Rapid Climate Adaption Assessment (RCAA) of water supply and sanitation services in two coastal urban poor communities in Accra, Ghana
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ABSTRACT
This study assessed the impact of different hydrological scenarios on existing vulnerabilities of water and sanitation services in Chorkor and Shiabu, two coastal urban poor communities in Accra, Ghana. The hydrological scenarios were developed from the literature on climate change projections. This paper recommends adaptations for community members, service providers, and the municipality based on the impact assessment. Chorkor and Shiabu are vulnerable to an increase in rainfall because of the lack of adequate solid waste management and hydrological sound drains. Shiabu’s topography and the indiscriminate sand mining along its beach make it vulnerable to an increase in sea level. Looking beyond Chorkor and Shiabu’s community boundaries, the urban water utility which supplies water vendors in both communities may be severely impacted by a decrease in rainfall, which would lead to water scarcity and a shortage in hydroelectricity. Regardless of which climate change scenario emerges, many of the recommended adaptations are good water management practice, for example, increasing the number of household connections and reducing non-revenue water. Putting climate change high on the agenda has the potential to generate additional funding to help address Chorkor and Shiabu’s water and sanitation problems, and climate-proof services for the future. However, the study method does not address the governance of these adaptations.

Key words | Accra, climate change adaptation, climate change impacts, Ghana, sanitation, urban poor

INTRODUCTION
Increasing concerns over climate change and its impacts continue to fuel a global debate on how to increase resilience and adapt to a changing climate. The impacts of climate change are likely to vary geographically and across societies. While it is difficult to make concrete projections, it is expected that the poor in low- and middle-income countries, especially in Africa, will be affected most (Boko et al. 2007). This is because climate change places additional pressure on countries which often lack sufficient economic resources and already face challenges such as rapid urbanisation and environmental degradation (Boko et al. 2007; Intergovernmental Panel on Climate Change 2007).

On a global level, climate change alters the hydrological cycle, which makes water one of the primary media through which climate impacts the earth’s ecosystems and human wellbeing (UN Water 2010). Therefore, water resources and the water and sanitation sector are expected to be particularly impacted by climate change (Bates et al. 2008; UN Water 2010).

doi: 10.2166/wcc.2019.204
The importance of access to and availability of safe water and sanitation was highlighted by the United Nations’ affirmation of the right to water and sanitation and its Sustainable Development Goal Six (SDG 6) (United Nations 2015). However, despite a series of high-level reports on climate change and water and sanitation, there is a striking lack of context-specific and pragmatic advice on adaptation measures for water and sanitation service providers (Oates et al. 2014). One attempt to fill this gap was made by Heath et al. (2012), who developed the Rapid Climate Adaptation Assessment (RCAA). This paper represents a further application and testing of the RCAA.

Africa’s capacity to adapt to climate change is reduced because of a combination of multiple stresses including ‘endemic poverty, complex governance and institutional dimensions; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts’ (Boko et al. 2007, p. 435). These existing vulnerabilities are exacerbated by population growth and urbanisation. This makes Africa the continent most vulnerable to the impacts of climate change (Parry et al. 2007).

In contrast to the rest of the world, population growth across Africa continues to accelerate. The United Nations Population Division (UNPD) estimated that by 2050, Africa’s population will have doubled to 2.4 billion (UNPD 2015). Most of this growth takes place in urban areas, and as the most rapidly urbanising region in the world, Africa is projected to see a 16% rise to 56% of its population living in its cities by 2050 (UNPD 2015). Ghana follows this trend.

As of 2015, 54% of Ghana’s population live in urban areas in which 38% of the population live in slums (The World Bank 2016a). It is the urban poor, often living in informal settlements which are unplanned and densely populated, who are most vulnerable to climate change in Ghana (Agyemang-Bonsu et al. 2009). In Accra (a rapidly growing coastal city of roughly three million people), these settlements are often located along the coastal areas or close to surface watercourses where sea-level rise, induced by climate change, and heavy rain events, are likely to exacerbate periodic flooding (Brown et al. 2011; Rain et al. 2011). There have been warnings that at the low-lying coastal environments in the west of Accra, the coastline could recede 202 m from 1970 to 1990 levels by the year 2100 due to sea-level rise. This could displace 26,000 people by the year 2050 and 646,000 people could be affected by inundation by the year 2100 (Appeaning Addo et al. 2011). Sea-level rise is also likely to cause saline intrusion of seawater into the groundwater (Brown et al. 2011; Rain et al. 2011).

Increasing temperatures could also cause additional public health risks as disease vector distribution patterns shift (Agyemang-Bonsu et al. 2009). Furthermore, with climate change increasing, temperatures are likely to increase evaporation, leading to lower water levels in Accra’s surface water reservoirs, on which the city mainly relies for its piped water (Abankwa et al. 2009).

