Water Resource Management under Changing Climate in Angola’s Coastal Settlements

Project Number: 107025-001

Final Technical Report

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by Development Workshop – Angola
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Location of Study: Cabinda, Benguela, Lobito, and Luanda in Angola

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<th>Description</th>
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<tbody>
<tr>
<td>CCW</td>
<td>Climate Change and Water Program of DRC</td>
</tr>
<tr>
<td>CEDOC</td>
<td>Centro de Documentação da DW (DW Documentation Centre)</td>
</tr>
<tr>
<td>CETAC</td>
<td>Centro de Ecologia Tropical e Alterações Climáticas or Centre for Tropical Ecology and Climate Change</td>
</tr>
<tr>
<td>CSAG</td>
<td>Climate Systems Analysis Group, University of Cape Town</td>
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<tr>
<td>CV</td>
<td>Coefficient of Variation</td>
</tr>
<tr>
<td>DFID (UK)</td>
<td>Department for International Development of the United Kingdom</td>
</tr>
<tr>
<td>DNA</td>
<td>Direccão Nacional de Águas (National Water Department)</td>
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<td>DW</td>
<td>Development Workshop - Angola</td>
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<tr>
<td>ENSO</td>
<td>El Niño-Southern Oscillation</td>
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<td>GEF</td>
<td>Global Environment Facility</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<td>IDRC</td>
<td>International Development Research Centre</td>
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<tr>
<td>IFAL</td>
<td>Instituto de Formação da Administração Local (Local Administration Training Institute)</td>
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<tr>
<td>INAMET</td>
<td>National Meteorology and Geophysics Institute of Angola</td>
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<tr>
<td>ITCZ</td>
<td>Inter-Tropical Convergence Zone</td>
</tr>
<tr>
<td>MAT</td>
<td>Ministério da Administração do Território (Ministry for Territorial Administration)</td>
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<tr>
<td>MoGeCA</td>
<td>Modelo de Gestão Comunitária da Água or Community Water Management Model</td>
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<tr>
<td>NAPA</td>
<td>National Adaptation Paper of Angola</td>
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<tr>
<td>NOAA (US)</td>
<td>National Oceanic and Atmospheric Administration</td>
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<td>ODK</td>
<td>Open Data Kit</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
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<tr>
<td>RELAC</td>
<td>Climate Change Network of the Lusophone countries</td>
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<tr>
<td>SASSCAL</td>
<td>Southern African Science Service Centre for Climate Change and Adaptive Land Management</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
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<td>SST</td>
<td>Sea Surface Temperatures</td>
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<tr>
<td>TAMSAT</td>
<td>Tropical Applications of Meteorology using SATellite data and ground-based observations</td>
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<tr>
<td>UCT</td>
<td>University of Cape Town</td>
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<td>UK</td>
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<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<td>UN Habitat</td>
<td>United Nations Human Settlements Programme</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<tr>
<td>US</td>
<td>United States</td>
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1 Executive Summary

Planning for adaptation to climate change in Angola is a problematic exercise because the period in which significant meteorological and hydrological records were collected is short (i.e., 1940 to 1975 for meteorological records, and 1960 to 1975 for hydrological records). The regular collection of climatic and hydrological data effectively stopped during the civil-war years from 1975 until 2002 as more than 500 stations were abandoned across the country. Limited information is available on the vulnerability of coastal cities, on rainfall variability and trends, on river flows and on areas at risk (now and in the future). Similarly, limited demographic and socio-economic information is available. Although new institutions have been set up to improve information and analysis in these areas and to improve civil protection against disasters, the paucity of data poses a significant barrier to carrying out their functions.

The overall objective of the project was to provide research evidence that will assist policy-makers to address climate-related water stress and environmental management challenges in Angola’s three coastal urban areas (Luanda, Benguela/Lobito, and Cabinda) to make water more accessible, available and affordable for vulnerable populations living in these areas.

The specific objectives were to:
1. Improve baseline information about rainfall patterns, hydrology and settlement patterns in coastal areas of Angola, which is essential information for understanding trends and variability and also for adaptation planning
2. Strengthen research capacity for assessment of climate risks at present and under future climate scenarios
3. Assess the impact of climate change on water supply issues, especially for vulnerable social groups, derive policy recommendations, and propose better water governance mechanisms for these areas
4. Share research findings to inform policy, service delivery and practice

Data from the project was used to produce three (3) monographs, two (2) journal articles, one (1) policy brief, one(1) workshop report, 15 presentations for conferences and meetings, and five (5) media dossiers (see Annex 2 – List of Research Outputs).

