Journal of Infrastructure, Policy and Development 2024, 8(14), 9053.
https://doi.org/10.24294/jipd9053

Article

Vulnerability and adaptation strategies of health facilities to climate change at greater Lomé in 2022, Togo (West Africa)

Piniouwe Andje[1,*], Tossou Atchrimi[2], Kossi Komi[3], Brigitte Koko Z. Houedakor[3], Tchakouni Sondou[1], Hezouwe Looky-Djobo[4], Essossinam Pali[1]

[1] Centre d'Excellence Régional sur les Villes Durables en Afrique (CERVIDA-DOUNEDON), University of Lomé, Lomé 01 BP1515, Togo
[2] CERViDA-DOUNEDON, Sport, Health, Development, (2SD), University of Lomé, Lomé 01 BP1515, Togo
[3] CERViDA-DOUNEDON, Research on Cash, Trade and Human Security (LaREESH), University of Lomé, Lomé 01 BP1515, Togo
[4] Public Health Training and Research Center (CRFSP), University of Lomé, Lomé 05 BP 919, Togo
*** Corresponding author:** Piniouwe Andje, andjesophie@yahoo.fr

CITATION

Andje P, Atchrimi T, Komi K, et al. (2024). Vulnerability and adaptation strategies of health facilities to climate change at greater Lomé in 2022, Togo (West Africa). Journal of Infrastructure, Policy and Development. 8(14): 9053. https://doi.org/10.24294/jipd9053

ARTICLE INFO

Received: 10 September 2024
Accepted: 29 October 2024
Available online: 21 November 2024

Abstract: Climate change is causing serious impacts, especially in sub-Saharan Africa, where poverty rates could increase by 2050 if climate and development measures are not taken. The health consequences are diverse and include transmissible and non-transmissible diseases. The objective of this study is to analyze the strategies implemented in health facilities in the Greater Lomé health region to cope with the impacts of climate change. The survey was carried out in 23 health facilities in 2022. It was a descriptive cross-sectional study which was carried out from July to September 2022. Qualitative and quantitative approaches were used. Non-probability sampling method and purposive choice technique were used. Four techniques made it possible to collect the data, namely documentary analysis, survey, interview and observation. The collected data were processed with Excel software and exported to SPSS for analysis. In total, 112 people were surveyed out of 161 planned. According to the results, 52.68% of health facilities did not implement adaptation strategies, 47.32% used adaptive strategies depending on to their means. Strategies exist but at low percentages due to limited technical and financial resources and the insufficiency of innovative policies. These strategies need to be supported in order to make them more effective. The study provides a basis for adopting innovative strategies and encouraging financing for adaptation actions.

Keywords: adaptation; mitigation; resilience; health facilities; climate change; greater Lomé (Togo)

1. Introduction

There is now growing evidence that the Earth is warming at an unprecedented rate due to anthropogenic activities, such as deforestation, urbanization, population growth, industrialization, gas release and greenhouse effect (Monday, 2019). The Intergovernmental Panel on Climate Change (IPCC) rapport projects an increase of 1.5 to 5.8 °C in global average temperature by 2100 due to greenhouse gas emissions (Houghton et al., 2001).

Even if the richest countries are disproportionately responsible for greenhouse gas emissions than developing countries, the consequences of climate change are more serious in the poorest countries, particularly in sub-Saharan Africa. In fact, developing countries are those that adapt the least, due to limited access to climate information, financial and human resources, as well as past and ongoing armed conflicts (Houghton et al., 2001). It is estimated that more than 30 million people in sub-Saharan Africa will fall into poverty if no substantial climate and development action is taken by 2050

(Schleussner et al., 2016). Furthermore, the Gross Domestic Product (GDP) is expected to decrease by 3%, a scenario that poses a significant challenge for adaptation and climate resilience efforts, as it will lead to an increase in the number of people affected (Jafino et al., 2020). In sub-Saharan Africa, the consequences of climate change vary from one country to another and sometimes within the same country due to the existence of several different ecosystems (Brown and Crawford, 2008). Studies have shown serious impacts of climate change on socioeconomic conditions and health outcomes, particularly in developing regions like sub-Saharan Africa. These impacts include a potential increase in poverty rates, a decrease in GDP, and an increase in transmissible and non-transmissible diseases. All sectors, especially health, are vulnerable due to their limited adaptation capacities and their great dependence on resources with high climate sensitivity (Solomon et al., 2007). Health facilities without good health infrastructure, as in most developing countries, will be least able to prepare and cope with the situation without assistance (WHO, 2021). Hospital installations are part of the most energy-intensive category of building installations due to charge management (Ekhaese, et al., 2024). Indeed, climate change has a strong impact on health systems (Sorgho et al., 2020).

The effects of climate change on disease prevalence and human health are multiple. Studies show that climate change is driving unprecedented increases in myriad non-transmissible (WMO, 2021) and transmissible diseases (Rother, 2020; Parihar et al., 2022), such as vector, waterborne diseases, respiratory and cardiovascular diseases (Parihar et al., 2022). Climate change has the potential to trigger heatwaves, floods, droughts and storms, leading to high numbers of deaths and injuries and changing disease scenarios (Campbell-Lendrum et al., 2015). Also, these events have other negative consequences on health, such as deprivation of health care, water facilities, sanitation systems and electricity (thus interrupting the cold chain of vaccines, reagents and certain medicines), blocking access to health facilities, destroying warehouses and stores of health consumables, causing delays and absences of health personnel. To be part of the dynamic fight against climate change, the Togolese government has developed several institutional documents, following the latest report from the Intergovernmental Panel on Climate Change (IPCC). Among these documents, we can cite: National Health Adaptation Plan (PNAS) in 2019, Planned contribution determined at the national level (CPDN) in 2015, National Plan for Adaptation to Climate Change (PNACC) in 2015, the Plan National Action for Adaptation to Climate Change (PANA) in 2009.The National Plan for Adaptation of the Health Sector (PNAS) to climate change with the support of German Cooperation through GIZ has enabled the Togolese government to assess the vulnerability of the health sector to the effects of climate change. Its investigations show that the Grand Lomé health region is an example as a very vulnerable region due to its history of natural disasters such as floods, rising sea levels, violent winds and drought. To do this, we wondered what strategies could be implemented in health establishments in the Greater Lomé health region to make them resilient to climate change. In order to answer this question, we formulate two hypotheses. The first hypothesis: adaptation strategies exist and facilitate the resilience of health establishments. The second hypothesis: adaptation strategies do not exist and health establishments have difficulty resisting the effects of climate change. In order to confirm or refute the two hypotheses,

we decided to conduct this study whose theme is: "Climate change in the health region of Grand Lomé in Togo: vulnerability and adaptation strategies to the environmental constraints of health establishments in 2022" The objective of this study is to analyze the adaptation measures that are put in place in health establishments and the adaptation needs of health systems in the health region of Grand Lomé in Togo with regard to climate change and the dangers associated with it. We will examine the strategies that are put in place on environmental levels, protection of hospital buildings and protection of health personnel and clients. This study is an important step towards the application of policies, plans and strategies to strengthen health systems, mitigate the impacts of climate change and improve overall resilience.