According to the World Health Organisation/United Nations Children’s Fund Joint Monitoring Programme (JMP), 95% of Ghanaians living in urban areas have access to an improved water supply (WHO/UNICEF 2015). However, only 20% of the urban population has access to improved sanitation. Another 73% use shared facilities (public toilets, compound toilets) and an estimated 7% openly defaecate.

However, due to a mix of ‘technical, institutional, and social constraints’ (Van Rooijen et al. 2008, p. 1) Ghana Water Ltd (GWCL), Ghana’s urban water utility, is only able to meet 65% of Ghana’s urban demand, and only 45% of Accra’s urban population has a piped household or yard connection. GWCL has introduced a drinking water rationing programme for Accra, to address the issue of demand outstripping supply. This leaves 75% of Accra with an intermittent water supply (Water Aid 2008). While the percentage of the urban population with access to an improved water source has increased from 84% in 1990 to 93% in 2015, the percentage with access to piped water has decreased from 41% to 32% over the same period (WHO/UNICEF 2015). Together with existing vulnerabilities in water and sanitation, achieving universal access to water and sanitation is increasingly at risk as climate change impacts water resources and services (Howard & Bartram 2010).

This paper describes the application of the RCAA to two coastal urban poor communities in Accra: Chorkor and Shiabu. The objectives were:
to conduct the first study applying the RCAA methodology to a coastal city, where water and sanitation services are likely to face challenges such as increasing sea level, coastal erosion, salinisation of groundwater, and subsidence of land; and

- to make recommendations on how to increase service resilience, considering current vulnerabilities in water and sanitation and the impact of future hydrological scenarios.

BACKGROUND

Chorkor and Shiabu

Chorkor and Shiabu are located alongside the western coastline of Accra (Figure 1). Chorkor and Shiabu have an area of ∼0.5 km² each, and it is estimated that around 15,000 people live in each of the two communities. They used to be isolated fishing villages that are now part of the urban area (Engstrom et al. 2013). They were selected as typical examples of coastal urban poor communities in Ghana.

The Accra-Tema Metropolitan Area (ATMA) is supplied with piped water from three water treatment plants: Weija (Densu river), Kpone (Akosombo dam), and a desalination plant at Nungua in the Kpeshie district. However, it is estimated that only 45% of Accra’s urban population has a piped household or yard connection (Van Rooijen et al. 2011). Most people in Chorkor and Shiabu are supplied with water by private water vendors who receive water from the Weija treatment plant, via GWCL. This is the most common supply situation in Accra (Abankwa et al. 2009). Population growth is as high as 9% in the urban fringe, and water supply lags behind population growth: the gap in 2008 was estimated to be 47%, although it might be less due to the contribution of informally operated boreholes (Van Rooijen et al. 2010).

The water from the water vendors is usually used for household purposes and personal hygiene. It is sometimes used for drinking, although studies have shown that in Accra’s slum neighbourhoods, 50% of households, particularly those with lower incomes, use sachet water from shops and street vendors for drinking (Stoler et al. 2012). This was confirmed by statements made in the focus groups. The water supply is being expanded into Chorkor by the $150 million Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project; this project also aims to increase the provision of environmental sanitation (GWCL 2017).

In Chorkor and Shiabu, the majority of the population relies on privately run ‘public toilets’, while some defaecate at the beach. Household toilets are rare and they are not sewered.

Climate change

McSweeney et al. (2008) projected that Ghana’s mean annual temperatures will increase by 1.0–3.0 °C by the 2060s and 1.5–5.2 °C by the 2090s. This largely corresponds with projections by Minia (2008) and Stanturf et al. (2011). Predictions regarding rainfall remain less certain: half of the models project an increase in rainfall, whereas the other half of the models project a decrease (Minia 2008; McSweeney et al. 2008; as summarised in Stanturf et al. 2011). Stanturf et al. (2011, p. 34) forecast that by 2080 ‘precipitation for Accra and the coastal Savannah zone [will] range from a 52% decrease to a 44% increase in wet season rainfall’. However, some research predicts that even without climate change considerations Ghana will become a water-stressed country by 2025 (Kankam-Yeboah et al. 2011). One- and five-day rainfall maxima tend to increase (MESTI 2015).

McSweeney et al. (2008) project an increase in the sea level from 1980 to 1999 levels, of between 0.13 and 0.56 m by the 2090s, depending on the emission scenario.

