Strategic agenda for adaptation to urban water-mediated impacts of climate change in Accra, Ghana

URAdapt: Managing water in the urban-rural interface for climate change resilient cities

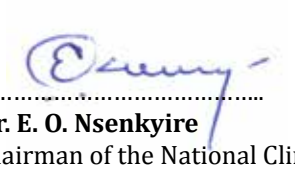
Foreword

Evidence shows that an increase in temperature due to climate change is expected, accompanied by changes in weather patterns. The impacts of these changes are perceived across the country, but more notably in the urban areas of districts and metropolitan assemblies which are home to nearly 50% of the Ghanaian population. Climate change adaptation measures in these areas are ad hoc with no long-term plans and strategies in place.

It is in this light that the Strategic Agenda plays an important role in supporting informed decision-making for combatting climate change impacts. It was developed on the basis of an exhaustive dialogue over a three-year period in which all the pivotal stakeholders participated.

This Strategic Agenda for Accra reviews the findings of research and provides recommendations, which can also be applied to other metropolitan areas in Ghana. The research shows that if water resources are managed properly, Accra can become considerably more resilient to climate change even when faced with projected population increases and other influencing factors. This is a significant opportunity for innovative policymakers at the cutting edge of the climate change debate. We can create a country and people that are prepared for climate change impacts and not constantly responding to emergencies.

The National Climate Change Committee will extend its full cooperation to implementing the strategic actions and recommendations proposed by the project. We invite all stakeholders and identified responsible organizations to support this endeavor.



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Chairman of the National Climate Change Committee
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Contents

Strategic agenda for adaptation in Accra

Cities are undergoing deep transformations throughout sub-Saharan Africa. Their populations are growing and their physical boundaries are expanding. Socioeconomic shifts – including the rise of an urban middle class – are leading to new patterns of production and consumption. Along with these shifts is a changing climate.

Accra is no exception. According to the 2000 census, the city has a population of 3.8 million (GSS 2012). The Metropolitan Area (AMA) is home to 1.8 million, but the extent of urbanized area easily exceeds the AMA administrative boundaries into what is known as the Greater Accra Metropolitan Area (GAMA), accounting for this difference. Estimates for the urbanized surface area vary between 422 km^2 (Soto 2006) and 751 km^2 (Yankson et al. 2004).

As Ghana transitions into middle income status, its key economic assets will be affected by climate change (MEST 2010). There is a clear need for new resource management practices that can secure a sustainable, climate-compatible future for cities and their surroundings. This is where the URAdapt strategic agenda comes in. The strategic agenda provides direction for city managers on how Accra's water and wastewater systems can respond to the impacts of climate change. It is intended for national, regional and municipal decision-makers as well as private sector and non-governmental actors.

The strategic agenda sets out key recommendations as the basis for more detailed action plans by different stakeholder groups. The recommendations are contextualized in terms of current practices and policies, as well as the measures needed to build the climate change resilience of urban water and wastewater systems.

The recommendations were developed on the basis of a science-based dialogue among representatives of research institutes, public authorities, industry groups and non-governmental organizations. Collectively, they identified topics for research which were carried out by a team of biophysical and social scientists. The results of these studies can be found in the section, *Case studies and findings*.

The agenda describes three strategic objectives of major and immediate relevance when addressing climate change adaptation options for Accra. It outlines the pertinent issues and concerns, and presents the strategic recommendations for each objective, in addition to describing the enabling conditions and designating the responsible organizations. The document conforms to the urban water and climate change governance contexts of Ghana and Accra, and refers to the national development priorities as described in the Ghana Shared Growth and Development Agenda.

STRATEGIC OBJECTIVE 1: ENHANCING THE ADAPTIVE CAPACITY OF THE CITY AND ITS COMMUNITIES TO FLOOD IMPACT OF CLIMATE CHANGE.

