

Water resource management under a changing climate in Angola's coastal settlements

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Development Workshop (DW) is a non-profit organisation working on research and project development in the fields of human settlements, water, sanitation and policy advocacy. Over more than three decades, DW has built a strong institutional partnership with Angolan government ministries such as environment, urbanisation and local government through practical projects and policy advocacy. Capacity building of local civil society, universities and communities is key to DW's way of working. DW has been a partner of the International Development Research Centre (IDRC) in researching climate change and urban water issues. See www.dw.angonet.org

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Angola's civil war caused a massive population movement from rural conflict areas to low-lying coastal zones between 1975 and 2002. More than half of Angola's 27 million people now live in urban coastal settlements, floodplains and steep ravines vulnerable to climate extremes. Climate-related risks are worsening and it is important to understand and prepare for them. Angola's coastal areas are experiencing increasingly variable rainfall and pressure on water supplies and markets. But a dearth of relevant data has made it difficult to assess these risks. This paper demonstrates innovative methods in filling the information gap and how changes were introduced in how water is governed in four Angolan coastal cities.

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Acronyms

CEDOC	Development Workshop's Documentation Centre
CSAG	Climate System Analysis Group, University of Cape Town
CSO	Civil society organisation
DW	Development Workshop Angola
EPAL	Luanda Provincial Water Company
GIS	Geographic information system
GPS	Global Positioning System
GSMA	Global System for Mobile Communications (GSM) Association
ICTs	Information and communications technologies
IDRC	International Development Research Centre
INAMET	National Meteorology and Geophysics Institute of Angola
ITCZ	Intertropical convergence zone
MINEA	Ministry of Water and Energy, Angola
MoGeCA	Community water management model

Summary

Angola's civil war caused a massive movement of more than 4 million people from rural conflict areas to settlements in places vulnerable to climate extremes: low-lying coastal zones, floodplains and steep ravines. By 2016, more than half of Angola's 27 million people were living in urban settlements along the Atlantic coast. Now, in the post-war period, public demands for safe and healthy cities and affordable water and sanitation services are increasingly being voiced. In this context, the Angolan government is attempting to meet the challenges of overpopulated, unstructured and unhealthy cities by implementing an ambitious programme of regional and urban planning.

However, planning for poverty reduction and environmental adaptation requires real data. Budgeting for water and sanitation infrastructure, for example, is most adapted to real needs when planned with community co-participation, especially in the initial collection of data, the planning of actions, the validation of results and eventually the monitoring of impacts. The research findings hence provide essential information, particularly in the coastal region where most Angolans live.

Climate-related risks to the population are likely to worsen in the future and it is important to understand and prepare for them. Unfortunately, a dearth of relevant data has made it difficult to assess these risks. The limited climate data that are available show that Angola's coastal areas are experiencing low annual rainfall, which is increasing pressure on water supplies.

This paper addresses climate risks and inadequate access to quality water faced by informal settlements in four Angolan coastal cities: Luanda, Cabinda, Benguela and Lobito. Through this paper Development Workshop (DW) has assessed the impact of climate variability on water markets, people and infrastructure, and proposes changes to how water is governed. In four urban municipalities, participatory methods were developed that have begun to contribute to improved water access. Changes in the management of public water points promoted by DW has widened access to clean water and reduced water costs by 90 per cent (from US\$0.50 to US\$0.05 per bucket). The Angolan government has replicated the community management model across the country, ensuring that ongoing maintenance is financed by locally elected committees who collect fees for services and promote hygiene and basic sanitation.

Systematic data collection has been supported and the environmental risks have been mapped and now feed into local municipal planning processes. Research capacity is being strengthened to better inform climate risk analysis and contribute to the development of Angolan water policy.

1

Water, climate and conflict-linked problems in coastal settlements

Angola emerged 15 years ago from what was one of Africa's longest protracted conflicts. The independence war that began in 1961 was followed by a civil war that lasted from independence in 1975 and ended only in 2002. Four decades of war caused a massive demographic shift of populations from rural conflict areas to the relatively safer coastal urban settlements, resulting in a rapid urbanisation of the country (see Figure 1). Angola, over this period, was the most rapidly urbanising country in the southern African region. The capital Luanda with a growth rate averaging at 7 per cent is the fastest growing city in Africa (Cain 2012). Its present population is more than 7 million and it could be a megacity of over 10 million people before the end of the decade.

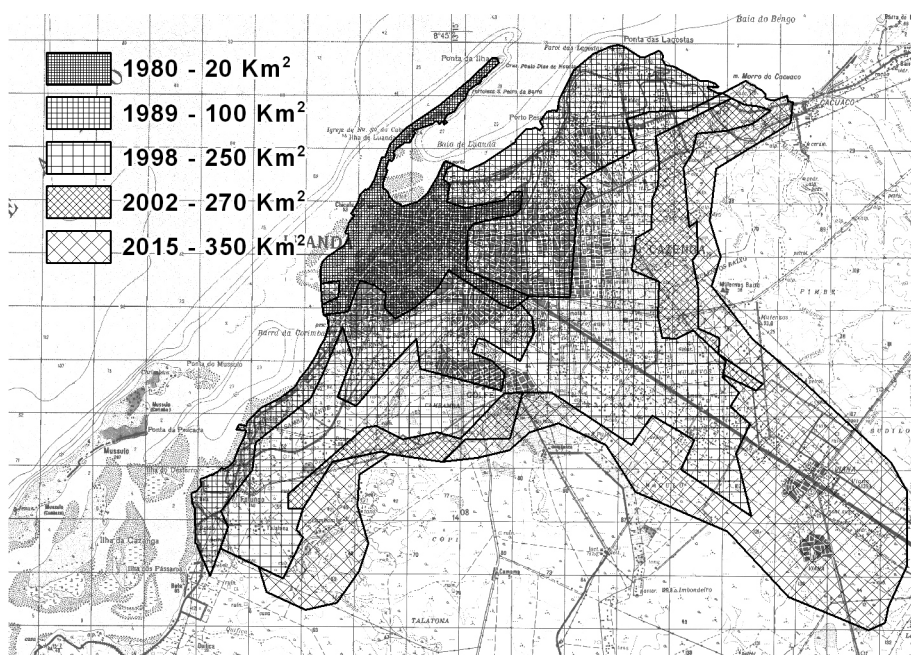
The war resulted in the destruction of infrastructure and the breakdown of institutions of all kinds during these four decades. The ability of government to maintain an administrative presence and collect data of all kinds was also negatively affected. The last complete national meteorological statistics were published in 1974. The colonial government had built up an extensive network of over 500 meteorological stations across the country. Except for a few urban stations like Luanda, most ceased reporting or were abandoned the following year.

The 'gap' of more than thirty years of meteorological information coincides with the recent period of accelerated climate change.

The coastal areas of Angola, where urban populations are growing most rapidly, experience lower rainfall than inland areas and are subject to sudden storms and high annual variation. In urban coastal areas, poorer communities of formerly war-displaced communities have purchased and settled on peripheral land beyond the water and sanitation network that is often at risk from flooding and erosion. These are the only affordable locations that are still near to economic opportunities.

There has been serious flooding in Angolan cities in recent years. In 2006, 3,000 families lost their homes in Luanda due to flooding and a subsequent cholera epidemic resulted in 76,959 cases and 3,006 deaths (UNICEF 2007). In 2015, flooding in the coastal city of Lobito led to 90 deaths and the displacement of over 300 families. There is a lack of urban land-use and disaster-planning capacity to deal with these issues, though institutions have been created in the last five years as part of the country's decentralisation strategy. Limited information was previously available on the vulnerability of these coastal cities, on rainfall variability

Figure 1. Map showing Luanda's rapid peri-urban growth over 35 years



Map developed by Mathieu Cain

and trends, on river flows and on areas at risk. Similarly, demographic and socioeconomic information was limited in the post-war years.¹

Economic activity and urban development in coastal locations often contribute to increasing environmental pressures that lead to flooding. Low-income settlements, and poor families within all settlements, tend to be the most vulnerable. Affluent groups are in a better position to take protective measures and to adapt or escape when flooding does occur (McGranahan *et al.* 2007: 19). The poorest residents of the cities of low-income countries like Angola are often forced (implicitly or explicitly) to settle in floodplains or other hazard-prone locations, as they cannot afford more suitable alternatives (Hardoy *et al.* 2001).

Historically, populations have preferred to live within 100 kilometres of coasts and near major rivers (Small and Nicholls 2003), and often in cities located in low-lying areas near the mouths of major rivers, which served as conduits for commerce between interior agricultural and industrial regions and the rest of the world. As it happens, these locations place global cities at greater risk from current and projected climate hazards such as cyclones, high winds, flooding, coastal erosion and sea-level rise (De Sherbinin *et al.* 2007: 39). Populations settling in low-elevation coastal areas are at risk from many of these hazards induced by climate change. These coastal settlements are

changing, especially due to population movements and need to adapt to increasing risk (McGranahan *et al.* 2007: 17).

More than half of all Angolans and almost two-thirds of the country's urban population² now live in the coastal provinces. The growing coastal urban settlements of Angola experience lower (though variable) rainfall than inland areas. However, urban areas of Angola have experienced flooding in recent years, such as Namibe in early 2001, Luanda in early 2008, Ondjiva in various years since 2002, and Lobito and Benguela in 2015. These floods have been due to localised heavy rain³ or high flows in rivers coming from inland areas. The succession of floods may be attributable to a combination of factors including increasing variability due to climate change, environmental changes induced by settlement in vulnerable zones, and the removal of natural vegetation in upstream river basins. Many of Angola's major coastal cities are located at the mouths of river basins, which places these settlements in particularly high-risk sites. There is consequently a concentration of people with limited coping abilities in these low-lying areas.

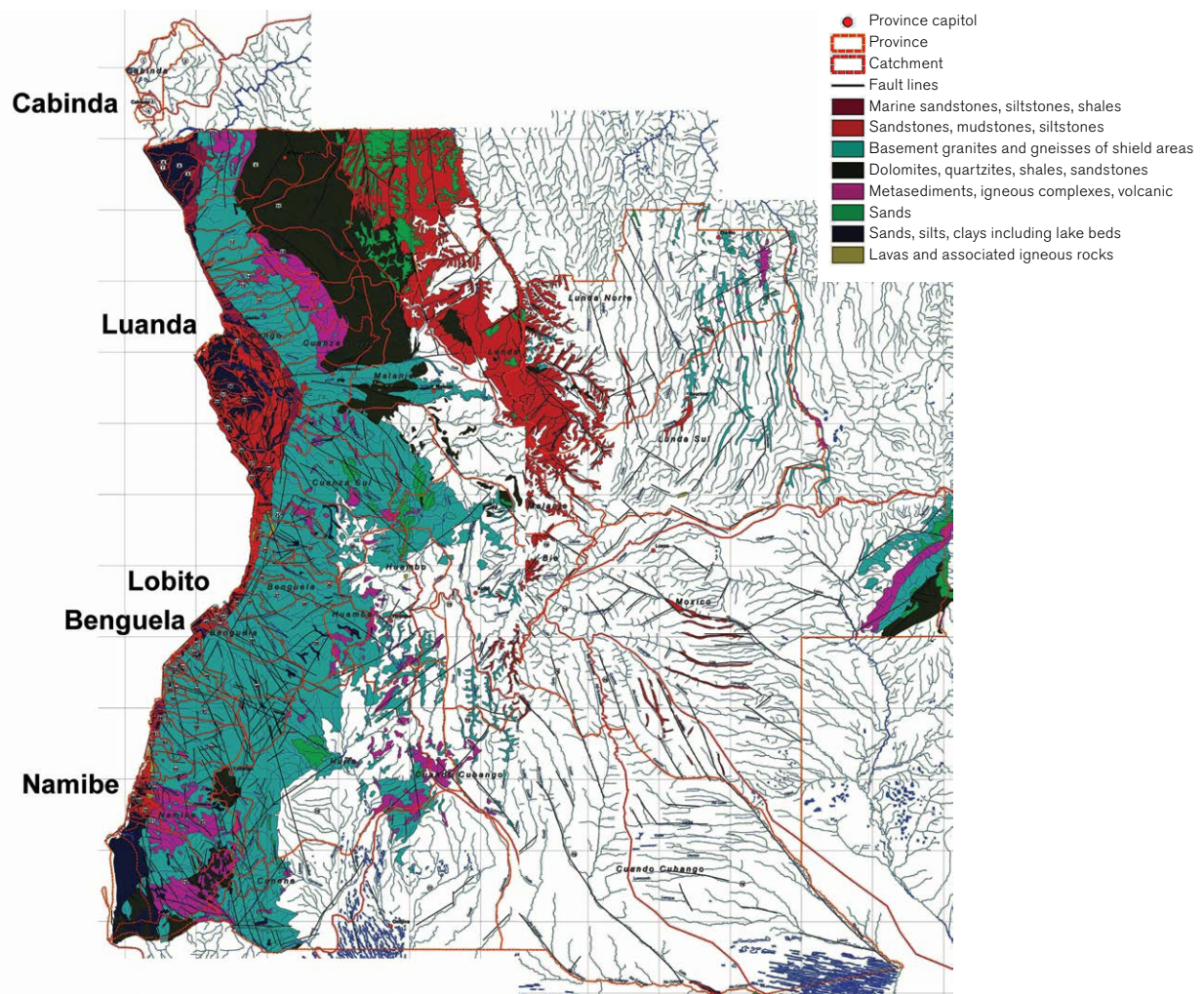
The environmental situation in Angola's peri-urban districts progressively deteriorated during the decades of conflict. These peri-urban areas can be considered to be in a chronic public health crisis. Rural populations which migrated to Luanda in search of a safe-haven

¹ Angola's first post-independence census was published only in 2016 based on data collected in 2014. The previous census dated back to 1973.

² Angola's May 2014 census statistics show that 51 per cent of Angola's population of 25,789,024 lived in the coastal provinces of Cabinda, Zaire, Bengo, Luanda, Cuanza Sul, Benguela and Namibe – 78 per cent lived in urban areas. By 2016 therefore it is estimated that over 11 million people live in cities in these coastal provinces.

³ There are fewer tropical storms or typhoons in comparison with those experienced in, for example, Mozambique.