METHODS

The RCAA was selected for this study because it is a bottom-up approach which allows local stakeholders and communities to inform the recommendations, rather than being more theoretical (van Aalst et al. 2008). An alternative is the CRiSTAL methodology (Dekens et al. 2012), but the RCAA is developed specifically for water and sanitation. A review by Doczi (2014) said that the RCAA ‘supports practical programme-level decisions on planned adaptation interventions specifically for the water sector’. RCAA
assesses how climate change will ‘interact with existing vulnerabilities in peri-urban and informal areas, and then recommends adaptations to the existing plans for water and sanitation providers to increase their climate resilience’ (Heath et al. 2012, p. 621). It does not seek to perform detailed hydrological or impact modelling but rather provides an overview, bringing key issues to the attention of stakeholders.

This study applied the RCAA in a new context. The RCAA was first proposed by Heath et al. (2012) who developed and trialled it in Zambia, Kenya, and Madagascar. The methodology assesses existing infrastructural vulnerabilities and the impact of climate change on urban water and sanitation services, and then generates recommendations for local adaptations.

RCAA combines a desk-based literature review of key climate change resources with fieldwork in local communities. The RCAA consists of five steps:

1. literature review;
2. vulnerability assessment through fieldwork;
3. hydrology scenario development;
4. impact assessment; and
5. climate-proofing recommendations.

**Literature review**

A review identified six key national climate change documents in order to identify climate projections for Ghana and develop likely hydrological scenarios for Accra:

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*Figure 1 | Overview of map of Chorkor and Shibu (OSM 2015).*

Fieldwork: vulnerability assessment

The fieldwork was undertaken in Accra from June to July 2016. It was conducted in two coastal urban poor communities in Accra: Chorkor and Shiabu.

Semi-structured interviews, focus group discussions, and direct observation were used to assess the current vulnerabilities of water and sanitation services and stakeholders’ perceptions of the sustainability of current water resource quality and quantity. Forty-six semi-structured interviews were conducted with stakeholders at the national, municipal, and community level, and two focus groups were conducted at the community level. A summary of the interviewees is found in Table 1.

At the national level, representatives from ministries, government agencies, development partners, NGOs, and researchers were interviewed. At the municipal level, interviews were conducted with representatives from Accra’s Metropolitan Assembly (AMA), municipal departments, GWCL, and local field officers from government agencies.

At the community level, the local chiefs (often landowners) and district assembly man (elected or appointed members of the district assembly (Parliament of Ghana 1994)) were interviewed. Furthermore, a community focus group was conducted for each community. The aim of the focus groups was to understand the communities’ perception of the impact of climate change on communities and their suggestions as to adaptations. 8–10 people were invited to each focus group by the local community leader, with the aim for an equal ratio of men and women, but in practice 16–18 people attended. A local Ga speaking translator facilitated the groups.

The questions varied according to the role and expertise of the interviewee. The topics covered in the interview included the following:

- Climate change awareness of the interviewee(s).
- Impacts of climate change on water and sanitation services: discussion of hydrological scenarios and extreme events and their impact on water and sanitation services.
- Other impacts of climate change (not related to water and sanitation): assessment of the wider impacts of climate change on the communities, such as people’s livelihoods, their diet, and the communities’ infrastructure.
- Water resources: discussion of quality and quantity of surface water and groundwater in Ghana, review of abstractions and competing uses, and the identification of major threats such as pollution.
- Existing climate change-related policies, strategies, and management plans.
- Adaptations: discussion of how stakeholders could adapt to long-term climate change and extreme events.

Questions were adapted for each stakeholder group. Verbal statements provided during the interviews and focus groups were confirmed, where appropriate, through transect walks and direct observations. During observations, special attention was paid to the local topography, and the general state of the local infrastructure, particularly infrastructure related to water and sanitation. Indicators of flooding and sea-level rise, such as water marks, water logging, and subsidence of land, were also identified during observations. Direct observations were documented through pictures and field notes.

Interviews and focus groups were recorded and notes taken during the interviews and focus groups were checked against the recording. The notes were transferred into NVivo, a qualitative data analysis software, which was used for ‘thematic coding’ – coding frequently emerging terms across the data set, and collating them into themes.

Table 1 | Type and number of stakeholders interviewed

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>National/municipal level</th>
<th>Chorkor</th>
<th>Shiabu</th>
</tr>
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<tbody>
<tr>
<td>Community leaders/elders</td>
<td>–</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Community focus groups</td>
<td>–</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Local service providers*</td>
<td>–</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Utility</td>
<td>3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Municipality</td>
<td>2</td>
<td>4</td>
<td></td>
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<tr>
<td>Government</td>
<td>7</td>
<td></td>
<td></td>
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<tr>
<td>International organisations</td>
<td>7</td>
<td>–</td>
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</tr>
<tr>
<td>Researchers</td>
<td>3</td>
<td>–</td>
<td></td>
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<tr>
<td>NGOs</td>
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</tbody>
</table>

*Local service providers included: water vendors, public toilet providers, and mixed providers offering toilet and bath house services at the same time.
(Boyatzis 1998; Braun & Clarke 2006). Initial themes, based on the literature review, were defined before fieldwork was conducted but were subsequently adjusted to account for themes that had emerged during the fieldwork. The final set of themes formed the basis for the analysis. Any conflicting data was compared and triangulated in order to present the results here.