Sub-issues	Concerns	Strategic recommendations/actions	Enabling environment	Responsible organizations
Lack of capacity to manage floods in the city.	• Inadequate capacity (financial and human resources). • Overlap and inadequate coordination and duplicated efforts between agencies. • No demarcation between flood management and response. • Outdated strategies for flood management. • Inadequate implementation of flood management strategies. • No flood early warning systems. • Inadequate design and poor construction of drainage systems. • Lack of maintenance of storm drains.	• Separate flood management from flood response and develop clear strategies for both. • Flood risk management should be integrated in the Medium-term Development Plan at the appropriate local government level. • Integrate local knowledge into flood risk mapping and warning. • Review design criteria of drainage structures to accommodate increased storm-flows due to climate change and urbanization (in the light of demographic and development changes). • Undertake regular maintenance of existing drains. • Build capacity to manage floods.	• Comprehensive policy guidelines on flood management. • Improved coordination between relevant stakeholders. • Availability of adequate technical and financial resources.	AMA, NADMO, HSD, MWRWH, local-level committees (area councils, unit committees), NCCC, GMet, CBOs and NDPC.
Flood-prone communities marginalized and highly vulnerable.	• Weak coping capacity due to recurrent floods. • Poverty contributing to vulnerability. • Lack of suitable affordable lands for the poor and migrants. • Lack of voice and participation in local planning. • Poor attitude to waste disposal and management.	• Support local-level initiatives for adaptation, e.g., community action plans and strengthen Community-based organizations. • Develop/update flood risk maps and resettlement plans for the most vulnerable areas and communities.	• Community participation processes in place and implemented.	AMA, NGOs, FBOs, CBOs, WRI, NADMO, TCPD, ILGS, private sector and community opinion leaders.
Communities exposed to health risks due to poor sanitary conditions.	• Limited waste disposal facilities in the communities. • Poor household sanitation conditions. • Inadequate education on exposure to health risks. • Little or no enforcement of bylaws.	• Manage solid and liquid waste in flood-prone areas to reduce flood damage and health risks. • Include health risk education in community level sensitization and awareness programs. • Enforce bylaws on environmental sanitation. • Integrate local knowledge and input into sanitation strategies and plans.	• Environmental Sanitation Policy implemented. • Enhanced awareness of community in sound sanitation practices.	AMA, CBOs, NGOs, FBOs, traditional authority, WRI, NADMO, ILGS, communities and private sector.
Obsolete spatial and land-use planning and regulation (in the light of demographic and developmental changes)	• Outdated building regulations. • Poor enforcement of regulations. • Intractable land tenure system. • Impact of upstream structural interventions on flooding in downstream AMA areas.	• Review and update legislation and building codes. • Enforce land-use regulations. • Promote community involvement in local-level planning and management. • Strengthen spatial planning unit at the Local and Regional Coordinating Council level. • Create retention ponds upstream of the flood-prone communities. • Digitize maps for easy access and use. • Streamline land tenure systems.	• Clear vision and policy on city planning and zoning. • Widespread dissemination of the vision to all stakeholders.	AMA, ILGS, relevant departments of the RCC, HSD, ISD and GES.

Note: The underlined organization(s) are those that are designated to lead the actions outlined.

STRATEGIC OBJECTIVE 2: ADOPTING INTEGRATED CLIMATE-RESILIENT WATER SUPPLY AND DEMAND MANAGEMENT IN THE DENSU BASIN.

Sub-issues	Concerns	Strategic recommendations/actions	Enabling environment	Responsible organizations
Water supply development	• Inadequate planned water supply development to meet the minimum water demand in the future. • Water resources of the Densu River under stress due to the high abstraction rate (34%). • High physical and commercial losses.	• Review plans for future water supply for GAMA to increase the water supply levels. • Abstract more water from the Lower Volta to cater to all of GAMA's current and future requirements of potable water. • Develop capacity to monitor and repair faults and make replacements in the distribution systems. • Promote rainwater harvesting in households and public institutions.	• Adequate financial resources. • Available technical expertise in rainwater harvesting. • Available cost-effective and appropriate rainwater harvesting systems. • Minimize political interference in water delivery.	GUWL/GWCL, AMA, MWRWH, CBOs, GoG; WRC, research institutions, NGOs, MMDAs, CWSA, funding organizations. development partners, private sector and NDPC
Water demand management	• Increasing water demand. • Poor water conservation. • Inequitable access to water, particularly in peri-urban communities.	• Implement demand-side management that can ensure equitable and efficient use of water - institute targeted water supply in a rationing regime. - institute an adequate pricing mechanism to cover the operation and maintenance of the system. This should encourage conservation measures and be pro-poor. - formulate and enforce regulation for installation of water-saving devices at points of use. - create/raise awareness of efficient water use. - Develop strategic plans for population growth and influx of city migrants. • Review existing policies and water supply standards.	• Densu Basin water demand management plan. • Existence of point of use water conservation policy and regulation. • Strategic plan for population growth. • Supported private sector in the promotion and provision of water-saving devices.	MWRWH, GUWL/GWCL, WRC, parliament, CWSA, PURC, MMDAs and NPC.
Climate change impact on water availability (rainfall and runoff)	• Drying conditions in the Densu Basin. • Reduced streamflows.	• Implement a holistic basin-wide water resources management system to ensure water use efficiency and conservation - Involve upstream and downstream stakeholders (rural communities and the city) in the water resources management of the basin. - Consider urban and rural water use in the basin together. - Enhance the environmental condition of the Densu River to ensure its continuous functionality, e.g., create and protect buffer zones of the river.	• Strengthened, expanded and well-resourced Densu Basin Board to include both urban and rural communities. A basin integrated water resources management (IWRM) plan.	WRC, MWRWH, MoFA, GIDA, MOTI, GUWL/GWCL, farmer organization, commercial plantation developers, MMDAs, EPA, research Institutions, MEST and CWSA.

Note: The underlined organization(s) are those that are designated to lead the actions outlined.

STRATEGIC OBJECTIVE 3: STRENGTHENING INSTITUTIONAL CAPACITIES TO ADDRESS WATER-RELATED CLIMATE CHANGE IMPACTS.

