

Article

Access to Early Warning for Climate Change-Related Hazards in Informal Settlements of Accra, Ghana

Ishmael Adams ^{1,*} , Sumita Ghosh ² and Goran Runeson ²

¹ Department of Construction and Infrastructure Management, Swinburne University of Technology, Sydney Campus, Sydney, NSW 2150, Australia

² School of Built Environment, University of Technology Sydney, Sydney, NSW 2007, Australia; sumita.ghosh@uts.edu.au (S.G.); karl.runeson@uts.edu.au (G.R.)

* Correspondence: ishmaeladams@swin.edu.au

Abstract: Climate change-related hazards will aggravate and impact differently on urban societies. Although early warning systems will be important for reducing the hazard risks in cities, the nature of early warning systems that are available to residents of informal settlements remains less understood. This paper aimed to assess the early warning systems through which informal dwellers reduce their hazard risks in an African city. Using Accra as the case, data were collected from 582 households using a structured questionnaire along with 25 institutional key informant interviews and 14 focus discussions with state and settlement actors in this study. Findings of the paper show that a mix of formal and informal early warning systems are utilized by residents of informal settlements, but the majority of them perceived state disaster management institutions as not performing optimally in their resident settlements. The nature of land ownership in the informal settlements influenced their political exclusion and state institutions' decisions not to locate weather monitoring equipment in their settlements. Respondents without the security of land tenure perceived state disaster management institutions as not performing optimally, which negatively affects their capacity to respond to climate change-related hazards. The paper thus recommends the incorporation of informal early warning systems into city-wide hazard early warning systems through participatory planning in Accra and similar contexts. Future scholars may extend this discourse by examining the effect of the use of informal early warning systems on the uptake of formal hazard early warning sources in informal settlements.

Keywords: early warning access; climate change hazards; informal settlements



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1. Introduction

Climate change-related hazards affect all urban societies, but future impacts are expected to affect developing countries the most owing to their limited adaptive capacities [1]. Such hazards are often associated with the destruction of infrastructure, livelihoods and even death, to mention but a few [2]. The urban poor are said to be most affected by these hazards in urban areas, owing to their limited risk reduction resources [3–5].

Scholars have variously argued for the diversification of hazard adaptation preparedness measures to include risk prevention measures [6,7]. They contend that hazard risk reduction planning improves risk awareness which is necessary for building hazard response capacity in cities. Part of such risk reduction planning will include an early warning system that allows the generation and dissemination of hazard risk information for all parts of cities [7].

Researchers also show how hazards emanate from climate change in Africa [8–11], Asia [12] and Latin America [13,14]. For instance, climate-related events such as wetter weather conditions [9], drought [10] and floods [11] have been found to destroy housing and livelihoods in Africa.

Many studies also discuss the non-climatic factors that underlie hazard occurrence in cities [3,15,16]. Karley [15] in his study claimed that, “*there is no evidence to suggest that the increases in flooding in Accra are associated with climate change*” (p. 4). To Karley [15] the increased flooding in Accra is accounted for by a dysfunctional urban planning system which leads to poor drainage infrastructure and poor siting of dwellings in waterways. These impede the flow of rainwater, causing flooding in the city. For Pelling [16], while flooding is associated with climate change in George Town (Guyana), the urban poor’s exposure to flooding was accounted for by the state’s negligence in not providing adequate housing in good locations for all residents in the city. Overall, this scholarship improved our collective understanding of climate change-related hazards in cities. However, the scholars did not examine the nature of early warning systems that are available to the urban poor.

There is, however, a growing scholarship on hazard early warning systems discussing their needs and varieties (e.g., [17,18]). Some of these studies show the prevalent early warning systems that are utilized for risk reduction [17], the phases or components of an early warning system [18] and the overall effectiveness of early warning systems for risk reduction [19,20]. Notable factors that affect early warning systems have included technology, level of skills to operate technologies and institutional gaps for coordinating the early warning systems. However, these studies have only analyzed early warning systems mainly in rural contexts.

Few studies have assessed early warning systems in urban areas, although hazard risks in urban areas are complex and continue to evolve [21–25]. They found that urban residents accessed early warning information from sources including radio stations [22], government officials [24] and from families and friends [23]. Codjoe et al. [25], for instance, found residents of poor urban settlements in Accra accessed information from family members and used celestial bodies, plants and animals to predict seasons and daily weather forecasts.

However, this study did not examine the extent to which the socio-political context of informal dwellers influences their access to climate-related hazard early warning systems in their communities. This is important since hazard vulnerability varies according to the context [26]. Furthermore, such an assessment is important given the comparatively less developed formal disaster early warning systems in developing countries [3]. In addition, the knowledge of informal residents’ perceptions of hazard early warning will be important if city planners have to integrate their perspectives in city-wide hazard response planning in Accra. This gives rise to the main question of this paper: what is the nature of the hazard early warning systems that are utilized by residents of informal settlements in Accra?

Three related sub-questions are: (1) What early warning systems are utilized by informal dwellers for climate-related risk reduction? (2) How do informal residents perceive the performance of state disaster management institutions involved in climate-related hazard early warning systems in their settlements? and (3) What accounts for the residents’ perception of the performance of the state disaster management institutions in the informal settlements?

This study answers these questions using Accra as representative of an African city. The study uses four informal settlements in Accra—Adedenpko, Ga-Nshonaa, Gbegbeyise and Old Fadama—as the cases.

2. Literature and Theoretical Underpinnings

Impacts of future climate change are expected to affect all urban dwellers, but these are suggested to fall disproportionately on the urban poor [25]. Accordingly, urban scholars have argued for a paradigm shift from disaster response planning to risk prevention and management, given the increasing complexity of the evolving risks in cities [7]. Definitions of an early warning system vary, but this has been popularly understood as “*a set of capabilities needed for the timely and meaningful generation and dissemination of alert information to individuals, communities and organizations at risk for optimal preparedness and response and at the appropriate time to reduce the likelihood of injury and death*” (United Nations Office

for Disaster Risk Reduction, (p. 4) [27]. Two important requirements of effective early warning systems are how they are developed and deployed [28,29]. Basher [29] observes that how an early warning system is deployed determines how it may significantly reduce climate-related risks among people. Coordination among the actors in its deployment and utilization was found to be the most important factor.

A growing body of literature has assessed and discussed different aspects of early warning systems and the outcomes [30,31]. Three main early warning components are identifiable in these studies, namely, risk knowledge, monitoring and response. Otiende, [31], in discussing risk knowledge and the economic access factors, shows that flood-affected settlements were left out of the dissemination of flood early warning information mainly due to a lack of access to the resources that help in accessing the information. Although the meteorological data generated had the potential to inform risk reduction, communication gaps between the staff and settlements affected the utilization of the data. Dulo et al., [32], similarly found that, although weather information was available to communities, their lack of access to assets for accessing information was a major barrier to their risk reduction responses. Weather forecasts were also in the English language, considered too complicated and were not very useful to the settlements. However, other studies found that early warnings that were communicated in local languages allowed community members to take appropriate risk reduction measures [33,34].

The studies conducted by Archer et al. [35] and Hansen et al. [33], which also adopted risk knowledge-based frameworks, found different combinations of factors that affected early warning systems. Key among these was lack of trust in the forecasts from state institutions, and weak financial capacity of households to access risk reduction information or implement risk reduction measures. Similar to these studies, the study of Baudoin et al. [19] study stresses the importance of trust in the successful deployment of an early warning system. They note that where past weather forecasts were found to be unreliable, farmers turned to their existing traditional sources of knowledge for early warnings.