In compliance with the requirements of the IDRC Open Access Policy, all
project outputs have been posted in the DW website (i.e., the Climate Change Project page --- see http://www.dw.angonet.org/content/climate-change). This site is accessible to the general public, and materials can be downloaded for free. All other project outputs that will subsequently be completed shall likewise be posted in the same location.

In the Angolan context, the project has been very important in bringing the various Angolan institutional actors together for the first time. The project has supported one of the first opportunities to bring concerns about climate change into the arena of public policy influencing and advocacy related to urban planning, and water access and affordability. The project was constrained by the fact that expected counterpart funding did not materialize during the lifetime of the project and that the budget was seriously constrained by the currency exchange losses due to the devaluation of the Canadian dollar. A no-cost extension of six months was agreed due to the delay in some project activities. However, the project has achieved its principal planned objectives, and it is anticipated that further policy outcomes will be evident in the near future after the end of the current program.

Concerning the project’s policy influencing on Water Governance, on April 15, 2016 the government of the province of Luanda adopted one of the project’s key policy recommendations on raising sustainable local government financing for rubbish management through local service charges, rather than depending on subsidies from the dwindling state central budget. This will create an autonomous, local-level financing mechanism for sanitation (i.e., rubbish collection) by cross-financing on municipal service bills (for electricity). A more efficient rubbish collection service is essential for Municipal Adaptation Planning in that it will help keep drainage channels open, thereby greatly reducing the risk of flooding. In March 2014 the Ministry of Water and Energy adopted another key water governance recommendation by adopting the Community Water Management Model (MoGeCA) that helped bring affordably-priced water to urban communities through a participatory enterprise model.

This project has demonstrated that reduced vulnerability of the communities themselves can be promoted through micro-planning and co-participation with municipalities to develop climate adaptation plans and build resilience to climate change and natural disasters. The project approach can thus be used by other low-lying African coastal cities who disproportionately suffer environmental risks (e.g., rising sea levels, flooding, strong tropical storms) to adapt to climate change.
2 The Research Problem

Angola emerged in 2002 from many decades of protracted conflict, which resulted in the destruction of infrastructure and the breakdown of institutions of all kinds. This in turn, has led to a lack of a national capacity for the systematic collection and analysis of relevant data that are crucial inputs into planning and long-term policy development. For instance, the climate parameters for Angola were calculated in the 1950s on the basis of only about 10 years of information, due to the limited data available on rainfall variability and trends, on river flows, and on areas at risk from flooding and erosion. While information about climatic hazards is essential information for adaptive capacity building, the limited analysis that can be done using the available data do not provide a sound basis for planning and decision making.

The systematic collection of meteorological data is identified as a priority in Angola’s first national communication to the United Nations Framework Convention on Climate Change (UNFCC). In the last five years programmes have been created to re-establish meteorological and hydrology stations all over the country. However, significant gaps in the past records remain. The lack of information also hinders international scientific research and the development of climate modelling for the country (currently, there is no in-country capacity for climate modelling), and existing General Circulation Models do not agree as to whether rainfall will increase or decrease over most of Angola. It is as yet not possible to downscale General Circulation Models and use these for adaptation planning in Angola. Because of the prolonged conflict, Angola only began to work on plans for adaptation to climate change after 2002 and is several years behind in its reporting obligations to the UNFCCC.

The conflict also caused large-scale migration of populations from the rural areas to the safer coastal settlements. Thus, Angola has been considered the most rapidly-urbanizing country in southern Africa, and most of this growth has been in urban coastal settlements. Due to population pressure and the lack of administrative guidance, communities have informally but steadily encroached on land normally considered unsuitable for habitation (e.g., low-lying, flood-prone areas). And while these urban coastal areas have haphazardly and rapidly expanded, the provision of basic services had not kept pace with such growth due to the lack of institutional capacity for land-use planning and service provision.