Sub-issues	Concerns	Strategic recommendations/actions	Enabling environment	Responsible organizations
Coordinating climate policy and mainstreaming.	• Climate policy frameworks and strategies still a work in progress, but very centralized and limited to some agencies. • No dedicated core capacity and expertise for coordination and direction. • Ad hoc donor-driven processes and actions, not based on local needs. • Slow and fragmented mainstreaming into development agenda.	• Incorporate climate change issues in the educational systems. • Review, strengthen and consolidate the functioning of the NCCC and support its establishment as a coordinating unit with dedicated core capacity to influence change. • Consolidate a climate change working group within the Environment and Natural Resources Management sector working group convened by MEST for government and donor coordination and climate financing. • Strengthen climate leadership skills at NDPC level to guide climate mainstreaming into the local and national planning processes and develop and rollout guidelines. • Strengthen EPA for quality assurance of NDPC guidelines. • Mandate of NCCC must be clarified.	• Effective climate coordination function. • Identified focal resource persons placed at all levels – national, regional and districts.	MEST, MoFEP, EPA, NCCC, NDPC, MLGRD, MWRWH and GES.
Developing an agenda to address climate change and water management.	• Sector policies and strategies in water, and agriculture, address climate variability and not change. • Present basin water management approaches not sufficiently sensitive or flexible to respond to climate change. • Weak evidence base for climate-related water management decisions at basin level.	• Review existing water and agricultural policies for climate change proofing and prepare a roadmap for implementation, e.g., permit system for water allocation at basin level should be used more effectively as an instrument for adaptation to climate change. • Review, consolidate and apply water information system for climate adaptation. • MMDAs must ensure implementation of environmental policies and resource data collection agencies.	• Effective climate coordination function with a collaboration platform for all key stakeholders.	WRC, MWRWH, MoFA, MoH, GMet, WRI, universities and other research organizations, and existing basin Boards.
Prioritizing the role of cities in climate adaptation.	• Rapid urbanization. • Inadequate expertise and resources to address climate change. • Water, sanitation, wastewater and storm water planned and managed in isolation. • Poor linkages between national and local actions. • Weak engagement with relevant stakeholders.	• Strengthen resource base to support integration in city-level planning for adaptation. • Forge new relationships that include CBOs and city authorities to address adaptation. • Establish an urban water component as part of the main water information system, to respond to climate implications on urbanization trends and patterns.	• Operationalization of the departments of the district and the real implementation of the composite budgeting.	AMA, decentralized departments of ministries and agencies, local CBOs and community-level planning units, MLGRD and NDPC.

Note: The underlined organization(s) are those that are designated to lead the actions outlined.

Background to the project

Growing cities strain basic service provision

In many parts of sub-Saharan Africa, rapid urbanization outpaces the ability of city managers to adjust basic service provision, including water supply, sanitation and flood protection (Mafuta et al. 2011). Urban water management systems become subject to a range of pressures. Unplanned urban developments within watersheds may pollute surface waters and complicate water source protection. Land clearance, deforestation and the expansion of impermeable surfaces increase the risk of flooding, and slow the rate of infiltration and aquifer recharge. As storm water and surface water runoff flow through built-up areas, their pollution loads increase, particularly where the necessary solid waste management practices are lacking (Palaniappan et al. 2010).

Cities change local ecologies

The absence of water and sanitation services, alongside inadequate drainage and flood protection mechanisms, increase the disease burden on urban populations and the vulnerability of urban communities to weather-related disasters. New disease vectors or new infections emerge among urban populations.

Urban water management is a complex undertaking

Urban water management goes much beyond providing water and sanitation services and overseeing related infrastructure. It also includes mitigating the risk of floods, landslides and other water-mediated disasters, as well as managing solid waste and storm water drainage. Conventionally, these services have been delivered in isolation. Yet, greater integration is key to safeguarding cities and water resources (Bahri 2012).

'Silo-thinking' is not limited to city managers. At the basin-level, water resources management often fails to account for the interdependencies between freshwater, wastewater, flood control and storm water (Parkinson et al. 2010).

Cities need water for residential, commercial and other uses. Yet, water may be located far away and is unlikely to be at the disposal of cities alone. Moreover, prevalent management practices make little distinction between different water qualities. A wide range of water needs are met using high-quality water, thereby exacerbating resource scarcity (van der Steen 2006). The situation is further complicated by the myriad authorities and legislative frameworks that govern urban water management.

Sustainable water management practices in cities benefit not only urban communities but also those in surrounding areas. URAdapt enrolled a wide range of stakeholders and devised an integrated research framework to account for the mutual dependencies between water sources, water use sectors and water management scales.

Climate change and urban water-mediated vulnerabilities

A changing climate demands that the management of water is approached in a different way. Research on climate change adaptation has focused mostly on rural agriculture, neglecting the shift of populations towards cities. At the same time, urban infrastructure responses to climate change have concentrated on transport and energy sectors, and only minimally on water and wastewater systems.

