduri	0	0	1	13	30	30	31	29	0	0	4	31	4	22	8	25.8	0	0	0	0	0	0	0	0	0	0	5	20	34	29	39	27
Builsa North	0	0	3	38	35	35	38	35	0	0	2	15.4	4	22	6	19.4	0	0	2	50	0	0	2	50	0	0	7	28	39	33	46	32
Talensi	0	0	4	50	35	35	39	36	0	0	7	53.8	10	56	17	54.8	0	0	2	50	0	0	2	50	0	0	13	52	45	38	58	41
Total	0	0	8	7.4	100	92.59	108	76	0	0	13	41.9	18	58	31	21.7	0	0	4	100	0	0	4	3	0	0	25	17	118	83	143	100

PHC denotes Primary Health Care, CHPS= Community-Based Health Planning and Services, LR=Lower Risk, MR=Medium Risk, HR=High Risk, T=Total

Facilitators and Barriers to Mainstreaming Climate Change Adaptation and Mitigation

Participants reported that climate change adaptation and mitigation align with the vision and mission of the Ministry of Health and Ghana Health Service. They suggested that pursuing PHC adaptation and mitigation could enhance the safety of both clients and staff and promote quality of care. Participants identified benefits of adopting the WHO framework to include prompt detection of climate-sensitive diseases, improved infection control, improved staff capacity to deal with emerging health system challenges, promotion of new and appropriate technology to support

proper and standard care, and improved access to a complete range of healthcare services during disasters and emergencies.

Facilitators

Six main themes were identified as facilitators to furthering climate change adaptation and mitigation: policy mainstreaming, active leadership, multi-sectoral collaboration, partnerships, prioritizing new projects and programs, and workforce capacity.

Policy mainstreaming of the national climate change agenda into health system policies, protocols, standards and accountability mechanisms, a recommendation we call "thick mainstreaming," was reported as crucial for climate action within PHC. For instance, one participant remarked:

> "*Policy; you know we here actually don't, we only make decisions to sometimes inform policy. We don't buildup policy, we implement the policy so once the Ghana Health Service structure accepts or adopt this as a policy [mainstream climate change adaptation and mitigation] for the implementation, we are there to implement it" [Participant, 13].*

Another participant remarked that:

> *Policy will influence because, if it [mainstreaming adaptation and mitigation] is not in line with Ghana Health Service or the Ministry of Health policies, there will be conflicting interest. [Participant 2].*

The participants emphasized the importance of policies, standards, and protocols in shaping PHC operations. Participants suggest that mainstreaming climate action in PHC policies, standards and protocols will support system enforce implementation through monitoring, reporting, and periodic

329 evaluations. This we call "Thick mainstreaming" would strategically trigger a system-wide
330 response to climate change adaptation and mitigation within the PHCs.
331
332 Participants reported that ac*tive leadership* could support the mainstreaming and successful
333 implementation adaptation and mitigation efforts. A participant remarked in response to the
334 importance of leadership in any mainstreaming efforts:
335 *"I will say leadership; if they are not showing leadership, it will affect the implementation*
336 *because, if you do not have that leadership to ensure sustainability, especially the*
337 *implementation stage, there is no sustainability. They [the leadership] will finish*
338 *implementing the whole thing, and you will go back to zero." [Participant 2]*
339
340 Participants emphasized the need for PHC leadership to *collaborate* with other health-determining
341 sectors and the community to ensure successful mainstreaming and implementation because the
342 PHC systems will need the support of these stakeholders to implement effectively. The participants
343 acknowledged the importance of a multisectoral approach with subnational or local government
344 actors. A participant further remarked that:
345 *"Whether it is developed by us or in collaboration, it will depend on how well we link up*
346 *with the other sectors to understand the impact of it on health systems" [Participant 2].*
347
348 The participants emphasized the need to get a "buy-in" of subnational actors because of their
349 contribution to operations of PHCs. To emphasize the need for buy- in of other stakeholders.
350 Another participant remarked that:

"If all stakeholders are brought on board and are ready to do the right thing: that is the community are giving us good lands, contractors are adhering to standards, we are sending the right staff and equipment, there is monitoring and supervision, it will work" [Participant 7].

