CCAPS CLIMATE CHANGE AND AFRICAN POLITICAL STABILITY

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CLIMATE CHANGE RESILIENCE IN URBAN AFRICA

PART I: THE POLICY CHALLENGE

EXECUTIVE SUMMARY

Changing weather patterns, driven by global climate change, will generate additional challenges in the growing cities of Africa where high levels of poverty, strained infrastructure systems, and lack of adequate housing already burden local governments. How will the consequences of future climate change affect people living in African cities and what determines the vulnerability to these exposures? This brief examines three types of hazards–flooding, sea-level rise, and drought–in ten African cities using a comparative case framework. The study identifies significant man-made sources of vulnerability stemming from inadequate infrastructure and land use planning, rapid population growth, and the location of significant transportation and economic assets in flood-prone areas.

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Climate change and its potential effects are increasingly important concerns to the scientific community, governments, international organizations, and exposed populations around the world. Over the past few decades, efforts to adapt to the changing climate have expanded. Although no region of the world is unaffected by climate change, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) identified Africa as "one of the most vulnerable continents to climate change and climate variability"[1] due partly to climate exposure, but also to low adaptive capacity. At the same time, Africa's annual rate of urbanization is second only to Asia's (1.08 and 1.47 percent, respectively), with sub-Saharan Africa's rate only slightly lower that Asia's at 1.37 percent.[2] Despite much attention to agriculture and other rural vulnerabilities in Africa, relatively little attention has been given to urban vulnerability, which stems from high rates of urbanization coupled with poor urban planning, gaps in public services and infrastructure, settlement in hazard-prone areas, and high levels of poverty, illiteracy, and poor health.[3]

The policy challenge results from the interaction of climate change *exposure* and *vulnerability* in urban areas. The former results from the location of people, property, and systems in areas that place them at risk of harm or loss due to a climate event.[4] The latter is the lack of *resilience* to such events, defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions."[5] In other words, vulnerability is the result of the characteristics of human systems, including the built environment, that contribute to establishing the level of harm that can accrue from

exposure to a climate event.[6] The combination of high exposure and low resilience make some African cities particularly vulnerable to the impacts of climate change.

The Climate Change and African Political Stability (CCAPS) program sought to assess the ability of local governance systems in large African cities to develop resilience and thereby enhance the collective well being of their populations.[7] This brief, the first of a two-part series, discusses the consequences of three climate-related hazards—flooding, drought, and sea-level rise—for people living in ten African cities, as well as factors that affect vulnerability to these exposures. The second brief in this series discusses the policy landscape for building resilience in these cities.

EXPOSURES

Weather patterns generate different types of hazards as well as different levels of exposure in specific geographies. Increasing atmospheric temperatures are projected to shift the frequency, intensity, duration, and timing of rainfall worldwide and lead to sea-level rise due to thermal expansion and melting of land-based ice. This study focused on three hazards: flooding, water scarcity, and sea-level rise.

Although much of Africa is projected to have less total precipitation, the intensity and variability of rainfall events is projected to increase in most areas, meaning that extreme rainfall events, i.e. storms, that previously occurred once every 20 years will occur once every 15 years.[12] Because water storage, river management, and flood mitigation infrastructure is lacking in most of Africa, this increases the chance for flooding, without improving the availability of water during the dry seasons.[13] Coastal areas are especially subject to flooding as a result of both precipitation events, inundation from sea-level rise, and increased exposure to storm surges. An estimated 54 million Africans live in vulnerable Low Elevation Coastal Zones (LECZ), defined as areas ten meters or less above sea level.[14] Areas around rivers and creeks are susceptible to riverine flooding, though localized flooding occurs outside these areas as well, especially in more heavily developed settings. Flooding can cause significant human and economic losses and is distinctive in the visibility of its effects, as both a fast-onset and localized hazard.