Hydrology scenario development

Variability in climate projections and lack of localised climate projections necessitated the development of simple conceptual hydrological scenarios. Scenarios were based on data found in the climate change literature. The lack of localised quantitative data meant the scenarios were only conceptual in accordance with the rapid nature of the RCAA method (Heath et al. 2012). These scenarios were tested for potential impacts on the local hydrological regime (groundwater and surface water resources) using the method proposed by Heath et al. (2012), with adaptations to account for the coastal location of Chorkor and Shiabu. Scenario testing included an analysis of the following risks:

- increased surface runoff and erosion;
- increased flooding;
- increased groundwater recharge and rise in groundwater levels;
- decreased surface water availability;
- decreased groundwater levels;
- coastal erosion and flooding;
- saline intrusion into groundwater; and
- subsidence of land.

Impact assessment

The impact assessment used the information from the vulnerability assessment and considered how the different hydrological scenarios would impact water resource quality and quantity of water and sanitation services and the community as a whole. It analysed how projected changes to the climate and hydrology would interact with already existing vulnerabilities by assessing the resilience of both communities’ water and sanitation technologies in the projected scenarios. It was important to assess the wider impact of climate change on the community as a whole since changes to people’s livelihoods can affect household income, which can affect the affordability of services and willingness to pay. In turn, the inability to pay could lead to a lack of funding for climate change adaptations (Peal & Drabble 2014).

Climate-proofing recommendations

Adaptations for community members, local service providers, GWCL, and the municipality were recommended, based on the results from the impact assessment (which included suggestions from the focus group and interviews) and technology-specific adaptations from Vision 2030 (Howard & Bartram 2010). This approach meant that recommended adaptations were specific to the local context.

RESULTS

Hydrological scenarios

Three hydrological scenarios were developed for Chorkor and Shiabu based on the climate change literature on Ghana. These were: (1) increase in rainfall and rainfall intensity; (2) decrease in rainfall; and (3) rising sea level.

Due to the variability of climate projection, the scenarios are qualitative only. These scenarios were used to analyse the impact of climate change on Accra’s water and sanitation services.

Awareness of climate change

During the interviews, national stakeholders such as ministries, academia, and development partners demonstrated a good understanding of climate change but showed less understanding of the specific impact of climate change on water and sanitation services. At the municipal level, only one out of five interviewees had a good understanding of climate change and an awareness of the National Climate Change Policy (NCCP).
Residents in both communities had a relatively high awareness of climate change. For example, the fisherman observed changes in the onset and offset of the rainy season, erratic rainfall patterns, and sea-level rise, and the people mentioned that they cannot dry foodstuffs like cassava in the sun. They also observed the sea coming closer, and believed it was only divine intervention keeping them alive.

Impacts of climate change on water resources

1. Increasing rainfall: Increasing rainfall would, on the one hand, have a positive effect on groundwater recharge and Ghana’s surface water reservoirs. On the other hand, it would increase surface runoff and flooding, resulting in solid waste and contaminants being washed into the surface reservoirs. This would likely increase water treatment costs. Interviews with GWCL suggested that the Weija treatment plant, which supplies Chorkor and Shiabu, already has to deal with poor raw water quality due to ‘human activities that generate waste, untreated sewage, fertiliser and pesticide runoff’ (Water Aid 2008, p. 36).

Furthermore, GWCL reported that after rain events, high levels of sediment being washed into surface water reservoirs forces them to shut down their treatment plant. In addition, interviewees said that the newly constructed seawater desalination plant has to be shut off after rain events due to a large amount of solid waste being washed into the sea and choking the intake screen.

2. Decreasing rainfall: Decreasing rainfall would lead to lower water levels in surface water reservoirs and a reduction in hydroelectric production (Kankam-Yeboah et al. 2011). This would impact the water treatment plant and pumps which require electricity. Thus, a decrease in rainfall is likely to lead to an even more intermittent water supply.

3. Sea-level rise: Sea-level rise could increase the salinity levels of groundwater (Addo 2013). However, some of Accra’s aquifers are already saline and the population relies mainly on surface water (Abankwa et al. 2009; Addo 2013).

A summary of the impacts can be found in Table 2.