Building the PHC *workforce's capacity* to understand the nexus between climate change and health was identified as important for mainstreaming climate action into PHC operations. Participants mentioned that the availability of a good mix of health staff could provide a base for the mainstreaming process but emphasized the need for their buy-in through a comprehensive, system-wide capacity building process. To illustrate, a participant remarked:

"So, it is the ability to explain the relationship between climate change and health for the health staff, especially leadership, to understand first, then the acceptability will be okay. [Participant 2]"

Another view regarding the capacity of the workforce was the need to integrate climate change and health into the curriculum of health training institutions. This view recommends integrating climate change and health considerations into the training curriculum of health professionals to ensure long-term sustainability. As a participant remarked:

"So, I think that climate change can be incorporated into our health training institutions so from day one, once you enter into any health institution before you come out, you are made aware of what climate change is" [Participant 16]."

373 Participants reported that collaborations with decentralized government departments, e.g. the
374 National Disasters Management Organizations (NADMO) to undertake climate-resilient actions
375 will enhance sustainability and buy -in of stakeholders. Collaborations with NADMO and other
376 decentralized departments were reported to be ad hoc with mostly no formal plans, designated
377 officers and budgets. A participant from one of the DHMTs in justifying his score during
378 vulnerability assessment remarked that:
379
380 *"Health emergency committees (are) in place but (there are) no budget and plans"*
381 *[DHMT member].*
382
383 *Partnerships* with NGOs were reported as crucial for mainstreaming climate action into PHC
384 operations. NGOs are already leading autonomous adaptation and mitigation efforts in WASH and
385 healthcare waste through capacity building and the provision of appropriate infrastructure. They
386 underscored the importance of NGOs regarding innovation and resources for PHC systems and
387 acknowledged a need to include and build partnerships with NGOs to enhance PHC adaptation
388 and mitigation efforts. A participant remarked that:
389
390 *"We have a partner [an NGO] in the district that is supporting us in terms of WASH and*
391 *infection prevention control, so they provide us with water, toilet facilities, bathrooms and*
392 *incinerators" [Participant 7].*
393
394 *New projects and programs* were reported as potential entry points for mainstreaming climate
395 change adaptation and mitigation within PHC. Proponents of this view suggest that PHC systems

can take advantage of new donor or government of Ghana funded projects and programs to mainstreamed resilience actions, learn lessons and institutionalize. They suggest that the financial constraints of PHC require a staggered approach starting with new projects. Other participants were of the view that benefits associated with mainstreaming climate considerations into newly funded projects can influence acceptability within PHC actors. Two participants remarked that:

> *"For example, as I said, the service has a standard of a building or infrastructure for the CHPS facility; if implementing this, there is a need for an addition, then it should start from the new ones" [Participant 2].*

> *"I think if mainstreaming climate change adaptation and mitigation in PHC a success and clients come for services, it's a motivation. I think they (PHC actors) will be motivated" [Participant 4].*

Barriers

Five themes were identified as barriers to effectively mainstreaming climate change adaptation and mitigation into PHC operations: costs, vertical/ top-down projects, complexity, inappropriate community entry, and health and workforce constraints.

Costs associated with mainstreaming are reported as a barrier due to the low capacity for revenue generation of the PHC facilities. Some participants reported that the PHC facilities could not undertake sustained mainstreaming of climate action into their operations due to their poor financial state and hence needed external support to initiate and sustain action. Some participants reported that PHC facilities can mainstream non-capital-intensive activities like communication and awareness if their capacity is built. However, mainstreaming is perceived as resource intensive (human, financial, technology and others), complicating any mainstreaming efforts due to scarcity and competition for resources. A participant observed:

The challenge regarding cost is that we are already a handicapped due to low internally generated funds and late reimbursement of NHIS; hence for a deprived health facility like ours, cannot be able to work on climate change measures without extra support" [Participant 3].

Even though cost is reported as a barrier, hospitals reported undertaking autonomous adaptations in WASH and healthcare waste and energy systems by acquiring small water systems and standby generators. All hospitals participating in the study reported to have financed these adaptations from their incomes. A participant reported that:

"For instance, I think some years ago, we used to depend on the community water supply. So, there were times there was no water, we decided to build a mechanized borehole, so for some years now, we have been having water supply every day in the year" [Participant 9].

Participants reported *top-down approaches or vertical programs* as a barrier to mainstreaming. Participants suggest that any mainstreaming efforts must involve all levels of PHC actors in the mainstreaming process. Two participants reported that:

"Apart from the capacity, sometimes they do not make the implementers or those who are supposed to use the policy own the policy. The policy is developed somewhere; I do not have any idea about it, and they push it down to me and say implement it, so sometimes, if you do not own the policy, it becomes difficult for you to even commit to implementing it" [Participant 15].