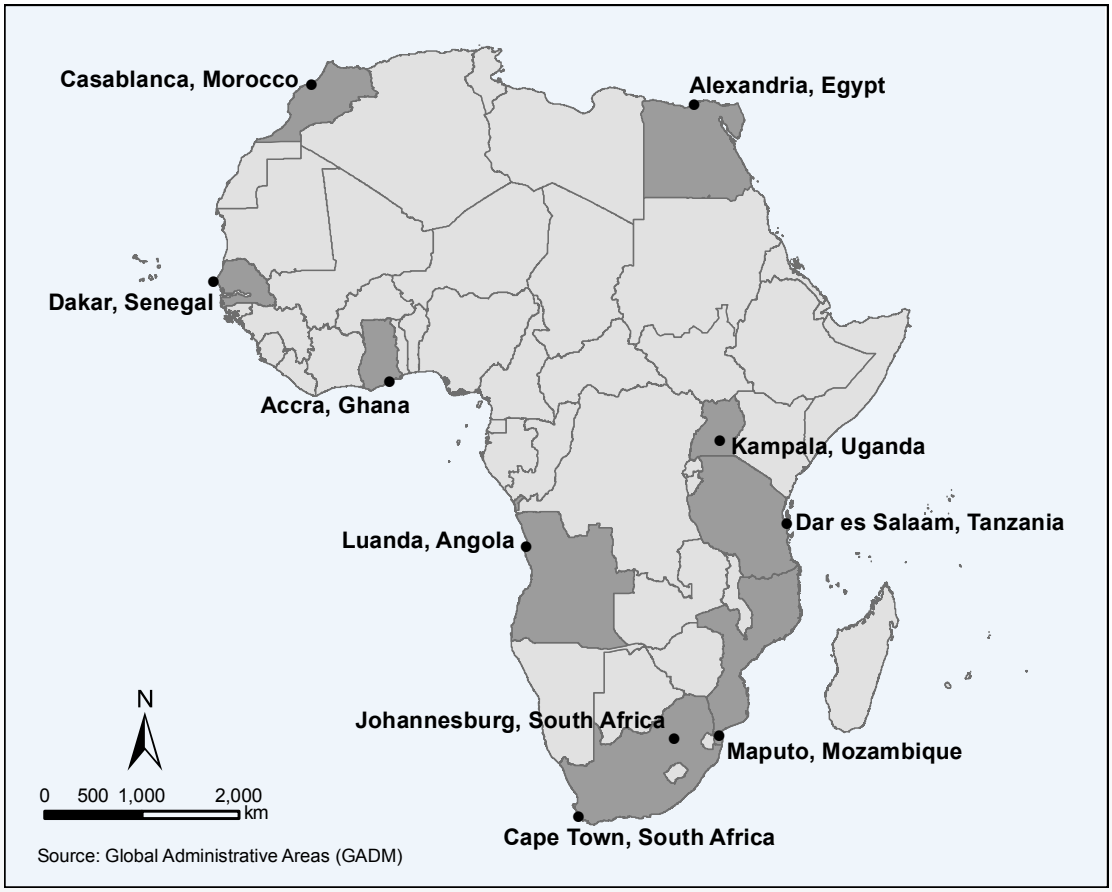
Despite projections for increased exposure to flooding in many parts of Africa, many regions are also at risk of water scarcity and drought.[15] Different climate models predict a 20 percent decrease in overall rainfall along the Mediterranean coast of North Africa, northern Sahara, and the west coast of Africa by 2099. North African cities

ADAPTATION AND RESILIENCE DEFINED

The complex policy domain of climate change has generated considerable disagreement amongst practitioners[8] and scholars[9] over the definitions of such important concepts as resilience and adaptation. The term resilience has a connotation of a system "bouncing back" (echoing a return to equilibrium in ecological systems or a material regaining shape following a perturbation, as in material sciences). One source of criticism of the use of the term in developing countries is that the pre-climate event status quo, especially the low socio-economic characteristics, is unacceptable and, therefore, building resilience should be framed as an issue of development and transformation of social conditions.[10] In other words, traditional efforts to improve social and economic development must not be displaced by initiatives that improve resilience without, simultaneously, improving socio-economic conditions.

The United Nations International Strategy for Disaster Reduction (UNISDR) defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."[11] This study largely adopted these definitions, but with the understanding that in practice these concepts are highly interdependent. Building resilience in the face of climate change refers to the ability of communities and cities not only to respond to and absorb the effects of individual potentially disruptive weather-related events, but also to sustain this ability in the face of climate change that may increase the frequency or intensity of such events in the future.

FIGURE 1. Map of Selected Cities



already have little rainfall, so the effects of this decreased precipitation could be significant. Additionally, southern Africa is estimated to see a 30 percent decrease in rainfall during the already dry winter period.[16]

Overall, these and other trends could mean that, as soon as 2020, anywhere between 90 and 220 million people across the continent would suffer increased water stress due to climate change.[17] While droughts are specific temporal events, water scarcity differs from flooding in that it has a slower onset time, and effects are often more distributed over space and time.

Sea levels are rising around the globe as a result of melting land-based ice, such as glaciers and ice sheets, and thermal expansion.[18] In addition to inundation of low-lying areas, coastal erosion is likely to damage vital infrastructure. Population concentrations in coastal cities and current projections for sea-level rise mean that the homes of an estimated 16 to 27 million people across the continent could be flooded annually by 2100, amounting to $5 to 9 billion per year in damage.[19] North Africa is considered particularly vulnerable to sea-level rise along the Nile Delta in Egypt where land elevation is especially low.[20] Additionally, saltwater intrusion into coastal underground aquifers can further exacerbate scarcity of drinking water in already water-stressed cities. Similarly to water scarcity, sea-level rise tends to have a slower onset time, though its effects are localized and visible.