2. Materials and methods

Our study took place in the Grand Lomé health region. Located in the southern part of the country, it has an area of 425.6 km^2 and a population of 2,188,376 inhabitants according to INSEED, (2022). This area is home to 40% to 50% of the national population and 80% of industrial and hotel infrastructure and equipment. The scale of climate risks such as floods are recurrent according to PNACC (2017). It is limited to the north by the prefecture of Zio, to the northwest by the prefecture of Avé, to the south by the Atlantic Ocean, to the southeast by the prefecture of Lakes and to the southwest by Ghana. The climate is dominated by two antagonistic trade winds including the northeast trade wind, regionally called harmattan (hot, dry and dusty) coming from the Sahara and the southwest trade wind or monsoon (humid) originating from the ocean. Atlantic. The zone of demarcation (convergence) between these two trade winds is called the Intertropical Front (ITF). In this region, rising sea levels combined with likely spring tides and storms will increase coastal erosion and subsidence of low-lying areas, leading to extraordinary shoreline setbacks of between 160 m and 240 m over 30 km of coastline, between the Port and Agbodrafo, by 2030 according to PNACC (2017). In Togo, the health system is under the responsibility of the Ministry of Health. It is organized according to a pyramidal structure with three levels: the first floor, the middle floor and the lowest floor. The first stage brings together the Minister's office, the general secretariat, general and central management. The intermediate stage concerns the health regions. The lowest level works with the prefectural health facilities. The Greater Lomé health region is made up of two health districts according to Houssou et al. (2015). These are on the one hand the Agoé Nyvé health district and on the other hand the Gulf health district. The Greater Lomé health region has two reference hospitals according to Houssou et al. (2015). Under each district are the health facilities. The regional management and the two districts operate according to the Bamako initiative with the State operating fund while the two reference hospitals operate only with the State operating fund. It has a subequatorial climate characterized by an alternation of two rainy seasons and two dry seasons with average annual temperatures between 27.2 °C and 30 °C on the coast according to Houssou et al. (2015). Annual precipitation is low, 700 to 800 mm, due to the position of the coast in relation to monsoon flows and the limited number of squall lines in the area mentioned by Ministry of Health and Public Hygiene and Universal Access to Healthcare (MSHP) (2019). Temperatures are high throughout the year, with low

thermal amplitudes between seasons. The seasons are generally divided between a dry season and a rainy season. The Lomé area experiences five (05) dry months, namely January, February, August, November and December. The other months are rainy. The longest rainy period begins at the beginning of the third month of the year and ends in the seventh month. An in-depth analysis of data from the National Directorate of Meteorology in 2022 shows that the shortest rainy period begins in the ninth month and ends at the beginning of the eleventh month. The shortest dry period occurs during the eighth month of the year while the longest dry period begins at the beginning of the eleventh month and ends at the end of the second month of the following year. Our type of study is a descriptive cross-sectional study which took place from Monday 4 July to Friday 2 September 2022, a period of 3 months. The profile of Our study population was made up of health personnel, notably those responsible for infrastructure services, biomedical services, paramedics services and supervisors (internal medicine, laboratories, Hepatho-Gastro-Enterology (HGE), neurology, pediatric surgery, maternity-gynecology, door emergencies, traumatology, pediatrics-neonatology, psychiatry, Oto-Rhino-Laryngology (ORL), stomatology, dermatology, cardiology, ophthalmology, radiology/scanner, hygiene-sanitation service). The inclusion criterion was to be a health personnel working in the health establishments visited or to be a manager of a health service of the health establishments visited. The non-inclusion criterion was refusal to participate in the survey. Regarding the selection of health establishments, it was done according to their intervention platform. The health system in Togo is organized according to a three-level reference pyramid structure: first contact care which constitutes the first reference level is structured in three levels, namely (i) community health agent (ASC), (ii) peripheral care unit (USP) and (iii) the District Hospital; the second level of reference is run by the Regional Hospital Centers (CHR), the Social Medical Centers (CMS), and the tertiary health care which constitutes the third level of reference is provided in the university hospital centers (CHU) and in the specialized referral hospitals. This study focuses only on the CMS in the Grand Lomé health region of which there are 35. But there are 23 Social Medical Centers (CMS) which are part of level 2 and located in areas identified at risk of floods by the Ministry of Health and Public Hygiene (MSHP) in 2022 were visited. For the people surveyed, the non-probability sampling method with reasoned choices was used. So, we made a census of all the people meeting the selection criteria. Apart from service managers, other health personnel capable of providing us with information, particularly surface technicians, were surveyed, always taking into account a reasoned choice. In total, 112 health personnel were surveyed. The number of health personnel surveyed by service and by health establishment is recorded in the **Table 1** below.

Table 1. Number of health personnel surveyed by service and by health establishment.

Region	Health districts	Health establishments	Number of people surveyed
Grand Lomé health region (23)	Agoé Nyvé (10)	CMS Cacaveli	7
		CMS Sangéra	4
		CMS Togblékopé	7

Table 1. (*Continued*).

Region	Health districts	Health establishments	Number of people surveyed
Grand Lomé health region (23)	Agoé Nyvé (10)	CMS Agoé Nyvé	7
		CMS Tsipklonou-kondji	3
		CMS Directaid	4
		CMS Adétikopé	7
		Polyclinic Démakpoé	5
		CMS Legbassito	5
		Clinic Barakat	4
	Golfe (13)	CMS Adakpamé	5
		Health center kodjoviakopé	7
		Lomé Health Center (CSL)	7
		CMS Adamavo	4
		CMS Bè Attikoumé	5
		CMS Devego	3
		CMS Ségbé	4
		CMS Nukafu	6
		CMS Baguida	5
		CMS Adidogomé	6
		CMS Bè Kpota	4
		CMS Nyekonakpoé	5
		CMS Gbétsogbé	4
Total			112

Source: Field data, 2022.

During our investigation, we encountered some difficulties and limitations. We had difficulties related to the accessibility of primary data and also the availability of people to survey. Qualitative and quantitative approaches were used. Four data collection techniques were used, namely documentary analysis, questionnaire survey, interview and observation. Our data sources are represented essentially by data from scientific evaluations and reference documents which were received from the General Directorate of National Meteorology (DGMN), the National Civil Protection Agency (ANPC), the Directorate of the Environment, the University of Lomé and the Ministry of Health and Public Hygiene. The data collected was processed using Excel software and SPSS (Statistical Package for the Social Sciences).

3. Results

In the following lines, we will discuss the results of our study.

3.1. Environmental measures taken in health facilities in the Greater Lomé health region

The **Table 2** presents the environmental measures that are put in place in health facilities for adaptation to climate change in the Greater Lomé health region over the last five years.