Figure 2. Map of Angola's water resource and most important coastal settlements



The colours illustrate the different watershed basins that drain into the coast. The coastal cities are all located at the mouths of these river systems, that contribute to the risk of flooding during the rainy season.

did not settle in an organised way and in some cases occupied environmentally risky sites such as those along riverbanks or drainage courses susceptible to severe erosion.

It is poorer families who are most vulnerable (Development Workshop 2011a). In Luanda, they have settled in the more environmentally risky parts of the city. The majority of Angolan slum residents bought their land on the informal market and can demonstrate declarations of purchase or sale contracts. Due to rapidly rising property values the poor have relocated into areas of increasingly higher risk out of economic necessity. This is sometimes due to forcible removal by government authorities or voluntary relocation after buy-outs from private real-estate developers. The new settlement areas occupied by the poor are almost always without piped water services. The lack of formal sanitation means that raw sewage pollutes the

groundwater and uncollected refuse is usually dumped in valleys or drainage channels.

Local and river flooding, erosion, inundations from sea-level rise and saltwater intrusion are all common risks in these urban coastal areas. An important effect of the prolonged conflict in Angola is poor urban land-use planning. There is a need for technical and policy innovation to deal with these risks, either from better planning, water supply management, improved flood defences or accommodation measures (such as early-warning and evacuation plans) to enable people to adapt to living in these settlements. This requires information about areas that may be affected, where flooding has occurred and when it may be expected to occur in the future and the potential impact on access to basic services. This information is rarely available to Angolan local government administrations or to communities at risk.



Many migrating rural populations in Angola settled in risky sites, such as this informal coastal settlement located in ravines in Lobito
© Development Workshop

There are indications that understanding climate change and planning for adaptation are now being taken more seriously in Angola, recognising the country's high levels of vulnerability. As well as completing its First National Communication (GOA 2012) and National Adaptation Programmes of Action (NAPA), Angola has taken steps to strengthen capacity in this area. There is a critical need in Angola to improve urban land-use and disaster planning and to build local capacity to deal with the management of basic services in these vulnerable areas where the majority of people live.

The limited metrological data available suggests that the coast of Angola has shown an increased variability in climate (especially rainfall) from one year to the next. This variability extends some way inland. Factors affecting this variability include the influence of the Benguela current and position of the intertropical convergence zone (ITCZ). Warm events in the Benguela current (years with above-average temperatures in the sea off northern Namibia and southern Angola) can lead to higher rainfall along the coast and sometimes inland (Fossil Park undated). Southwest Angola is close to an extremity of the ITCZ and rainfall is highly sensitive to the position of the ITCZ between November and April in any particular year. Qualitative indicators from oral histories and media archives suggest that drought and flooding events have increased during recent years. Most models of the region project that climate change will mean more variable climates (Fidel and O'Toole 2007). It is believed that global climate change will affect various parameters of the Benguela current.

Little was known about the impact of environmental factors on urban areas in Angola, and information on this had not been gathered in one place. The

growth of coastal cities in areas with increasingly variable rainfall implies constraints on water supply for these settlements.

Potentially, Angola can exploit 140 billion m³ of surface (river) water and 72 billion m³ of sustainable groundwater (Figure 2). In the years following the end of the civil war the country has committed itself to investing in building infrastructure to deliver water to all its citizens. Angola has enjoyed economic growth during the years since the end of the conflict. In theory, Angola has a permanent guarantee of drinking water for its citizens. Today, however, almost half of Angola's population remains without access to a sufficient supply of affordable potable water and adequate sanitation facilities.

Urban coastal settlements in Angola are still partly supplied through informal water markets, in which the poor pay high prices for inadequate quantities of low-quality water. The functioning of these water markets was incompletely understood, as were the constraints on management and how these could be overcome. With support from the International Development Research Centre (IDRC), Development Workshop set out to address these challenges.

In 2007, the Angolan presidential Water for All programme was launched to achieve, by 2012, an improved source of drinking water for 80 per cent of peri-urban and rural populations and guarantee a minimum daily per capita consumption of at least 40 litres of water. The programme intended to construct new water systems from groundwater as well as surface sources (rivers or lakes). The planned infrastructure would include pumping, treatment and distribution

networks that give priority to health centres, schools and administration buildings as well as a network of standposts to supply peri-urban areas. These targets were not met by 2012, and the government's own evaluation of the programme concluded that it did not meet the goals of efficiency and effectiveness, and that only 50.3 per cent of the target population was reached. The reality is that many of the systems installed (mostly diesel-powered generators, submersible pumps and expensive treatment systems) remain non-functional and thus the communities still depend on traditional unimproved water sources. Angolan politicians have traditionally defended the position that basic services like water should be provided free of charge. This simplistic populist position has in practice resulted in a lack of funds being available for maintenance of the existing services. The weakening of the Angolan government's capacity to subsidise⁴ the maintenance of public services has contributed to their unsustainability.

The supply of urban services to coastal urban areas has not grown in line with the growth in population. Water supply networks, built in the colonial period for relatively small urban populations, have not been maintained adequately nor upgraded regularly to meet the rapid

growth in city size. In the growing coastal urban areas of Angola, experiencing lower (though variable) rainfall than inland areas means that access to water from shallow wells (a common source of water for poorer communities in inland cities) is increasingly unavailable to urban populations. Urban water is therefore supplied through formal piped water systems, or informal systems (usually transporting water by lorry and storing it in tanks). Payment for water is thus more common for water in the growing coastal urban areas than in inland areas, and with it the development of an informal water market. In Luanda, an informal and highly expensive water market has developed to meet essential needs. Informal water markets predominate in the other coastal urban areas, which have growing populations and also increasingly variable rainfall. Under a changing climate, there are indications that future water availability, accessibility and reliability will be constrained by these supply factors. The informal water markets in these areas charge high prices for poor-quality water, which vary with the season. As prices increase, water consumption per person per day tends to be reduced, resulting in poorer hygiene and an increase in environmentally linked diseases.



Photo of a water market in Luanda © Development Workshop

⁴In the years following the 2014 world commodity price collapse, the Angolan state budget has been cut by more than 50 per cent.

2

Filling the war-year gaps – what we don't know

Angola needs to strengthen its capacity in climate change adaptation by developing tools and improving water governance in these cities. It also needs to provide information that addresses information gaps about rainfall patterns and hydrology and their likely impact on environmental risks and water-supply issues in Angola's coastal urban areas.

This paper discusses the results of the IDRC-supported project Water Resource Management Under a Changing Climate in Angola's Coastal Settlements. The project aimed to address the lack of information on water access and price (by geographic area and social group) and on how informal water markets work in urban coastal areas and how they affect poorer communities. Information was needed to design practical interventions and make technical adaptations to water supply systems. The project also addressed the need for policy and management innovation, to make water supplies more accessible, available, reliable and affordable in urban coastal areas.

The project's specific objectives were to:

- Reconstruct lost data so as to improve knowledge about rainfall patterns and hydrology in coastal areas of Angola. This knowledge is essential for understanding trends and variability and also for adaptation planning.
- Improve information about settlement patterns and population in Angola's urban coastal areas, and assess the risks, impact and vulnerability from flooding and erosion at present and under future climate scenarios, especially for vulnerable social groups.
- Improve information about water markets in Angola's urban coastal areas, assess the impact of climate change on water supply issues, especially for vulnerable social groups, and develop options for better water-governance mechanisms for these areas.

3

Innovation, co-production and finding the missing data

The project involved collaboration with the Ministry of Environment's efforts to build national research capacity and to develop a framework for future continuous data collection and analysis. It also involved collaboration with the new National Institute for Water Recourses (responsible for the study of and development of river basins) and the existing National Water Department (responsible for water supply and sanitation). Development Workshop has had a longstanding institutional relationship with the government and was seen as a partner which could provide a platform for influencing public policy on issues related to water governance. The project also involved collaboration with the local government administrations for each urban area. In this way, better information was made available⁵ in the form of maps and local-level data presented in usable forms for planners, academics and researchers working on climate and environmental issues in Angola. The project aimed to provide a much-needed baseline for continued work in these areas and for on-going adaptation planning at municipal levels. Project activities included the collation and reanalysis of existing climatic

data, media and archive research,⁶ remote sensing from satellite images, field mapping and surveys, oral histories and questionnaire surveys.

Scientists have tried to study climate change by seeking trends in the data or by using models of atmospheric systems. Climate modelling is relatively new in Africa. Few scenarios have been developed for Africa, partly due to the lack of computers or human resources (IPCC 2007). Almost no work had been done for Angola and the Democratic Republic of Congo to the north. For this reason, the project aimed to address the lack of meteorological records available for Angola.

The recovery and analysis of historic meteorological information involved the collection of detailed data for Luanda going back to 1875.⁷ There are no other 19th century records apart from this station, aside from a few months of data for M'banza Congo in Zaire province. Efforts were made by the Portuguese colonial authorities to set up meteorological stations in other cities of Angola from 1913 onwards, but the number of stations opened was very limited.

⁵ All information and data from the project Water Resource Management Under Changing Climate in Angolan Coastal Cities is free to download: www.dw.angonet.org/content/climate-change

⁶ See Development Workshop (2014a). This working paper reports on a component of DW's current research project involving the recovery and analysis of historic meteorological data.

⁷ Observatório João Capelo meteorological station was the first station created by the Portuguese colonial government.

There were immediately gaps in the records of these stations and they ceased functioning after a few years. The comprehensive collection and analysis of Angolan climatic data, which only began in the early 1930s, ceased in 1974 when the Portuguese colonial administration abruptly abandoned the country. The subsequent years of war resulted in the closure of almost all of the meteorological data collection stations (more than 500). During the critical decades when global climate change entered the consciences of global environmentalists, Angola produced no useful data. Only in the post-war years after 2002 did Angola start to reconstruct a network of meteorological stations. By 2007, the country had only 11, approximately the same number of data-collection stations as in 1932, 65 years earlier (see Figure 3).

Angola's existing data had not been digitised and risked being lost. Data on paper had even been discarded as paper-based records take up office space. There were three types of data gaps: spatial gaps that were the result of sparse station distribution, temporal gaps due to interrupted observations, and lost data due for example to communication problems or abandonment of stations due to the war. These gaps needed to be filled to have spatially continuous and temporally complete climate time series. One approach is combining observations from all available meteorological stations

with global products such as satellite proxies and climate model reanalysis data and also the mobilisation of non-conventional qualitative information from innovative sources. DW therefore undertook the initial task of rescuing the undigitalised data and digitalising it, while taking steps to fill spatial and temporal gaps in climate observations and devising new approaches to the task.

Angola has produced insufficient data to be of use to institutions such as the Climate System Analysis Group (CSAG)⁸ at University of Cape Town. CSAG is attempting to build a climatic model of the Southern African region using data from the fixed meteorological stations in order to predict local trends in global climate change patterns. Angola was a blank spot on the maps when the authors first visited CSAG in 2012.⁹ DW set an early task in the IDRC project to compile and digitalise all available historical data on Angola and the bordering regions dating back from the early 20th century to the present. The documental research involved retrieving the incomplete archive material from Angolan libraries and from the National Meteorology and Geophysics Institute of Angola (INAMET) from the few meteorological stations still operating at present for the years 1960 onwards. More complete historical paper records were copied and digitalised at the National Meteorological Library and Archive in Exeter, UK.

Figure 3. Growth and decline of numbers of meteorological stations during war and peace

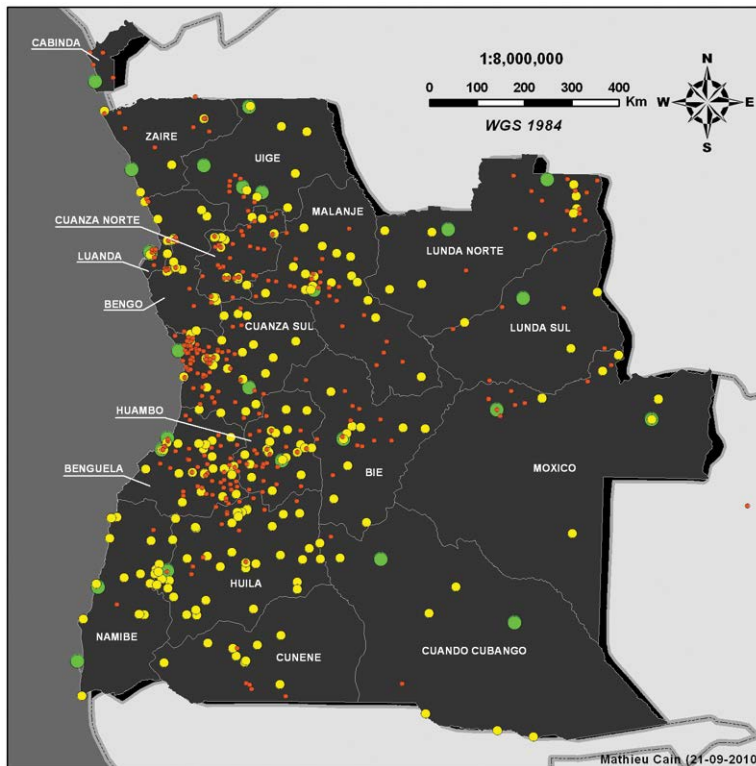
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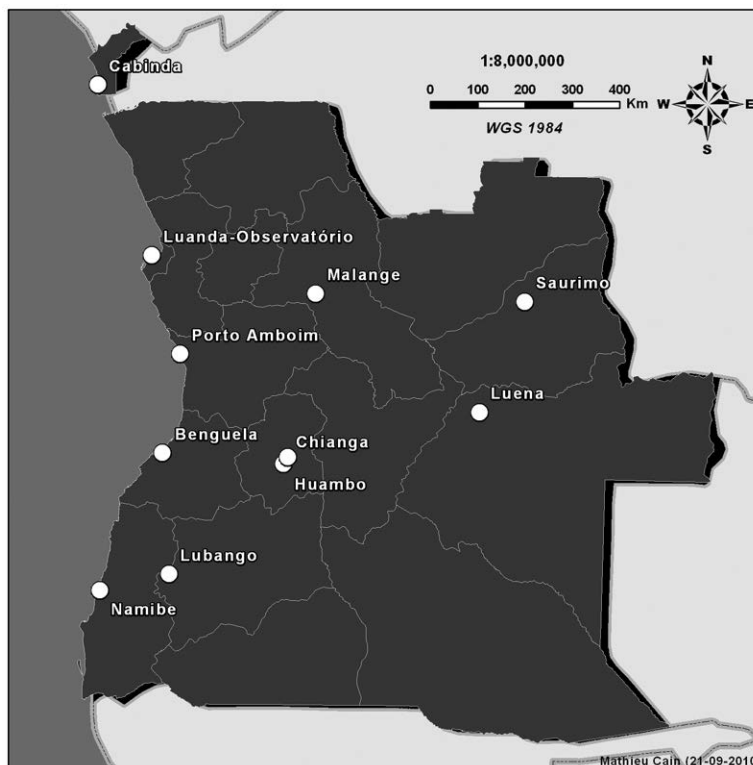
⁸ CSAG required chronological meteorological data over a continuous ten-year period in order to provide the level of confidence to feed into their model.