Many of the studies on early warning systems also adopt frameworks that emphasize integrated early warning systems [28,36–38]. For instance, Basheer's review has shown that assessment of hazard early warning systems should integrate the physical and social aspects of risks, with human agents at the center since they are the main object of risk reduction [29]. Lassa [38], however, argues that an early warning system should address decision-making since a collection of actors will only play their respective roles if there is clarity in the roles. The United Nations Office for Disaster Risk Reduction [27], however, proposes warning dissemination as the third phase of an early warning system, namely risk knowledge, monitoring, warning dissemination and risk response. The commonality of findings from these studies is that differences in people's social characteristics affect the availability of assets for generating, disseminating and accessing hazard risk warnings in given contexts. However, these studies have not theorized the context of informal urbanization and its influence on the residents' access to an early warning on hazards. Informality refers to the "*modes of human settlements and trade or exchange that occur outside of formal legal structures and processes*" (Porter et al. (p. 115) [39]. This is important as the Intergovernmental Panel on Climate Change [40] (p. 13) has noted that "*squatter and other informal settlements with high population density, poor shelter, little or no access to resources such as safe water and public health services, and low adaptive capacity are highly vulnerable*" to hazards.

Theories of informality explain why informal dwellers may not have access to information such as early warnings on climate change. The first of these theories posits the rise and vulnerability of informal dwellers from a mismatch between labor supply and demand in an economy [41,42]. However, Lewis [43] suggested that both the modern and traditional sectors of the economy will see improvements in a dual economy over time. Viewed this way, attention is often paid to the discrimination that is suffered by the informal sector through their exclusion from state policy and support, such as hazard early warning information [41,44,45]. Overall, although this theory highlights the informal

sector's vulnerability, it overlooks the power dynamics that underlie their exclusion in the economy.

Institutionalist theorists [46–48] also posit informality as an entrepreneurial response to cumbersome state regulations. In this view, market actors who seek to operate underground of state control are those that appear informal to the state. A response to informality is to simply reduce regulations on the economy to allow the private sector to provide needed services in the economy, such as hazard early warning information. Proponents of this theory, however overly simplify the role of the state and overlook its provision of certain essential services that cannot be left to only market forces to determine, such as hazard prevention early warning information generation.

A relevant theory on informal dwellers' access to an early warning on hazards is the neo-Marxist theory of informality. Neo-Marxists [49–51] view informality as a permanent feature of the capitalist economic system, which leads to the exclusion of informal actors from the market. Rather than supporting the urban poor, the state is viewed as promoting market-based solutions that put essential services out of the reach of the poor, such as early warning information from formal state sources [52]. To respond to this exclusion, the state is called to address all forms of exclusion, such as not providing weather information to informal dwellers.

Adopting a theoretical framework that addresses this exclusion in informality, Roy et al. [53] discussed the socio-economic, political and institutional factors that underlie informal residents' access to resources, such as for disaster reduction in Bangladesh. This is against the backdrop that early warning and hazard vulnerability risk reduction are contextual. This study thus adopts the theoretical framework by Roy et al. [53] to assess the influence of informal dwellers' context on their access to early warning for responding to climate change-related hazards in Accra (Figure 1).

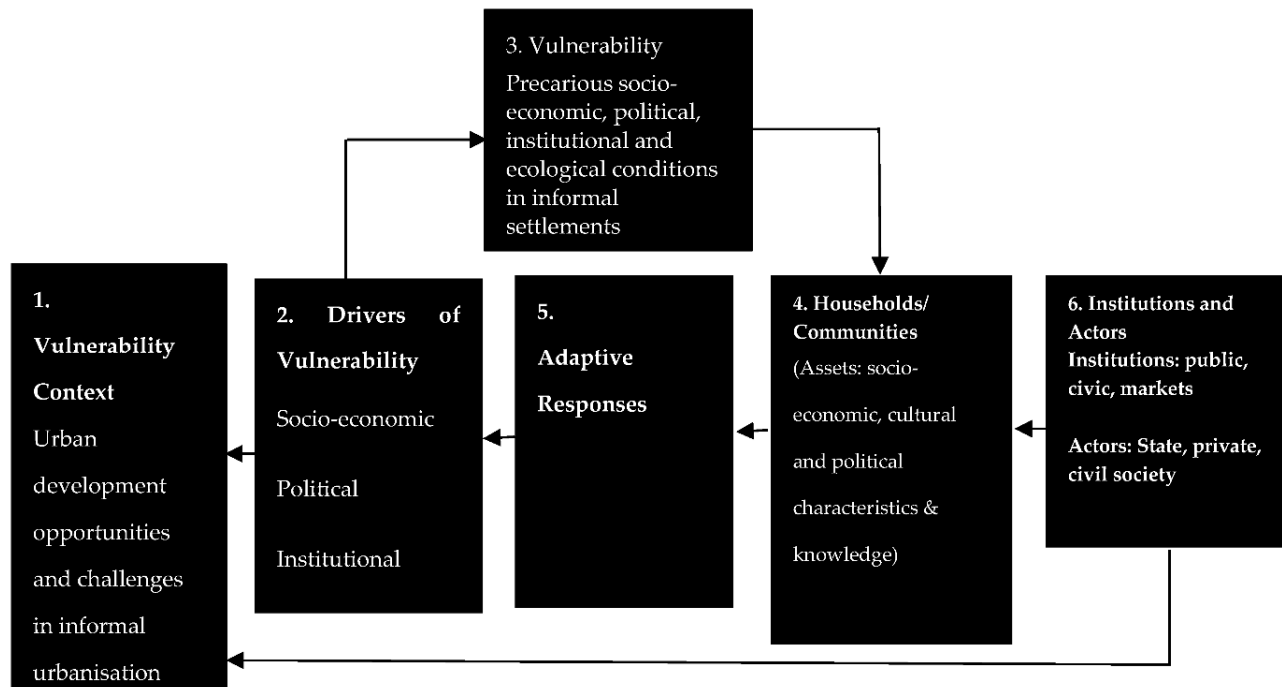


Figure 1. Theoretical Framework. Source: Authors' adaptation of Roy et al. (2013, p. 159) (Reprinted/adapted by Permission of SAGE Publications. Copyright© 2013 by Roy et al. 2013).

It is shown in Figure 1 that the social exclusion of informal settlements makes them vulnerable to climate-related hazards (p. 159) [53]. Social exclusion results in limited social infrastructure, unreliable jobs, limited hazard risk reduction assets, absence of disaster management institutions in their settlements and exclusion from formal planning, among

others, making them susceptible to hazards. Residents cope with these hazards using limited assets which include the knowledge of hazards.

3. Materials and Methods

3.1. Study Settlements

This study was conducted in the Accra Metropolitan Area in Accra, Ghana's administrative capital, where an estimated 1.9 million people lived. Rapid increase in the city's population has been associated with the growth and persistence of informal settlements, which are without risk reduction infrastructure [3]. Added to the challenge of managing informal settlements are the effects of climate change, such as rising temperatures and increased flooding that affect livelihoods [4]. Recognizing this challenge, the Accra city authorities have mapped out the 82 settlements in their jurisdiction, categorizing them according to land tenure security and access to sanitation and water [54]. Four different categories of vulnerable informal settlements were selected for this study: Adedenkpo, Ga-Nshonaa, Gbegbeyise and Old Fadama (Figure 2) based on the city's mapping of informal settlements [54]. Therefore, the settlements were selected based on two criteria: (1) the different land tenure arrangements for informal settlements in Accra and (2) their locations of the informal settlements and likely exposure to climate change—whether inland or on the coastline of Accra. Adedenkpo is an indigenous informal settlement located inland, while Ga-Nshonaa is a squatter settlement located on the coastline of Accra. Residents of Ga-Nshonaa are exposed to coastal erosion, sea-level rise and other climate-related impacts. Located on the shoreline, Gbegbeyise is an ethnically-heterogenous informal settlement with multiple forms of land ownership, while Old Fadama is an inland squatter settlement. Residents of both settlements are exposed to different climate change-related impacts such as more frequent fire outbreaks, excessive heat and flooding.