By analyzing **Table 2**, in terms of preventive measures, 51.52% of respondents in the Golf health district indicated that PCI committees are set up in their health facilities compared to 47.83% in that of Agoé Nyvé; 59.09% in Golf District have trained HA staff on the process of reducing vector breeding sites (such as water pools) on facility property and surrounding areas compared to 46. 65% in that of Agoé Nyvé; 62.12% in Golf compared to 30.43% in Agoé Nyvé have put in place mechanisms for evacuating wastewater from the health facilities so as not to contaminate drinking water intended for consumption; 37.88% in Golfe versus 30.43% in Agoé Nyvé have developed disaster response plans and water system restoration plan with adequate supplies (such as chlorine, filters or other water treatment technologies). Water treatment, rapid water analysis kit) easily accessible. Regarding the improvement of training and support provided to health personnel to enable them to better know how and when to disseminate messages on water, we record 49.91% in Golfe against 32.61% in Agoé Nyvé; 36.36% in Golf compared to 28.26% in Agoé Nyvé have kitchens with a sufficient supply of clean and drinking water. 48.48% Golfe versus 39.13% Agoé Nyvé have fitted their water storage tanks with appropriate covers to prevent access or contamination; 31.82% versus 43.48% installed check valves on water supply lines to prevent backflows. Areas of natural infiltration of flood waters exist to reduce the risk of flooding of the establishment according to 34.85% of respondents in the Golf health district compared to 19.57% in that of Agoé Nyvé; 43.94% against 21.74% built water evacuation channels. Waste problems resulting from climatic hazards are assessed in order to develop and implement safe procedures and specialized treatment, if necessary, according to 30.3% of respondents in the Golf district compared to 17.39% in that of Agoé Nyvé. 56.06% versus 47.83% have a means of transporting healthcare waste (including hazardous waste from healthcare facilities) that is properly managed in the event of extreme weather events. According to the respondents, 39.39% versus 43.48% have waste pits built to withstand climatic events and emergency situations. The safety of waste disposal from health facilities is ensured during emergency or disaster situations linked to climate according to 48.48% of respondents in the Golfe district compared to 47.83% in that of Agoé Nyvé; 36.36% against 26,09% of respondents have designed sanitation technologies to be more resilient to climatic hazards and capable of operating in various climatic conditions, ensuring that a failure in one part of the service chain does not lead to the failure of the entire service. Regarding the implementation of arrangements for staff catering (rehabilitation or temporary relocation of the restaurant), we had to record 7.58% in the Golfe district compared to 6.52% in that of Agoé Nyvé.

Table 2. Environmental measures taken.

	Golf (*n*: 66)		Agoé Nyivé (*n*: 46)	
	Yes	**No**	**Yes**	**No**
Preventive measures				
Functional establishment of PCI (Infection Prevention and Control) committees	34 (51.52%)	32 (48.48%)	22 (47.83%)	24 (52.17%)
Training HA (Hygiene and Sanitation) staff in reducing vector breeding sites (such as pools of water) on facility property and surrounding areas	39 (59.09%)	27 (40.91%)	21 (45.65%)	25 (54.35%)
Implementation of wastewater evacuation mechanisms from the health establishment to avoid contaminating drinking water intended for local consumption	41 (62.12%)	25 (37.88%)	14 (30.43%)	32 (69.57%)
Developing the disaster response plan and restoring the water system with adequate supplies (such as chlorine, filters or other water treatment technologies, rapid water testing kit) easily accessible	25 (37.88%)	41 (62.12%)	14 (30.43%)	32 (69.57%)
Improved training and support for health workers to better understand how and when to deliver water messages	27 (40.91%)	39 (59.09%)	15 (32.61%)	31 (67.39%)
Provide kitchens with an adequate supply of clean, potable water	24 (36.36%)	42 (63.64%)	13 (28.26%)	33 (71.74%)
Provide water storage tanks with appropriate covers to prevent access or contamination	32 (48.48%)	34 (51.52%)	18 (39.13%)	28 (60.87%)
Install check valves on water supply lines to prevent backflows	21 (31.82%)	45 (68.18%)	20 (43.48%)	26 (56.52%)
Areas of natural floodwater infiltration exist to reduce the risk of flooding of the facility	23 (34.85%)	43 (65.15%)	9 (19.57%)	37 (80.43%)
Construction of water drainage channels	29 (43.94%)	37 (56.06%)	10 (21.74%)	36 (78.26%)
Waste issues resulting from climatic hazards are assessed to develop and implement safe procedures and specialized treatment where appropriate	20 (30.3%)	46 (69.7%)	8 (17.39%)	38 (82.61%)
Transport of healthcare waste (including hazardous waste from healthcare facilities) is properly managed during extreme weather events	37 (56.06%)	29 (43.94%)	22 (47.83%)	24 (52.17%)
Waste pits are built to withstand weather events and emergencies	26 (39.39%)	40 (60.61%)	20 (43.48%)	26 (56.52%)
Safe disposal of waste from healthcare facilities is ensured during climate-related emergencies or disasters	32 (48.48%)	34 (51.52%)	22 (47.83%)	24 (52.17%)
Sanitation technologies designed to be more resilient to climatic hazards and capable of operating in a variety of climatic conditions, ensuring that a failure in one part of the service chain does not lead to the failure of the entire service	24 (36.36%)	42 (63.64%)	12 (26.09%)	34 (73.91%)
Implementation of arrangements for staff catering (rehabilitation or temporary relocation of the restaurant)	5 (7.58%)	61 (92.42%)	3 (6.52%)	43 (93.48%)
Curative measures				
Implementation of the risk management plan linked to the effects of climate change on WASH (water, sanitation and hygiene) services	28 (42.42%)	38 (57.58%)	15 (32.61%)	31 (67.39%)
Water of appropriate quality is provided for medical activities as well as vulnerable patients	36 (54.55%)	30 (45.45%)	26 (56.52%)	20 (43.48%)
Healthcare facility is able to provide clean water to clients and healthcare staff during climate-related disasters	39 (59.09%)	27 (40.91%)	24 (52.17%)	22 (47.83%)
Implementation of disaster response plan and water system restoration plan with adequate supplies (such as chlorine, filters or other water treatment technologies, rapid water testing kit water) is easily accessible	27 (40.91%)	39 (59.09%)	14 (30.43%)	32 (69.57%)
Efficient and rapid distribution of safe water is ensured in emergency situations, in the short term and in the long term	27 (40.91%)	39 (59.09%)	16 (34.78%)	30 (65.22%)
Improvement of storage areas to store additional waste generated by increased demands on healthcare facilities (for example, in the event of epidemics or in the face of the consequences of climate-related events)	26 (39.39%)	40 (60.61%)	10 (21.74%)	36 (78.26%)
Healthcare facilities conserve and manage water to reduce consumption	29 (43.94%)	37 (56.06%)	20 (43.48%)	26 (56.52%)

Table 2. (*Continued*).

	Golf (*n*: 66)		Agoé Nyivé (*n*: 46)	
	Yes	**No**	**Yes**	**No**
Ability to store water safely, avoiding mosquito breeding sites	34 (51.52%)	32 (48.48%)	27 (58.7%)	19 (41.3%)
Water is not contaminated in the healthcare facility during storage, distribution and transportation	32 (48.48%)	34 (51.52%)	25 (54.35%)	21 (45.65%)
Rainwater is treated safely (avoid stagnant water near the establishment or affecting surrounding homes)	21 (31.82%)	45 (68.18%)	4 (8.7%)	42 (91.3%)
Drinking water in healthcare facilities is treated with residual disinfectant to ensure microbial safety until the point of consumption or use, particularly after a flood disaster	24 (36.36%)	42 (63.64%)	26 (56.52%)	20 (43.48%)

Source: Field data, 2022.