⁹ United Nations Economic Commission for Africa (UNECA 2011) indicates that the region of Africa including Angola has one of the most significant gaps in meteorological data with a large number of stations that are not sending data or incomplete data to international reference centres.

1974



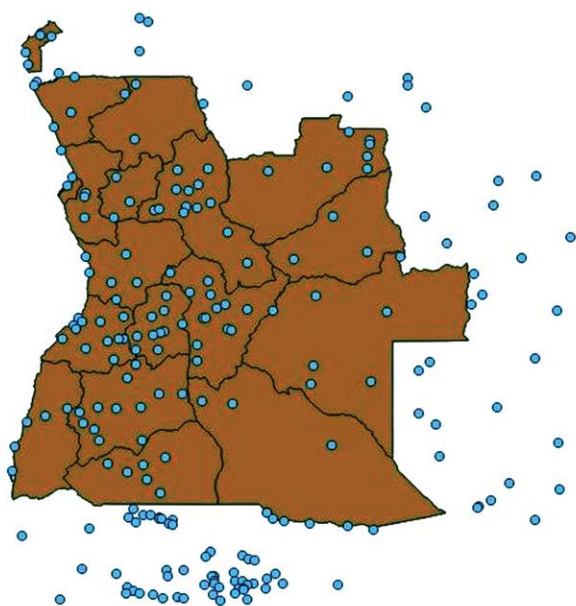
2007



A database was created containing monthly rainfall records for 199 stations in Angola and further stations in the Democratic Republic of Congo and Zambia close to the Angolan borders (Figure 4). The choice of stations was made so as to have a reasonable representation of

different areas of Angola, including those stations that have long records of monthly rainfall data. The project generated the most extensive database of monthly rainfall data for Angola available to date.

Figure 4. Map of meteorological stations studied offering historical data



3.1 Oral history research

Development Workshop has also been exploring the use of indigenous knowledge and community memories as one of several methods for filling the four-decade gap in knowledge about climate (Development Workshop 2011b). Oral histories were collected in order to understand the vulnerabilities of communities whose livelihoods, housing and settlements were influenced by the weather. The risks posed to livelihood activities by the climate, and the capacity of communities to manage those risks were investigated. A further aim was to understand how vulnerable communities have adapted to change and variability in the climate, what barriers there are to adaptation, how communities might adapt and what policies local government agencies could follow. Research involved discussions with community groups as well as key informant interviews often using audio and visual recordings. Oral histories were collected around a number of historical flooding events in Cacuaco municipality in Luanda and in Lobito and Benguela. Group discussions were held with communities, some close to cities and others at some distance from urban centres.

The group discussions often used visual techniques and began by collecting information about livelihood strategies and the social situation of the communities and then moved on to questions about climate, variability and changes and how these affect livelihoods. An historical timeline was developed for each community, such as when it had been affected by war and when and if it had been displaced. Years with particular climate events such as floods or droughts were added to the timeline. Diagrams such as seasonal calendars

and chronologies were drawn to aid analysis, ensuring that there was consensus among the community informants and ensuring that the researchers had understood correctly.

Communities were interested in discussing such issues in depth as they have a great deal of knowledge about their environment and rarely have the opportunity to talk about it. Most community informants have heard of the idea of 'climate change', though they may be unclear about what it is. Experience in the project showed that there is a risk that community informants will say what they think researchers want to hear and will try to give examples of climate change if they think that this is what researchers are looking for. It proved to be more reliable not to mention climate change in the introduction to the discussion or in early questions.

The project showed that local communities have a good memory of important weather events going back several decades. This helped to pinpoint issues that were not at first obvious in meteorological data such as the impact on their livelihoods and housing. It also helped to deepen information from incomplete climate records. The research team used information collected through oral histories to show the constraints that these communities face in adapting to climate variability. Collecting information through community knowledge provides an understanding of how vulnerable communities have adapted to change and variability in the past and what barriers there may be to successful adaptation in the future. Participatory approaches are important tools for encouraging the sense of co-ownership of information and for the building of local capacity for introducing discussions on appropriate adaptation strategies.

3.2 Media monitoring

A media-monitoring project by Development Workshop's Documentation Centre (CEDOC)¹⁰ in Luanda was launched in 2001. It tracks the Angolan published media on a daily basis. All of the publicised sources (printed, internet-based and social media) on a set of subjects including the environment, water and sanitation, urban development and governance and seven other issues of interest to the organisation are tracked. The project monitors the official state media, the independent press and community media sources. Full articles are scanned, catalogued by date, source, author, title and theme and uploaded to DW's online library.¹¹

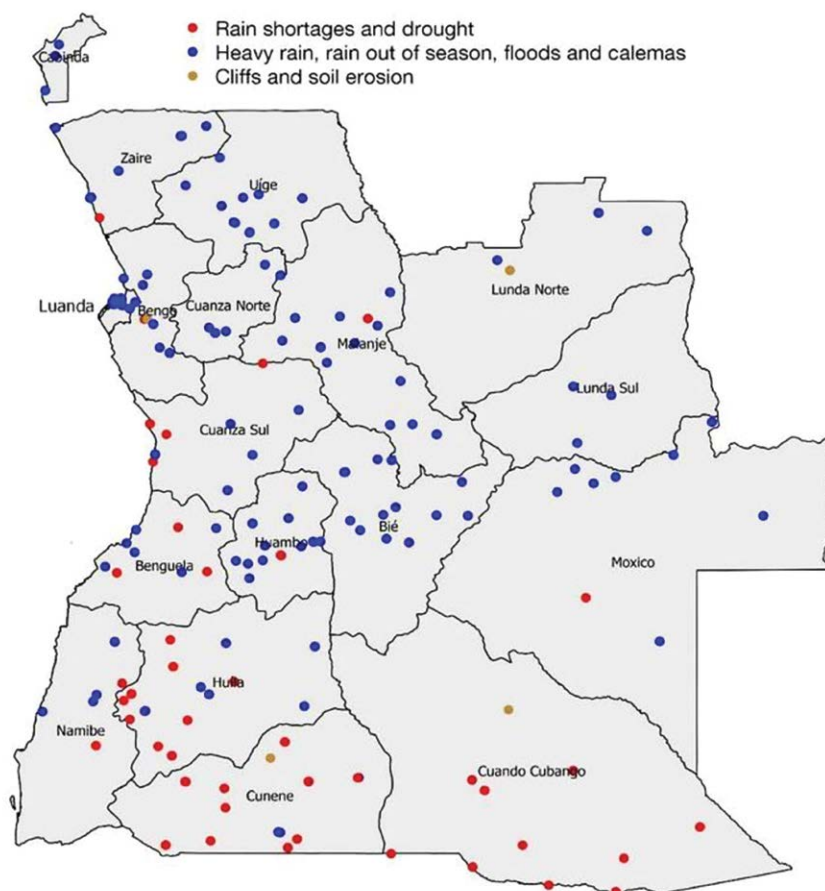
The component of the project related to climatic events was initiated in January 2009 and continues today. The capture of climatic events through the media provides DW with another opportunity to build a complementary dataset that helps fill the information gap of incomplete climatic data. With only 11 reporting meteorological stations¹² the monitoring of media allows the capture of information from a much wider geographical area which can be triangulated with other data. The national

network of journalists provides evidence from virtually every corner of the country. Figure 5 shows the reporting of climatic events from approximately 310 sites, including some of the low-density remote districts of the country.

The monitoring of climatic events has grown from 22 reports in 2009 to 86 in 2012 and 56 in 2015. Media reports reveal more than the location and dates of climatic events. In 2015 alone, the media-monitoring data revealed that climate events caused 129 deaths due to storms and flooding, 4,180 homes were destroyed and that 780,000 people were affected and required humanitarian assistance.

The analysis over several years provides strong evidence of a trend in media attention and of an increasing public interest. Attitudes and editorial opinions on climate awareness can be tracked by taking note of the language used in media commentaries about the events. Development Workshop has noted that these issues are increasingly reported by the independent and community media and climate change has entered into the public discourse.

Figure 5. Map of climatic events captured in the media and databased (2009–2016)



¹⁰ CEDOC manages DW's online library and website.

¹¹ Angolan Media Scan. See <http://dw.angonet.org/pt-pt/cedoc>

¹² In 2007, only 11 stations were operational (see map in Figure 3). By 2016, INAMET aimed to have meteorological stations in all of Angola's 18 provinces.

3.3 Mapping of environmental burdens

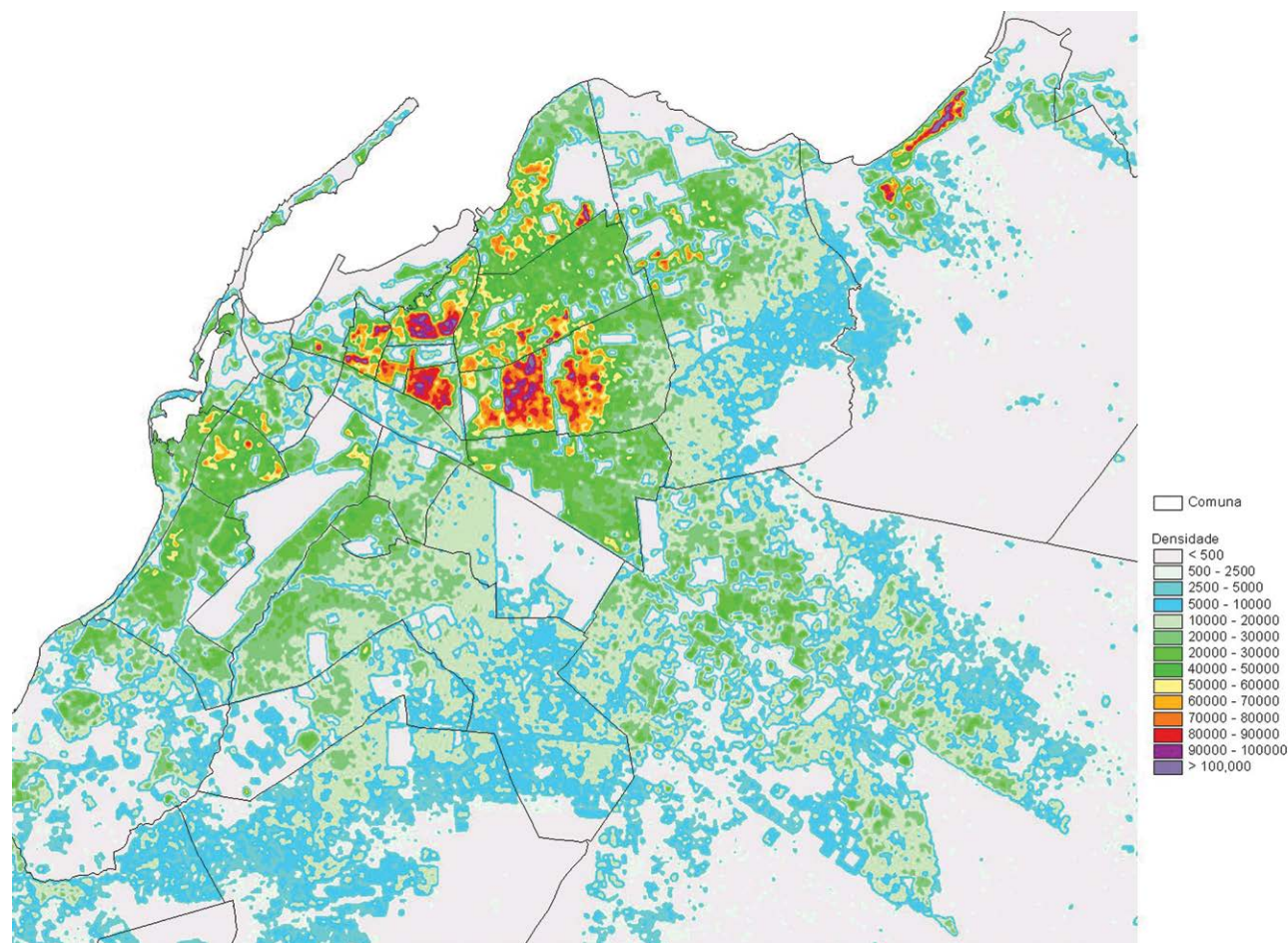
Additional participatory research tools were developed by DW in the IDRC-supported project Poverty and Environmental Vulnerability in Angola's Growing Slums.¹³ The project divided Angolan cities into differing social zones, estimating the population of different areas and mapping environmental hazards.

Satellite images, coupled with information from onsite observations and interviews with key informants, have been used to delimit zones of all the relevant research areas with similar dates of construction and social characteristics, creating housing and neighbourhood typologies (Figure 6). All rooftops were mapped from the satellite images to make a count of the number

of structures in each delimited zone (to be used in conjunction with data on numbers of people per structure to estimate population numbers and densities of an area).

DW applied the classic 'inverse problem' approach that is familiar to remote sensing: obtaining a reasonable estimate of the variable that interests you by counting a related variable that is easier to measure. In this case, the researchers estimated population distribution in part by counting rooftops (IDRC 2012). Technicians inspected high-resolution satellite images of the four coastal cities and, using a system of digital markers, mapped every rooftop. In Luanda alone, over one million buildings were electronically tagged. Since satellite data is one-dimensional, however, the researchers also employed a team of on-the-ground local informants to supply additional details.