Impacts of climate change on existing vulnerabilities

1. Increasing rainfall: Shiabu, which translates as ‘sandhole’, would be particularly impacted by increasing rainfall: it is extremely low lying and used to be a sand pit (Figure 2). Community members reported frequent flooding, even during minor rainfall events.

Shiabu’s susceptibility to flooding is exacerbated by community members filling up the watercourse with rubbish to reclaim land for construction (Figure 3).

The watercourse is the only effective drain towards the nearby lagoon. The only other drains are found along the road that runs along the beach (‘beach road’), which acts as a dam between the sea and the community. However, these drains are parallel to the coastline and are insufficiently sloped, as is evident from the stagnant water found days after the last rainfall and accounts from the local National Disaster Management Organisation’s (NADMO) field officers (Figure 4). Furthermore, the community often dumps household waste in the drains, leading to the drains being choked. As a result, during rain events, these drains often overflow back into the community and cause flooding. Increasing rainfall and rainfall intensity would likely exacerbate this situation. While water and sanitation vendors along the beach road are relatively safe from flooding, vendors within the community frequently see their infrastructure flooded (Figure 2).

Flooding causes sediment and garbage to be deposited and block the drain. Overflowing septic tanks and damaged sewers crossing the community can potentially contaminate standing water after flood events and re-contaminate piped water – especially if the water supply is intermittent (Figure 5).

Chorkor gently slopes towards the sea, and is, therefore, not at risk of flooding. However, the part of the community which is located along the coastline has no storm drains. Therefore, increasing rainfall would cause intensive surface erosion, exposing pipes, and causing damage to the water infrastructure.

Public toilets in both communities are vulnerable to Accra’s frequent power outages. All public toilets that were visited were pour-flush toilets, which often relied on boreholes in order to flush the toilets. These boreholes had mechanical pumps; however, there was only limited storage capacity available, so that when the power was out some sanitation vendors had to go to the sea to fetch water for flushing. Sanitation vendors described as their main issue the frequent power outages, which are often caused by strong winds during heavy rain events damaging electricity wires.
Table 2 | Summary of impacts and adaptations

1. Increasing rainfall and increasing rainfall intensity

**Impact:** Surface runoff and flooding causes damage to water and sanitation infrastructure, spreads liquid and solid waste in the community, washing litter, sediments and contaminants into surface water reservoirs

- Dispose solid waste at public waste collection points
- Stop flushing faeces on the roads
- Clean drains
- Stop building in flood-prone areas
- Consider household water connection
- Account for climate change in planning and design
- Assess infrastructure at flood risk
- Monitor water quality during flooding
- Improve coordination with the water resources commission for source protection
- Improve the urban drainage system
- Improve solid waste collection
- Enforce urban bylaws
- Build capacity at a sub-metro level to monitor contracts with water and sanitation service providers

2. Decreasing rainfall

**Impact:** Decreasing groundwater and surface water availability; decrease in hydroelectric production; increase in competing water demands due to increasing irrigation needs

- Increase capacity for household storage
- Consider a household connection
- Increase water storage capacity
- Treat stored water
- Take action to reduce spillage at taps
- Invest in a generator
- Account for climate change in water resource planning
- Rehabilitate pipe network, reducing non-revenue water
- Increase the energy efficiency of treatment plants
- Introduce a truly ‘pro-poor’ tariff
- Investigate inter-basin water transfers
- Improve efforts to educate regarding water use

3. Increasing sea level

**Impact:** Coastal erosion, destroying infrastructure; increasing coastal flooding; saline intrusion into groundwater

- Stop sand mining
- Stop constructing alongside the beach
- Identify infrastructure at risk of sea-level rise
- Enforce the existing spatial plan
- Plan for the relocation of residents

Figure 2 | Shiabu – flood-prone area (assessed by water marks on the houses).
2. Decrease in rainfall: Neither community was concerned about the effects of a decrease in rainfall. However, they reported frequent power outages during the dry season. While some power outages are related to strong winds, others are connected to decreasing levels of hydroelectric productivity during the dry season (Agyemang-Bonsu et al. 2009). Although Ghana’s energy issues are complex and not solely related to climate change, a decrease in rainfall would likely exacerbate the situation. This would particularly affect sanitation service providers who use groundwater from boreholes for flushing their toilets. The community could also be affected by a reduced availability of drinking water.