In terms of curative measures, the proportion of 42.42% of respondents in the Golfe district compared to 32.61% in that of Agoé Nyvé implemented the risk management plan linked to the effects of climate change. on environmental services. A percentage of 54.55% of respondents in the Golfe district compared to 56.52% in Agoé Nyvé provide water of appropriate quality for medical activities as well as vulnerable patients. According to 59.09% versus 52.17% of respondents, their healthcare facility was able to provide clean water to patients and healthcare staff during climate-related disasters. The respondents at a percentage of 40.91% compared to 30.43% were implementing the disaster response plan and the water system restoration plan with adequate supplies (such as chlorine, filters or other water treatment technologies, rapid water analysis kit) are easily accessible. According to the respondents, 40.91% in the Golfe district compared to 34.78% in that of Agoé Nyvé have an efficient and rapid distribution of safe water is ensured in emergency situations, in the short term and the long term. 39.39% compared to 21.74% of respondents have storage areas making it possible to store additional waste generated by the increase in demands on health facilities (for example, in the event of epidemics or in the face of the consequences of events climate-related) improved. According to 43.94% of respondents in Golfe and 43.48% in Agoé Nyvé, water was conserved and managed in order to reduce consumption in their health establishment while 51.52% against 58.7% have opportunities to store water safely, avoiding mosquito breeding sites. According to 48.48% against 54.35%, water is not contaminated in the healthcare structure during its storage, distribution and transport. According to 31.82% of respondents in the Golfe district and 8.7% in that of Agoé Nyvé, their rainwater is treated safely (avoid stagnant water near the establishment or affecting surrounding homes). A percentage of 36.36% versus 56.52% of respondents treated their water with a residual disinfectant to ensure microbial safety until the stage of consumption or use, particularly after a flood.

3.2. Measures taken to protect buildings in health facilities in the Greater Lomé health region

Table 3 presents the measures taken in health facilities to protect buildings from the impacts of climate change in the Greater Lomé health region over the last five years.

Table 3. Measures taken to protect buildings.

	Golf (*n*: 66)		**Agoé Nyivé (*n*: 46)**	
	Yes	**No**	**Yes**	**No**
Preventive measures				
Assess climate change risks to health facility infrastructure to identify locations where services could be disrupted by flooding, water shortage, high winds, rising water levels	28 (42.42%)	38 (57.58%)	9 (19.57%)	37 (80.43%)
Establish a schedule for emptying latrines before flood season to avoid overflows	33 (50%)	33 (50%)	11 (23.91%)	35 (76.09%)
Installation of waterproof covers for septic tanks and check valves on pipes to prevent backflows	39 (59.09%)	27 (40.91%)	22 (47.83%)	24 (52.17%)
Please ensure that sewer and septic vents are above anticipated flood lines	37 (56.06%)	29 (43.94%)	22 (47.83%)	24 (52.17%)
Compliance with building construction standards (dominant wind direction, room ventilation, etc.)	36 (54.55%)	30 (45.45%)	32 (69.57%)	14 (30.43%)
Use of suitable materials for the construction of buildings	43 (65.15%)	23 (34.85%)	31 (67.39%)	15 (32.61%)
Curative measures				
Spot treatment	35 (53.03%)	31 (46.97%)	24 (52.17%)	22 (47.83%)
Relocation	21 (31.82%)	45 (68.18%)	8 (17.39%)	38 (82.61%)

Source: Field data, 2022.

In terms of preventive measures, 42.42% of respondents in Golfe compared to 19.57% in Agoé Nyvé carried out an assessment of the risks of climate change for the infrastructure of the health establishment in order to identify places where Services could be disrupted by flooding, water shortage, strong winds, rising water levels. Fifty percent (50%) in Golfe compared to 23.91% in Agoé Nyvé had established a timetable for emptying latrines before the rainy season in order to avoid overflows. In the Golfe district 59.09% compared to 47.83% in the Agoé Nyvé district had installations of waterproof covers for septic tanks and non-return valves on the pipes to prevent backflows. Respectively in Golfe and Agoé Nyvé, 56.06% and 47.83% ensured that sewer and septic tank vents were above the planned flood lines. According to 54.55% of respondents in Golfe compared to 69.57% in Agoé Nyvé, they respected building construction standards (prevailing wind direction, ventilation of rooms, etc.). In the Golfe district 65.15% compared to 67.39% in the Agoè Nyvé district used suitable materials for the construction of buildings.

In terms of curative measures, in the Golfe district 53.03% compared to 52.17% in Agoé Nyvé carried out localized treatments and 31.82% compared to 17.39% carried out relocation.

3.3. Measures taken to protect health personnel and clients in health facilities in the Greater Lomé health region

Table 4 presents the measures taken to ensure the protection of health personnel and clients against the impacts of climate change in health facilities in the Greater Lomé health region over the last five years. It emerges from the analysis of **Table 3** that 60.61% of respondents in Golfe compared to 56.52% in Agoé Nyvé train their staff and 28.79% compared to 23.91% plan motivation measures (because of the increased workload) in terms of preventive measures. On the other hand, as curative measures, 57.58% of respondents in Golfe compared to 32.61% in Agoé Nyvé use

health personnel from other centers, 62.12% compared to 69.57% use emergency plans from the ministry in charge of health and 56.06% compared to 45.65% use emergency plans of health training.

Table 4. Measures taken to protect health personnel and clients.

	Golf (*n*: 66)		**Agoe Nyivé (*n*: 46)**	
	Yes	**No**	**Yes**	**No**
Preventive measures				
Staff training	40 (60.61%)	26 (39.39%)	26 (56.52%)	20 (43.48%)
Forecast of motivation measures (due to increased workload)	19 (28.79%)	47 (71.21%)	11 (23.91%)	35 (76.09%)
Curative measures				
Use of health personnel from other centers	38 (57.58%)	28 (42.42%)	15 (32.61%)	31 (67.39%)
Use of ministry emergency plans	41 (62.12%)	25 (37.88%)	32 (69.57%)	14 (30.43%)
Use of health facility emergency plans	37 (56.06%)	29 (43.94%)	21 (45.65%)	25 (54.35%)

Source: Field data, 2022.

4. Climate risk adaptation strategies implemented in health facilities in the Greater Lomé health region

The **Table 5** presents the climate risk strategies implemented in health facilities in the Greater Lomé health region over the last five years.

4.1. Measures taken in the event of drought

Table 5 presents the measures taken in relation to drought. It appears from the analysis of **Table 5** that the following measures are taken in the event of drought (delayed rain) to ensure patients' level of protection.

Table 5. Measures in the event of drought (delayed rain) to ensure staff and customers their level of protection.