Figure 6. Map of population densities in Luanda compiled by remote sensing and participatory mapping enumerations



¹³ For the full set of project reports see <http://tinyurl.com/dw-2012-pov-angola-slums>

3.4 Participatory enumeration with mobile technologies

A household questionnaire was designed, tested and implemented in all four cities: Luanda, Cabinda, Lobito and Benguela. A total of 4,500 household interviews were done. Electronic questionnaires were used rather than paper-based questionnaires as a way of ensuring improved data quality. The decision was taken to use mobile phone-enabled hand-held electronic devices (Android tablets) for administering the household surveys. Tablets¹⁴ reduced paper and sped up the process of transferring survey data to a database server, avoiding errors usually associated with data entry from traditional questionnaires. The pre-loading of skip patterns¹⁵ into the questionnaire simplified the task for the interviewers, allowing them to proceed through the interviews logically and quickly without having to search through reams of paper for the next question after a multiple-choice question. On completion of each household survey, data was transferred to the database server through the mobile-phone network (and subsequently downloaded to SPSS¹⁶ for data analysis). Interviews took less time than a paper-based interview would have taken and the errors were fewer. Data was generally of good quality, with few invalid responses.

The Android tablets were Global Positioning System (GPS) enabled and also loaded with 0.80cm-resolution digital satellite imagery and maps of the areas under study. The mapping of urban settlement typologies and land use can identify areas with different social characteristics and identify areas of flooding and erosion risk, in order to diagnose the impact of environmental hazards.

Enumerators drawn from local community associations were trained to rapidly carry out automatically georeferenced household surveys, make observations, and conduct interviews and focus groups. They captured information on socioeconomic conditions, housing quality, access to water services and costs. DW's innovative blending of geographic information system (GIS) technologies with participatory diagnostic methods is believed to be unique to this project in Angola.



Participatory mapping using a GSMA-GPS-enabled Android tablet © Development Workshop

3.5 Water market monitoring

Some of the tools have been developed in the water component of another IDRC-supported project Post-Conflict Transformation in Angola's Informal Economy¹⁷ and in work for the World Bank on water supply and markets in inland cities in Angola (Cain and Mulenga 2009). The analysis of the water supply system in Luanda and its effect on poorer communities combines questionnaire surveys (to collect information about water prices, quantities used and household data), observations of supply systems to map the supply chains, and the evolution of prices through the chain (see mapping of prices in Figure 12). Data is collected in participation with local community associations and municipal government technicians who validate data and findings and own the findings from the research. The co-ownership of information by both government and communities contributes to its usefulness for policy development and in advocacy for improved services.

¹⁴ Samsung Android tablets were employed with in-built functions (eg GPS receiver, GSMA SIM cards and photo, video and sound recording). Geo-referenced location maps can be pre-programmed into the tablets to help interviewers locate pre-selected households. Surveys can be downloaded onto the mobile phone network via the internet and be completed and cleaned offline and then uploaded to the project's internet server.

¹⁵ A skip pattern is where respondents are able to skip any questions that are not relevant to them.

¹⁶ SPSS Statistics is a software package used for logical batched and non-batched statistical analysis.

¹⁷ See <http://dw.angonet.org/content/post-conflict-transformation-angolas-informal-economy-2007-2009>

4

Variability, flooding and water markets

It has been possible to recover and digitalise monthly rainfall data for 199 stations in Angola and further stations in the Democratic Republic of Congo and Zambia close to the Angola borders. This has allowed some analysis of rainfall patterns in Angola, and in particular rainfall variability in coastal areas. Rain in this area tends to fall as very heavy, isolated storms late in the rainy season and a high percentage of the mean annual rainfall can fall in one day. This creates the conditions for flooding in the rapidly growing cities of the coastal regions of Angola. This increases run-off and water levels in rivers rise quickly. Cities can also be affected by rainstorms in the urban area itself, especially those situated at the mouths of rivers. Flooding and erosion are common in coastal urban areas in Angola.

The pattern of mean annual rainfall derived from this data shows the extent of variability in relation to the mean of a dataset. The coefficient of variation of precipitation serves as a measure of dispersion of the observed values from the average, as a measure of regularity of rainfall in the regions for which they are calculated. The issue of rainfall variability is particularly important in the context of Angola. The calculation of two measures of rainfall variability demonstrates that rainfall variability is high along the Atlantic coast of Angola and some adjacent areas inland, particularly in the south of the country.

It is interesting to note that the highest variability is along the coast where rainfall is low (see Figure 7). The main Angolan urban areas are in relatively low-rainfall areas. The cold current that flows from south to north along the coast usually inhibits rainfall, but with the risk in some years of very heavy isolated storms that have a high impact (especially in March and April). Therefore,

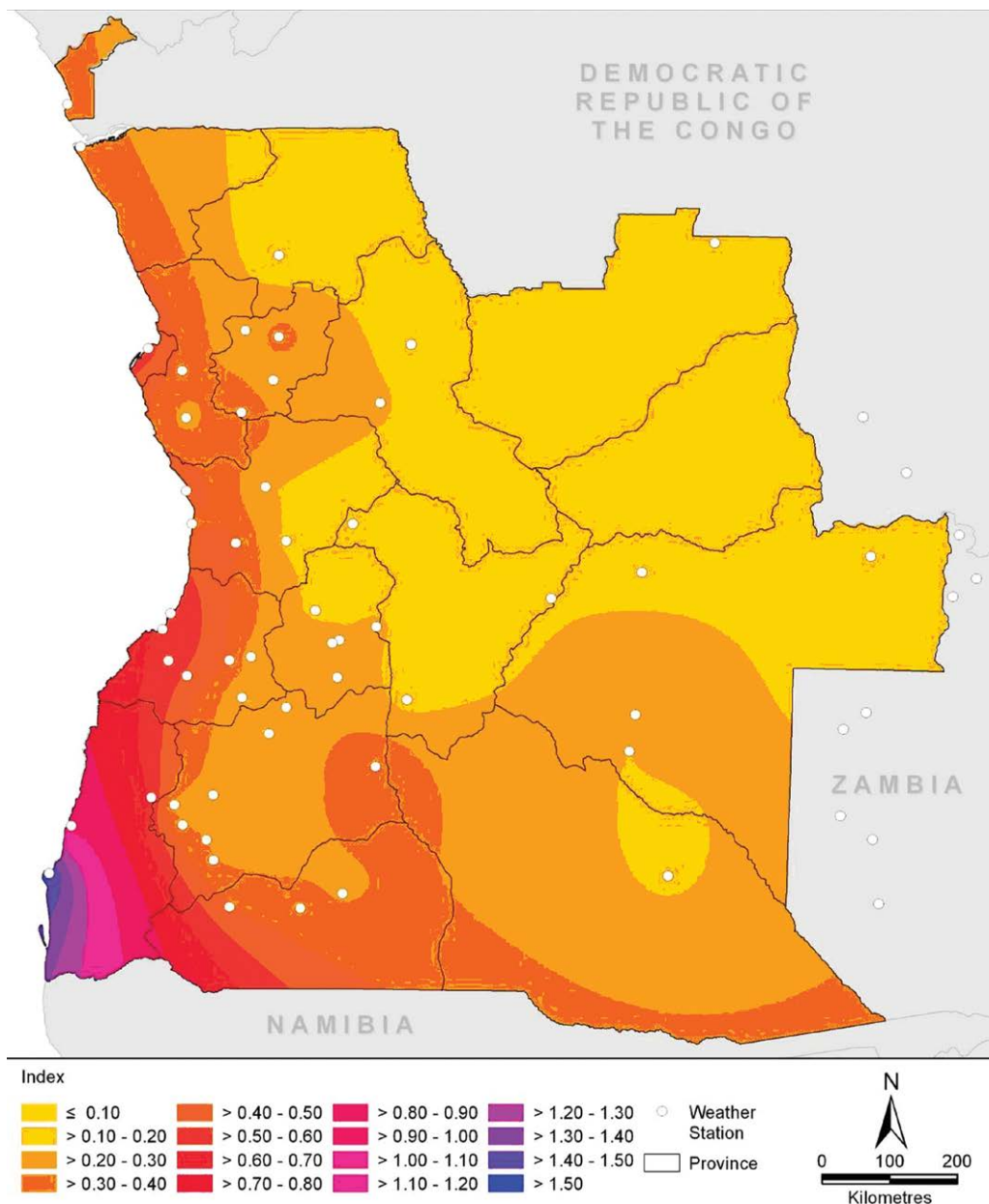
even though the mean rainfall is relatively low in coastal Angola, large amounts can fall in a short period and drainage systems are often incapable of dealing with this.

Significant numbers of households in Development Workshop's household surveys say that they have been affected by flooding and erosion (20 per cent of households in Luanda and 6.4 per cent of households in Cabinda). It should be noted that more households in Luanda are affected by flooding and erosion than in Cabinda even though rainfall in Luanda is lower. Flood and erosion risks are not necessarily higher where rainfall is higher and the variability of rainfall is an important factor. Observations in Cabinda suggest that individuals and the municipal and provincial government take more mitigation measures because the risks are clearer.

The years in which heavy rainfall occurs tend to be those in which there are higher ocean temperatures off Angola. Understanding the mechanisms that lead to higher ocean temperatures in some years may help to improve warning systems, and lead to better predictions of whether the climate is likely to change. In the longer term, it may be possible to forecast years that are high risk for heavy rains along the coast if there is a better understanding of why some years have higher sea temperatures.

Rainfall in Luanda is highly variable from one year to the next (as it is in Lobito and Benguela). The annual total per calendar year has been as low as 52mm (1982) and as high as 860mm (1984). Most rainfall is in short, heavy storms, particularly in March and April: when these storms do not develop rainfall is low.

Figure 7. Map showing Angola's coefficient of variation of annual rainfall



The high variability in rainfall between years may be caused by long-term changes occurring in sea-surface temperatures in the Benguela current and other parts of the Atlantic Ocean and in the position of the ITCZ which may have implications for rainfall and its variability in Luanda.

While Luanda is in a relatively dry region, with an average of 340mm of rain per year, there is high variability. It is not unknown for that amount to fall in one month (six times in the last 100 years, one of which, 1969, had 680mm in two months). It is also fairly common for large amounts of rain to fall in one day. The large amount of rain at one time means that rainfall

rapidly exceeds the absorption capacity of the soil or its ability to lose water sufficiently from evaporation and transpiration.¹⁸ Surface run-off is therefore common. Water from such storms flows as sheets and then begins to concentrate in rills and gullies. The quantity and velocity of water has a significant erosive power that scours the earth and deepens the gullies into ravines.

In Luanda, refuse has often been dumped in gullies, and there is often sediment from previous erosion: these can create dams in gullies or blockages in culverts under roads. When sufficient water has built up behind these blockages, they may give way rapidly, causing a very high flow of water with considerable erosive power that

¹⁸ Large amounts of rain falling over a short period of time are conducive to erosion: the raindrops are large and their impact closes the pores on the soil's surface and moves soil particles down slopes.

can damage bridges, as well as causing the sides of the gullies to collapse and damage to buildings near their edge. In the heavy rains that have occurred in Luanda and Lobito/Benguela, structural damage has mainly occurred in steep places near the coast, for example in Sambizanga district in Luanda, or where homes have been built close to rivers or man-made drainage canals, and in Alto Liro in Lobito, where houses are built on steep slopes. As would be expected, most homes that were physically damaged were ones with rudimentary foundations and flimsy walls.

4.1 Settlement patterns and environmental burdens

The population of the coastal cities increased rapidly during the years of civil conflict (1975 to 2002), the annual rate of increase being approximately 7 per cent in Luanda (see Figure 8) and 4 per cent in other cities. There was a migration of people from rural areas to the cities, and from other cities to Luanda. In the years of conflict, migrants to the city tended to first stay with other families in the older areas close to the centre of cities (usually in the older informal settlements/ slums known as *musseque* areas). This led to high numbers of people per household and high population densities in these areas – in the 1990s, the average number of people per household was about eight. As families found land in areas further from the city centre, they moved out to these new areas (peripheral slum *musseques*) to build their own homes, gradually expanding the geographical area covered by the cities.

However, population density remained high in the old *musseques* as new migrants arrived in the cities.

Now in the post-war years, the overall population of the cities still continues to grow annually at 4–6 per cent due to migration. This is well above the natural annual growth rate of about 3.3 per cent. Today, over 50 per cent of Angola's population of 25.8 million lives in the vulnerable coastal regions (National Statistics Institute 2016).

Research has demonstrated that in Luanda, many internally displaced and other poor families have settled in some of the most environmentally risky parts of the city. As discussed earlier, the poor have relocated into areas considered to have high environmental burdens. These areas tend to be low coastal zones, river basins susceptible to flooding or steep ravines with high erosion risks. These settlement areas almost always lack a piped water supply. Poor sanitation means that groundwater is either polluted or brackish when near the coast. Informal water markets predominate with very high prices and consequently very low water consumption per person per day. Diarrheal diseases such as cholera are endemic in Luanda and some other coastal cities that lead to periodic outbreaks such as the one in 2006 with over 60,000 cases and several hundred deaths. Malaria is the principal cause of mortality in these areas where poor drainage, flooding and the lack of sanitation combine to produce chronic crisis conditions (Figure 9).