Because water storage, river management, and flood mitigation infrastructure is lacking in most of Africa, this increases the chance for flooding, without improving the availability of water during the dry seasons.

TABLE 1. Development Indicators for Various Years (%)

CITY	ACCESS TO ELECTRICITY	ACCESS TO IMPROVED SANITATION	ACCESS TO IMPROVED WATER	NET PRIMARY SCHOOL ATTENDANCE RATE	NET SECONDARY SCHOOL ATTENDANCE RATE
Accra	85.8	89.4	64.0	80.1	53.4
Alexandria	100.0	99.9	100.0	90.6	70.6
Cape Town	94.0	95.9	97.1	76.6	71.0
Casablanca	91.8	96.4	76.8	-	-
Dakar	94.0	97.8	95.9	73.6	42.7
Dar es Salaam	63.0	43.0	59.4	89.0	42.6
Johannesburg	90.8	99.0	97.8	76.8	78.7
Kampala	60.7	79.1	93.5	89.1	42.7
Luanda	-	-	-	-	-
Maputo	39.6	23.6	82.8	88.8	18.8

Source: DHS Surveys for Accra 2008, Alexandria 2008, Dakar 2011, Dar es Salaam 2010, Kampala 2006, and Maputo 2003; Annuaire Statistique for Casablanca 2010; and Statistics South Africa for Cape Town and Johannesburg 2011.

Turning to the ten cities studied here, their geographic locations create unique hazard profiles (see Figure 1). Cities along the coast or major rivers—locations that contributed to their past and current growth—are exposed to sea-level rise and flooding. Cape Town, for example, is at risk for storm surge and experienced significant coastal erosion during a powerful 2008 storm. Dakar sits on a peninsula that extends into the Atlantic Ocean, the most western point of mainland Africa. Rising sea levels will have a dramatic impact on industry (especially ports), residential communities, and tourism. But even inland cities, such as Kampala, may also be subject to riverine and localized urban flooding. The North African cities of Casablanca and Alexandria experience arid climate conditions and are exposed to the hazard of drought. Johannesburg, born of gold deposits between two river basins, is reliant on inter-basin transfers for its water supply making it particularly vulnerable to water shortages.

MAN-MADE SOURCES OF VULNERABILITY

The realities of urban life can dramatically increase vulnerability to climate hazards. Each of these major African cities has areas of high population density and poor residents. Past urban development practices have exacerbated vulnerability not only in these ten cities, but also across urban Africa. Most cities remain subject to legacies of colonial planning systems. The South African cities of Cape Town and Johannesburg grew under the system of racial separation established by the British colonial government and continued under the apartheid system of the National Party government, resulting in low residential densities in city centers and higher-density, low-income areas in the city's periphery and townships. In addition, land tenure systems can create uncertainty concerning land ownership and prevent the adoption of sound urban development practices. For example, in Accra, tribal authorities often control the distribution

and use of large tracts of land and lack of clear and unencumbered land titles can constrain investments in public infrastructure as well as in private residences.

Deficiencies in infrastructure, drainage, and sanitation, a common problem among many of the cities in this study, also exacerbate vulnerabilities (see Table 1). Alexandria, Cape Town, and Johannesburg, cities in middle-income countries, exhibit better infrastructure coverage than in the other seven cities in lesser-developed countries. All cities in this study are experiencing rapid population growth, placing further strain on these infrastructure systems and disaster response systems.

Population growth increases land values in city centers and leads to increased settlement in areas previously deemed unfit for development, such as on wetlands, in floodplains or natural drainage corridors, and on sandy soil with foundations that may be eroded during floods.

Vulnerabilities are further accentuated by poorly regulated urban development. Zoning regulations may prohibit settlement and development in vulnerable areas but are too often not enforced. The loss of wetlands in Kampala due to urban development, for example, exacerbates flooding. Paving over previously permeable natural areas will also disrupt the natural absorption of water, and if development occurs over river and creeks, it can block natural outlets for water and create regular flooding. The local government of Dar es Salaam has been without a comprehensive city plan for an extended period. In Accra, some residents have reported waiting almost ten years for a building permit, often resulting in unregulated construction before permits are received. In Casablanca, both informal settlers and businesses routinely disregard land use regulations for riverbeds and coastal areas. Kampala's drainage system, built in 1960 for the population of 137,000 of that period, is ill-equipped to serve today's 1.7 million residents. In Dakar, economic interests often trump land use planning codes, resulting in high-cost residential buildings constructed on the city's coastline, which is vulnerable to erosion.