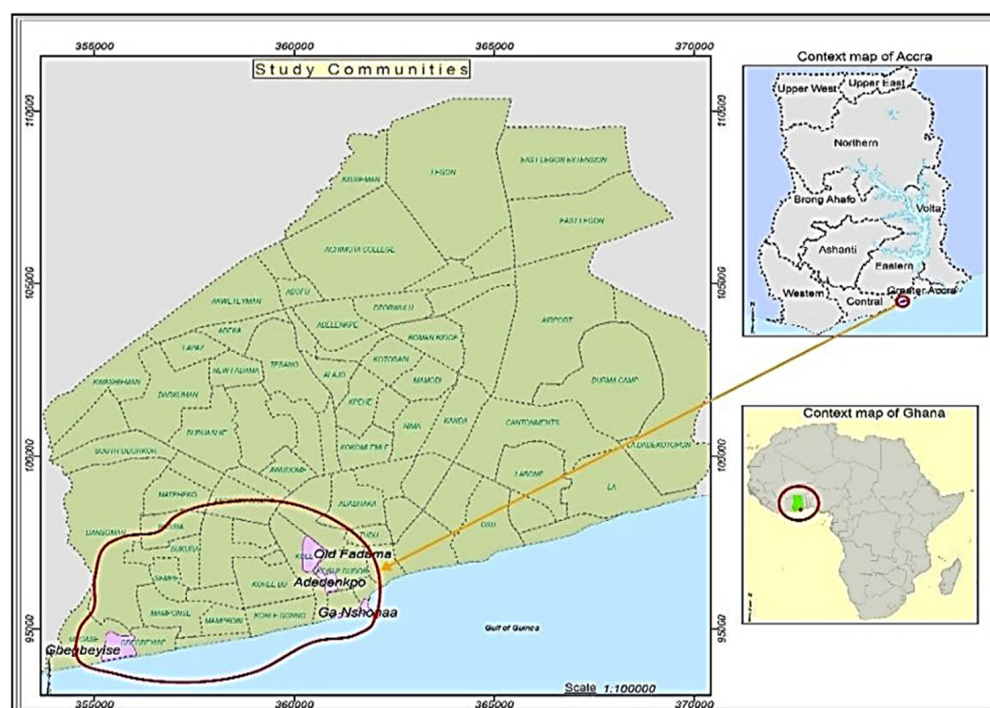


Figure 2. Map of Accra and Study Locations, Source: Authors' construct.

3.2. Research Approach

This research began with a review of literature on climate change and informal settlements. The review included peer-reviewed and gray materials of global and national coverage on the topic. Following the identification of the knowledge gap, a theoretical framework was adapted to contextualize analysis in this case study. The case study ap-

proach was adopted as it allowed us to describe the phenomenon in its real-life context [55], using Accra as a case, as presented in Figure 3.

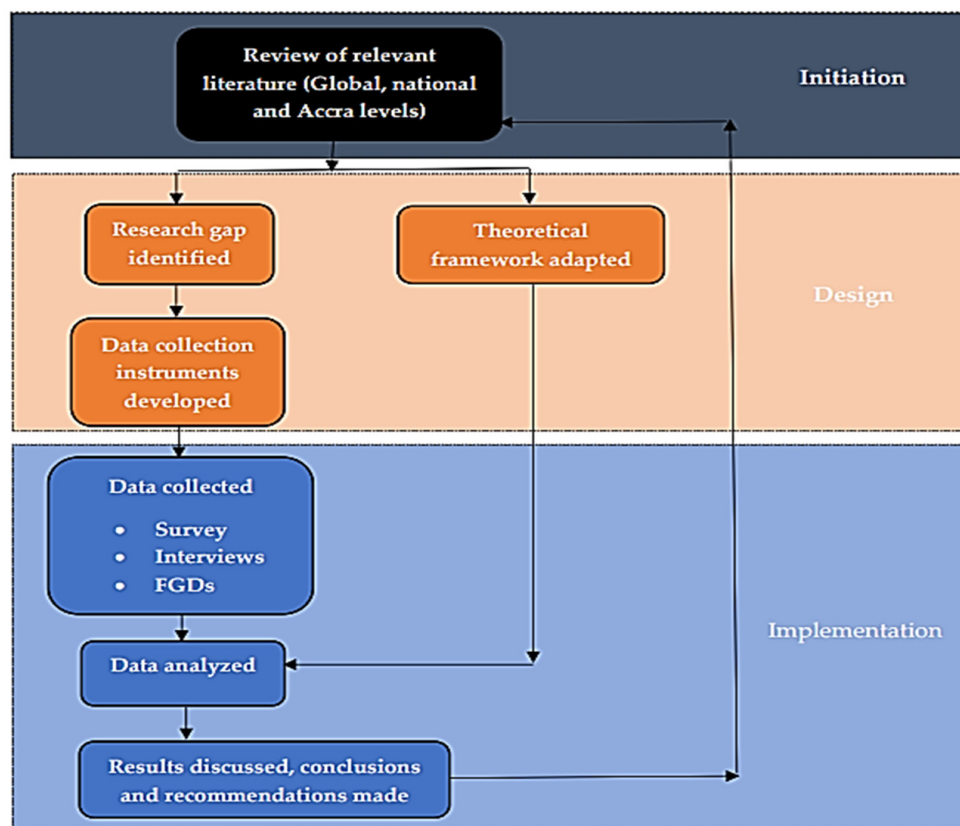


Figure 3. Research flowchart. Source: Authors' construct.

3.3. Data Collection and Analysis Methods

Both quantitative and qualitative data collection instruments were developed and applied in this study. Data were collected from April 2017 over four months. As a quantitative method, a structured questionnaire was used to collect household data. This questionnaire covered: (1) demographics such as age and gender educational status, as well as perceptions about access to an early warning on climate change and (2) the nature and institutional access of early warning systems and their presence in the settlements as part of the data collection instruments. A total of 582 questionnaires were returned covering the four informal settlements: Adedenpko (148), Ga-Nshonaa (138), Gbegbeyise (146) and Old Fadama (150) (Table 1). The households were selected through systematic sampling using maps in each informal settlement. Samples were determined using the formula [56]:

$$n = \frac{[Z^2 \times p(1 - p) / (\alpha)^2]}{[1 + (Z^2 \times p(1 - p) / (\alpha^2)N)]}$$

where Z = z-score for a given confidence level which was 95 percent in this case, while P is the proportion of the population. This is often considered at 50 percent to maximize samples where the total population is inexact, while α is the margin of error (0.08) and N is the estimated population (total households). Qualitative data were collected from representatives of institutions and the study communities. Semi-structured interviews were conducted with subject-matter specialists of the institutions that have the mandate for climate change hazard-related planning in Accra. The institutions were the National Disaster Management Organization (NADMO), the Environmental Protection Agency (EPA), Accra Metropolitan Assembly's Town Planning and Development Planning Depart-

ments, Ghana Meteorological Service, Ashiedu Keteke Sub-Metro and People’s Dialogue on Human Settlements. A total of 25 interviews were conducted involving two or three officials in each of the institutions. The interviews covered their climate change experiences, socio-ecological conditions in the informal settlements and their institutional engagements with these communities in planning for climate change adaptation and early warning mechanisms in Accra.

Table 1. Sample Population of the Case Study Settlement.

Study Settlement	Total Population	Household Size	Approximated Number of Households	Size of the Sample (Nos. of Households)
Adedenpko	32,340	3.3	9800	148
Ga-Nshonaa	5001	3	1667	138
Gbegbeyise	13,349	2.7	4944	146
Old Fadama	81,325	2.2	36,966	150

Source: Authors’ construct.