In Angolan coastal settlements environmental burdens, whether climatic or disease based, vary significantly between urban areas, depending on their geographical

Figure 8. Annual population growth rate from 1950 to 2015, Luanda

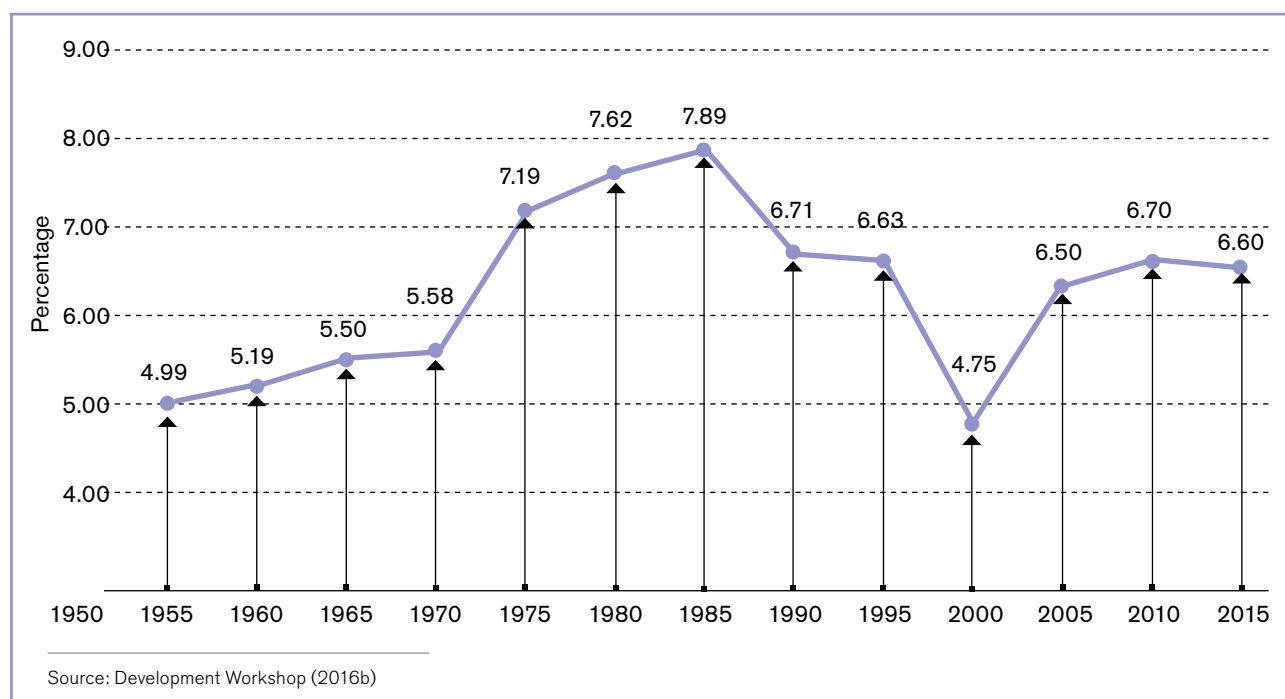
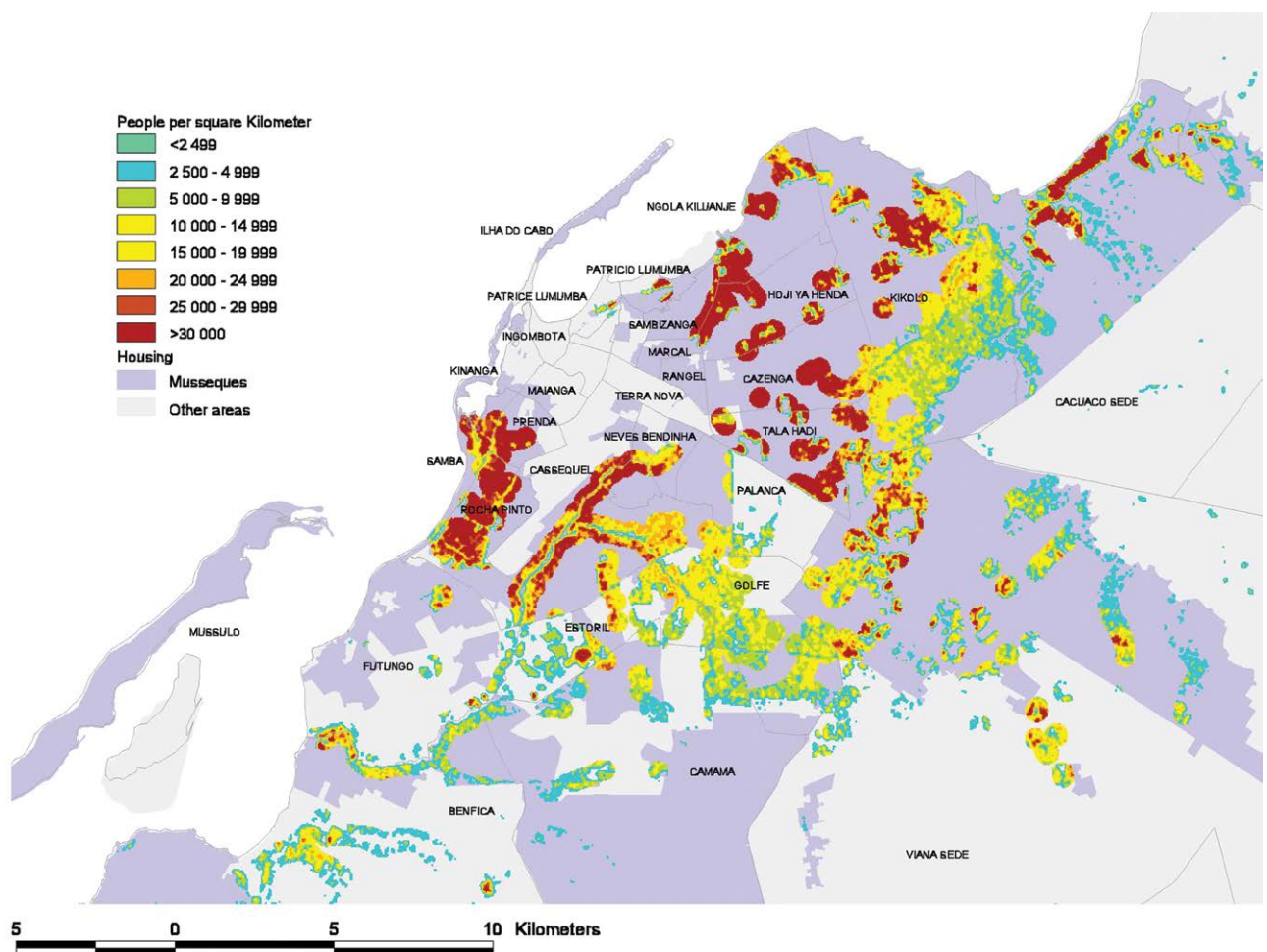


Figure 9. Malaria map of Luanda showing critical high-density hotspots



situation, the size of the town or city, the population density and the topography. It is likely that environmental factors impact on livelihoods in a variety of ways and this varies between urban areas. In large urban areas such as Luanda, floods and erosion disrupt communications and urban economic activities, destroy housing and destroy water and sanitation systems.

Construction has also occurred in basins such as borrow pits (resulting from the excavation of material for use in embankments) and old excavations from which building sand has been removed. These have pools of water at the bottom after heavy rain. Some also have steep walls, immediately above or below which homes have been built and these are at risk of collapse after heavy rains.

Ponds of standing, stagnant water occur after heavy rains in some flatter areas more distant from the coast, in the municipalities of Cazenga, Viana and Kilamba Kiaxi. Clay soils predominate in these flat areas, whereas sandy soils through which water drains more rapidly occur closer to the coast. In Cazenga, housing was built in the colonial era in areas subject to this type of flooding and, although a few houses have been abandoned, many continue to be occupied, despite

flooding. Some roads are badly flooded and completely impassable after heavy rains. In Viana and Kilamba Kiaxi, in areas that have mainly been occupied in the last 10 years, the pressure on land is not yet so great that much housing has been built on land subject to flooding. However, informal housing does appear to be gradually moving into these areas.

As the occupied area of Luanda has grown eastwards and southwards in the last 10 years, it has begun to encroach onto the floodplain of streams that flow into the sea at Cacuaco or the network of streams that reach the sea southwest of Luanda. The variability of rainfall leads to significant and rapid changes in the level of streams in certain years, amplified by refuse and sediment blocking drainage channels and culverts. This leads to flooding of properties built closer to streams, where construction has not taken account of the possibility of high rainfall. While this flooding may not damage housing, it does damage the contents. Flooding leads to higher incidences of sickness, especially where there is stagnant water. The most commonly reported disease is malaria. The consequences of flooding are aggravated by the volume of refuse close to residential areas, and by poor sanitation. Stagnant pools tend



Flooded *bairros* and accumulated refuse in Luanda © Development Workshop



Permanently flooded basins due to poor drainage and impermeable soils © Development Workshop

also to having refuse around them. Refuse may include faecal material, as some households report defecating in plastic bags, which are then discarded with other domestic waste (on the street, in drainage channels or around permanent pools). Better maintenance of drainage channels would enable some stormwater to flow away rapidly. Improvements to sanitation and refuse collection could reduce the health impact of flooding, and could reduce the blocking of drainage channels, which contributes to flooding and also to water surges when the blockages give way. Some stagnant pools could be filled in.

The following factors were identified as the main environmental issues affecting coastal urban areas in Angola:

- Flooding of homes and commercial premises.
- Insufficient capacity to deal with stormwater flooding. Because there are more hard surfaces and less green space, even moderate storms produce high flows and flood drainage channels.
- Structural damage to buildings, especially those located near to overflowing drainage channels and near borrow pits.
- Erosion along drainage channels and sloped land.
- Inadequate solid waste disposal results in refuse being deposited in drainage channels.
- Lack of piped and potable water distribution systems.
- Poor quality and quantity of groundwater.
- High prices of water sold on the informal markets.
- Increased incidence of environmentally related diseases.

Environmental risk maps were developed for the four urban areas addressed by the project, overlaying and incorporating key the factors mentioned.

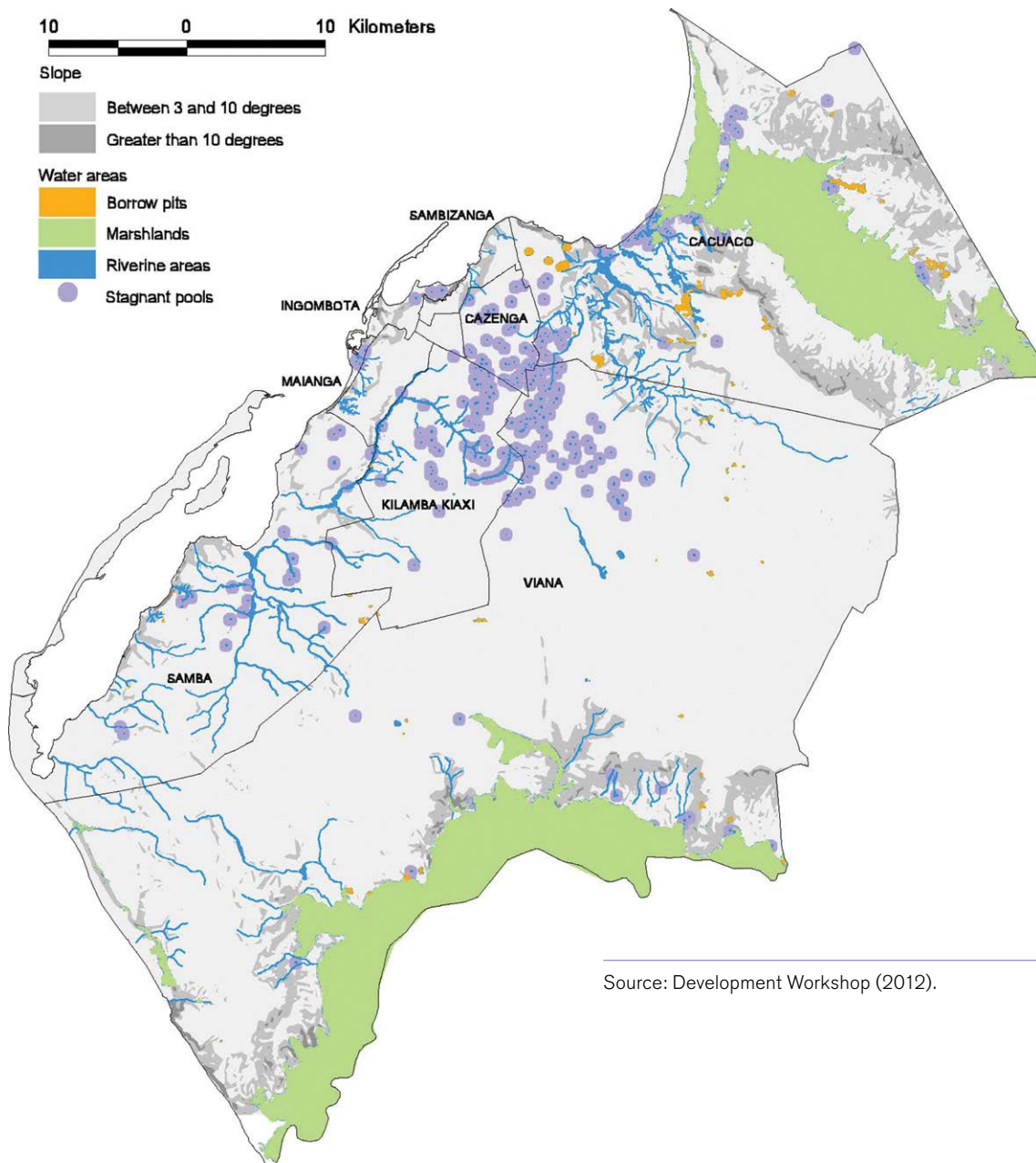
Environmental burdens are exacerbated in coastal regions of Angola by climate change and there is evidence of increased climatic variability. Working with the Ministry of Environment with support from IDRC, Development Workshop is working in coastal settlements to pinpoint more exactly these environmental hazards, mapping their locations, and measuring their impacts and the processes that cause them.

In Luanda, the water supply is from rivers and not groundwater. The main environmental burdens are flooding, erosion and the endemic environmentally

related diseases such as malaria and cholera. From the environmental risk map for Luanda (Figure 10) it can be extrapolated using the GIS-based population model developed by DW that by 2016, of the city's 7 million people, over 157,500 people were living within potential flood-risk areas surrounding rivers, pools and borrow pits (see also Table 1). Of these people, approximately 127,700 live in *musseque* housing which is characterised by its informal nature and high-population density, flimsy building construction and general absence of services, such as safe water, sanitation and refuse removal.