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1Development Workshop Angola contributed to the process by preparing a Report entitled “Impacto das Alterações Climáticas em Angola, Vulnerabilidade e Adaptação” for the Ministry of Environment in 2011.
The coastal areas are known to have a low but highly variable rainfall pattern and floods have been experienced in recent years in many Angolan urban areas as settlements have developed in an unplanned manner. These flooding events have drawn attention to the issue of environmental risks and to the fact that cities have developed and grown without taking these risks into account.

The regular collection of climatic and hydrological data effectively stopped during the civil-war years from 1975 until 2002 as more than 500 stations were abandoned across the country. Due to these significant geographical and historical gaps in the rainfall record, it is difficult to assess whether a heavy storm or an extreme drought is part of the normal variation in rainfall, or if it is part of an emerging trend. The pace at which mapping of river basins and collection of information on stream flows is proceeding is too slow to meet the demands of the fast-growing coastal cities. The limited hydrological monitoring network which had been set up in Angola before 1975 was disrupted by the lack of staff and by conflict from 1975 onwards and it has only been since 2002 that this work has been effectively re-established (DNA, 2005).

The growth of coastal cities in areas which usually have low rainfall also implies that there will be constraints on water supply for these settlements. Urban coastal settlements in Angola are supplied through a water market, in which the poor pay for inadequate quantities of low quality water. The functioning of these water markets is not completely understood, as are the constraints on supply and how these could be overcome. Planning of water management infrastructure requires climate and hydrological information that is lacking, and on the other hand, water investments should be designed to perform under future climate regimes as well as present-day ones.

Limited information is available on population and land-use in coastal cities, the vulnerability of these coastal cities, and how they may be affected by climatic hazards. These have been identified as a priority area for developing adaptive capacity in Angola, as it is an actual problem which could become more serious with a changing climate.

It is expected that Angola’s water resources will be increasingly important in the southern African region, which, according to climate model projections, is likely to become drier. However, Angola has only recently begun efforts to address some of the serious and long-term issues related to adaptation to climate change.

The overall objective of the project was to provide research evidence that will assist policy-makers to address climate-related water stress and environmental
management challenges in Angola’s three coastal urban areas (Luanda, Benguela/Lobito, and Cabinda) to make water more accessible, available and affordable for vulnerable populations living in these areas.

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4. Share research findings to inform policy, service delivery and practice

This project has made a real contribution in terms of testing new and innovative data collection methods and providing improved meteorological and hydrologic information for modelling and planning. The assessment of the impacts on water supply and environmental risks in urban areas now provides a good entry point for practical adaptation planning in the short- to medium-term.

In the Angolan context, the project has been very important in bringing the various Angolan institutional actors together for the first time. The project has supported one of the first opportunities to bring concerns about climate change into the arena of public policy influencing and advocacy related to urban planning, and water access and affordability.

3 Achievement of project Milestones

1. First Semester Milestones
   1.1 Official commencement date
       The official project commencement date was set on November 1, 2012
   1.2 Received Initial payment
       The initial payment of $163,367.83 was received by DW on October 23, 2012, after the Memorandum of Grant Conditions was signed
   1.3 Established relations with partner institutions outside Angola
   1.4 Obtained data on satellite images, rainfall, vegetation, geology and hydrology
1.5 Established relationships with national and local government institutions
1.6 Held an Inception Workshop— the Inception Workshop was held on November 20, 2012 at the DW offices in Luanda
1.7 Refined research design and methodological approach
1.8 Established a system to scan the public, independent and community media
1.9 In Luanda: urban zones were defined and delimited; counted structures in each zone and mapped current area and urban growth
1.10 Submitted First Technical Progress Report
The First Technical Progress Report covering the first 6 months of research work was submitted on April 30, 2013. This is within the stipulated 6-month period after the Commencement Date.
1.11 Submitted First Financial Report
The First Financial Report, covering the first 6 months of research work was submitted on May 30, 2013. This is within the stipulated 7-month period after the Commencement Date
1.12 Receive Second Payment
Following the acceptance of the first technical progress report and satisfactory financial report, the second payment of US$ 96,889.84 was received from the IDRC on July 31, 2013