Water will mediate climate change impacts on ecosystems, livelihoods and the well-being of societies in urban areas and beyond (UN-Water 2010). Climate change is expected to influence the intensity, timing and reliability of rainfall.

In many developing cities, existing infrastructure struggles to cope with current weather conditions. Climate change will place further strain on water, transport, energy and ecosystems. Where no safety nets are in place, basic service provision is interrupted, local economies come to a halt and urban populations may be forced to seek new livelihoods elsewhere. Within cities, existing inequalities will be made worse (UN-Habitat 2011). Yet, current projections of water supply and sanitation supply and demand only account for population increase, and not for the impacts of climate change.

Urban water demand can be expected to increase in the future as a result of growing populations, rising temperatures, and more frequent and extreme heat events. Changes in temperature and precipitation patterns are predicted to impact the availability (in terms of both quantity and quality), treatment and distribution of water (UN-Habitat 2011).

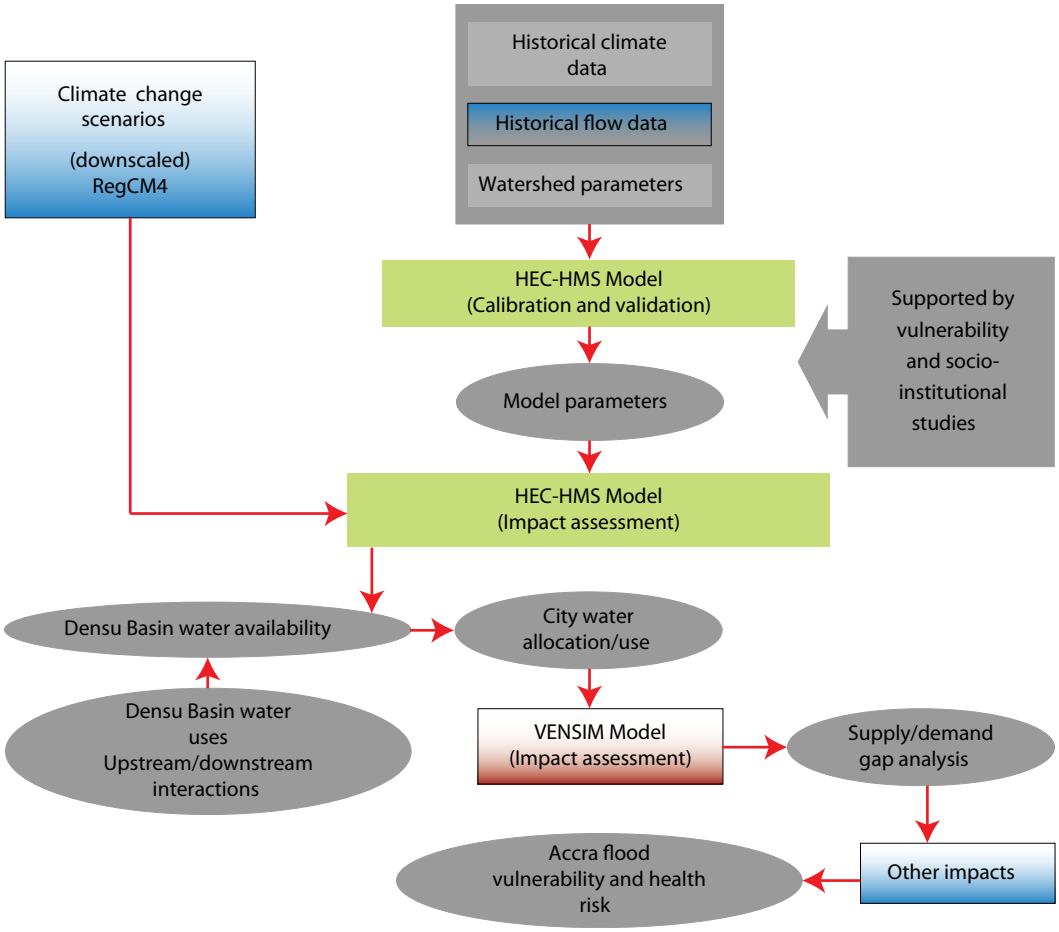
More rain and heightened flood risks imply higher costs for road, drainage and flood protection infrastructure. Some lands may no longer be habitable.

Climate change will impact water-based sanitation. In areas where precipitation decreases, water-dependent sewerage systems may be damaged. Elsewhere – particularly in cities with combined sewer networks – treatment facilities may flood, leading to water contamination and public health risks (Tucci 2009). Simultaneously, in areas where groundwater levels are expected to rise, pollution caused by pit latrines may become more difficult to manage (WHO and DFID 2009). As a whole, sewage treatment lags behind coverage. Under climate change, performance requirements, costs and potentially also the carbon footprint of wastewater treatment will increase (WHO and DFID 2009; Bahri 2009).