The highest-density settlements are in areas most likely to be flooded after heavy rain. Figure 11 demonstrates the informal settlement areas where environmental

Figure 10. Environmental risk map for Luanda



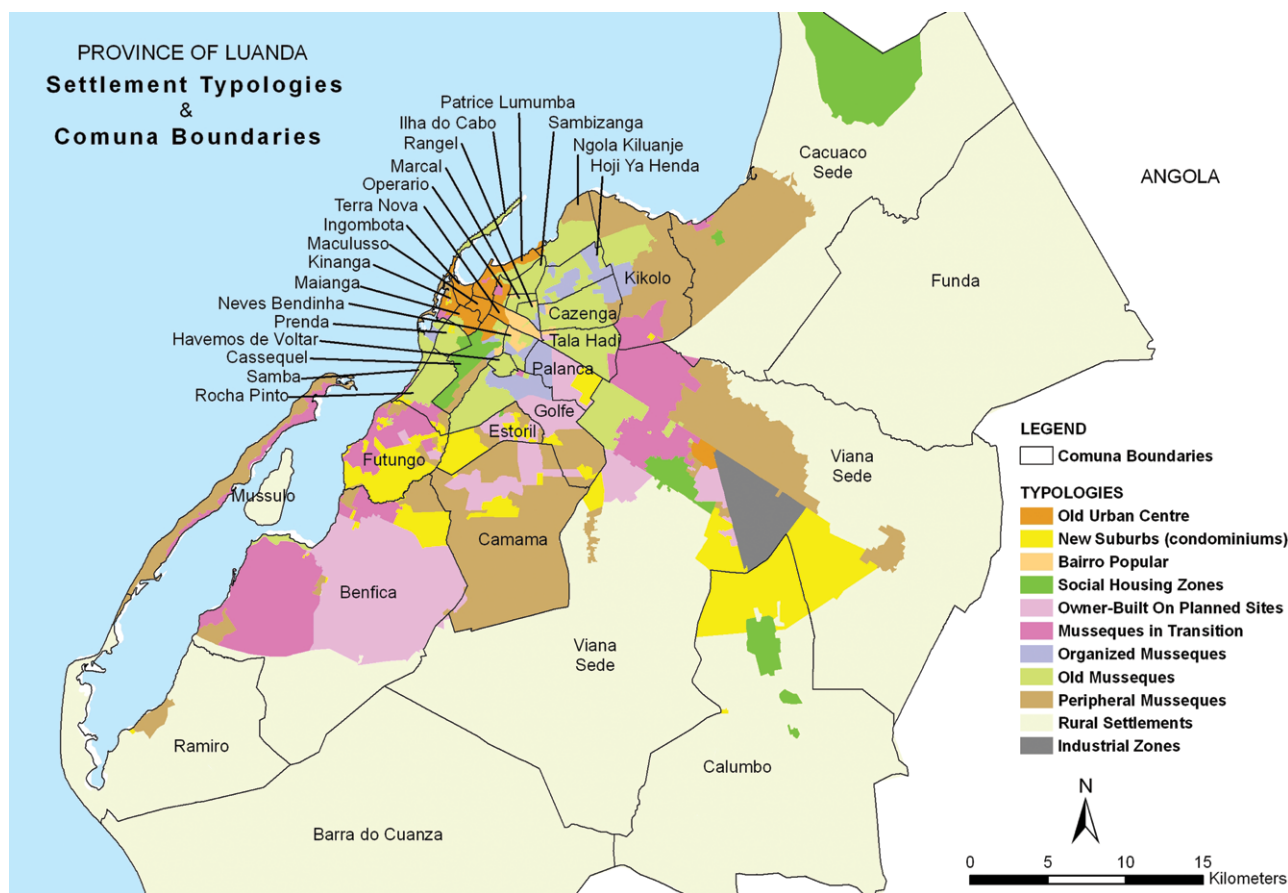
Source: Development Workshop (2012).

Table 1. Percentage of populations living in environmental risk areas in Luanda*

SETTLEMENT TYPOLOGIES	POPULATION ESTIMATE (2016)	FLOOD RISK AREAS	MALARIA RISK	EROSION RISK SLOPE >10°	EROSION RISK SLOPE 3°-10°
Old central business district	87,000	0.06%	1.63%	0.97%	14.85%
New suburbs & condominiums	1,730,400	1.77%	32.68%	0.31%	5.19%
Bairro Popular	53,200	0.12%	13.57%	0.00%	0.00%
Social housing	210,400	1.10%	16.47%	0.00%	2.03%
Owner-built on planned sites	173,500	2.47%	46.38%	0.00%	1.01%
Transitional musseques	150,300	0.88%	30.50%	0.18%	2.65%
Organised musseques	642,900	1.00%	33.27%	0.10%	3.49%
Old musseques	1,724,500	2.29%	38.96%	0.99%	12.19%
Peripheral musseques	197,800	3.48%	49.55%	0.30%	15.85%
Rural settlements	235,900	4.38%	27.30%	0.83%	10.88%
Proportion of Luanda	6,986,100	2.25%	37.79%	0.56%	9.91%

* Estimates of populations at risk in 2016 were done using a GIS spatial projection of geographic areas delineated from the map in Figure 11 and the population model map Figure 6 corrected using census data published in 2016.

Figure 11. Map showing the location of different settlement types in Luanda



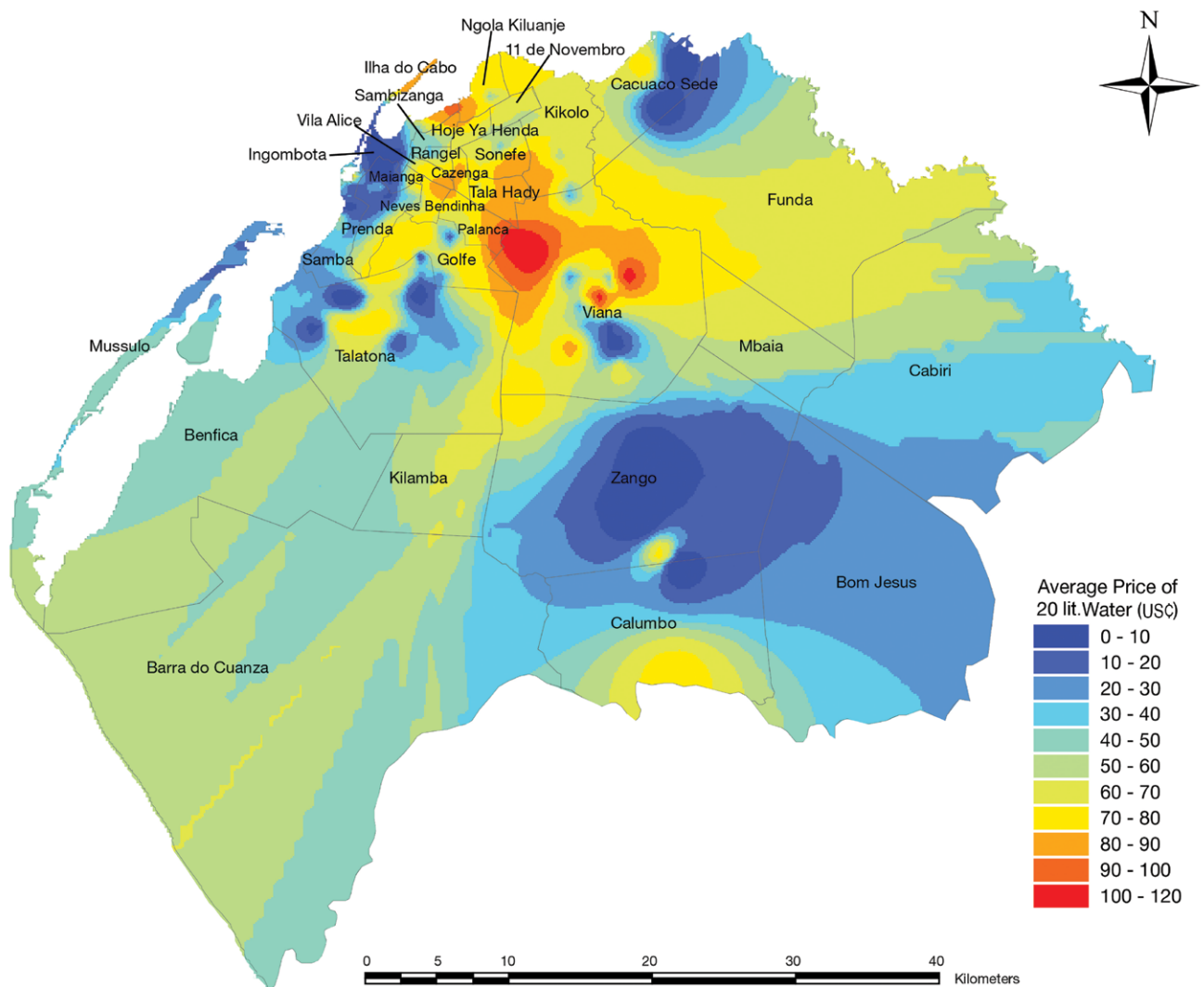
Source: Development Workshop (2011a)

burdens are most critical for each of Luanda's settlement typologies. Almost 694,000 people are estimated to live in the gradient zone between 3 and 10 degrees while over 39,000 people live in steep gradient zones of greater than 10 degrees. More than 2.5 million people live in areas with a high risk of malaria. While most of these inhabitants live in informal low-income *musseque* areas, a significant proportion of middle-income residents live in the new formal suburbs and planned sites and service areas, where adequate sewage and stormwater drainage systems have not yet been completed. They are also at risk of contracting malaria. Since these areas are also within proximity of flood and standing water, they are also places where other water-borne diseases are prevalent.

4.2 Water markets and community water management

Less than half of Luanda's residents receive piped water on a regular basis to their homes. An informal water-supply system is based on tanker truckers that sell river water or water drawn from the piped system through supply depots at various points in the system. Figure 12 compares informal water market prices for a 20-litre bucket across the city of Luanda, where costs vary between US\$0.05 and US\$1.20.¹⁹ Informal water market prices depend on various factors including the scarcity or distance from the source, the quality

Figure 12. Map of water prices for one 20-litre bucket in metropolitan Luanda, 2014



¹⁹In 2014 in the local currency, Kz100 was equivalent to one US dollar.

(whether untreated river water or potable water from the treatment plant) and the current demand which depends on shortages and the season of the year. The map illustrates the gaps in the formal supply system, shows where prices are highest, and provides local authorities with a valuable tool for planning the locations where new investments will have the greatest impact.

Water price maps have been co-produced for Luanda on an annual basis, demonstrating where government infrastructure investments have had localised influences on reducing water prices. Co-production also means that communities in high-price areas have access to information and are encouraged by the project to use mapped data to advocate for improvements and a more equitable distribution of services.

Since groundwater is extremely deep and brackish, drinking water in Luanda is sourced through two formal piped and treated river-water systems at Kifangondo and Kikuxi, as well as from an informal trucked private market fed from river-water pumping stations (called '*girafas*'). At some points along the formal piped system, water is siphoned off and enters the informal trucked system. More than half of domestic consumers do not have piped water in their homes. They either get water from public standposts or have to buy water by the bucket from informal truckers or sellers who intermediate between the tanker-truck operators and re-sell water from storage tanks in their homes (see Figure 13). Most peri-urban residents, in the absence of a public water supply, are continuing to pay high prices for often-contaminated water from the private suppliers.

The informal water distribution system is severely affected during periods of heavy rains and flooding, making water exorbitantly expensive for a large part of the urban population. While the informal operators deliver an important service in the absence of universal household connections, trucked delivery is inefficient and costly, even when the mark-up for profit is small. Of the US\$250 million spent annually by Luanda's residents on the purchase of water, less than 10 per cent is recovered by the provincial water company (Cain and Mulenga 2009; see Figure also 13).

Development Workshop has worked with the Luanda Provincial Water Company (EPAL)²⁰ to expand public access to water through community standposts linked to the mains water supply and to implement a

programme of community management to guarantee adequate maintenance (Cain *et al.* 2002). Because of the limited overall supply of piped treated water to Luanda, families still only obtain from standposts an average of five buckets of water per day (100 litres) at a cost of US\$0.25 per day. This corresponds to US\$2.50 per cubic metre, which is 10 per cent of the price charged by private water vendors selling water from tanks supplied by trucks.