Additionally, qualitative data were gathered from community leaders through focus group meetings. A total of 14 focus group meetings were held in the four study settlements. Participants in the focus groups included leaders of landlords’ and tenants’ groups, leaders of trade associations and general leaders of each community. Using focus group discussion guides, the focus group meetings covered their perceptions about climate-related early warning mechanisms, their inclusion in planning and their engagement with the disaster management-related institutions. Notable scholars in research methods, such as Bryman [57] and Creswell and Creswell [58], assert that since a case study involves the study of a phenomenon in its real-life context, case studies need to provide these detailed contextual explanations rather than focusing on quantifiable matrices. In line with this argument, scholars on hazards, such as Amoako and Inkoom [3], Cutter et al. [59], Karley [15], Pelling [16] and Roy et al. [53], apply qualitative analytical techniques and seldom include descriptive statistical analyses based on survey data to explain their case studies. Inspired by the analytical approaches of these scholars, data analysis in our study involved the application of descriptive quantitative and explanatory qualitative analyses.

Quantitative data from households were entered into the Statistical Package for Social Sciences (SPSS) Version 24, cleaned and analyzed. This involved descriptive analysis to establish associations between the respondents’ demographic characteristics and their perceptions of early warning systems in their communities.

Qualitative data, which were manually analyzed through thematic analysis, helped to offer the contextual details that were missing from the survey data. To do so, the qualitative data were transcribed and read repeatedly. The results from these analyses are discussed under four key themes, namely: (1) Access to State Disaster-related Institutions and Early Warning on Hazards; (2) Main Source of Early Warning over the Last 1–2 years and (3) Awareness and Application of Informal Knowledge according to Gender of Respondents.

4. Results

The results of the data analysis are discussed in this section. Respondents’ access to State Disaster-related Institutions and sources of early warnings on hazards are discussed first. This is followed by the sources of early warnings from external sources and the prevalent informal early warning mechanisms that are accessed by the residents.

4.1. Demographic Characteristics of the Study Respondents

Out of the 582 household study respondents, 52.6 percent were youth aged between 18 and 35 years but about 3 percent were older than the retirement age of 60 years in Ghana (Table 2). Most (80 percent) respondents had lower to no formal education. In addition, most (87.5 percent) respondents were male. The respondents were also mainly migrants

(63 percent), but 35.7 percent also claimed to have indigenous roots in Accra potentially conferring on them land use rights, a reflection of the diversity of informal settlement categories in the city. Furthermore, the respondents mostly (63.9 percent) reported having lived in the settlements for a considerable period of between 10 years and 20 years, although over a quarter (34.2 percent) reported having also lived in the settlements for less than ten years. Differences in the length of stay in a settlement are often associated with the ability to establish and maintain social ties with influences on their social capital [60]. Respondents' incomes were also unevenly distributed, with the maximum monthly earning at AU\$4327 and the minimum at less than AU\$7 (Table 2). The mean household size was 2.87 with respondents' mean monthly income at AU\$367, evidence of the socially and economically differentiated nature of the respondents.

Table 2. Socio-demographic characteristics of the Study Respondents.

Variable	Sub-Category	Proportion of Respondents (%)
Age of household head	Between 18 and 25 years	6.9
	Between 26 and 35 years	46.7
	Between 36 and 45 years	22.9
	Between 46 and 55 years	12.5
	Between 56 and 60 years	7.9
	61+ years	3.1
Gender of the household head	Male	87.5
	Female	12.5
The ethnicity of the household head	Ga	35.7
	Akan	28.2
	Ewe	8.4
	Guan	0.2
	Gurma	1.7
	Mole- Dagbani	19.6
	Grusi	2.9
	Mande	0.3
	Other	2.9
Education of household head	Primary	27.5
	Junior High School	30.4
	Middle School Leaving Certificate	10.1
	Secondary	12
	Vocational/Technical	5.2
	Tertiary	3.8
	Professional	0.2
Length of stay in the settlement	None	10
	Less than ten years	34.2
	Between 11 and 20 years	29.7
	Between 21 and 30 years	18.6
	Over 30 years	17.5
Incomes per month/households	Less than AU\$100 (AU\$1 = GHC3.3)	4.6
	Between AU\$100-AU\$200	23.7
	Between AU\$201 and AU\$300	22.2
	Between AU\$301 and AU\$400	12.37
	Between AU\$401 and AU\$500	16.2
	Between AU\$501 and AU\$1000	9.8
	Over AU\$1000	2.7
Mean income per month/households	AU\$361	

Source: Authors' construct.

4.2. Access to State Disaster-Related Institutions and Early Warning on Hazards

The importance of access to early warnings about disasters among urban dwellers has been emphasized in the disaster risks' literature; access to early warnings increases people's knowledge beyond their everyday knowledge of the climactic events they face [61]. Specific hazards explained during data collection included frequent fire outbreaks, storms, flooding, coastal erosion and excessive heat, all of which negatively affected the study respondents. By arrangement, the main institutions that are responsible for knowledge generation and early warnings on climate change-related hazards in Accra are four. The first is the Ghana Meteorological Agency (GMA), followed by the National Disaster Management Organization (NADMO), the Ghana Fire Service (GFS) and District Assemblies (decentralized local governance authorities) [62]. Interviews conducted with relevant staff members revealed that the GMA generates information, which is shared with NADMO, whenever there is an adverse weather condition in the forecast. The GMA also directly engages in the public weather service by informing the public about adverse weather conditions through radio and television stations. The Ghana National Fire Service, which is also responsible for education on prevention, as well as extinguishing fire outbreaks, does so directly in communities. Added to the three institutions are the local authorities which are responsible for coordinating with the relevant agencies to directly provide early warnings and disaster relief in settlements [62].

The study sought to know the extent to which the respondents were aware of the work of the key disaster management institutions, and found it 'satisfactory' or 'not satisfactory'. Survey results show that at least 74.6 percent of the respondents in each settlement were aware of but found the work of the Ghana Fire Service as unsatisfactory. Moreover, this perception was differentiated among respondents in the various case study communities; it was highest (54.1 percent) in Adedenpko and lowest (44.2 percent) in Ga-Nshonaa, although the settlements differed in terms of their tenure security statuses. Ga-Nshonaa is a squatter settlement while Adedenpko has recognized tenure security by the local authorities, as an indigenous informal settlement. Put together, these perceptions, however, contrasted with the view of staff at the Ghana Meteorological Agency where it was claimed that *"we use agencies and groups, FM station and television stations and so forth, to inform the public about the weather, as promptly as we can"* (Interview #17).

It was also found that the majority of respondents' perceived the performance of the Ghana Fire Service as unsatisfactory, as shown in Figure 4. At least 74.6 percent of the respondents in each settlement reported this perception. This perception differed in terms of the settlement, with the highest percentage of responses in Gbegbeyise (82.2 percent), and the lowest in Ga-Nshonaa (74.6 percent). In addition, the lowest percentage of those who claimed to be unaware of the Ghana Fire Service was in Gbegbeyise (13.7 percent), compared to 21.7 percent in Ga-Nshonaa. This finding suggests that the level of awareness and satisfaction among the respondents, per se, was not associated with their tenure security status of the settlement. In addition, the results show that most respondents were aware of the Ghana Meteorological Agency, but found its performance as unsatisfactory (at least 52 percent in each settlement). However, a lower percentage of respondents (at least 12.9 percent) in each of the study settlements found the work of the Ghana Meteorological Agency as satisfactory while a much lower percentage (at least 18.9 percent in each settlement) reported being unaware of the same. Thus, more than half of the respondents in all the four study settlements held the perception that the performance of the statedisaster management institutions was unsatisfactory or were unaware of the presence of such institutions in their settlements.