Half of the world's population live within 100 km of the sea and three-quarters of all large cities are located on the coast (UNEP and UN-Habitat 2005). Climate change-related sea level rise will lead to the intrusion of seawater into coastal freshwater systems, making groundwater sources and estuaries increasingly saline, particularly where reduced river flows are unable to prevent the flow of seawater upstream (Sadoff and Muller 2009).

URAdapt builds city resilience to climate change by generating projections of future water resources management in and for cities in light of population increases and impacts of climate change.

Generating knowledge for decision support



Conceptual research study framework

Definition of the research framework

URAdapt devised an integrated analytical framework to produce new knowledge on climate adaptation in support of decision-making. The project has taken as its starting point the interdependencies between water sources, scales and sectors that cut across the urban-rural continuum.

URAdapt has recognized that contextually relevant and sustainable solutions can only arise out of mutual learning and collective action. With this in view, the project applied a Participatory Action Research (PAR) approach, which involved setting up the Research into Strategic Action Platform (Re-SAP). This platform provided an opportunity for a novel constellation of stakeholders to come together to discuss how Accra can reduce its vulnerabilities to climate change through improved and integrated urban water management. The Re-SAP has provided critical input into research activities through data provision, monitoring of progress, and evaluation of research quality and relevance. A smaller Consultative Group has provided strategic direction to the project, deliberating conceptual questions (such as the future of decentralization and privatization in the water and sanitation sectors in Ghana) that have implications for research content and uptake of research results.

Using regional climate models (RegCM4), URAdapt scientists downscaled global circulation models to the level of the water basins serving Accra in order to understand their exposure to climate change under Intergovernmental Panel on Climate Change (IPCC) scenarios A1B and B1. This information was fed into a hydrological model (HEC-HMS) which projected water availability and allocation under different climate and basin water use scenarios. At the city level, URAdapt investigated urban water and wastewater interactions, including the water supply-demand gap under different scenarios of per capita water use and population growth, as well as the temporary water storage potential of Accra. Finally, the project also examined vulnerability in terms of exposure to flooding and the associated health risks for low-income communities.

Selection of stakeholder groupings (boundary partners)

Stakeholder selection was guided by two principles: the reflection of multiple perspectives on urban water management, and the participation of organizations and individuals in positions of incorporating project knowledge into policy debates and everyday working practice. More specifically, the project sought to enrol actors who could account for the following:

- The continuum of water use and management across urban and rural spaces (rural water supply, agriculture, irrigation), and reflect both the basin and national water resource management perspectives.
- Climate change (climate change lead organization in the government, implementers of adaptation measures and disaster risk mitigation).
- Socioeconomic factors that may compound vulnerability to climate change and be able to convey the voices of vulnerable women, urban slum dwellers and communities living in flood-prone areas.
- Local-level water governance (urban and rural local authorities, including those in charge of water supply and wastewater in the two project cities).
- Any health-related issues (including flooding and water contamination from poor sanitation).

The platform itself ensured that its composition continued to reflect the purpose of the project, and the in-built flexibility of the project ensured that new actors could be invited to platform meetings as and when needed. The specific tasks and operational mode of the platform were defined by stakeholders themselves. The Re-SAP also sought alignment with other water-related multi-stakeholder platforms in Accra.

Process for stakeholder engagement in order to have impact

The Re-SAP and Consultative Group have served as the main channels for stakeholder engagement. Collectively, they have discussed findings and their implications for policy formulation and implementation, and in this way, continually provided further definition to the types of impacts that the project could pursue. As a sign of further commitment to the project, platform members themselves gave presentations and facilitated discussions at platform meetings.

In pursuit of wide-scale impact, the URAdapt project team and Re-SAP members have participated in climate change-related policy consultations and networked with communities of water management practitioners both in Ghana and elsewhere. They represent a resource base that can be drawn upon in future work on climate change, water resources and cities.

At a more local level, URAdapt carried out targeted engagement with AMA. This involved focus group sessions with representatives of the waste management, sanitation, public health, urban roads, drainage, sewerage, town and country planning departments, and the development planning and coordinating unit. The project learned about the structure and functions of the AMA departments, as well as their information needs and data availability. As a result, the project was able to remain up-to-date on municipal initiatives and identify opportunities for integrating URAdapt research into the ongoing work of the local authority. The project also interacted closely with vulnerable communities as part of the case study analytical process.

At the final stages, in support of the uptake of the research findings, one-on-one meetings were held with high-ranking officials of stakeholder organizations. This culminated in a policy roundtable with heads of key organizations and sector ministries. The outcomes of this roundtable may result in the 'resource base of individuals' facilitating 'intra-organizational' assimilation and utilization of project knowledge, through seminars or focus group discussions and visits to some of the at-risk communities.