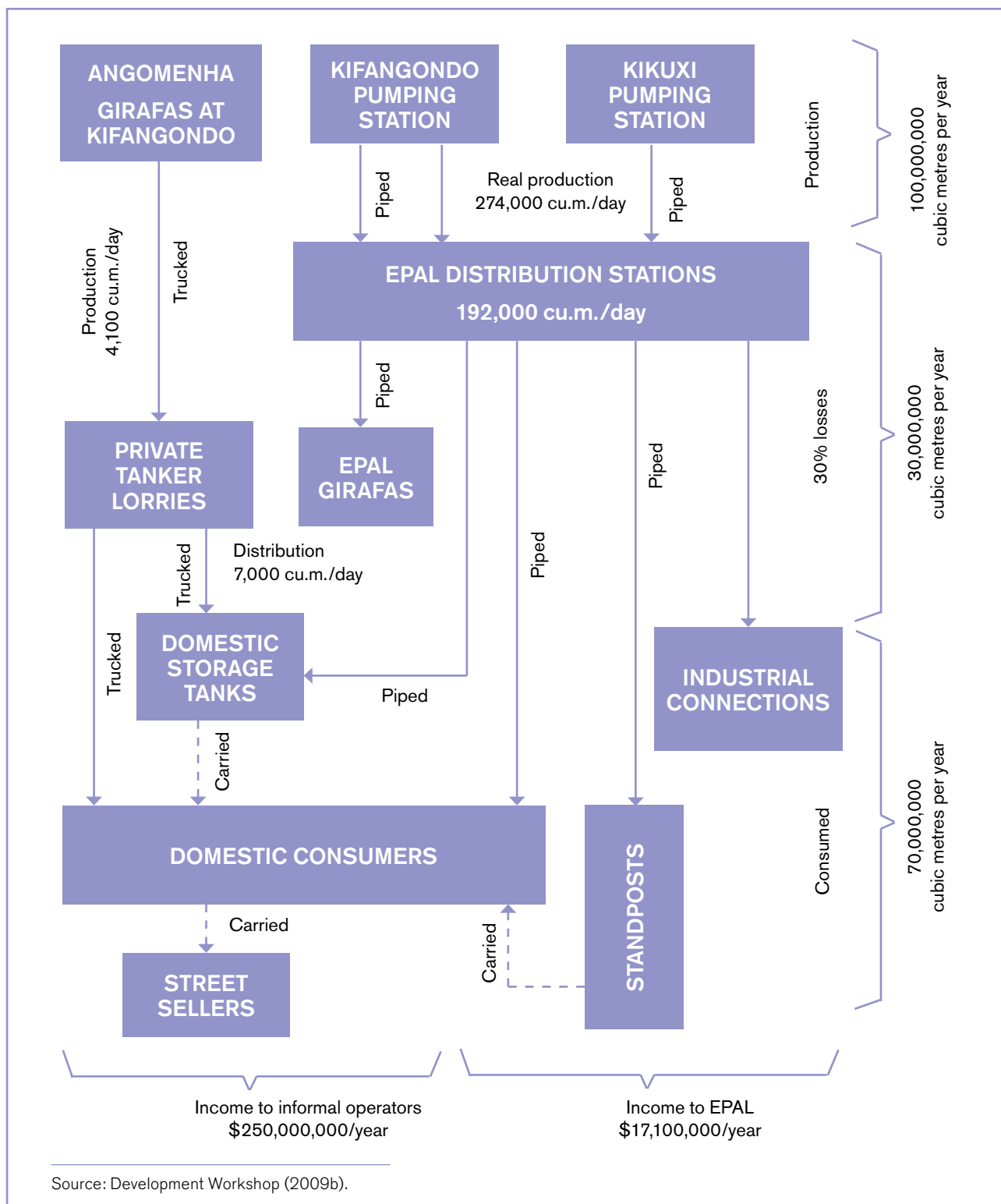
The amount of income earned at standposts has proved to be adequate to maintain and repair the taps and pipes, pay a monitor and pay a contribution to EPAL for the water supplied. The aim is to bring water to within 100m of every house.²¹ The government has made a political commitment to bring water connections to each household. Users may be willing to pay more for a household or yard tap, and there are health benefits from the greater use of water that normally results from individual water connections. In practice, however, this has still not been possible in Luanda: not enough treated water is yet supplied to the city and water pressure has not been sufficient to allow this coverage. Community standposts will remain an equitable option for water distribution for the next decade until new urban water treatment and distribution systems are in place.

DW's community consultations indicate that residents of the *musseques* are willing to pay for better water supply services, especially if they know where their money is going. They supported a form of community management of water points whereby the users have control over the water point and elect caretakers for maintenance and who are entrusted to collect fees. Communities consulted, however, were reluctant to pre-pay for services unless the state could guarantee a regular water supply. DW's experience has shown that the management and maintenance of standposts locally, by committees chosen by the users, is an effective system – especially when there is transparent financial accountability to the consumers (Cain *et al.* 2002). DW formed neighbourhood committees before the construction of the water networks, and consulted them on planning the layout and location of standposts. After construction, the committees usually found solutions for most of the problems that occurred in order to maintain the service, and kept all taps and other components in good condition.

²⁰ EPAL is a state-owned water company, answering to the Luanda provincial government. EPAL is aware that it does not have the capacity to manage water supply at the community level. It has been willing to participate with Development Workshop to develop models for local management of standposts while it concentrates on upgrading, maintaining and managing the main water system.

²¹ When water is supplied at a distance of less than 100 metres from the house, demand tends to increase beyond the capacity of the current system in Luanda to deliver.

Figure 13. Water resource delivery chain in Luanda delivers US\$250 million per year to informal operators



It was found that master-planning water management infrastructure needs consumer consultation but also requires climate and hydrological information that is often unavailable in Angola. Water investments needed to be designed to perform under future climate regimes as well as present-day ones. It is necessary to be able to predict average rainfall and stream flows (to determine

water availability and storage requirements) as well as extreme flows and storms to design infrastructure to withstand them (Muller 2007). DW's research on climate change has provided useful data, which has been mapped in forms that are accessible to infrastructure and programme planners in Angola.

5

Towards improved water governance and participatory planning

There are indications that understanding climate change and planning for adaptation are now being taken more seriously in Angola, recognising the country's high levels of vulnerability to climate change. There is a need, however, to strengthen the recognition that there is a critical relationship between climate change, urban land-use planning and water-resource management. Urban planning can substantially reduce the vulnerability of communities to the impacts of climate variability and water-based natural disasters if supported by reliable climatic risk and flood data that can be provided to water managers. Resilience can be improved by involving communities in planning approaches that prevent settlements from being located in vulnerable areas (Muller 2007) and by developing remedial actions for settlements that are already situated in these areas.

Development Workshop's research presented to the Ministry of Water and Energy (MINEA)²² showed that in many communities, the Water for All programme has failed to put in place sustainable water systems that will guarantee true 'access' to water for the long term. Of the pumping and water treatment systems installed, only 48 per cent were functional. This study also found that

local capacity for operation and maintenance of water systems is very weak, that there is almost no collection of user fees, and that local administrations and communities have a limited sense of local ownership of the water systems and therefore feel no responsibility for sustaining them. One main conclusion of these studies was that of weak 'water governance': technological solutions were rarely discussed with the communities and usually do not respond to the preferences of users.

South-South exchanges were developed through the project to assist government and civil society organisations to share policy experiences and technical approaches, and to make institutional linkages and build capacities. South-South collaboration was promoted through exchanges with a number of IDRC-funded projects and others that have similar experiences and which were shared. These include the Climate System Analysis Group's (CSAG) Global Forecasting Centre for Southern Africa at the University of Cape Town and the Brazilian project Risk Perception and Vulnerability of Wetlands Areas in South American Atlantic Coasts. Collaborative partnerships have been built through the joint publications of some of the research findings.²³

²²Development Workshop and Cowater International implemented this project.

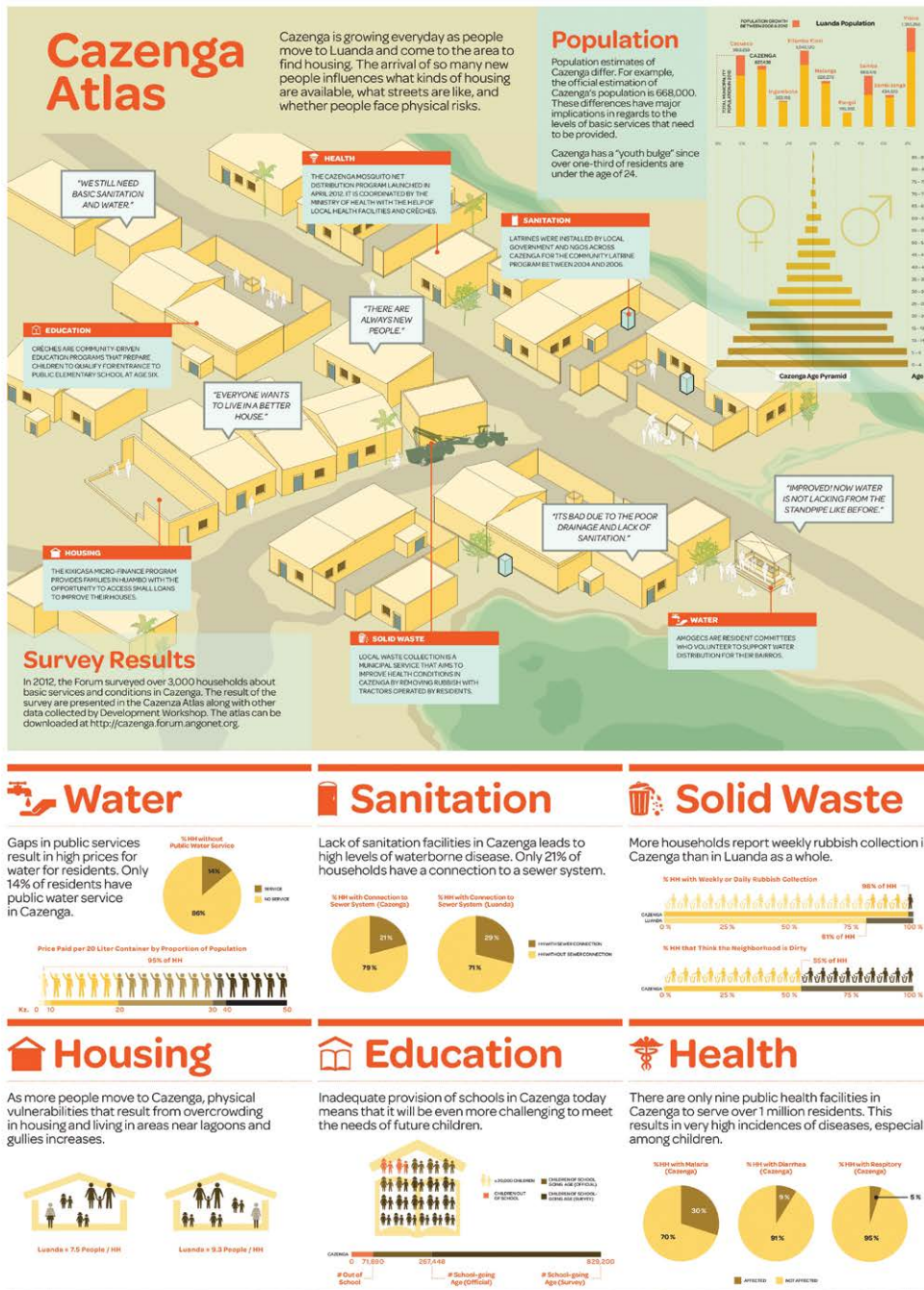
²³Angolan Centre for Tropical Climate Research is a new institution supported by the Ministry of Environment. It has published a paper on climate data that the project has compiled.

DW has also engaged students from several universities and members of civil society organisations (CSOs) as researchers and enumerators in gathering data and carrying out group discussions so as to contribute to the capacity development of those CSOs. Staff from the relevant government agencies are also included in teams to increase buy-in to the project and build capacity.²⁴

5.1 Municipal adaptation planning

Maps in the form of posters were produced containing information useful for physical planning for all four coastal cities (Cabinda, Luanda, Lobito and Benguela). The posters are essential tools now being used to plan adaptation strategies to reduce climate risks in the vulnerable urban communities (see figures 14 and 15).

Figure 14. Poster showing participatory mapping in Luanda



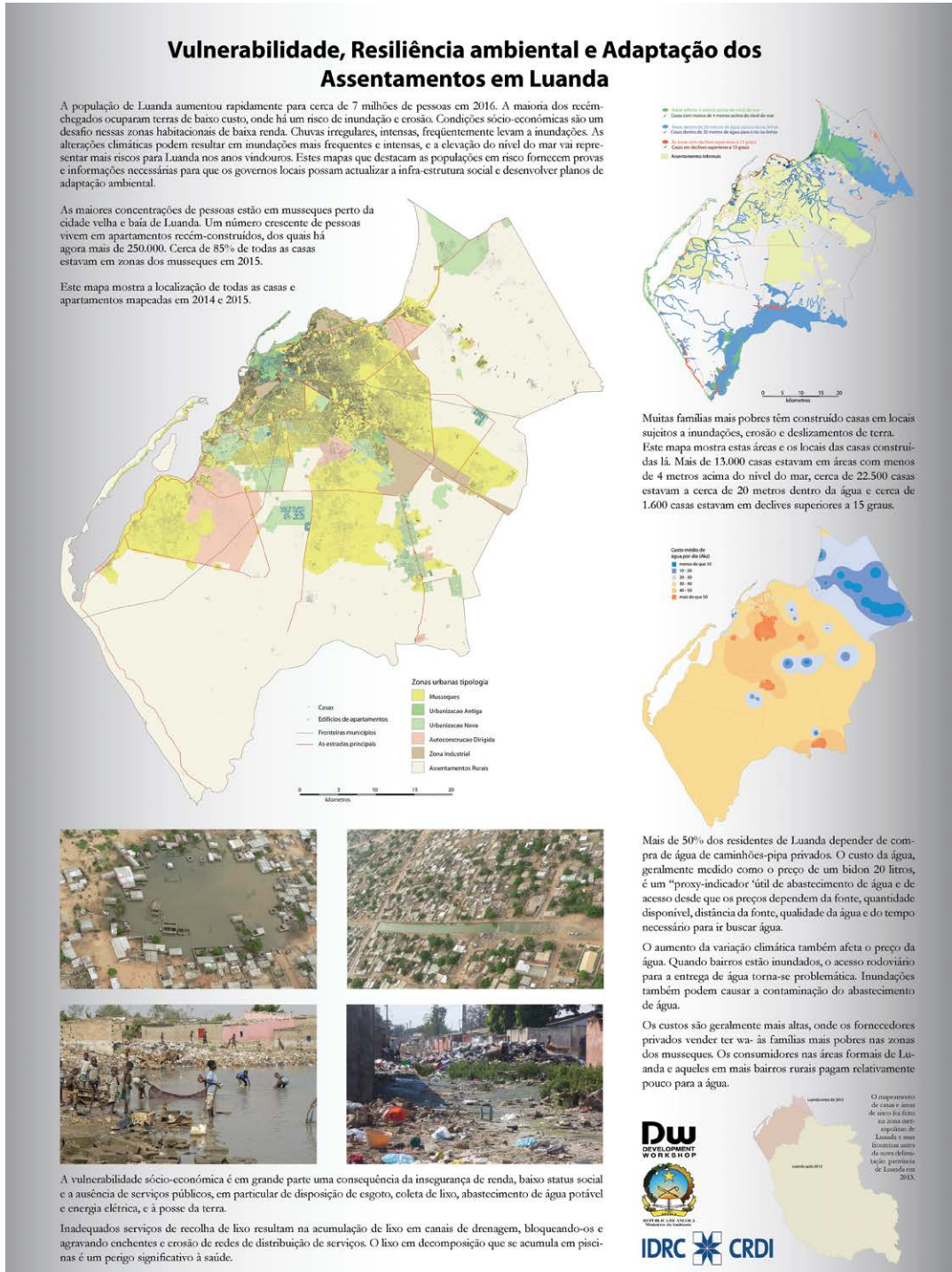
Source: Development Workshop (2016a)

²⁴ Collaboration with Angolan researchers and institutions is documented on Development Workshop's climate change website: www.dw.angonet.org

Figure 15 shows the Luanda poster, which includes maps with overlays of variables such as population density, environmental burdens and poverty levels to show areas and populations at risk from flooding and erosion. The poster for Luanda demonstrates to the urban planners and the municipal policymakers that the highest concentrations of people live in *musseques* near the old town and in the bay of Luanda. The data show

that about 85 per cent of all the homes are located in slum areas. Maps show the locations of all households and that many poor families have built houses in areas subject to flooding, erosion and landslides. The areas prone to erosion are indicated. More than 13,000 homes are located in elevations of less than 4m above sea level, about 22,500 homes are in flood-risk areas located about 20m from the water, and about

Figure 15. Urban vulnerability mapping plans



Source: Development Workshop (2016a)

1,600 houses are built on land with slopes greater than 15 degrees.