2. Second Semester Milestones
2.1 In Luanda: Conducted household surveys
2.2 In Luanda: Estimates were mapped of population, population densities and population trends, and socio-economic indicators
2.3 In Luanda: Diagnose done of water system, mapped and described key variables, assessed impact of climate change, and examined policy options
2.4 In Cabinda: Defined and delimited urban zones; counted structures in each zone and mapped current area and urban growth
2.5 Submitted Second Technical Progress Report
The Second Technical Progress Report covering the second semester of research work was submitted on October 31, 2013. This is within the stipulated 12-month period after the Commencement Date
2.6 Submitted Second Financial Report
The Second Financial Report, covering the second semester of research work, was submitted on November 30, 2013. This is within the stipulated 13-month period after the Commencement Date
2.7 Received Third Payment
Following the acceptance of the second technical progress report and satisfactory financial report, the third payment of US$ 65,829.98 was received from the IDRC on June 03, 2014

3. Third Semester Milestones
3.1 In Cabinda: Completed household surveys
3.2 In Cabinda: Mapped estimates of population, population densities and population trends, and socio-economic indicators
3.3 In Cabinda: Mapped areas at risk from flooding and erosion
3.4 In Cabinda: Diagnosed water system, mapped and described key variables, assessed impact of climate change, and examined policy options
3.5 In Benguela and Lobito: Defined and delimited urban zones
3.6 In Benguela and Lobito: Counted structures in each zone
3.7 In Benguela and Lobito: Mapped current area and urban growth
3.8 Submitted Third Technical Progress Report
   The Third Technical Progress Report covering the third semester of research work was submitted on April 30, 2014. This is within the stipulated 18-month period after the Commencement Date
3.9 Submitted Third Financial Report
   The Third Financial Report, covering the third semester of research work, was submitted on May 31, 2014. This is within the stipulated 19-month period after the Commencement Date
3.10 Received Fourth Payment
   Following the acceptance of the third technical progress report and satisfactory financial report, the fourth payment of US$ 71,339.34 was received from the IDRC on July 16, 2014

4. Fourth Semester Milestones
   4.1 Completed the Cabinda outputs
   4.2 In Benguela and Lobito: Completed household surveys
   4.3 In Benguela and Lobito: Mapped estimates of population, population densities and population trends, and socio-economic indicators
   4.4 In Benguela and Lobito: Mapped areas at risk from flooding and erosion
   4.5 In Benguela and Lobito: Completed diagnosis of water system, mapped and description of key variables, made assessment of impact of climate change, and examination of policy options
   4.6 In Benguela and Lobito: Collected written records and oral histories of notable climate events, flooding, erosion or drought events and create database events
   4.7 In Benguela and Lobito: Calculated and mapped annual, seasonal and monthly means and variability of rainfall, and assessed linkages between events and outside factors
   4.8 In Benguela and Lobito: Analyzed trends and variability in key river basin parameters and investigate implication of climate change on basin parameters
   4.9 Submitted Fourth Technical Progress Report
      The Fourth Technical Progress Report covering the fourth semester of research work was submitted on October 31, 2014. This is within the stipulated 24-month period after the Commencement Date
   4.10 Submitted Fourth Financial Report
      The Fourth Financial Report, covering the fourth semester of research work, was submitted on November 30, 2014. This is within
the stipulated 25-month period after the Commencement Date

4.11 Received Fifth Payment
Following the acceptance of the fourth technical progress report and satisfactory financial report, the fifth payment of US$ 28,601.92 was received from the IDRC on March 18 2015

5. Fifth Semester Milestones
5.1 Completed Benguela and Lobito outputs
5.2 Completed the reviews of policy developments in the areas of climate change, water and poverty-alleviation, and assessed public awareness in Luanda, Cabinda, Benguela and Lobito based on information from local media
5.3 Disseminated available information to local policy-makers and to influence public policy change; finalize outputs, data sets, presentations and poster format documentsPrepare monographs and papers
5.4 Submitted Fifth Technical Progress Report
The Fifth Technical Progress Report covering the fifth semester of research work was submitted on April 30, 2015. This is within the stipulated 30-month period after the Commencement Date
5.5 Submitted Fifth Financial Report
The Fifth Financial Report, covering the fifth semester of research work, was submitted on May 31, 2015. This is within the stipulated 31-month period after the Commencement Date
5.6 Received Sixth Payment
Following the acceptance of the fifth technical progress report and satisfactory financial report, the sixth payment of US$ 53,616.04 was received from the IDRC on November 18, 2015