Case studies and findings

Research theme	Research/study topic	Main findings/likely scenario
Climate downscaling and hydrological modeling	Climate Downscaling of the Densu and Akosombo sub-catchments.	• General drying conditions projected for future climate. • Inter-annual rainfall variability is more pronounced and the SPI also indicates an increase in frequency of moderate to severe drought years for the future in the Densu Basin. • Dynamic downscaling of ECHAM5 emissions scenario IPCC A1B and B1 show that, in April, which is the usual transition from the dry to the wet season, precipitation will decrease by up to 70% and the duration of the rainy season will narrow, which may have extensive implications for agriculture and city water supply.
	Impact of climate change on water availability in the Densu Basin.	• A 10% reduction projected for Densu streamflow.
	Baseline water availability and use in the Densu Basin.	• Current total annual water abstraction is 34% of Densu's annual streamflow - basin already under water-stressed conditions. • Water abstraction upstream of the Weija Dam is small, just 1% of basin streamflow.
	Flood risk mapping in the GAMA of Ghana.	• Baseline urban flood risk maps produced with overlay of current flood-prone areas. Some floods are occurring even in the lower risk areas due to inadequacy of storm drainage networks in the built areas.
	Surface water availability in the Lower Volta Basin.	• More than enough water in the Lower Volta to cater for all of GAMA's current and future requirements of potable water.
Urban water balance trajectories	Water storage capacity in Urban Accra.	• Urban temporary water storage systems within GAMA have enough capacity to store a day's production of Ghana Urban Water Limited (GUWL). • The storage explains how the supply-demand gap is temporarily bridged. • Buffer storage for managing the supply-demand gap is biased to the high-income group, who are therefore less vulnerable to the water shortage situation.
	Water supply and demand situation modelling using VENSIM.	• Planned water supply development for GAMA is inadequate even to meet the minimum water demand scenario of 3.1% population growth and 60 liters per capita per day (l/c/d) consumption for Accra. • A shift in any of the non-climatic drivers will increase the water supply-demand gap of Accra. • High physical losses in the system exacerbate the supply-demand gap.

(Continued)

Case studies and findings (Continued)

Research theme	Research/study topic	Main findings/likely scenario
Human and institutional vulnerability	Quantitative Microbial Risk Assessment of Gbegbeyese.	• All indicator organisms (E. coli, fecal streptococci, and fecal coliform and Cholera spp) were low in population counts or not present in Gbebu (a shallow well sometimes used by inhabitants for domestic purposes) before flooding. • E.coli and fecal streptococci population levels increased significantly after floods from 0 to 1.9 x 10^{-5} to 2.3 x 10^{-4}. These levels exceed the standards for inland waters for bathing (9.0 x 10^{2} and 3.3 x 10^{2} (cfu 100 ml-1) for E. coli and intestinal Streptococci, respectively). • Levels of fecal coliforms, E. coli and fecal streptococci estimated in flood water in Gbegbeyese were relatively lower than the stream water which was highly polluted. • Fecal coliform and E. coli in soil samples collected from flood-prone areas increased significantly by 1.3 log units, after flooding. Similarly, Vibrio. parahaemolyticus populations increased from zero before flooding to 3.97 log units after flooding. • Varying levels of Vibrio spp were found in drinking water samples. These pathogens are not expected to be present in any drinking water source. Drinking water samples collected did not meet the standards for potable water.
	Hydro and climate institutional mapping.	• Climate change and decentralization (local government) as policy issues are in a state of flux. Both the climate policy framework and the climate adaptation strategy have been critiqued in their drafting for lack of an inclusive process. • There is no single point of coordination and direction, with dedicated core capacity and expertise thus limiting the framing of climate-related issues. Various interventions are donor-initiated and not responsive to local needs. • The macro-policy environment has paid heed to project-relevant themes, discursively if not effectively. Sector policies and strategies on agriculture, water and health sectors do not address climate change specifically but climate variability. • Mainstreaming climate change into the development agenda and MTDPs requires capacities and climate leadership skills at the level of the NDPC and the local level. • Resource constraints (finances and human) limit the enforcement capacities of responsible institutions, such as local government (AMA) and local-level TCPD. • A deep research-policy gap exists, due to poorly articulated knowledge requirements. The evidence base for informed decisions on climate-related issues needs to be strengthened through policy change on climate adaptation information systems. • There is some degree of overlap between organizations dealing with flood management and flood response, leading to a lack of clarity and direction both at national and local levels. • The Densu Basin Board is not adequately resourced (financial and technical skills) to respond to climate-influenced decisions on basin water management. • Water allocation by permit system provides sufficient flexibility to adapt to changes in water availability at the basin level, and should be used more effectively at basin level as an instrument for adaptation to climate change. • There is inadequate institutional flexibility for stakeholder participation in water allocation and management decisions.
	Community adaptation to flooding risk and vulnerability.	• Communities are capable of articulating their adaptation needs, which are not yet integrated into the local development planning process. • Involvement at the local level in the development planning process stops at the district level due to lack of resources, but should be decentralized further. • Spatial and land-use planning is critical for managing flood-related risks, but is not sufficiently prioritized in terms of implementation at national and local levels. • Poor attitude to waste disposal and management is a contributory factor to increased flood risk and health risk at community level. • Waste management is a decentralized function but there is inadequate investment. • There is a strong base of local knowledge of community members to tackle vulnerability and flood management as well as early warning signs.