"Sometimes it has to do with funding; when programs come, the real implementors of the program are left out. So, when the funding stops, then they will now be pushing the one

that was not actually trained to continue. In that sense, you will be reluctant" [Participant 14].

Some participants reported that mainstreaming efforts will be *complex* due to the need for buy-in from local government and informal actors like communities and traditional authorities, which might not necessarily perceive climate change adaptation and mitigation as a priority. For instance, a participant observed:

For me, I think the four approaches are okay, we might not need to make any changes when it comes to the four approaches, but we may have to first, let the people understand the essence and impact of climate change and when they buy into the idea, I think that we will be" [Participant 8].

Participants underscored the need for in-depth *community entry* and participatory process to ensure that internal and external PHC stakeholders, especially staff, clearly understand the nexus between climate change and health and the need to mainstream climate change into PHC operations proactively. They reported poor community entry and stakeholder participation would hinder mainstreaming climate change adaptation and mitigation into PHC.

"I think that receptivity will be good but depending on the entry process, if people have that understanding of the benefits it will have on the healthcare systems, they will accept it" [Participant 2]."

Limited staff and current staff workloads were identified as constraints for mainstreaming. Participants reported that mainstreaming climate change adaptation and mitigation into PHC would worsen their workloads and result in inefficiency if PHC does not recruit additional staff. A participant remarked that:

"For me, I will say maybe it might be a little harder when it comes to staffing because as [it is] now, we don't have enough staff and the workload is there, so if this policy comes to add and it has to add more load on what I am already having and there isn't enough staff to maybe share the work, I think that one will also not make it ineffective"[Participant 18].

Discussion

Even though Ghana's national climate change agenda underscores the importance of health sector adaptation (24) and mitigation (22,53), this is not adequately translated into the mainstreaming of climate resilience in Primary Healthcare (PHC) operations in the low resourced setting of Northern Ghana. Despite substantial exposure of PHC healthcare facilities to multiple climate hazards, PHC managers identified low human resource capacity on the nexus between climate change and health systems, cost, and weak subnational inter-sectoral collaboration as barriers to mainstreaming. PHC managers also identified systematic mainstreaming climate change adaptation and mitigation into PHC policies, protocols and standards with inbuilt accountability mechanism- "thick mainstreaming", leadership commitment, improved sub-national multi-sectoral collaboration, NGOs and improved workforce capacities as important facilitators.

Ghana's National Climate Change Adaptation Framework Plan (54) and Climate Change Master Plan 2015- 2020 (24) underscored the need for mainstreaming climate action into health system policies. The Master Plan developed a mainstreaming methodology to assist health system mainstream climate action at all levels of planning. However, these national level policies and plans have not being further mainstreamed into health system and PHC policies resulting in limited climate action in PHC operations. This finding aligns with Tye and Waslander (2021), who suggest that sectorial policy inconsistency leading to poor mainstreaming in health sector policies has resulted in limited climate action within the health sector (55). The poor mainstreaming of

488 climate action into health systems may have an implication for climate action within PHCs across
489 the country because PHCs have the same structure, mandate with their operations guided by health
490 systems policies (45).

491 PHCs are the primary operating unit of the Ghanaian health system, accounting for over half of
492 essential public health services, and are at the forefront of managing public health emergencies
493 related to natural disasters (45) . This presupposes that mainstreaming climate action into PHC
494 policies and standards is crucial for moving from policy to action at the subnational level. Despite
495 the current challenges, mainstreaming climate action in PHC policy and systems will trigger
496 innovation and autonomous adaptation within PHC such as new training infrastructure or
497 partnerships that can be forced to integrate climate considerations. These also offer the potential
498 to leverage resources for PHC mainstreaming agenda. This finding aligns with Mogelgaard et, al
499 (2018) who argues that, for countries to bridge the implementation gap for adaptation, they must
500 achieve the five levers of leadership, policy frameworks, information and tools, coordination
501 mechanism, and financial processes (56).