6. End-of-Project Milestones
6.1 Completed the dissemination of information to local policy makers, presentations to municipal administrators; influence public policy change through national forums and climate working-groups
6.2 Completed finalization of outputs, data-sets, presentations and poster format documents
6.3 Completed preparation of monographs and papers
6.5 Submitted Final Financial report 30 April 2016
6.6 Receive final payment (pending)

4 Synthesis of Research Results and Development
The first phase of the project contributed towards helping to fill the forty-year post-independence meteorological information gaps in data on coastal areas in Angola. Historical archive data was obtained, digitalised, and made available to Angolan authorities and international researchers. The data were used to fill in
some of the unmapped space of the Southern African climatic prediction models. Information was also compiled by the research team using informal methodologies such as oral histories and media monitoring to help fill the information gaps caused by the closure of most meteorological reporting stations in 1974.

The project made an important contribution to raising the awareness of the need to adapt the planning of coastal urban settlements to the effects of climate change. Policy makers in the Ministry of Environment and Angolan environmentalists were made aware of the increasing impact of rising sea levels and increased frequency of adverse climatic events such as storms, floods and droughts on the Atlantic coast of Angola. In the past, this sector had focused their attention mainly on the impact of climate change on biologically-vulnerable areas such as mangrove swamps. The current project, for the first time, raised the awareness that these same factors had a serious effect on the human settlements in these same areas where 70% of Angola’s population live. The project successfully engaged other disciplines such as urban planners, demographers, water supply providers, civil-protection professionals and local municipal authorities, raised their awareness, and encouraged them to interact with the environmentalists, meteorologists, and hydrologists in the country. The project focused on making environmental information available in the form of maps that could be understood and used by urban practitioners and decision makers.

The project promoted the engagement of Angolan academic institutions on water and climate change issues in several ways. During the three years of project implementation, Development Workshop regularly employed, on average, four university student interns to work on media monitoring, mapping and field research. Students were encouraged to use information in their own studies and dissertations. Development Workshop developed research relationships with three universities in Angola with the aim of sharing data and disseminating findings of the research. The project created a close partnership with the government-funded Centre for Tropical Environment and Climate Adaptation (CETAC) in Huambo -- they subsequently took on the task of assisting in disseminating the findings of the project.

The impact of the project has been felt in a number of public policy areas even before it has officially ended. For instance, the problem of rubbish accumulation in the drainage channels has been mentioned occasionally in the project progress reports. A growing awareness of this problem has spun off a DW advocacy on rubbish policy. One activity promotes a social media campaign called Selfie-Lixo (or Selfie-Rubbish) where young people take Instagram
pictures of themselves and the rubbish piles in front of their homes, and then post the images on social media sites. This was designed to raise awareness of and to protest against the unsanitary condition – the Instagram pictures have gone \textit{viral} in Luanda (see http://viana.forum.angonet.org/campanha-selfie-lixo/). Part of the DW media campaign included two, 2-hour long radio interviews of the Project Leader on the National Radio and the Catholic Radio (see: http://www.dw.angonet.org/forumitem/allan-cain-intervista-sobre-plano-de-luanda-e-saneamento-radio-ecclesia), a television spot (see: http://www.dw.angonet.org/forumitem/allan-cain-sobre-ambiente-urbano-e-saneamento-em-luanda), and a feature article in the weekend journal (see: http://www.dw.angonet.org/sites/default/files/online_lib_files/allan_cain_-_grande_intervista_-_o_pais_-_18_setembro_2015.pdf). The interviews focused on the interrelationships and interactions between rubbish accumulation, climate risk, and flooding.

In March 2014 the Ministry of Water and Energy adopted the key water governance recommendation by adopting the Community Water Management Model (MoGeCA) that helped bring affordably-priced water to urban communities through a participatory enterprise model. DW worked with the Ministry to support the “Water for All” program that commits to achieve the Millennium Development Goals and bring water services to 80% of the country’s population, wherever they live, including in high-risk zones. Together with the Ministry, DW tested this model of water governance in Luanda and several other provinces. In March 2014 the Secretary of State for Water announced that the community water model (\textit{Modelo de Gestão Comunitária de Água} - MoGeCA) has been adopted as national policy and the training manual developed by the project team was distributed to municipalities across the country. The African Development Bank, together with the National Water Directorate, then engaged Development Workshop and its partner institution, the Canadian company CoWater International, to develop the post-2015, ten-year strategy for sustainable community water\textsuperscript{2} to be piloted in provinces across the country. (see: http://dw.angonet.org/forumitem/programa-nacional-de-abastecimento-de-gua-saneamento-e-higiene-rural)