Research gaps and suggested further studies

- Developing a scalable approach or methodology for addressing urban adaptation to climate change applicable across African cities.
- Water demand management and options for developing alternative water sources (rainwater harvesting, grey water/wastewater recycling, groundwater, water conservation).
- Decision support system for IUWM to mainstream climate change.
- Modelling water allocation in the Densu Basin under future climate and development scenarios.
- Applying regional downscaling models to understand climate impact in other major cities in Ghana.
- Coupling the expansion of built environment with climate change, and consequences for design of urban storm drainage systems.
- Climate information and attribution of impacts in understanding urban flooding in Accra.
- Improving urban flood hazard and risk mapping methods, and developing a current risk map for Accra and other urban areas in Ghana.
- Flood control and adaptation measures for greater Accra.
- Community participation and management for addressing flood adaptation.
- Quantitative microbial risk assessments and health impact analysis across flood-prone areas in Accra.
- Costing adaptation measures for informed decisions.
- Understanding and facilitating organizational change for mainstreaming climate change adaptation into working practices.

Boundary partners

Representatives/individuals from the following organizations participated in the Research into Strategic Action Platform (Re-SAP) meetings.

Accra Metropolitan Assembly
Association of Ghanaian Industries
Community Water and Sanitation Agency
Environmental Protection Agency
Ghana Health Service
Ghana Irrigation Development Authority
Ghana Urban Water Limited
Ghana Water Company Limited
Great Thinkers Club
Greater Accra Regional Coordinating Council
Hydrological Services Department
Institute for Environment and Sanitation Studies
Institute of Local Government Studies
Institute of Statistical, Social and Economic Research
Ministry of Food and Agriculture
National Disaster Management Organization
People's Dialogue
Regional Institute of Population Studies
SWITCH Project
UK Department for International Development (DFID), Ghana
University for Development Studies
Ministry of Water Resources, Works and Housing
Water Research Institute
Water Resources Commission

Representatives/individuals from the following organizations participated in the Consultative Group meetings.

Community Water and Sanitation Agency
Environmental Protection Agency
Ghana Water Company Limited
Institute of Local Government Studies
Ministry of Food and Agriculture
People's Dialogue
Regional Institute of Population Studies
Ministry of Water Resources, Works and Housing

Lead partners: International Water Management Institute (IWMI) and Council for Scientific and Industrial Research (CSIR) - Water Research Institute (WRI).

Lead researchers: The research team for the development of the Strategic Agenda includes Dr. Barnabas Amisigo and Fred Logah, CSIR-WRI; Dr. Ohene Sarfoh and Mr. Felix Amakye, Institute of Local Government Studies; Dr. Raymond Kasei, University for Development Studies; and Dr. Liqa Raschid-Sally, Dr. Philip Amoah and Mr. Edmund K. Akoto-Danso, IWMI.

Project funder: International Development Research Centre (IDRC), Canada; and the Department for International Development (DFID), UK.

List of acronyms

Acronym	Name
AMA	Accra Metropolitan Assembly
CBO	Community-Based Organization
CGIAR	A global research partnership for a food secure future
CSIR	Council for Scientific and Industrial Research
CWSA	Community Water and Sanitation Agency
EPA	Environmental Protection Agency
FBO	Faith Based Organization
GES	Ghana Education Service
GAMA	Greater Accra Metropolitan Area
GIDA	Ghana Irrigation Development Authority
GMet	Ghana Meteorological Agency
GoG	Government of Ghana
GSGDA	Ghana Shared Growth and Development Agenda
GUWL	Ghana Urban Water Limited
GWCL	Ghana Water Company Limited
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modelling System
HSD	Hydrological Services Department
ILGS	Institute of Local Government Studies
ISD	Information Services Department
MEST	Ministry of Environment, Science and Technology
MLGRD	Ministry of Local Government and Rural Development
MMDAs	Metropolitan, Municipal and District Assemblies
MoFA	Ministry of Food and Agriculture
MoFEP	Ministry of Finance and Economic Planning
MoH	Ministry of Health
MOTI	Ministry of Trade and Industry
MTDP	Medium-term Development Plan
MWRWH	Ministry of Water Resources, Works and Housing
NADMO	National Disaster Management Organization
NCCC	National Climate Change Committee
NDPC	National Development Planning Commission
NGO	Non-governmental Organization
NPC	National Population Council
PURC	Public Utilities Regulatory Commission
RCC	Regional Coordinating Council
RegCM4	Regional Climate Model version 4
SPI	Standardized Precipitation Index
TCPD	Town and Country Planning Department
VENSIM	Ventana Systems Environment Model
WRC	Water Resources Commission
WRI	Water Research Institute

Glossary and terms used

Climate change: is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate variability: refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

HEC-HMS: A hydrologic modelling system for modelling runoff at the catchment scale.