502 The progress which has been made by PHCs in the resilience component of integrated monitoring
503 and early warning systems, climate-informed programming and management of environmental
504 determinants of health, was primarily because of the availability of a protocol for integrated disease
505 surveillance and response system (57). This reinforces that these resilience components are
506 integrated into the health management information systems of PHC and its facilities (58). This
507 example illustrates how the mainstreaming climate action into PHC policies and standards with
508 inbuilt accountability mechanisms can trigger systemwide action, and how essential capacity to
509 mainstream climate action into PHC may already be present.

PHC System preparedness

PHC systems in the three study districts show incomplete preparedness (medium risk) to climate exposures compared to 83% of PHC facilities that show higher risk. Participants from District Health Management Committee (DHMT) of PHCs credited collaborations with NGOs for climate action. For instance, NGOs were credited for the preparedness (low risk) of a few lower-level healthcare facilities in the components of WASH and healthcare waste (1% of CHPS, 3% of health centers/clinics) and infrastructure, technology, products, and processes (7% of health centers/clinics). The Health Sector Waste Management Policy developed in 2020 (22) triggered most of these collaborations and provides guidance for interventions. Collaborations with decentralized government departments and the National Disaster Management Organization (NADMO) are cited for the development of emergency preparedness plans for disease outbreaks and natural disasters. These collaborations provide a springboard for bottom-up approaches, buy-in and ownership by PHC actors, and infusion of context-specific knowledge and experience in future health system agenda on climate action. We recommend health system policymakers adopt and encourage decentralized and bottom-up approaches for future mainstreaming efforts.

Incomplete preparation (medium risk) of PHC had not translated to deepening climate action in the operations of the majority of PHC facilities which they supervised. For instance, 93% of community-level CHPS, the community-based clinics with a focus on close-to-client services and 58% of higher-level health centers or clinics to which CHPS refer within the PHC system were unprepared (i.e. unable to respond or higher risk) to observed climate hazards. The inability of PHC systems to translate their resilience, capacity, and associated knowledge to PHC facilities is primarily due to the ad hoc nature of the existing collaborations, which contributes to the disconnect between capacities and preparedness of PHC and PHC facilities. These collaborations

may not always align with formal plans, budgets, knowledge dissemination, support and monitoring systems of PHCs hence difficulties in translating PHC system capacities to practice by healthcare facilities. Even though these partnerships are enhancing climate action within PHC, we argue that these partnerships are not sustainable due to the short -term nature of donor funding. They lack a system-wide approach with institutional integration, and limited learning and scale up opportunities due to poor transition management. This view was reinforced by a participant who suggested capacity building for climate change adaptation should directly target lower level PHC facilities from inception to enhance sustainability. We recommend PHC broadens these collaborations to involve health research and health training institutions to undertake implementation research to enhance scale-up efforts, and government should take steps to integrate planetary health into training curricula for long-term sustainability as observed by a participant. The integration of planetary health in (para) medical curricula also encourages various professional bodies and health care professionals to adequately prepare for climate -related challenges and show leadership for sustainable climate action in PHC operations(59–63). Secondly, mainstreaming climate action into PHC operations requires a shift in mindset and systems to broaden its systems and integrate climate considerations in their operations. This shift requires PHC to develop and incorporate into its systems a strategy to help build and stabilize intersectoral climate action. Such system-wide sustainability transitions have been conceptualized to have inherent tensions, as illustrated in the 'X-curve', developed by Dercks et al. While building better, more sustainable health systems, the existing systems need to be destabilized to allow for the sustainable alternatives to emerge and institutionalize, while undesirable (i.e. unsustainable) practices of the past phase out (64) . As such, health system policy makers and others responsible within the transition need to engage a diversity of PMC stakeholders to gather support and create momentum.

PHC Facility preparedness

Despite the observed multiple exposures of PHC facilities to extreme weather events linked to climate change such as storms, heatwaves, floods, wildfires, and droughts – 83% were reported to be unprepared (higher risk) for these events. The risk level differs by the size of the health facilities, with the larger healthcare facilities generally at lower risk: half (50%) of District hospitals - the most developed and resourced facilities within PHC (65), had a higher risk (unprepared), compared to 58% of health centers/clinics and 93% of the community-based healthcare CHPS facilities. The low revenue generation capacity of lower-level healthcare facilities (CHPS and health center) presents significant challenges to undertaking autonomous adaptation because they have a higher dependency on allocated financial resources which are erratic. The situation presupposes that policymakers need to identify a funding mechanism for active PHC adaptation and mitigations. This finding aligns with the views of Tye and Waslander (2021) who identified funding as a significant challenge for progress in health system adaptation in Ghana (55). On the contrary, hospitals financed autonomous adaptations from their revenues because they generate higher incomes(65). For instance, interview participants from hospitals reported acquiring backup generators and localized water systems from their revenues.