3. Increase in sea level: An increase in sea level and saline intrusion would have no direct impact on local water resources, as the community only uses...
groundwater, for flushing the public toilets as it is already saline. However, combined with a receding coastline, increasing sea levels would destroy houses and infrastructure close to the existing shoreline (see Figure 6). Both communities lie in an area with a high vulnerability to coastal erosion, with a historic erosion rate of $1.50 \pm 0.17$ m/year (Addo 2016). The trend is likely to continue due to sea-level rise, a deficit in the sediment budget for littoral transport and anthropogenic activities such as sand mining (Appeaning Addo et al. 2011; Addo 2013). Due to its geology (mainly unconsolidated alluvial sediments) and its extremely low-lying topography, Shiabu is more vulnerable than Chorkor to coastal erosion and flooding.

Shiabu’s residents and the local chief confirmed that the row of houses closest to the coast was destroyed by waves within the last 2 years, and the sea has come gradually closer over the past 30 years.
Other impacts of climate change on the communities

Fishermen reported that during the rainy season a lot of sediment is washed into the sea, and that this, along with plastic waste which gets caught in their nets, reduces their catch. An increase in rainfall intensity is likely to exacerbate this problem.

A reduction in rainfall and an increase in temperature in the north of Ghana has resulted in a reduction of crop yields. Interviewees stated that the scarcity of certain crops has resulted in a change in their diets. It has also forced many people who rely on farming to migrate into urban centres in order to find a job (Abankwa et al. 2009; Rain et al. 2011). This migration is one of the major causes of urbanisation and slum development in Accra and increases the pressure on land and infrastructure in communities like Chorkor and Shiabu.

Climate-proofing recommendations

Climate-proofing recommendations have been developed for four main stakeholders: community members, local service providers, GWCL, and the municipal government. Since many of the impacts and vulnerabilities are inter-related, recommendations tackling the same issue may target various stakeholders. It should be noted that the RCAA does not consider the available resources which is a clear limitation. Nevertheless, the recommendations should be useful to help stakeholders prioritise actions.

1. Increasing rainfall: Both communities described increasing rainfall as the main threat to the community, with the potential to exacerbate surface runoff and localised flooding. However, it appears that the actual threat is not increasing rainfall, but the underlying issue of the lack of adequate drainage and poor solid waste management.

The RCAA made the following recommendations to address an increase in rainfall:

• Municipalities should incentivise residents to bring their waste to the communal collection points instead of dumping waste on the road, in the drains or on the beach.
• Local water and sanitation service providers should protect their infrastructure from surface flow in order to prevent infrastructural damage and, in the case of water vendors, contamination of the stored water.
• The municipality, together with local waste collection services, should provide enough collection points to encourage appropriate waste disposal.
• The municipality should monitor the performance of the waste collection contractors, formalise the role of tricycle collectors, and enforce existing law on illegal waste disposal.
• The municipality should rehabilitate the existing drains and build new drains in both communities. In Chorkor and Shiabu, additional drainage is required to drain access water from the ‘beach road’ into the sea. Shiabu is also in urgent need of a drainage channel directing water into the lagoon, to prevent flooding.
• The municipality should dredge and stabilise the existing watercourse, which acts as a natural drain, and prevent people from filling it up with rubbish to reclaim the land.

The recommended measures are likely to reduce the pollution of ground and surface water, reduce surface runoff and flood risk, and prevent the re-contamination of drinking water.

2. Decreasing rainfall: This paper makes the following recommendations to address a decrease in rainfall:

• Residents should consider increasing household storage capacity and harvest rainwater to prepare for water shortages.
• Water vendors should also increase safe storage capacity and treat stored water.
• The owners of public toilets which rely on boreholes should invest in a generator to mitigate the effect of power outages – likely to increase in frequency if rainfall decreases.
• GWCL should consider climate change in the planning and design of its treatment and distribution infrastructure.
• GWCL should reduce non-revenue water, which is currently at 50% (GWCL, personal communication), in order to save water and increase its revenue. This revenue could be used to subsidise a pro-poor tariff, and thereby increase the number of people with a household connection.
3. Sea-level rise: Sea-level rise and increased coastal erosion will impact both communities. However, due to its topography Shiabu may be hit hardest.

This paper makes the following recommendations to address a rise in sea level:

- Community members should stop constructing houses along the beach and stop sand mining.
- NADMO should provide education on the consequences of sand mining and enforce the ban on this activity.
- The municipality should consider relocating people in the long-term, in addition to its plans to construct a sea defence.

DISCUSSION

Heath et al. (2012) found that community members often had a little awareness of climate change. However, fieldwork in Chorkor and Shiabu suggests that coastal fishing communities may represent a special case. Residents in both communities, particularly fishermen, were found to have a relatively high awareness of climate change. This could be explained by the fact that they are exposed to the daily weather and are affected by seasonality. Indeed, Yaro (2013) explained by the fact that they are exposed to the daily relatively high awareness of climate change. This could be edged that the inability of the GWCL to increase water contamination of drinking water. It should also be acknowledged that the inability of the GWCL to increase water supplies at the same rate as urbanisation (Van Rooijen et al. 2010) means that population growth may be having a bigger effect than climate change, an argument also put forward by Carter and Parker for Africa (2009).