	Golf (*n*: 66)		**Agoe Nyivé (*n*: 46)**	
	Yes	**No**	**Yes**	**No**
Preventive measures				
Development of a long-term water harvesting system is in place to ensure access to water during extreme climatic events (such as rain catchment during the monsoon and storage of water in reservoirs in view of its use during the dry season	16 (24.24%)	50 (75.76%)	6 (13.04%)	40 (86.96%)
Installations of rainwater harvesting devices (with safe storage), in locations where rainfall is sufficient and regular or easy to collect, and regularly inspected for possible damage	12 (18.18%)	54 (81.82%)	4 (8.7%)	42 (91.3%)
Provide water storage in the health facility sufficient to meet the needs of the facility in the event of a climatic phenomenon	27 (40.91%)	39 (59.09%)	21 (45.65%)	25 (54.35%)
Water storage tanks are not located in areas susceptible to flooding, reducing the risk of contamination	28 (42.42%)	38 (57.58%)	20 (43.48%)	26 (56.52%)
Plastic water storage tanks supported and anchored to withstand high winds	24 (36.36%)	42 (63.64%)	11 (23.91%)	35 (76.09%)
Curative measures				
Biocleaning reinforcement	37 (56.06%)	29 (43.94%)	32 (69.57%)	14 (30.43%)
Use of ministry emergency plans	40 (60.61%)	26 (39.39%)	30 (65.22%)	16 (34.78%)
Use of health facility emergency plans	37 (56.06%)	29 (43.94%)	19 (41.3%)	27 (58.7%)

Source: Field data, 2022.

As preventive measures, 24.24% of respondents in Golfe compared to 13.04% in Agoé Nyvé have a long-term water collection system which is put in place to guarantee access to water during extreme climatic phenomena. (such as capturing rain during the monsoon and storing water in reservoirs for use during the dry season). According to those surveyed, 81.82% in Golfe compared to 91.3% in Agoé Nyvé have not installed devices for collecting rainwater (with safe storage). According to 59.09% in Golfe and 54.35% in Agoé Nyvé have not provided for sufficient water storage in the health establishment to meet the needs of the establishment in the event of an extreme climatic phenomenon. According to the respondents, 57.58% against 56.52% did not install water storage tanks in areas likely to be flooded to reduce the risk of contamination. The results show that 63.64% of respondents in Golfe compared to 75.09% in Agoé Nyvé do not have plastic water storage tanks supported and anchored to resist strong winds.

Considering the curative measures, a proportion of 56.06% of respondents in Golfe compared to 69.57% in that of Agoé Nyvé proceed to strengthen biocleaning, 60.61% compared to 65.22% resort to emergency plans of the ministry in charge of health which developed emergency medical services and developed and implemented a national health monitoring system (MSHP, 2019) and 56.06% against 41.3% use emergency plans of health training.

4.2. Measures taken in the event of flooding

Figure 1 illustrates the measures that are taken in the event of flooding. The analysis of **Figure 1** shows that 58.7% of respondents in the Agoe Nyivé district and 53.03% in the Golfe district, or 55.87% of respondents in the Greater Lomé health region, made the chlorine for water treatment in the event of flooding, 41.3% versus 57.58% or 49.44% of respondents emptied the pits and cesspools; 43.48% against 40.91% or 42.20% of respondents respected the medical waste management plan; 21.74% against 28.79% or 25.27% of respondents carry out localized treatment of slabs and 13.04% against 16.67% or 14.85% of respondents temporarily move the places where health services are provided.

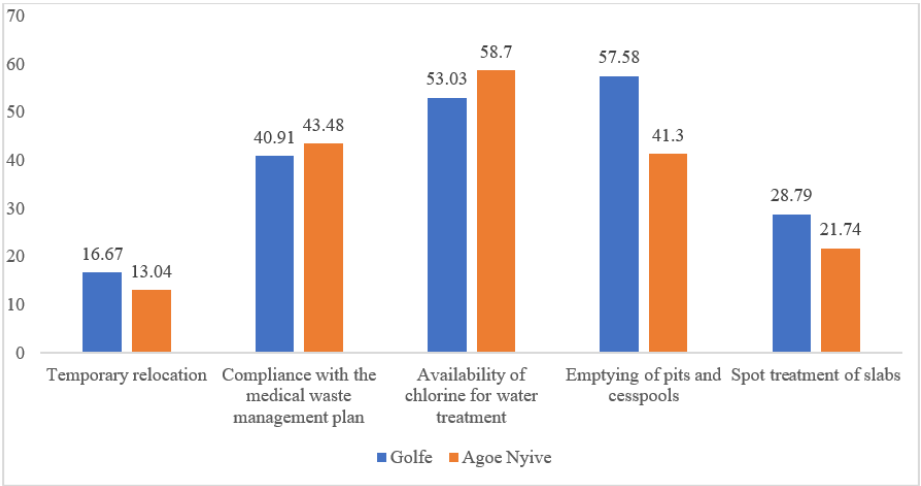

Figure 1. Actions taken in case of flooding (%).

Source: Field data, 2022.

4.3. Measures taken in case of high heat

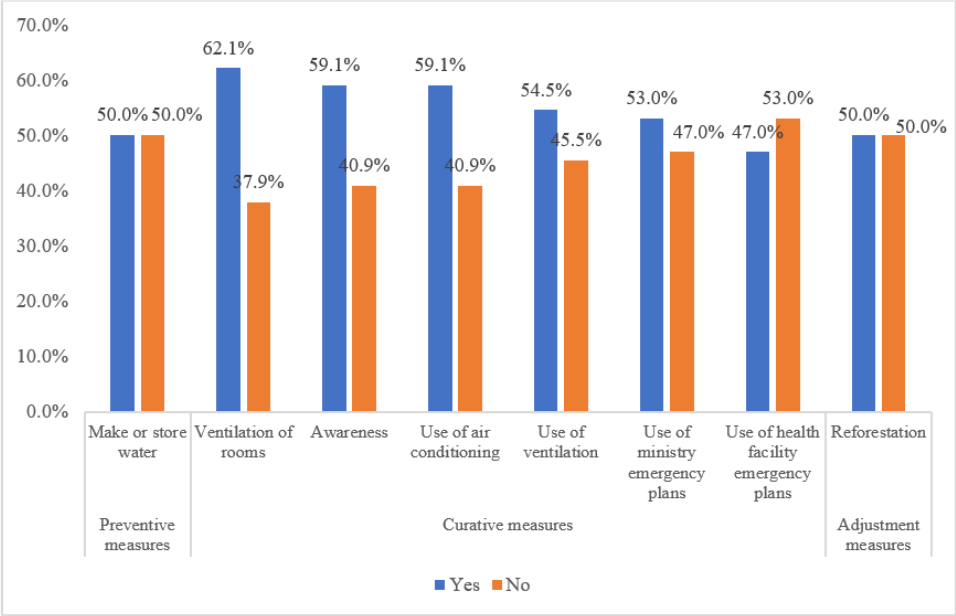

Figure 2. Measures in case of excessive heat in the Golf.

Source: Field data, 2022.

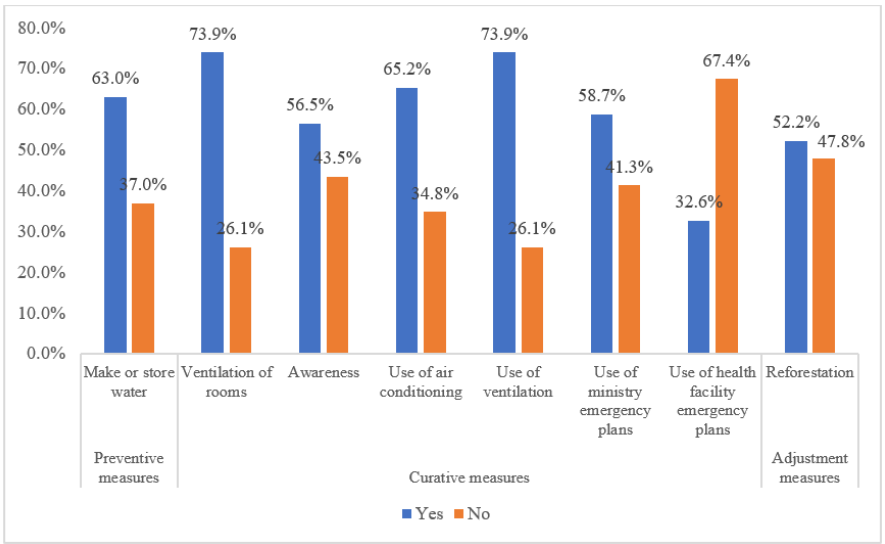

Figure 3. Measures in the event of excessive heat in the Agoé Nyvé district.