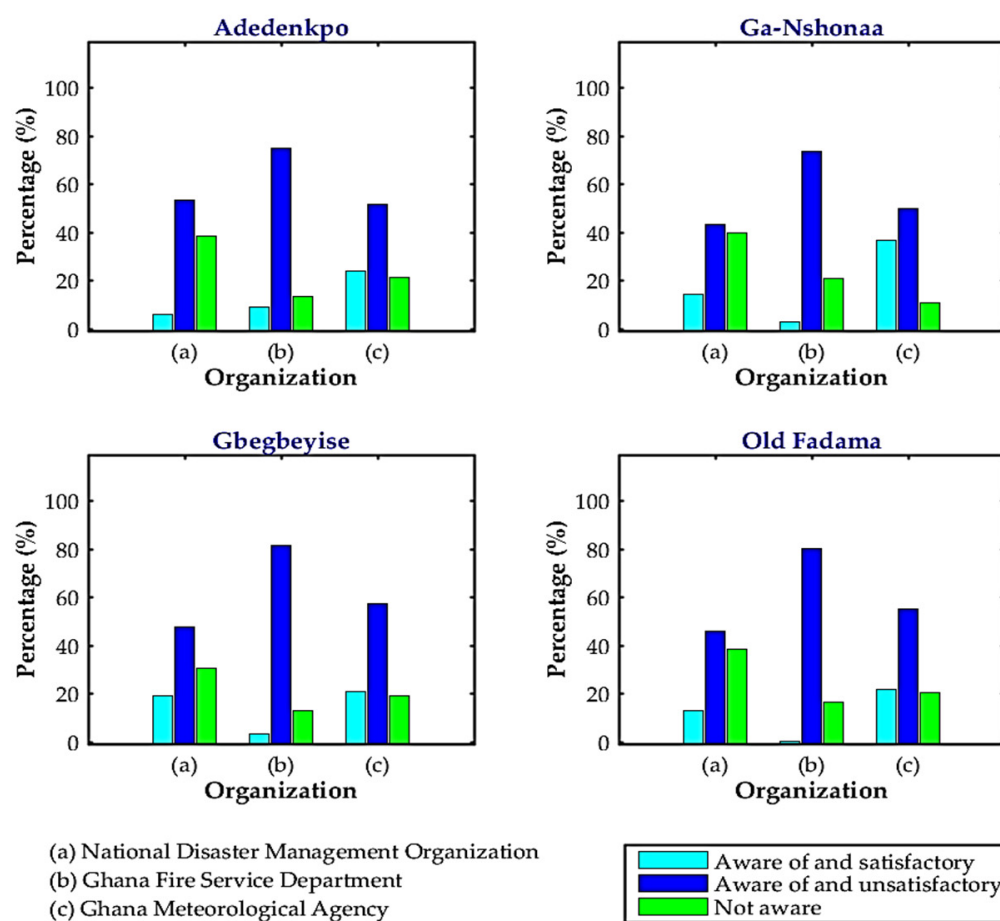


Figure 4. Perceived Presence and Performance of State Disaster Management Institutions. Source: Authors' construct, based on household survey.

The study respondents were also asked if their households had received an early warning on climate-related hazards from external sources over the last 1 to 2 years. External sources were viewed as all sources excluding friends and family. While most respondents in Adedenkpo (87.1 percent) and Old Fadama (82.7 percent) reported having received an early warning from external sources over the last 1 or 2 years, the percentage was relatively lower in Gbegbeyise (76 percent) and much lower in Ga-Nshonaa (11.6 percent) (Figure 5). External sources of early warnings included television broadcasts, radio broadcasts, government officials or settlement-based groups. The much lower percentage reported in Ga-Nshonaa can be associated with their lack of assets, such as radio sets to access information. Residents in Ga-Nshonaa did not report consulting television sources as they did not have access to electricity connection in their homes.

In terms of gender, a slightly higher proportion of female respondents than male respondents in Adedenkpo reported having received early warning information from external sources in the period. This contrasts with slightly more male respondents than female respondents in Gbegbeyise and Old Fadama who reported doing the same. This finding suggests that access to early warning information was gendered in the study communities, contrary to findings from other studies conducted in similar contexts. For example, Oloukoi et al. [63] claimed in their study in northern Nigeria that women had less access to early warning information than men. The scholars suggested this was due to their extra burden as managers of their homes, making women comparatively less able to contact external agents.

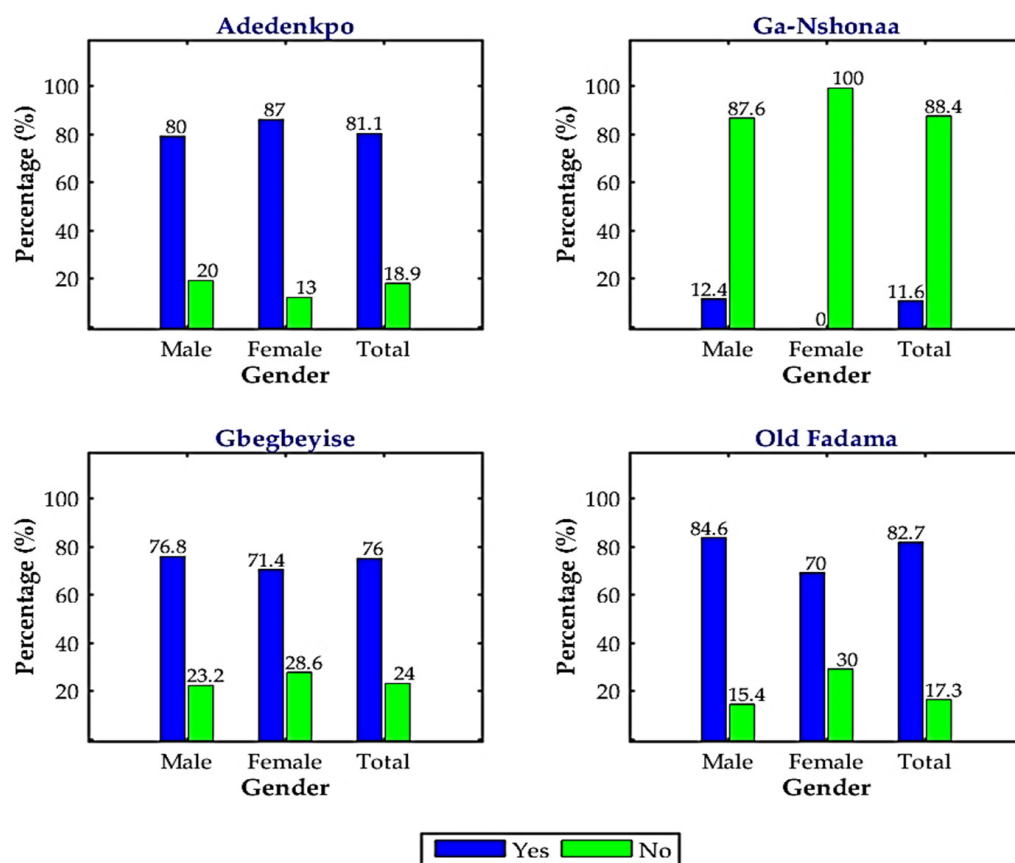


Figure 5. Sources of Early Warning from External Sources Over Last 1 to 2 Years According to Gender. Source: Authors' construct, based on household survey.

4.3. Main Source of Early Warning

Respondents were asked: "What is the main source of climate-related early warning received by your household over the last 1 to 2 years?" The response options were determined through a literature review and fine-tuned during pilot testing of the questionnaire in a community similar to the study settlements. The study respondents mainly consulted a variety of sources of early warnings over the last—1 to 2 years, including radio, television, 'relatives and friends' and related government officials (Figure 6). This result, however, differed across the settlements; the highest percentage of respondents (41.2 percent) in Adedenkpo claimed to have mainly received an early warning from a radio broadcast, while most respondents (88.4 percent) in Ga-Nshonaa mainly received—the same from 'relatives and friends'. That contrasted with most respondents in Gbegbeyise (58.9 percent) and the highest percentage in Old Fadama (44.0 percent) who mainly received early warnings through television broadcasts, as shown in Figure 6.