Septic tanks, which use water for flushing, may be impacted by a drying environment, whereas the current flooding situation already leads to overflowing septic tanks and widespread environmental contamination. These findings are confirmed by the general technology assessment in Vision 2030 (Howard & Bartram 2010).

The community’s belief that they are more vulnerable to an increase in rainfall and rainfall intensity may result from the fact that localised flooding already poses a major challenge. Furthermore, an increase in flooding would cause more immediate damage to infrastructure at the community level than the other scenarios. Nonetheless, research shows that both scenarios are equally likely (Kankam-Yeboah et al. 2011; Stanturf et al. 2011; McSweeney et al. 2008).

Boakye (2008) compared the preliminary findings from this study to two other low-income coastal communities in Accra where the RCAA methodology was also applied: Glefe and Jamestown. He found that the services and vulnerabilities were similar except that Chorkor and Shiabu had no bath stalls which he attributed to the greater population density in these communities.

Ghana’s high inter-annual variability (MESTI 2015) leads to uncertainty in climate change projections and, therefore, makes it challenging to manage surface water and groundwater (Oates et al. 2014). However, many of the recommendations provided in this study are simply good water management practice, and their implementation would aid water and sanitation management and climate-proofing, regardless of which climate change scenario occurs. For example, if GWCL were to reduce its high level of non-revenue water, this would, on the one hand, enable GWCL to adapt to a decrease in rainfall, while on the other hand, it would generate revenue which could be used to subsidise a pro-poor tariff. The introduction of a truly pro-poor tariff would be significant, as ‘the lifeline’, a reduced tariff, has increased in cost in 2015 by 69% and the eligible allowance was reduced from 20 to 5 m³ (PURC 2015). The cost of water is even higher for those who are unable to afford access to a pipe connection: research has shown that in Accra, those who buy water supplies at the same rate as urbanisation (Van Rooijen et al. 2010) means that population growth may be having a bigger effect than climate change, an argument also put forward by Carter and Parker for Africa (2009).
from water vendors are likely to pay 4–18 times more than users with a regular connection (Van Rooijen et al. 2008). There is a $150 million World Bank project to expand the water network and increase the provision of environmental sanitation, but these efforts will only affect Chorkor, not Shiabu (GWCL 2017). There is an estimated $327 million annual funding gap required to meet the Sustainable Development Goal for Water in Ghana (Safe Water Network 2017), so even this investment is still woefully inadequate.

Ghana ratified the UNFCCC in 1995. It submitted its first, second, and third communication in 2000, 2011, and 2015, respectively. Within Ghana’s Government, MESTI and EPA are the key institutions that implement and coordinate climate change-related policies and programmes (MESTI 2015).

In order for the recommendations to be successful, they need to be integrated into the existing policy framework (Sanchez-Rodriguez 2009; Simon 2010). This is the major limitation of the RCAA methodology: while it is a suitable tool to identify hydrological scenarios and their impacts it does not address governance, policy, and finance-related issues. It was evident from the fieldwork that Ghana’s vast legislative and executive portfolio on climate change is not translated into real actions.

There are a range of complex reasons for this, from a lack of government prioritisation (Arthur 2015), through to the Government’s failure to provide the funding and support to comply with its own the standards and regulation — observed both by Oates et al. (2014) and by a number of interviewees. This is further confirmed by AMA itself which identified ‘poor governance as the core developmental problem’ (AMA 2016, p.1) and found that its effects, which include ‘inadequate revenue mobilisation’ and ‘low institutional and financial capacity of AMA departments’, lead to inadequate service delivery. Furthermore, stakeholders also suggested that Ghana’s climate change policies are too generic and fail to meet local needs: one interviewee commented that the policies ‘look as if they have been written in a hotel room in London’. This is borne out by reports that there are ‘no directives or implementation plans tackling climate-related risks at the district level’ in Ghana (Delali et al. 2014).

The authors realised that the lack of attention of the RCAA to resource availability and more broadly the governance of adaptation was a major limitation, and decided to further explore it by revisiting some of the stakeholders to discuss their adaptive capacity and build an Adaptive Capacity Wheel, assessing eight dimensions of their adaptive capacity: variety, learning capacity, room for autonomous change, leadership, availability of resources, fair governance, adaptation motivation, and adaptation belief (Gupta et al. 2010; Grothmann et al. 2015). The conclusions are presented in detail in Boakye (2018) and highlight how informal providers are often able to be more nimble and quickly adapt to changing situations, whereas larger organisation are more inflexible. However, the informal sector lacks coordination and their adaptations can compromise services elsewhere, for example, water vendors pumping directly from main water pipes. The RCAA methodology is a rapid methodology and does not include detailed scenario development and modelling. However, because it is quick and cheap to undertake, it can be completed in low resource settings and can be a practical call to action for stakeholders.