The Project Outputs section cites that risk maps and physical planning information were co-produced and validated with the participation of local communities and municipal government administrations on-the-ground. The maps are essential tools now being used to plan adaptation strategies to reduce climate risks in vulnerable urban communities. On one hand, the municipal authorities who are responsible for delivering adequate and affordable services

\textsuperscript{2} Programa Nacional de Abastecimento de Água, Saneamento e Higiene Rural (2015) - http://dw.angonet.org/forumitem/programa-nacional-de-abastecimento-de-gua-saneamento-e-higiene-rural
to their constituencies now have access to regular and reliable information in usable and easily understandable forms, and on the other, the communities themselves are empowered with information that allows them to actively and intelligently participate in neighbourhood adaptation planning (particularly the planning of informal settlements). The plans that result from these exercises will prevent the construction of new homes in flood-prone basins, and will promote the greening and protection of drainage courses that slow rainwater run-off.

One incident clearly illustrates how the outputs of this project have promoted the importance of the concepts of climate change adaptation planning and positively influenced the uptake of risk assessments and risk mapping. From February to April, 2015 Benguela and Lobito and were hit by a series of devastating storms that resulted in heavy flooding. DW had used near-real-time satellite imagery to track the approaching storms and used these together with the results of the preliminary risk assessments for these cities to provide the Ministries of Environment and Territorial Administration with advice on projected storm and flood-risks. When the storms hit the Benguela and Lobito coastal areas, the subsequent flooding destroyed hundreds of homes in the areas that DW had mapped to be high-risk settlements. Access to water supplies and other basic services were also affected, and approximately 90 persons lost their lives. During the critical weeks of the most serious flooding, DW sent the research team to Lobito and Benguela to work with the municipal authorities in mapping the damage within the coastal settlements. These tragic events have highlighted the importance of risk assessments and municipal risk maps as essential components of coastal settlement adaptation strategies. The maps below are examples of risk maps that were produced for Lobito and Benguela by the end of April 2015.
Figure 1. Lobito sea level rise (April, 2015)

Figure 2. Sea-level rise affecting a coastal settlement in Lobito (April 2015)
Figure 3. Lobito houses affected by flooding (April, 2015)
Figure 4. Lobito houses on steep slopes (April, 2015)
Figure 5. Areas at risk of sea level rise in Benguela (April, 2015)
Figure 6. Benguela houses at risk of flooding (April, 2015)

The maps produced are important tools for the Civil Protection Departments of Municipalities and Provincial Governments who are responsible for disaster mitigation, early response and disaster management. The data and risk maps also provide essential information for municipal planners and administrators.

The Local Administration Training Institute (IFAL) of the Ministry for Territorial Administration (MAT) is responsible for training municipal administrators and building the technical capacities of local governments across the country. In April 2015, an agreement was between Development Workshop and IFAL for DW to mount training courses for local administrators provides an opportunity to disseminate project results, raise the awareness of local government functionaries about environmental risks, and train the technical staff of municipalities in participatory risk mapping and climate change adaptation planning. To sustain these efforts in the long term, DW plans to incorporate the project results into their standard training materials. This partnership provides another opportunity for the lessons and methodologies developed in this project to be scaled up to the national level and achieve a more significant impact.

One of the most important uses of the results of the research is to influence urban planning in Angola. In 2014, information in the form of mapped data was shared with the team preparing the Luanda Metropolitan Master Plan. The
planners subsequently made use of our research approaches and data for the preparation of the Luanda Metropolitan Plan for 2015 – 2030. Development Workshop proposes to use the project outputs on city-wide data and work with each local district to produce participatory municipal adaptation plans by engaging community forums and local government administrations.