The results also differed according to the gender of the respondents; a relatively higher proportion of male respondents than female respondents claimed to have mainly received an early warning through 'friends and relatives' in all the four study communities. The socio-economic characteristics and the nature of amenities that are available in the study settlements have influenced this pattern of sources of early warnings for the respondents in this study. It is logical to conclude that, since most (88.9 percent) respondents of Ga-Nshonaa were found without electricity connection in their dwellings, they were unable to use television sets. However, the dominance of radio and television as sources of early warnings in the three other settlements is understood by the fact that most radio stations and few television stations in Ghana use local dialects to broadcast their messages [64]. This allows residents who have access to both television and radio sets to consult them for early warning of disasters.

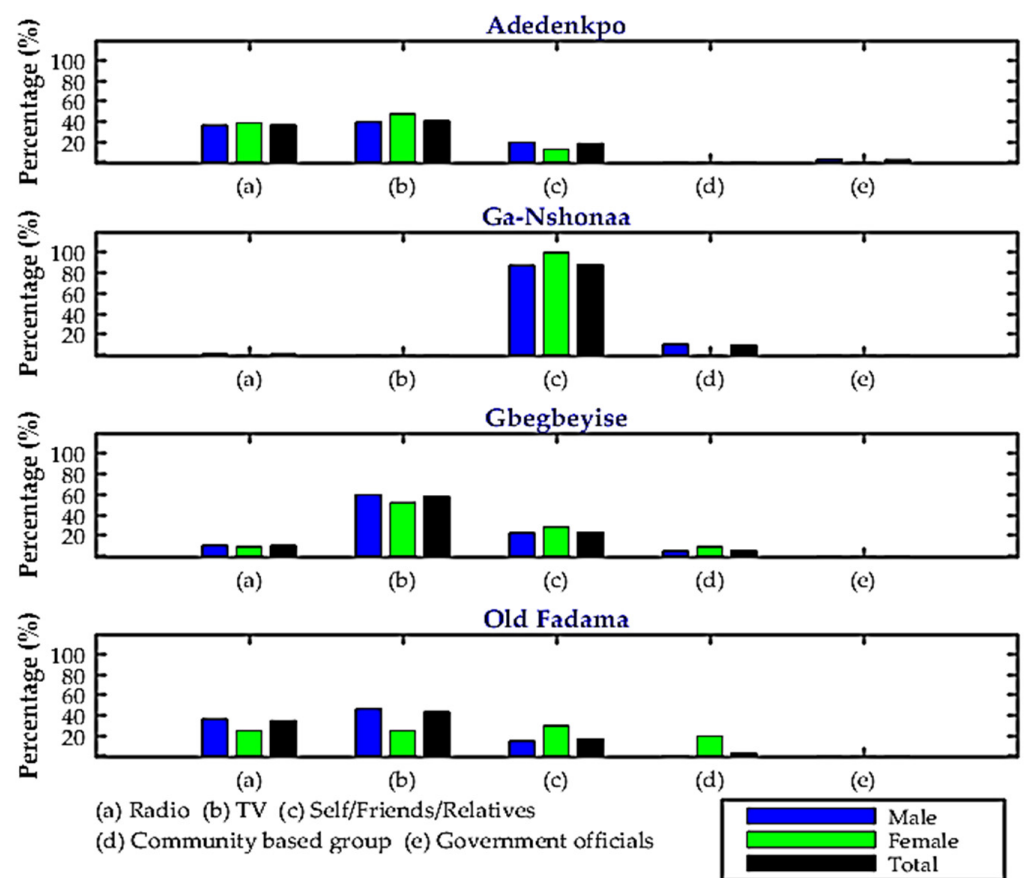


Figure 6. Percentage of Main Source of Early Warning over the Last 1–2 years. Source: Authors' construct, based on household survey.

Overall, the variety of sources of early warning reported in this study were similar to those reported in a study conducted by Wamsler and Brink [14] in Latin America and Asia. In this study, Wamsler and Brink [14] reported that unequal access to information on disasters between residents of informal settlements and more formalized settlements had enabled the latter to better respond to disasters. The respondents in our study held different perceptions about the performance of the different disaster management-related institutions. Our finding from informal settlements in Accra underscores the importance for understanding the differentiated socio-political characteristics of informal settlements in the development of early warning systems in cities.

The importance of community-based organizations as a source of climate change-related knowledge may also have been influenced by the nature of early warning information they received from the state disaster management-related institutions. For example, residents of Ga-Nshonaa reported being regularly threatened with forced eviction by the city authorities. The constant threat of eviction in Ga-Nshonaa did not allow the residents to access electricity which would have allowed them to use radio and televisions sets, since the state utilities will not extend electricity to the settlement.

Moreover, it was found that the legal status of the residents of informal settlements also influenced the nature and quality of early warnings they received from the state institutions. For instance, the legal status of informal settlements was linked with the siting/location of weather monitoring equipment by the GMA, where the interviewee said that: "Unfortunately, we do not deploy monitoring equipment in places like Old Fadama, given their challenges with state agencies. They, like other squatters, are located in hazardous places, and our equipment could be easily damaged." (Interview #17).

A similar finding was reported by Amoako and Inkoom [3] in their study in Accra, which suggests a pattern of the relationship between the Ghana Meteorological Agency and

residents of informal settlements. By not locating/siting weather monitoring equipment in informal settlements, localized weather information from these settlements is often not generated. This may have influenced the nature of the perceptions reported by most respondents, to the effect that state disaster management institutions are performing unsatisfactorily. The poor performance of the state disaster management institutions has always affected informal settlement dwellers' reliance on early warnings from formal sources. Examples of these cases were given during the focus group meetings in the study settlements. One person in Gbegbeyise observed that: "*Even the infrequent forecasts from Ghana Meteorological Agency are sometimes not reliable. A lot of the time, they send us a message that the sea will be calm in the week. We go on fishing only to meet a heavy storm which destroys our fishing boats. This also sometimes causes flooding in our community.*" (Participant #2, Focus Group, Ga-Nshonaa).

4.4. Awareness and Application of Informal Weather and Climate Monitoring Methods

As has been argued by Orlove et al. [30], local knowledge can make a valuable contribution in gaining a better insight into climate change in places where formal early warning systems are weak. The study then asked respondents if they were aware of, and often resorted to, any local knowledge of climate change in their daily lives. Findings of the survey in Figure 7 show that at least 73.2 percent of the respondents in each study settlement reported applying informal monitoring methods of weather and climate-related phenomena. They are the monitoring methods for early warnings of weather and climate-related phenomena. They typically originate within settlements through the inhabitants' observation of their environment, and are orally handed down from generation to generation. This was more so among female than male respondents in all the study communities, except for Gbegbeyise, as shown in Figure 7. This finding also differed among the study settlements; it was highest in Adedenpko (93.9 percent) and significantly lower in Ga-Nshonaa (73.2 percent). In terms of the gender of the respondents, only marginal differences were noticeable, with more female respondents than male respondents, in three of the four case study settlements except Gbegbeyise reporting this practice (Figure 7). The longevity of the stay of the residents in the various settlements partly explains this finding. Residents of Adedenpko who are mainly ethnic 'Ga' have lived longer in their settlement than in the case of Ga-Nshonaa, a relatively younger squatter settlement.

Findings from focus group meetings provided further details of the nature and variety of informal weather monitoring arrangements that are applied in the case study communities. They were found to be based on observation of life patterns of living organisms (animals and plants), reading of atmospheric and extraterrestrial bodies as well as daily observation of the conditions in the oceans.

Generation and transmission of specific informal weather and climate monitoring methods which constitute informal early warnings for hazards were discussed during focus group meetings in the settlements. For example, the sighting of cowbirds was said to often signify impending rains in a settlement. Movements of winds northwards of Accra with thunder were reported to often signify impending rains. A very dark-colored cloud sighted, moving from east to west, when accompanied by winds, indicated heavy rainfall within hours. Dead whales swept onto the shores also showed conducive sea temperatures and a bumper fish harvest shortly. In addition, different colors of the moon (brownish or greyish) sighted at dawn signified intensive rains in the day. Sighting a vulture incubating in June showed an impending drought or that limited rainfall would be more prolonged in the settlement. The appearance of a rainbow indicated that rains would not fall immediately. The generation of weather-related information and its dissemination involved individuals, families and groups, such as fisher folks.