Hospitals show more resilience in the energy component (none of the hospitals in the current study were identified as having a higher risk), primarily because of their ability to finance adaptation measures for energy. The acquisition of diesel-powered generators provides the necessary backup for the provision of essential healthcare services when they encounter challenges with the national grid. Even though these investments in fossil fuel-dependent technology provides some level of energy security, it also contributes to the carbon footprint of hospitals. This calls for increased

investments in green technology alternatives to meet the demands of healthcare facilities. For example, small solar units can provide alternative power for critical departments of the hospital. Some CHPS and health centers/Clinics combined the national electricity grid and solar energy to maintain critical supplies and departments. NGOs and central government projects largely financed these energy resilience efforts.

Infrastructure, technology, products, and processes show significant unpreparedness (higher risk) across all categories of healthcare facilities (50% of hospitals, 68% of health centers, and 89% of CHPS). This is partly because most health centers and hospitals were constructed decades ago, providing an opportunity to couple maintenance cycles with the need for substantial investments to improve their resilience and sustainability. The Ministry of Health, through the CHPS policy, has improved and standardized design for CHPS (66,67) , with an emphasis on adaptation to context. However, local government authorities do not use these designs because of the associated costs and appetite for quick fixes for political gains (as reported by respondents). The appetite for short-term gains by local government authorities results in a missed opportunity to incorporate context-specific climate considerations into projects, considering that CHPS has witnessed a tremendous increase in numbers (63% or 2,086 facilities) between 2015 (68) and 2017 (69), with the local government authorities accounting for construction of 47.8% of them (70) and CHPS remain Ghana's key strategy for attaining universal Health Coverage. (45) Therefore, the PHC should take steps to deepen collaborations with its actors to improve understanding of the nexus between climate change and health through the relevant collaborative and community-based structures to secure buy stakeholders for increased investments to avert cost in the future.

Conclusion

The lack of mainstreaming of Ghana's national climate change and health systems agenda into policies, protocols, standards, and guidelines of PHCs, coupled with limited funding and capacity, largely accounts for the disconnect between the national agenda and PHC operations. Key recommendations include the mainstreaming national climate change and health systems agenda into health policies, protocols, and guidelines with built-in monitoring, accountability, and participatory mechanisms. This approach, which we call "thick Mainstreaming", will stimulate climate-sensitive investments in PHC by local government actors and collective action because of trust and the willingness to invest in PHC. This approach will stimulate autonomous contextual adaptation and provide a framework for PHC to partner with NGOs, who are essential partners in developing PHC systems. It also can allow PHC to create on potential co-benefits with health-determining sectors, engage community actors and strengthen bottom-up approaches for sustainable action for climate-resilient health systems.

Limitations

The authors acknowledge the difficulty in generalizing results of vulnerability assessments. Notwithstanding this, the results can be applicable to most settings in the five northern regions and some transitional zones in the middle belt of Ghana because they share similar ecological characteristics. The results of the vulnerability assessments are context-specific and might not be applicable to settings that experience different hazards. Secondly, only PHC facility managers participated in the Vulnerability assessments of their respective facilities because we believed that they have a good understanding of their operations. Even though the study highlighted the

vulnerabilities of PHC facilities, more inclusive assessments involving teams of diverse staff from PHC facilities especially district hospitals, would have enriched assessments. Nonetheless PHC facility managers have rich experience and knowledge of their respective health facilities, and we believe their assessments are reflective of the respective vulnerabilities of their facilities.

Regarding key informant interviews, this study focused on only PHC leadership, however, we believe that their in-depth knowledge of PHC operation, policies, Ghana's health systems and first-hand application of the relevant WHO tools, making their perspectives reflective of PHC systems. Finally, the focus on PHC managers is because they are solely responsible for health systems policy implementation. Even though the study highlighted facilitators and barriers of national nature, including perspectives from broader local government and policy level actors would have deepened understanding of their perspectives. Nonetheless, PHC mangers have substantial experience with Ghana's health sector policy processes, and we belief that reported facilitators and barriers are likely to be relevant at the policy level. PHCs are standardized across the country and operate based on same policies, standards and programs, hence we envisage that similar results could be obtained by replicating same study approaches in other PHCs in Ghana. Future studies involving broader local government and national level health system actors would further enhance understanding of this topic.