Integrated urban water management (IUWM): seeks to change the impact of urban development on the natural water cycle, by managing the urban water cycle as a whole.

IPCC Scenarios A1B and B1: These are scenarios constructed on the basis of 4 narrative story lines (A1, A2, B1 and B2), used to explore future developments in the global environment and their impact on climate. The A1 scenario story line emphasizes globalization, with intensification of market forces and rapid globalized economic growth. B1 emphasizes sustainability, with equity globalized, and extensive sustainable development. Scenario A1B is a subset of A1 indicating balanced energy across all sources both fossil and non-fossil (http://www.ess.co.at/METEO/CCS.html, and http://www.ipcc.ch/ipccreports/tar/wg1/029.htm).

RegCM4: A regional climate model for dynamic downscaling of outputs of Global climate models (GCMs).

Solid waste: Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances.

Standardized Precipitation Index (SPI): is a measure of the degree of dryness or wetness in a given time period. It is estimated from precipitation and used mainly to monitor drought.

Storm water: the rainfall that flows over yards, streets, alleys, parking lots, farms and buildings, and enters the storm drain system.

VENSIM: The Ventana Systems Environment model (VENSIM)is a visual modelling tool that serves to conceptualize, document, simulate, analyze and optimize models of dynamic systems.

Wastewater: Water carrying wastes from homes, businesses and industries that is a mixture of water and dissolved or suspended solids and other contaminants.

Waterborne diseases: are caused by pathogenic microorganisms which are directly transmitted when contaminated freshwater is consumed.

References

Bahri, A. 2009. *Managing the other side of the water cycle: Making wastewater an asset*. Global Water Partnership (GWP) Technical Committee (TEC) Background Paper No. 13. Stockholm, Sweden: Global Water Partnership (GWP).

Bahri, A. 2012. *Integrated urban water management*. Global Water Partnership (GWP) Technical Committee (TEC) Background Paper No. 16. Stockholm, Sweden: Global Water Partnership (GWP).

GSS (Ghana Statistical Service). 2012. *2010 Population and housing census: Summary report of final results*. Accra, Ghana: Ghana Statistical Service (GSS).

Mafuta, C.; Formo, R.K.; Nellemann, C.; Li, F. (eds). 2011. *Green Hills, Blue Cities: An Ecosystems Approach to Water Resources Management for African Cities*. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal. Available at http://www.grida.no/publications/rr/blue-cities/ (accessed on January 28, 2013).

MEST (Ministry of Environment, Science and Technology). 2010. *Ghana goes for green growth: National engagement on climate change. Discussion document - Summary*. Government of Ghana. Ghana: Ministry of Environment, Science and Technology.

Palaniappan, M.; Gleick, P.H.; Allen, L.; Cohen, M.J.; Christian-Smith, J.; Smith, C. 2010. *Clearing the Waters: A focus on water quality solutions*. Nairobi, Kenya: United Nations Environment Programme (UNEP).

Parkinson, J.N.; Goldenfum, J.A.; Tucci, C.E.M. (Eds.). 2010. *Integrated urban water management: Humid tropics*. Urban Water series – UNESCO-IHP. CRC Press.

Sadoff, C.; Muller, M. 2009. *Water management, water security and climate change adaptation: Early impacts and essential responses*. Global Water Partnership (GWP) Technical Committee (TEC) Background Paper No. 14. Stockholm, Sweden: Global Water Partnership (GWP).

Soto, I.T. 2006. Accra urban area definition using GIS. Unpublished data.

Tucci, C.E.M. 2009. *Integrated urban water management in large cities: A practical tool for assessing key water management issues in the large cities of the developing world*. Draft paper prepared for World Bank, July 2009.

UNEP (United Nations Environment Programme) and UN-Habitat (United Nations Human Settlements Programme). 2005. *Coastal area pollution – The role of cities*. Nairobi, Kenya: UNEP and UN-Habitat. Available at http://www.unep.org/urban_environment/PDFs/Coastal_Pollution_Role_of_Cities.pdf (accessed on January 25, 2013).

UN-Habitat (United Nations Human Settlements Programme). 2011. *Cities and climate change: Global report on human settlements 2011*. London: Earthscan.

UN-Water. 2010. *Climate change adaptation: The pivotal role of water*. UN-Water Policy Brief. New York: UN-Water.

van der Steen, P. 2006. *Integrated urban water management: Towards sustainability*. Paper presented at the first SWITCH Scientific Meeting, University of Birmingham, UK, January 9-10, 2006.

WHO (World Health Organization) and DFID (UK Department for International Development). 2009. *Summary and policy implications Vision 2030: The resilience of water supply and sanitation in the face of climate change*.

Yankson, P.W.; Kofie, R.Y.; Moller-Jensen, L. 2004. *Monitoring urban growth: Urbanization of the fringe areas of Accra*. Bulletin of the Ghana Geographical Association.

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