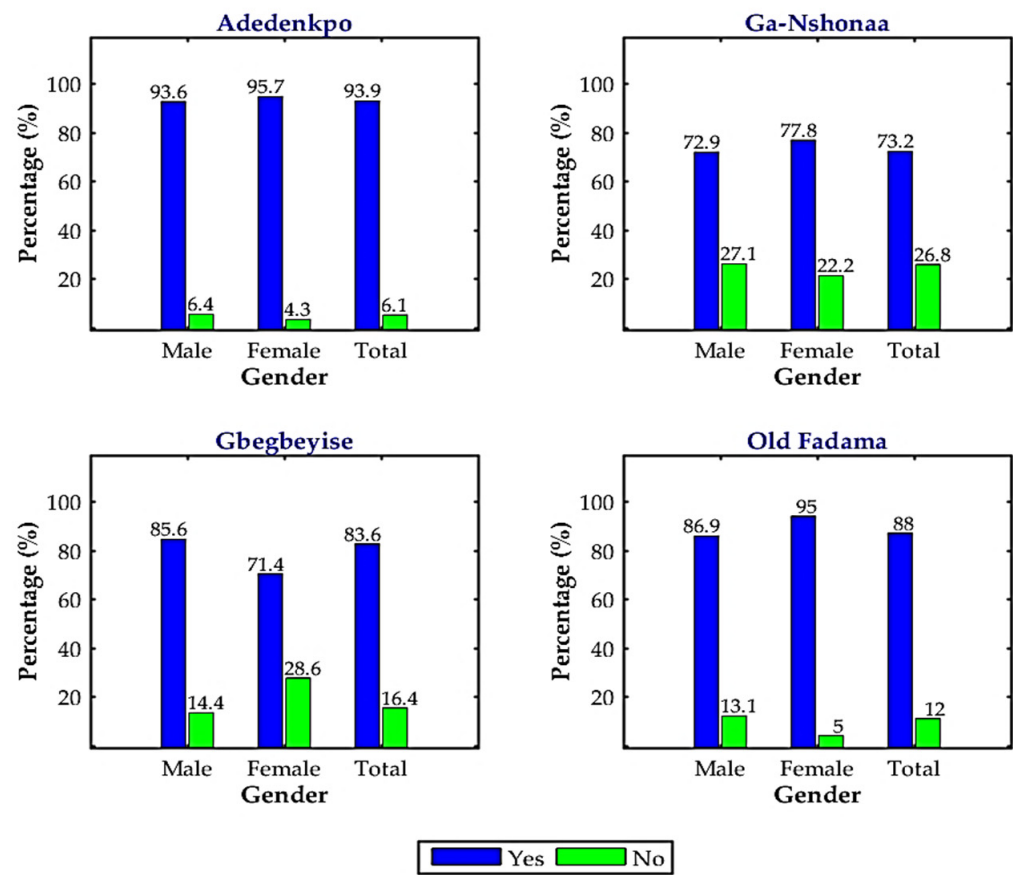


Figure 7. Application of Informal Knowledge According to Gender. Source: Authors' construct, based on household survey.

Focus group discussants further explained how they applied these observation methods in reducing hazard risks to their lives and livelihoods. For instance, a community member in Old Fadama observed during a focus group meeting that:

“When I feel very dry hot winds in June or July, I know no rain will fall immediately. But if the wind is moist, I start to prepare for rains to fall within days. Dangerous winds accompany rains that fall following the appearance of very dark clouds. So I do not go out to work during those weeks as I could get hurt.”

(Participant #4, Focus Group, Old Fadama)

A discussant from Adedenkpo also noted how she applies observation methods in reducing risks to her economic livelihood when she noted that:

“Sometimes when you wake up at about five o'clock in the morning, you realise that the moon has changed colour. When the moon changes from white to ash colour then you realise that it will rain continuously that day. And if in the morning the sky changes and becomes reddish, I know no matter what, it will rain the following day. When this happens, I pack my wares from outside into the home since the storms can destroy our wares.”

(Participant #2, Focus Group, Adedenkpo)

5. Discussion

The ways by which urban dwellers become vulnerable to climate change-related hazards in developing countries have been variously discussed (e.g., [65,66]). Two main views are expressed in these debates relating to hazard early warnings. Firstly, vulnerability is said to arise from the underlying socio-economic and institutional processes in cities that differentially expose urban dwellers to climate change-related hazards such as flooding,

increased fire outbreaks and excessive heat [65,66]. Urban dwellers' ability to respond to these hazards partly depends on the nature of their access to early warning information. The second view emphasizes the variety and role of the actual climate-related impacts which affect all urban dwellers, regardless of the differences in their socio-economic and political contexts (e.g., [22]). Our study has shown that residents of informal settlements have been rendered vulnerable to climate-related hazards in urban areas due to their socio-political exclusion in the city. They have also had unsatisfactory early warning coverage from the state disaster management institutions which negatively affects their ability to respond to hazards. Overall, the finding supports the often expressed view that the urban poor are the most affected by climate change in urban areas due to their lack of risk reduction assets (see the examples in Amoako and Inkoom [3]; Cutter et al. [59] and Karley [15]). Cutter et al. [59] assert that climate-related hazard risk exposure and capacity to respond are partly determined by the socio-economic, political and institutional context of the affected population in space and time.

Our study has also highlighted the nature of access to early warnings for responding to climate change-related hazards in informal settlements. This focus is important due to the present limited discussion of early warning systems in cities of developing countries, where the adaptive capacity for responding to climate change is said to be below the necessary level. In our study, the residents of the four study settlements were found to have different security of land tenure which influenced the nature of their access to institutional early warning. In Accra, the main institutions that have responsibility for hazard early warnings are the Ghana Meteorological Agency (GMA), the National Disaster Management Organization (NADMO), the Ghana Fire Service (GFS) and the Accra Metropolitan Assembly (AMA). Information on adverse weather conditions is usually generated by the GMA and shared with the NADMO, GFS and AMA for action. The information is also often shared with radio and TV stations for dissemination and may be directly disseminated by the AMA, NADMO and GFS through mobile van announcements in communities. However, respondents from Adedenpko and Gbegbeyise were found to barely have access to hazard reducing infrastructure and limited access to an early warning from the state institutions in their communities. Residents of Old Fadama and Ga-Nshonaa were without the same infrastructure and had limited to no presence of the state disaster management institutions. The differences in access are due to differences in tenure security: Ga-Nshonaa and Old Fadama are squatters while Adedenpko and Gbegbeyise are not. However, rather than being passive victims of hazards, our findings show that informal dwellers have developed their own systems for monitoring weather conditions as part of their early warning on climate-related hazards. The findings highlight the need for the scholarship on hazard early warnings in urban areas to pay attention to the informal mechanisms that are often integrated into early warning systems in urban areas.

The importance of stakeholder active participation in the generation and dissemination of information for an early warning system has been widely discussed [7]. In our study, the sources of early warnings for weather and climate change-related hazards included television, radio, local groups as well as traditional monitoring systems. This is understood in the context of the sub-optimal performance of state disaster management institutions in the study settlements. Yet, the state departments responsible for weather monitoring and early warning systems legitimized the different treatments meted out to settlements based on issues of land tenure security. The socio-political context of the respondents may have influenced their access to an early warning on climate change-related hazards. The nature of land ownership in the informal settlements determined the level of this political exclusion and decisions on the location of weather monitoring equipment in informal settlements in Accra. Respondents without the security of tenure more perceived state disaster management institutions as not performing optimally affecting their knowledge and capacity to respond to climate change. Therefore, settlement members mainly relied on their local knowledge about past events from communal sources. Such local knowledge of storm routes, wind patterns, cloud formations or animal behavior have been found to often

enable residents of settlements to reduce their risk from hazards [13]. This finding shows the need for hazard scholars to consider issues of land tenure security in the planning of hazard early warning systems in cities of the developing world. It uniquely does so by highlighting the influence of land ownership and politics in the preparation and deployment of hazard knowledge systems.