Supporting Information

S1File. Key Informant Interview guide
S2File. Checklist for measuring the climate -resilience of PHC systems

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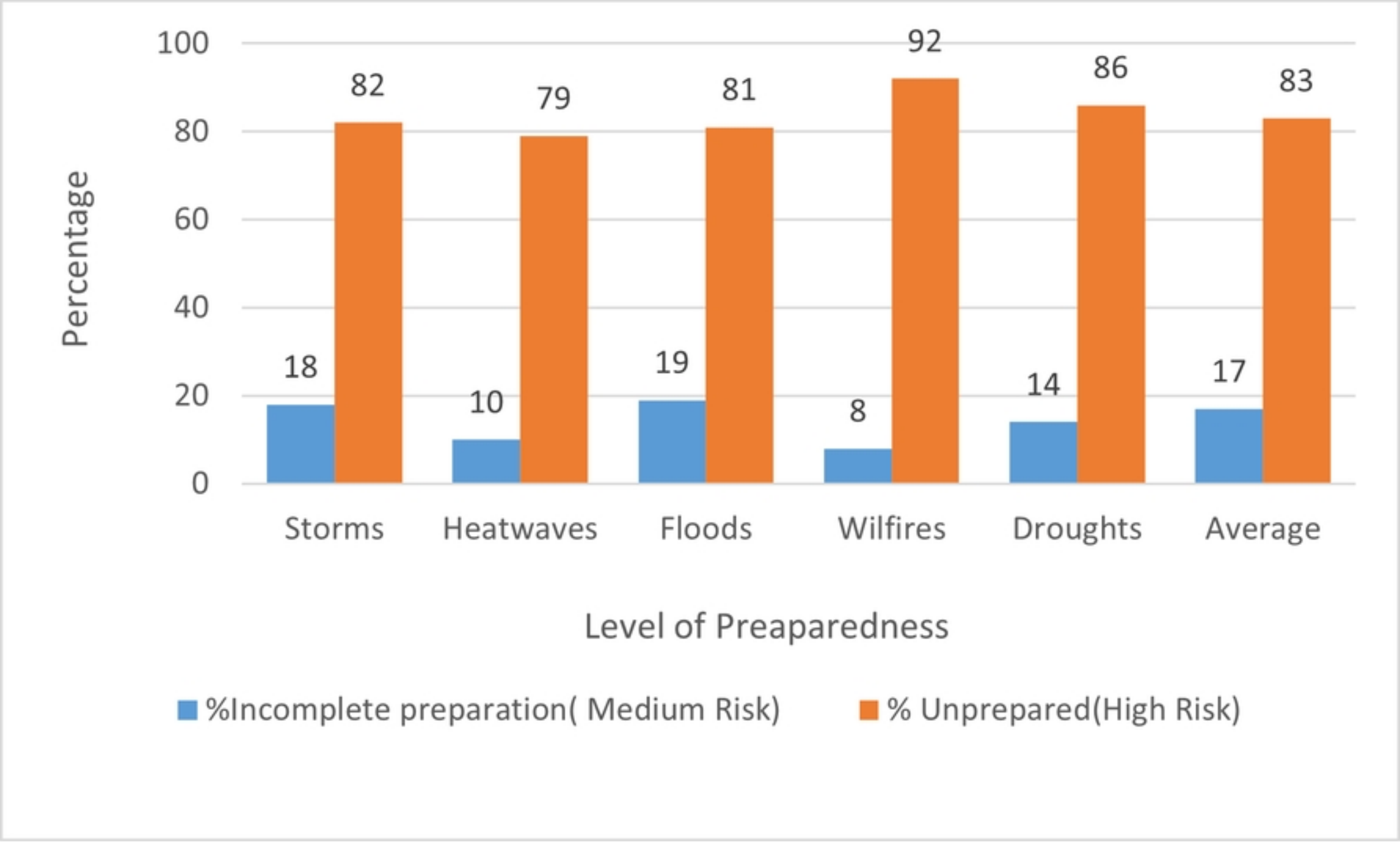
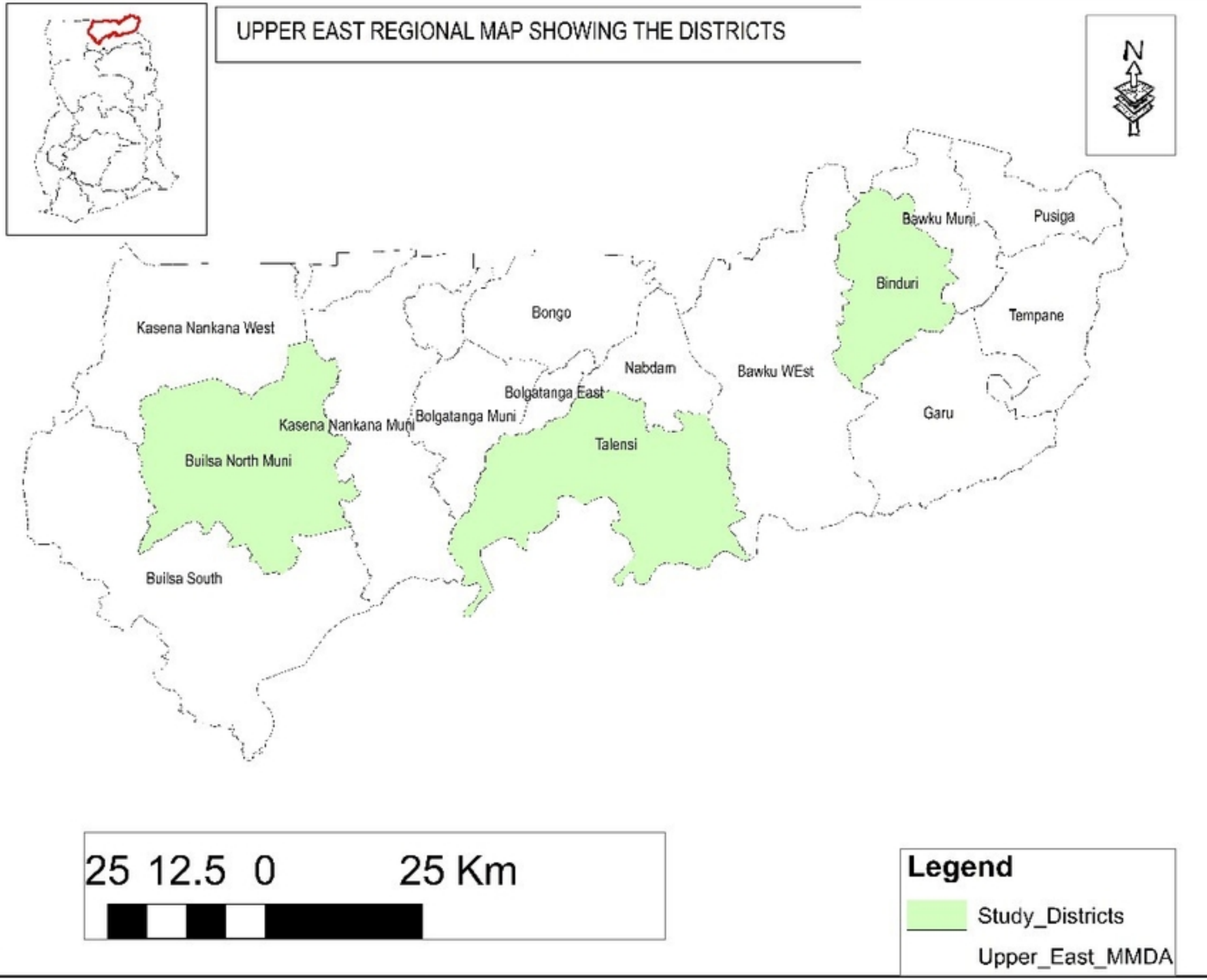

100
80
60
40
20
0
Percentage
82
79
81
92
86
83
18
10
19
8
14
17
Storms
Heatwaves
Floods
Wilfires
Droughts
Average
Level of Preaparedness
%Incomplete preparation(Medium Risk)
% Unprepared(High Risk)

Figure


UPPER EAST REGIONAL MAP SHOWING THE DISTRICTS
N
Bawku Muni
Pusiga
Binduri
Tempane
Bongo
Kasena Nankana West
Nabdam
Bawku WEst
Bolgatanga East
Garu
Kasena Nankana Muni
Bolgatanga Muni
Talensi
Builsa North Muni
Builsa South
25 12.5 0 25 Km
Legend
Study_Districts
Upper_East_MMDA

Figure