Source: Field data, 2022.

Figures 2 and **3** present the measures taken during the heat to ensure the protection of health personnel and clients in health facilities in the Greater Lomé health region made up of the Golfe district and that of Agoé Nyvé. **Figure 2** shows the different measures taken in health facilities in the Golf district to protect staff and customers in the event of high heat. **Figure 3** shows us the different measures taken in health facilities in the Agoé Nyvé district to protect staff and clients in the event of high heat. By analyzing **Figures 2** and **3**, 50% of the people surveyed in Golfe compared to 63.04% in Agoé Nyvé made or stored water as preventive measures. As curative measures, 62.12% of respondents in the Golf district compared to 73.91% in

that of Agoé Nyvé carried out ventilation of the rooms; 59.09% versus 56.52% raise awareness; 59.59% versus 65.22% used air conditioning; 54.55% versus 73.91% used ventilation; 53.03% versus 58.07% used the ministry's emergency plans and 46.97% versus 32.61% used the health facility's emergency plans. The results show that 50% of respondents in the Golf district compared to 52.17% in that of Agoé Nyvé carried out reforestation in terms of adjustment measures.

4.4. Measures taken against strong winds

Table 6 shows us the measures taken against violent winds. Addressing preventive measures, 54.55% of respondents in the Golfe district compared to 65.22% in Agoé Nyvé carried out reforestation; 50% versus 58.7% used suitable materials for the construction of buildings and 62.12% versus 58.7% respected building construction standards (prevailing wind direction, ventilation of rooms). With regard to curative measures, 54.55% of respondents in the Golfe district compared to 69.57% in the Agoé Nyvé district used the ministry's emergency plans and 54.55% compared to 45.65% used the emergency plans of the health facility. According to 53.03 respondents in the Golfe district compared to 50% in the Agoé Nyvé district, reforestation constitutes their adjustment measure.

Table 6. Measures taken against strong winds.

	Golf (*n*: 66)		**Agoe Nyivé (*n*: 46)**	
	Yes	**No**	**Yes**	**No**
Preventive measures				
Reforestation	36 (54.55%)	30 (45.45%)	30 (65.22%)	16 (34.78%)
Use of suitable materials for the construction of buildings	33 (50%)	33 (50%)	27 (58.7%)	19 (41.3%)
Compliance with building construction standards (dominant wind direction, room ventilation, etc.)	41 (62.12%)	25 (37.88%)	27 (58.7%)	19 (41.3%)
Curative measures				
Use of ministry emergency plans	36 (54.55%)	30 (45.45%)	32 (69.57%)	14 (30.43%)
Use of health facility emergency plans	36 (54.55%)	30 (45.45%)	21 (45.65%)	25 (54.35%)
Adjustment measures				
Reforestation	35 (53.03%)	31 (46.97%)	23 (50%)	23 (50%)

Source: Field data, 2022.

4.5. Inability to implement adaptation measures

Figure 4 gives us the proportions of non-implementation of adaptability measures in health facilities.

According to the results in **Figure 4**, 53.03% of respondents in the Golf district said that they were unable to implement adaptation measures due to insufficient resources compared to 52.17% in the Golf district. 'Agoé Nyvé or 52.68% in the Greater Lomé health region.

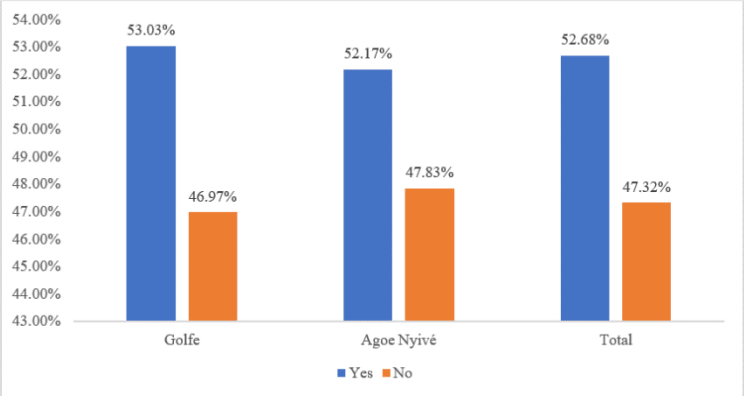

Figure 4. Inability to implement adaptation measures to climate change.
Source: Field data, 2022.

5. Discussion

The discussion of the results was essentially based around the following points: the achievement of objectives and quality and the validity of the results and

comparing the results with those of other studies.

5.1. Achievement of objectives and the quality and validity of the results

In total, 23 health facilities were visited and 112 health personnel were involved in the study out of the 161 (7 for each CMS) planned. The general objective of this study was to study the vulnerability of health facilities to climate change: adaptation strategies to environmental constraints in the Greater Lomé health region. Using the collection techniques and tools selected, the data that was collected from all our targets (nursing staff, administrative staff), processed and analyzed, allowed us to:

1) Describe the different types of measures taken by healthcare facilities for the protection of the environment, buildings and healthcare staff and clients.
2) describe adaptation measures to climate risks
3) Thus, our objectives were 100% achieved given the results obtained.

Non-probability sampling method with purposive choice technique were used.

The collection tools used were an interview guide, an observation grid, a questionnaire and a documentary exploitation sheet. We carried out a pre-test of these tools and some questions were reformulated. The diversity of tools made it possible to collect data from various sources, this made it possible to triangulate the data and reduce bias. Also, at the end of each survey day, we ensured that there was no missing data. The training of the investigators made it possible to reduce possible bias. The choice of health facilities and people surveyed for the study was reasoned. It was based on health facilities at high risk of vulnerability to the risks of climate change in the Greater Lomé health region. This method made it possible to minimize selection and memory bias. The documents that were used allowed us to collect complete information to achieve our study objectives. The individual interview and the administration of the questionnaire to the reference people made it possible to assess the organization of the implementation of adaptation strategies to environmental constraints.