The findings of the methods adopted for monitoring weather through an examination of celestial bodies, plants and animals in this study are similar to findings from other studies conducted in similar contexts [25,30]. Codjoe et al. [25] report, from their study in three other underprivileged settlements, that this variety of modes of monitoring weather was also related to the cultural practices of the residents. Another study in Lake Victoria showed that local settlements applied indigenous knowledge to mitigate climate-related disasters as early warning systems [32]. In this study, simple traditional measures adopted for early warnings included bird migration, the prevalence of swarms of bees and riverine fog. However, these monitoring methods were found to be limited in application in the rural context but were deemed necessary given the absence of formal early warning arrangements [32]. Together, the findings further support the importance for adaptation scholars to pay attention to the relationship between the different socio-cultural characteristics of urban dwellers and their access to early warning systems for disasters.

Findings from this study also have practical implications for risk prevention-based disaster management planning in Accra and similar contexts as presented in Figure 8. Cannon [66] asserts how local government disaster management institutions often define climate change related to the exclusion of local settlements, noting they often proffer “solutions that are defined in terms of what is possible rather than what is needed” by the affected settlements (p.15). This is despite the common knowledge that the institutional capacity for hazard planning in developing countries remains very weak [67]. This study shows that households in the study settlements access informal early warnings on weather and climate changes, which helps them to plan their livelihoods despite the unsatisfactory performance of state disaster management organizations in their communities. While some residents have developed an elaborate informal monitoring system for weather and climate change-related variables, the formal knowledge system has been mainly perceived as not performing optimally for risk reduction.

Two important entry points could be considered in the design of hazard early warnings and management systems in Accra and similar contexts, as shown in Figure 8. The first way is to incorporate informal weather and climate-related early warning methods into city-wide hazard early warning systems. A starting point for incorporating informal early warning methods into city-wide disaster management plans is to first assess these methods at a larger scale in both informal and formal settlements in the city. This is essential since communities are ethnically diverse and of different periods of existence, which may influence the level of development of the prevalent informal monitoring systems in the communities. Data collected on informal monitoring methods can then be synthesized during plan preparation to ensure only the most significant and tested monitoring methods are considered for incorporation into the plan.

A practical way for integrating informal early warning systems into city-wide early warning mechanisms is through participatory planning at community and city-wide scales. By engaging opinion leaders and community representatives during plan preparation, city planners will learn more about the informal monitoring methods to enable them prioritize the most significant, tested and successful methods for incorporation in hazard risk management plans. Landlords’ and tenants’ associations can be the entry points for mobilizing these communities.

The second entry point for improving access to hazard early warnings in informal settlements is to improve their access to an early warning from formal sources. It has been found from this study that informal dwellers access multiple sources of information, through different media and other mechanisms from formal sources. To do so will require an improvement in the residents’ ability to acquire the assets used for accessing early

warnings from formal sources, such as radio sets and television sets. By improving relations and trust among hazard planning experts and informal communities, infrastructure such as settlement weather monitoring systems may be set up in selected informal settlements to generate local weather-specific information for the given local areas. In addition, improving other community infrastructure through good land use planning has the potential to build the residents' capacity for hazard management and resilience to disasters in cities [14,68]. Overall, the adoption of inclusive planning methods in the preparation and deployment of a city-wide hazard management system will be part of the city's planning processes and integrated with other development concerns in informal settlements to ensure the residents' continued participation in the planning and hazard management in the city.

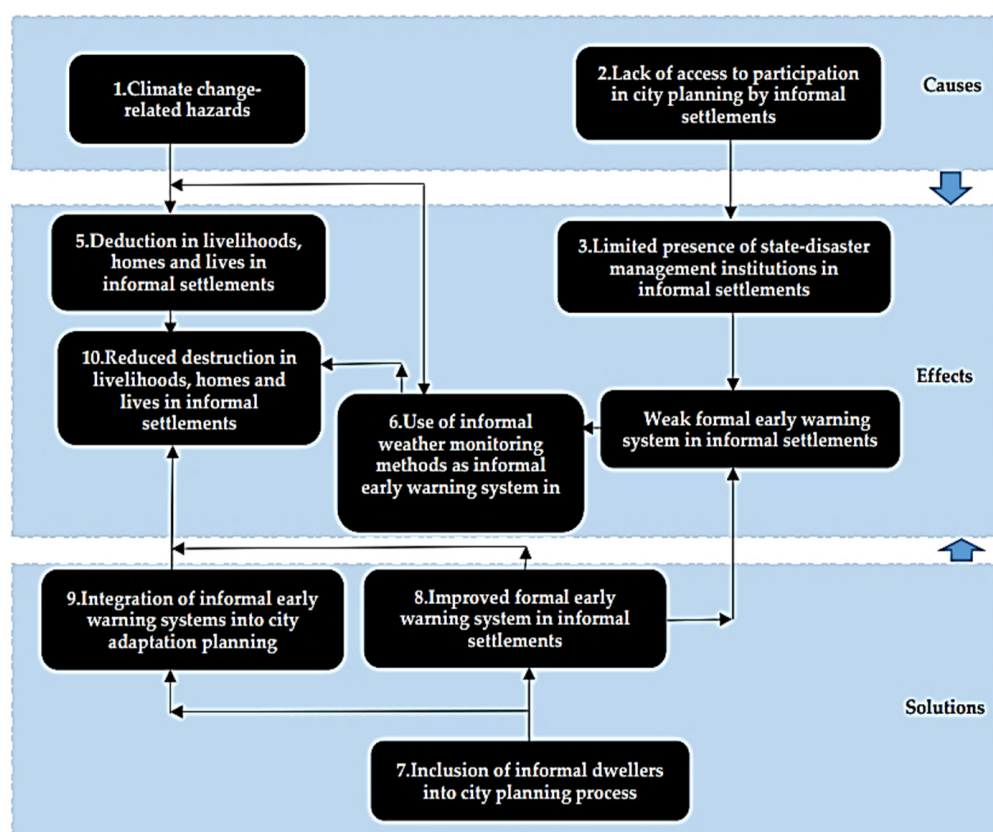


Figure 8. Improving hazard early warnings in informal settlements. Source: Authors' construct.

6. Conclusions

The need for addressing climate change-related hazards among the urban poor toward meeting the global sustainable development goals has been widely acknowledged. Adoption of participatory planning approaches is also widely acknowledged if climate risk reduction planning is to produce the desired sustainable outcomes in cities. However, residents of informal settlements are continually excluded from formal planning in many African cities including Ghana. This is despite the notion that the urban poor are likely to bear the brunt of climate change in cities. While research on hazards in cities continues to grow, the nature of early warning systems in informal settlements remains unexamined. Consequently, this study aims to assess the early warning systems through which informal dwellers reduce their hazard risks in an African city, using four settlements as case study communities.

It has been found in this study that most respondents viewed state disaster management institutions as not performing up to their expectations to reduce hazard risk. The main factor that differentiated settlement responses, however, was the nature of land tenure in the study communities. Those without the security of land tenure perceived state

disaster management institutions as not performing their role as expected. Resulting from this finding, the paper suggests the incorporation of informal early warning systems into city-wide hazard early warning planning.

Going forward, this research suggests that future studies may examine the effect of the use of informal early warning systems on the uptake of formal early warnings that are available in informal settlements. This is important given the present lack of knowledge of the extent to which reliance on informal early warning may have influenced the acceptance of early warning from formal sources in the informal settlements. Doing so will help to ascertain the effectiveness of the informal early warning sources, as well as in guiding planners on different combinations of early warning sources in adaptation planning in the city.

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