The RCAA methodology does not aim to address governance-related issues. However, if applied differently, it could contribute to solving this bottleneck: by sending feedback on local climate change adaptations to national level actors, to enable them to refine national policies. Taking a bottom-up approach could make Ghana’s climate change policies less generic and, therefore, more implementable. Nevertheless, Ghana’s political priorities need readjusting: climate change should be mainstreamed into Ghana’s water and sanitation policies and into sectoral development plans. Furthermore, sufficient funding at the municipal level needs to be sought to enable policy implementation. Two communities were selected for this study that were on the coast in Accra. A subsequent wider study of other communities in Accra (Boakye 2018) had similar findings, suggesting that these two communities were typical and community selection is not biasing the results.

At a time where Ghana’s budget is limited and the water and sanitation sector needs significant investment, climate change could pose an opportunity for the introduction of new water and sanitation technologies and for additional funding, given its prominence on the international stage. One interviewee from an international organisation alluded to this idea that climate change could be an agenda for change, suggesting that ‘Climate change … has the potential...
to create a double stream which also allows [for] fixing ... [Accra’s] ... water and sanitation problem.'

CONCLUSION

For the purpose of this study, the RCAA methodology was applied to coastal communities for the first time. Three hydrological scenarios were developed and the impact of the scenarios on water and sanitation services in Chorkor and Shiabu, as well as their direct impact on existing infrastructural vulnerability, and their indirect impact on the communities, was assessed. Based on the results from the fieldwork, the development of hydrological scenarios and the impact assessment, the following is concluded:

1. **Despite the uncertainty involved in making climate projections, climate change is very likely to impact water and sanitation services in both communities.** An increase in rainfall and rainfall intensity is likely to exacerbate the already high risk of localised flooding during the rainy season, while a decrease in rainfall, which is equally likely, would particularly affect GWCL’s drinking water production. The communities’ low-lying topography means that sea-level rise could lead to a receding coastline inundating large parts of the communities.

2. **Residents in coastal communities demonstrated a good awareness of climate change; however, the perception of climate change needs to be critically reviewed.** During the focus groups, community residents did not see themselves as being vulnerable to a decrease in rainfall, which is as likely as an increase, and could lead to water scarcity.

3. **Adaptations at the local level are good water management practice and should be implemented regardless of climate change projections.**

4. **At the regional level, climate change considerations become increasingly important.** GWCL should take climate change considerations into account when rehabilitating infrastructure and in the planning and design of new infrastructure.

5. **The RCAA methodology does not address governance-related issues but, if used differently, its results could provide valuable feedback about local-level issues to policymakers.** Ghana’s climate change policies have been criticised for being ‘too generic’ and not localised enough, which impedes implementation.

6. **Barriers to implementation need to be addressed and policies need to be made implementable.** Steps should be taken to put in place funding to address Ghana’s array of climate change policies.

7. **The prominence of climate change on the international stage means that it could be used as an ‘agenda for change’ in the water and sanitation sector.** Placing a stronger emphasis on the impact of climate change on the water and sanitation sector could attract funding from actors concerned about the impacts of climate change. This could enable the funding of climate change resilient technologies.

This paper makes two key recommendations for future research: First, localised climate projections for Ghana should be developed, together with risk maps, in order to provide a solid baseline for policymakers and effective climate-proofing. Second, governance issues at the national and particularly municipal level which impede the implementation of climate adaptations and successful water and sanitation service delivery should be investigated.

To conclude, the RCAA methodology is a suitable tool to provide an overview of the impact on water and sanitation services at a local level. Climate change may not be the root of many of the vulnerabilities of these services but will most certainly exacerbate most of them. However, the RCAA needs to be extended to address governance, policy, and resourcing issues. The recommendations made in this paper are good water management practices and should be implemented regardless of climate change. However, addressing climate change and putting it high on the agenda has the potential to generate additional funding with which to address Chorkor and Shiabu’s water and sanitation problems, while climate-proofing services for the future.

ACKNOWLEDGEMENTS

This research was funded by Water & Sanitation for the Urban Poor (WSUP). The authors thank WSUP for their
support and assistance with the fieldwork. Furthermore, the author would like to thank all interviewed stakeholders and the participants in focus group discussions for their time and co-operation in conducting this research.

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First received 9 August 2018; accepted in revised form 20 September 2019. Available online 16 December 2019.