Past urban development practices have exacerbated vulnerability not only in these ten cities, but also across urban Africa.

Ineffective development controls in natural drainage systems, such as in low-lying areas near rivers or natural drainage corridors, are at considerable risk and increase vulnerability of residential populations.[21] Unplanned development in coastal areas and in wetlands can also increase vulnerability to sea-level rise and coastal erosion. Similarly, the removal of trees and plants in Accra destroys natural barriers along coastlines and exacerbates coastal erosion. Since wetlands naturally expand inward with a rising sea and prevent erosion and saltwater intrusion, development in these areas prevents the wetlands from serving their natural purpose.[22] Even when drainage systems are present, undersized drainage pipes and channels or the presence of trash blocking water flow can lead to flooding even with relatively minor precipitation events.[23]

All cities in this study are experiencing rapid population growth, placing further strain on these infrastructure systems and disaster response systems.

Management of water resources is increasingly critical in cities both in terms of supply of water and its distribution to growing urban populations. Many countries dedicate scarce water resources to irrigating agriculture, despite typically low economic returns. Dumping of untreated water combined with agricultural and industrial runoff can pollute ground and surface water resources.[24] Unregulated extraction of groundwater can lead to depletion of aquifers, raising the risk of saltwater intrusion and the subsequent pollution of the groundwater. Inefficient water distribution systems and inadequate water storage capacity lead to the inefficient use of precipitation.

Even though climate change scientists are reluctant to attribute specific effects of climate change on water resource availability due to natural variability in precipitation, governments are fully aware that the rapidly growing demand for water due to high population growth and economic development has the potential to exhaust scarce resources. In sum, both water management policies and quality of infrastructure have significant effects on water stress and scarcity.

Finally, many of these cities have grown into vital transportation hubs and major centers of economic activity. The Johannesburg area accounts for nine percent of the GDP of the entire continent.[25] Major economic interests and assets in Senegal are concentrated in Dakar, a city uniquely exposed at the tip of a peninsula. The ports in coastal cities are especially vulnerable to storm events and sea-level rise. In addition, tourism is a common and essential industry in many of Africa's major coastal cities. The concentration of economic and physical assets further heightens vulnerability to hazards in these cities.

Despite projections for increased exposure to flooding in many parts of Africa, many regions are also at risk of water scarcity and drought.

Each of the ten cities is uniquely exposed to a range of climate hazards, and exposure to a single hazard can vary across different parts of a city. Only low-lying areas of a city may be exposed to flooding, as in Luanda where much of the city is elevated. In contrast, water scarcity can affect a city's entire population as seen in Casablanca. While exposure is largely determined by weather patterns, which are being affected by climate change, vulnerabilities are determined both by geography and human settlement characteristics. Differing housing and infrastructure conditions can make some neighborhoods of a city more vulnerable than others.

MOVING FORWARD

The impending impacts of climate change will pose significant challenges for public policy in African cities. Adaptation efforts must take into account a range of exposures, each with varying impacts and uncertainty around frequency of events and each affecting a different set of government functions.

Furthermore, the impact of one hazard can be affected by other hazards. For example, sedimentation derived from flooding can later affect river flows and contribute to water scarcity. Current urban development practices and behaviors found in local populations can exacerbate such vulnerabilities. Even though deleterious effects of current urban development practices are known, establishing a policy framework that accounts for the diversity of the challenges and integrates new policy concerns into existing governmental structures and policy systems is daunting. This is a topic further explored in the second brief of this two-part series.[26]

Adaptation efforts must take into account a range of exposures, each with varying impacts and uncertainty around frequency of events and each affecting a different set of government functions.

ENDNOTES

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15 Water scarcity and drought are two different but related phenomena. A meteorological drought is any extended period in which actual rainfall is significantly lower than the average, expected rainfall. A hydrological drought exists when a shortfall in precipitation depletes water resources, such as rivers, lakes, and aquifers. Agricultural drought occurs when crop water requirements are unable to be met, resulting in lower than expected crop yield. Finally, socio-economic drought is when water distribution systems are unable to meet consumer demand because of precipitation shortfall or inadequate infrastructure. See Ashok Mishra and Vijay Singh, "A Review of Drought Concepts," *Journal of Hydrology* 391, 1–2 (2010), 206. Water scarcity, on the other hand, is a more consistent state in which demand for water exceeds water resources. However, water scarcity is heightened in times of drought, and more droughts occur when water is scarcer. See Peter Gammeltoft, "Water Scarcity and Drought in the EU" (Presentation in Brussels on April 27, 2012), http://ec.europa.eu/environment/water/quantity/pdf/stakeholders/0%20Overview%20Water%20Scarcity_Droughts%20PG.pdf.

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