5.2. Comparison of results with those of other studies

Indeed, referring to the measures that had been taken by health system managers to adapt to extreme weather events, the results of our survey showed low proportions. This shows that our study area was not far from suffering the consequences in accordance with the report of WMO (2021) according to which, by 2030, it is estimated that up to 118 million extremely poor people (i.e., living on less than $1.90 per day) will be exposed to drought, floods and extreme heat in Africa if adequate measures are not taken. Going in this direction and according to the results of our research, 52.68% of respondents in the Greater Lomé health region said that they were unable to implement adaptation measures due to incapacity. These results are consistent with the study conducted by Szivós et al., (2024). Our results showed that 44.99% of respondents in this region say they cannot implement adaptation measures because of the unavailability of adaptability measures in the environment; 48.02% said that it is due to insufficient financial means, 30.48% said that it is the lack of mastery of technology and 7.69% in the district of Agoé Nyvé said that there is a lack of innovative sustainable development policies. These results rhyme with those of Weijian et al. (2024) according to which public health experts, administrators, sociologists, psychologists, urban planners, architects, landscapers and public safety officials must collaborate effectively to create feasible interventions to increase levels of resilience. This analysis is supported by the WHO (2019) which states that despite progress in adaptation in the health sector, the implementation of the adaptation framework continues to face certain technical and institutional challenges at the national level, namely: the weakness of technical and scientific capacities in the field of climate change and health, the inadequacy of integrated approaches; insufficient funding; and the lack of advocacy regarding the health effects of climate change. This analysis was also confirmed by Solomon et al., (2007).

The study by Oyedepo et al. (2022), on the other hand, showed that technological innovation had provided opportunities for the development of multifunctional applications in the fields of energy, construction, infrastructure, electronics and buildings. This result shows that Togo must make an effort in technological innovation.

Our study on the level of implementation of adaptation strategies revealed that the problems of availability of water resources to secure the availability of drinking water and adapt to the acceleration of intense precipitation phenomena in the middle of care exists. In comparison with the results of Szivós et al. (2024), our results are consistent on the basis that social protection systems are only partially able to adapt to change due to a lack of resources, and therefore health integration alone cannot be assessed (Josep et al., 2008). Thus, in interpreting the functions of the health system, it will be necessary to give importance to the financing of health services, the quality of care, the development of resources and the appropriate level of government intervention (Carrin, 2003).

The results of our study agree with those obtained by Redaud1 et al. (2009) who noted that water saving campaigns (fight against leaks on the networks, public information campaigns, renewal and improvement of performance of sanitary or washing equipment) are very effective in France because, for several years, a reduction in the volumes of water distributed to populations for a level of service has been

maintained. Also, referring to the same author (Redaud1 et al., 2009), in certain conditions and in particular in contexts of climate change, the water supply, at the level of health facilities, now led to balancing the traditional resources (surface water and groundwater) with the interest of developing alternative resources (wastewater recycling, rainwater recovery, aquifer recharge, desalination). From this study, we can note that the repercussions of climate change on the operation of sanitation systems have been examined and some will be positive (accelerated biological reactions) and others negative (increased energy consumption). Sanitation networks will be more affected than wastewater treatment plants, particularly in terms of managing rainy events. Problems linked to odors and corrosion phenomena will also become acute if arrangements are not taken.

The results of our study corroborate with those of Kouamé et al. (2022), according to which, despite the efforts made at the national and international levels to mitigate the harmful effects of climate change on the environment and human health in developing countries. It is clear that the associated risks and associated effects persist.

Eghosa et al. (2024) conducted a study on identifying bioclimatic design strategies that could optimize energy efficiency in orthopedic hospitals, assessing energy efficiency needs in the hospital orthopedic and analysis of the effects of bioclimatic design strategies aimed at improving energy efficiency in an orthopedic hospital in Nigeria. From this study and in view of our results, similar studies should be requested. In the same sense, Xhexhi (2023) also claimed in his study that bioclimatic changes and the benefits of energy-conscious building design improved the overall quality of life.

Referring to this study, we can say that these bioclimatic design strategies could be implemented in health facilities in the Greater Lomé health region to improve energy efficiency.

6. Conclusion

The issue of climate change and variability is a concern of governments, international organizations and several scientific entities because of their damaging effects on ecosystems and human activities. The objective of this study was to analyze the strategies implemented in health facilities in the Greater Lomé health region to cope with the impacts of climate change. Following our study, we note that adaptation strategies exist and health establishments are able to fight against the effects of climate change, which confirms hypothesis 1, therefore the hypothesis 2 is rejected. The results obtained showed that the health region of Grand Lomé in Togo faces significant challenges with regard to adaptation, whether it involves taking into account the reality of today's climate and the effects expected in the more or less distant future, the consequences of the changes are predictable. These challenges concern the inadequacies noted in part in the use of materials resistant to violent winds, ventilation and air conditioning of rooms, availability of safe drinking water, compliance with the medical waste management plan, implementation adaptation measures due to incapacity of technical and financial means and the insufficiency of innovative sustainable development policies. It should also be noted that at the end of this study,

we note that the implementation of adaptation measures also depends on the perception that the people interviewed have on climate change. The perceptions of those interviewed differ from one person to another. This is sometimes explained by the level of information on climate change and its impacts on health. Also, by the level of education, the level of access to information, the sources of the information received and the influence of tradition (because some people think that it is the non-compliance with prohibitions and disobedience of the gods) and advocates sacrifices to ask forgiveness from the gods. Thus, the priority political actions are: support and accompaniment of health establishments to prevent and fight against vector-borne diseases; establishment of an early warning system to provide real-time information about flooding; strengthen the coastal protection system against coastal erosion in the eastern part of the autonomous port of Lomé; support for the capture of water resources. Many actions must be taken by leaders to adapt and mitigate the effects of climate change in health facilities in Togo. Health system managers in the Greater Lomé health region could draw on experiences developed elsewhere.

The attention of managers should also be directed towards the search for solutions to adapt to climate change by encouraging researchers to take an interest in it to make their contributions to reducing risks and effects and proposing adaptation approaches. which take into account the realities of the country. It is also important that health system managers focus on finding adaptation measures in relation to each health structure according to its intervention level (Type 1, Type 2 or type 3).

Author contributions: Conceptualization, PA; methodology, PA; validation, TA, KK, BKZH and HLD; formal analysis, PA; investigation, PA; resources, PA and EP; data curation, PA; writing—original draft preparation, PA; writing—review and editing, TS, EP, HLD and BKZH; visualization, TA; supervision, TA and KK; project administration, PA, EP and TA; funding acquisition, TA. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Regional Center of Excellence on Sustainable Cities in Africa (CERViDA-DOUNEDON), the Association of African Universities (AAU) and the World Bank, grant number IDA 5360 TG.

Acknowledgments: We would like to thank the Regional Center of Excellence on Sustainable Cities of Africa (CERViDA-DOUNEDON), the Association of African Universities (AAU) and the World Bank for providing the necessary funding that facilitated our research work leading to these results. We would also like to express our gratitude to Coffi AHOLOU, and Kossiwa ZINSOU-KLASSOU, for their support and enlightened leadership in promoting this Center of Excellence.

Conflict of interest: The authors declare no conflict of interest.

References

Brown, O., & Crawford, A. (2008). Climate change: A new threat to stability in West Africa? Evidence from Ghana and Burkina Faso. African Security Review, 17(3), 39–57. https://doi.org/10.1080/10246029.2008.9627482

Campbell-Lendrum, D.; Manga, L.; Bagayoko, M.; Sommerfeld, J. Climate change and vector-borne diseases: What are the implications for public health research and policy? Philos. Trans. R. Soc. B Biol. Sci. 2015, 370, 20130552. [CrossRef] [PubMed]

Carrin, G., & Hanvoravongchai, P. (2003). Provider payments and patient charges as policy tools for cost-containment: How successful are they in high-income countries? Human Resources for Health, 1(1). https://doi.org/10.1186/1478-4491-1-6

Ekhaese EN, Mohammed IA, Akindoyin PO. (2024). Bioclimatic design strategies and energy efficiency in an orthopaedic hospital in Nigerian cities: A cross-sectional study. Journal of Infrastructure, Policy and Development. 8(7): 2736.