The posters feed data from research on environmental and socioeconomic vulnerability into the municipal planning process and introduce the need to adapt these plans to increasing risks. Participatory planning (see poster in Figure 15) has been piloted in four of Luanda's most vulnerable municipalities between 2011 and 2015, using the framework of municipal and communal forums. Forums engage community groups and CSOs with municipal administrations, service providers and provincial and central government working commissions in the respective municipalities. The sharing of information on environmental vulnerability and raising of expectations between stakeholders through the forums keeps pressure on municipal administrators and service providers to perform their duties. The forums are consultative spaces that focus on reinforcing the Angolan local governance process and, through that, improving service provision to all, especially the citizens living in the *musseques*. Increasingly, the provincial governor and the directors of the main public-service sectors also participate in these meetings in order to hear what the community proposes. DW and its partners at the community and provincial levels have advocated for a permanent and more systematic engagement with the participation of the central government.

5.2 Improvements in water governance

Conscious of the shortcomings of the Water for All programme, MINEA took the decision to address the sustainability problem by adopting a community water-management strategy as part of the government of Angola's water-sector policy. The principles grew out of the many years of partnership with Development Workshop in the water sector and research supported by IDRC. DW's research has demonstrated that peri-urban residents are not averse to the idea of paying for a public water supply, provided that the cost is less than what they pay for water from private water tanks and that they have some assurance about the quality of the service provided (Development Workshop 2009a).

DW has transformed its knowledge gained from research and experience into a set of good practices in local water governance as follows (Development Workshop 2013):

- Partnership with community members and key stakeholders, such as public service providers, is key to promote sustainability of water and sanitation.
- Cost recovery for maintenance of water services must be financially sustainable yet affordable to the urban poor.
- It is important to focus on strengthening community capacity to participate as stakeholders in planning and management.
- Ensure community and government co-ownership of initiatives with clear roles and responsibilities and accountability mechanisms in place.
- Value existing knowledge, ideas and lessons learnt from experience and past practice.
- Promote equality, non-discrimination and inclusion to ensure the voices of women, youth and men are all listened to and that they are active participants in decision-making processes.

The National Water Directorate which is part of MINEA and the secretary of state for water sought the assistance of DW in developing the community water-management model (MoGeCA) based on the above principals. The strategy of community management of local community water points²⁵ involves the election of water caretakers by local consumers and the creation of legally constituted water associations that collect user fees, manage maintenance, and buy water in bulk from the parastatal provincial water companies.

Together with the ministry, DW tested this model of water governance in Luanda and several other provinces and proposed it as a remedial tool for incorporation into the Water for All programme. In late February 2014, the secretary of state for water announced that the community water-management model was adopted as national policy and the training manual developed by DW was distributed to municipalities across the country supported by a structured training programme. The African Development Bank with the National Water Directorate has engaged Development Workshop along with the Canadian company Cowater International to develop the post-2015, 10-year strategy for sustainable community water to be piloted in provinces across the country. The programme draws on the evaluation of the past experience, findings from the research supported by IDRC and incorporates the water governance lessons from the community water-management model.

²⁵ 'Water points' refers to all community shared-access standposts, wells, boreholes and other public water-distribution systems.



Community-managed standpost in Luanda © Tim Hetherington

By 2014, about 7.5 million Angolans, out of the total population of 25.8 million, relied on community-accessed shared water sources that are not piped to individual households, with the majority of those being in urban areas (World Bank undated). However, many of these sources are still unreliable, often functioning intermittently. Even Angolans considered to have 'improved access' are often forced to rely on unsafe or distant alternative sources. It is these consumers who are targeted by the MoGeCA programme. At the same time, over 60 per cent of the Angolan population has access to mobile phone GSMA networks (GSMA Intelligence 2015).²⁶ This means about 20 per cent, or 4.5 million people, are within the addressable market that has access to communal water sources considered to be potential MoGeCA beneficiaries and are covered by GSMA networks which could be leveraged for monitoring to ensure reliable services. Advances in information and communications technologies (ICTs) and improved GSMA coverage in Angola have created an opportunity for the voices of *musseques* dwellers to be heard.

In addition, DW is also using social media campaigns to highlight problems related to refuse management. Angola has a significant oil industry. But when the fall of oil prices resulted in the cutting of state budgets in 2015 and 2016, municipal financing for sanitation and refuse removal was drastically reduced in Luanda and other cities. A public health crisis ensued as refuse accumulated in the streets, public spaces and alleyways. Highschool and university students mounted a social media campaign called Selfie-Lixo using Facebook, Instagram and DW's Urban Digital Forum.²⁷ Development Workshop advocated for raising sustainable local-government financing for refuse management through local service charges, rather than depending on subsidies from the dwindling state central budget. The campaign engaged with students and youth in affected communities in the use of social media advocacy by promoting the Selfie-Lixo platform, as well as influencing policy through the press, radio and TV. The campaign attracted wide public media attention and invitations to participate in prime-time television debates on the issues of urban sanitation and climate change risks.

²⁶ The GSM Association (commonly known as GSMA) is a trade body that represents the interests of mobile operators worldwide.

²⁷ Selfie-Lixo (meaning 'Selfie-Rubbish') can be found on DW's Digital Urban Forum website: <http://cazena.forum.angonet.org/campanha-selfie-lixo/>



Selfie-refuse campaign on Facebook © Development Workshop Angola

In April 2016, the government of the province of Luanda adopted one of the campaign's key policy recommendations on raising sustainable local-government financing for refuse management through local service charges. This will create an autonomous, local-level financing mechanism for sanitation (ie refuse collection) by cross-financing municipal service bills (for electricity). A more efficient refuse-collection service is essential for municipal adaptation planning in that it will help keep drainage channels open, thereby greatly reducing the risk of flooding.

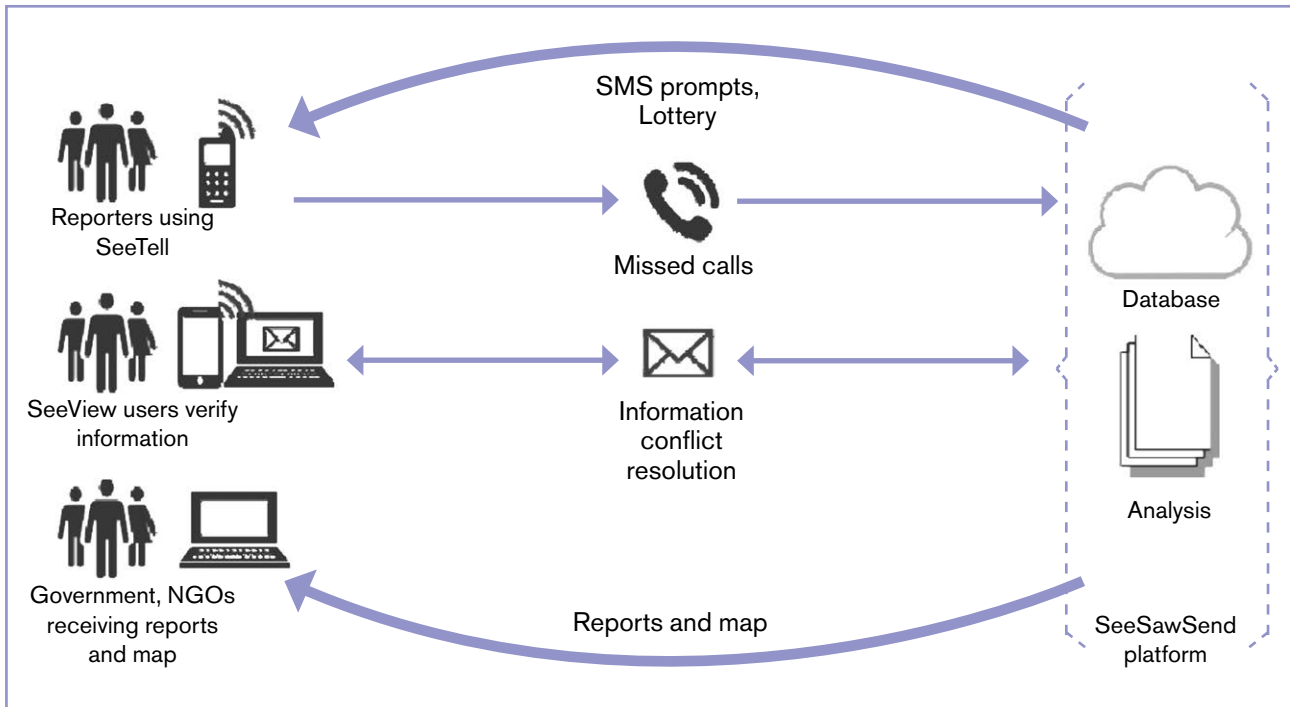
Community access to mobile networks was exploited to promote participation in water governance. Building on the networks of communities participating in the MoGeCA programme, DW has piloted a mobile phone-based water-monitoring system²⁸ in four municipalities, using interactive information sharing to ensure government accountability in the delivery of services (Ndaw 2015; see also Figure 16). ICTs are used by MoGeCA to encourage citizens to voice their concerns and put pressure on the local government to address problems with their water and sanitation services, increasing government accountability and empowering citizens. ICTs can be used to create a system of transparency and accountability, to promote public participation, to improve monitoring and management of services and reduce the cost of access

to information and service delivery. Improving ICT usage at the local level enhances and supports socioeconomic development by empowering community leaders to provide timely, efficient, transparent and accountable services (Misuraca 2007). ICTs can build capacities of people previously excluded from the political process, including women, youth and minorities (Adesida 2001).

A monitoring of service systems has also been put in place to provide timely and adequate water supply, water quality and water-use management giving a real-time picture of the level of access. Using basic (non-smart) mobile phones, the project is designed to gather information from water caretakers and members of community associations who manage the standposts. Caretakers make a mobile phone call to an online server that records the incoming call but does not pick up and therefore does not register a fee payment. The 'free' missed call is recorded, indicating that the standpost has no water, and reports the hours of service for each water point. The system helps the caretakers to report the functionality of each standpost, allowing the water service provider to compare the information submitted about the functionality (working hours of each connection line to the standpost) and compare them with the hand-written reports provided by the caretakers. The ICT-based water-monitoring system aims to enhance MoGeCA to empower underserved

²⁸ The Ver Água system piloted by DW is based on SeeSaw's platforms which utilise mobile services (specifically free missed calls, SMS and data) to relay information about water service status. SeeSaw designed the missed-call platform to receive calls from both of Angola's GSM operators Unitel and Movicel. No formal partnership with a mobile operator was created for this pilot.

Figure 16. Diagram of the Ver Água mobile phone-based system for monitoring standposts



communities with better information about water availability, price and quality. Accurate water-timing information can reduce long waits for consumers fetching water at standposts, prevent lost workdays and allow individuals to effectively plan their water usage. The mobile phone-based system allows for real-time monitoring of standposts, reduces repair response time and improves water quality.

The information collected is accessed and used by the service providers to ensure the system is easy to use and effectively managed. The data assists in verifying the quality of water supply, and ensuring government-agency service providers respond to the demands from consumers.

6

Conclusions

The project has successfully built a database of climatic information that has helped to fill the gaps of some of the information that has been missing from Angola's four decades of conflict. Digitalised historic data has been triangulated with information gathered from oral histories and monitoring the media. INAMET, the Angolan government and regional partners are beginning to reconstruct a network of meteorological and hydrological stations and together with satellite-based imaging will be able to fill in the climatic modelling maps that have been blank over the southwest-central African coast. Weather-station data, however, will always need to be validated with on-the-ground observations and the qualitative and quantitative participatory research methods developed by DW will continue to be important for transforming data into information and maps that will be useful for adaptation planning of coastal settlements and for the provision of services like water in these vulnerable areas.

Angolan experience to date has shown that relying solely on subsidised funds from the state budget to maintain local water infrastructure in the peri-urban *bairros* has proved unrealistic.²⁹ While the government's Water for All programme aims eventually to deliver piped water to all households, community water points will remain the most equitable and cost-effective service for some decades to come.

The research project has developed diagnostic tools for better understanding informal water markets that still serve almost half of households in coastal cities. DW has promoted the co-production of information with communities and local governments that facilitates monitoring of the provision of basic services. It has demonstrated the principles of cost recovery, and shown that when charged an affordable fee for water, communities can be engaged to keep the local infrastructure operational. A governance model for sustainable water that serves the collective good will be supported by people who are willing to pay – as long as they have trust in a locally accountable institution. The project has demonstrated how the co-production of information has been used for advocacy and to influence local planning. A model of water governance based on the concept of community management and accountability is providing improved service to consumers in Angola's coastal urban settlements.

²⁹ In Portuguese-speaking countries, a *bairro* is a community or region within a city or town.

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Angola's civil war caused a massive population movement from rural conflict areas to low-lying coastal zones between 1975 and 2002. More than half of Angola's 27 million people now live in urban coastal settlements, floodplains and steep ravines vulnerable to climate extremes. Climate-related risks are worsening and it is important to understand and prepare for them. Angola's coastal areas are experiencing increasingly variable rainfall and pressure on water supplies and markets. But a dearth of relevant data has made it difficult to assess these risks. This paper demonstrates innovative methods in filling the information gap and how changes were introduced in how water is governed in four Angolan coastal cities.

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