Gautam A., GP Shivakoti, Evolution and Impacts of Community Based Forest Management in the Hills of Nepal, Asian Institute of Technology Thailand, 2001.

GIEC, 2007: Bilan 2007 des changements climatiques, Contribution des Groupes de travail I, II et III au quatrième Rapport d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat (Équipe de rédaction principale, Pachauri, R.K. et Reisinger, A.), publié sous la direction de GIEC, Genève, Suisse, 103 p.

Houghton, J.T.; Ding, Y.; Griggs, D.J.; Noguer, M.; van der Linden, P.J.; Dai, X.; Maskell, K.; Johnson, C.A. Climate Change 2001:The Scientific Basis; Contribution of Working Group I to the Third Assessment Reportof the Intergovernmental Panel on Climate Change, (IPCC), Cambridge University Press: Cambridge, UK, 2001; Volume 881. Available from: https://www.researchgate.net/publication/216811760_Climate_Change_2001_The_Scientific_Basis [accessed November 18, 2024].

Houssou SC, Boko NPM, FK Medeou, Vissin EW, Gibigaye M., (2015). Bioclimatic weather type and population health in coastal towns of Benin.

INSEED, (2022). Final results of the fifth General Census of the Human Population of Togo, URL: https://inseed.tg/presentation-des-principaux-resultats-definitifs-du-rgph-5/ (accessed April 17, 2023)

Redaud L., Gillet M., Chartier-Touzé N., (2009). Adaptation au changement climatique dans le domaine de l'eau : où en est la France ? Techniques Sciences Méthodes (TSM) numéro 1/2 - 2009 - 105e année, p. 77-90. https://astee-tsm.fr/Umbraco/Surface/Articles/GetArticlePdfFile?articleId=4212. (accessed September 12, 2022)

Jafino, B. A.; Walsh, B.; Rozenberg, J.; Hallegatte, S. Revised Estimate soft he Impact of Climate Change on Extreme Poverty by 2030; Working Paper; Work Bank: Washington, DC, USA, 2020.

Josep, F., Martin, M., Suszy, L., et al. (2008). Health systems, health and wealth: assessing the case for investing in health systems: background document 3. World Health Organization. Regional Office for Europe, European Observatory on Health Systems and Policies. pp. 1-80.

Kouamé PK, Fokou G, Koffi AJD, Sani A, Bonfoh B, Dongo K. Assessing Institutional Stakeholders' Perception and Limitations on Coping Strategies in Flooding Risk Management in West Africa. Int J Environ Res Public Health. 2022 Jun 6;19(11):6933. doi: 10.3390/ijerph19116933.

Monday, I. F. Investigating Effects of Climate Change on Health Risksin Nigeria. In Environmental Factors Affecting Human Health; Uher, I., Ed.; Intech Open: Rijeka, Croatia, 2019; Chapter2. [CrossRef]

Oyedepo, S. O., Dirisu, J. O., Udoye, N. E., Fayomi, O. S. I. (2022). Progresses on green and smart materials for multifaceted applications, In: Hussain, C. M., Di Sia, P. (editors). Handbook of Smart Materials, Technologies, and Devices. Springer.

Parihar, R.S.; Bal, P.K.; Saini, A.; Mishra, S.K.; Thapliyal, A. Potential future malaria transmission in Odisha due to climate change. Sci. Rep. 2022, 12, 9048. [CrossRef]

Parihar, R.S.; Bal, P.K.; Thapliyal, A.; Saini, A. Climate Change Projections and its Impacts on Potential Malaria Transmission Dynamics in Uttarakhand. J. Commun. Dis. 2022, 54, 47–53. [CrossRef]

PNACC, (2017). National Plan for Adaptation to Climate Change in Togo https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Togo%20NAP.pdf accessed September 12, 2023

Ministry of Health and Public Hygiene and Universal Access to Healthcare (MSHP), 2019. National plan for adaptation of the health sector to the effects of climate change in Togo. https://www.giz.de/en/downloads/plan-national-dadaptation-dusecteur-de-la-sante.pdf [accessed November 18, 2024]

Rother, H. A. Controll in gand preventing climate-sensitive no ncommunicable diseases in urbansub-Saharan Africa. Sci.Total Environ.2020,722,137772. [CrossRef][PubMed]

Schleussner, C.F.; Donges, J. F.; Donner, R. V.; Schellnhuber, H. J. Armed-conflict risks enhanced by climate-related disaster sin ethnically fractionalized countries. Proc. Natl. Acad.Sci.USA2016,113,9216–9221. [CrossRef]

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor M., and Miller, H.L. (eds.) Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007 Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. archive.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf [accessed November 18, 2024].

Sorgho R, Quiñonez CAM, Louis VR, Winkler V, Dambach P, Sauerborn R, Horstick O. Climate Change Policies in 16 West African Countries: A Systematic Review of Adaptation with a Focus on Agriculture, Food Security, and Nutrition. Int J Environ Res Public Health. 2020 Nov 30;17(23):8897. doi: 10.3390/ijerph17238897. PMID: 33265971; PMCID: PMC7731384.

Szivós E, Hegedűs M, Balogh S, et al. (2024). Impact of changes of hospital integrations spanning a decade in Hungary: Modern diagnostic services: CT care based on a Hungarian sample. Journal of Infrastructure, Policy and Development. 8(6): 4215. https://doi.org/10.24294/jipd.v8i6.4215

WHO, (2021) Countries commit to develop climate-smart health care at COP26 UN climate conference. Available online, URL : https://www.who.int/fr/news/item/09-11-2021-countries-commit-to-develop-climate-smart-health-care-at-cop26-un-climate-conference (accessed november 20, 2023)

Weijian Zhang , Li Y, Guo P, Guo X. (2024). Effects of urban green space (UGS) quality on physical activity (PA) and health, controlling for environmental factors. Journal of Infrastructure, Policy and Development. 8(4): 3162. https://doi.org/10.24294/jipd.v8i4.31 62

WHO, 2021: Conférence des Nations Unies sur le climat COP26, les pays s'engagent à concevoir des soins de santé respectueux du climat.

WHO,2019 : rapport de situation sur la mise en œuvre du cadre pour l'adaptation de la santé publique au changement climatique dans la région africaine

WMO. Climate Change Triggers Food Insecurity, Poverty and Displacement in Africa. 2021. Available online: https://www.un.org/africarenewal/magazine/climate-change-triggers-food-insecurity-poverty-and-displacement-africa(accessed February14, 2023).

Xhexhi, K. (2023). Ecovillages and Ecocities. Springer International Publishing.

Zakaria, Z., Kamarudin, S. K., Abd Wahid, K. A., et al. (2021). The progress of fuel cell for malaysian residential consumption: Energy status and prospects to introduction as a renewable power generation system. Renewable and Sustainable Energy Reviews, 144, 110984. https://doi.org/10.1016/j.rser.2021.110984