Influenced by the activities of this study, the National Directorate of Environment of Angola’s Ministry of Environment is now involving more para-statal and non-state partners in the planning and implementation of environmental and climate-related projects. DW is being consulted on planning for adaptation and resilience in the Cuvelai Basin in the Angolan province of Cunene (http://dw.angonet.org/content/cuvelai-basin-its-water-and-its-people-angola-and-namibia). The National Institute of Water Resources expressed concerns that there are low levels of data sharing between institutions and stakeholders, and hoped that cooperation between the project and the institute will raise these levels, increase the participation of university students in water-related field research projects, and enhance research partnerships with the various universities in the country.

On April 15, 2016 the government of the province of Luanda adopted one of the project’s key policy recommendations on raising sustainable local government financing for rubbish management through local service charges, rather than depending on subsidies from the dwindling state central budget (http://www.dw.angonet.org/online_library). This will create an autonomous, local-level financing mechanism for sanitation (i.e., rubbish collection) by cross-financing on municipal service bills. This will be implemented by adding a charge on rubbish collection in the electricity bills of consumers. A more efficient rubbish collection service will help keep drainage channels open, thereby greatly reducing the risk of flooding.

This project has demonstrated that reduced vulnerability of the communities themselves can be promoted through micro-planning and co-participation with municipalities to develop climate adaptation plans and build resilience to climate change and natural disasters. The project approach can thus be used by other low-lying African coastal cities who disproportionately suffer environmental risks (e.g., rising sea levels, flooding, strong tropical storms) to adapt to climate change. Discussions have been initiated with UN-Habitat’s Resilient City Program to use the approach developed in the current project to share through a Lusophone network that they are establishing to share knowledge between Mozambique, Sao Tome and apo Verde which are all impacted by coastal climate change.
The exchange between other IDRC partners from three continents at the World Water Congress in Edinburgh in May 2015 was extremely useful, as was the African research partners’ workshop in Pretoria in September 2014. The sharing of research approaches and policy influencing strategies between institutions is extremely valuable. Development Workshop is keen to explore the possibility of scaling up the current research and policy development program on coastal urban settlements on a regional basis, involving at least one other country (ideally more than one) with the aim of sharing approaches and strengthening policy advocacy actions.

IDRC invited Development Workshop to present the results of the project at the Adaptation Canada Conference in Ottawa on the 13 April 2016 and to a select group of IDRC interested partners on the 12th April. Our project was honoured to be chosen to participate in this panel of four successful climate change projects that had archived a significant scale of impact. The exchange between partners in Africa and Asia was extremely useful, and noteworthy in that the projects from different geographical regions had all developed innovative participatory research methods using ICTs and social media tools.

5 Methodology

5.1 Social Research Methods
A variety of social research methods were used to collect data for this study, such as social and environmental risk vulnerability assessment, economic analysis, gender analysis, population density estimate correlations, and historical documented and oral discourse analysis.

5.1.1 Settlement Typologies
Development Workshop has developed a strong capacity in geographic information systems and remote sensing using satellite imagery. Together with an extensive network through civil society partners to carry out qualitative research and rapid appraisals, an innovative approach to participatory mapping and settlement typology modelling has been developed that helped the project in building geographic/demographic models of the four coastal urban settlements of focus.

Housing and neighbourhood types were identified based on properties such as dates of construction and other social attributes (see Table 1). Satellite images, coupled with information from on-site observations and interviews with key informants were used to further define the geographic limits of each housing type. Figure 7 below shows the geographical location of the different settlement types in Benguela. It can be noted, for instance, that the communities made up
of self-constructed homes are clustered to the north-east of the city, much more distant from the city centre and the main transportation corridors compared to the other settlement types.

Table 1. Settlement Typologies Characterizations

<table>
<thead>
<tr>
<th>Settlement Typology</th>
<th>Age</th>
<th>Settled by</th>
<th>Layout</th>
<th>Location</th>
<th>Service Level</th>
<th>Structures/houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Peri-Urban Musseque (slum)</td>
<td>Built less than 15 years ago, after the end of the war in 2002</td>
<td>Mainly initiated by families with low incomes</td>
<td>Unplanned, irregular street pattern</td>
<td>Peri-urban</td>
<td>Water access through cistern trucks and private tanks; no formal electricity (private generators or PTs are used); no formal sewage system (high use of septic tanks)</td>
<td>Precarious construction standards, poor house quality</td>
</tr>
<tr>
<td>2 Old Musseque (slum)</td>
<td>Older than 40 years, constructed before independence</td>
<td>Self (residents / individuals/low-income families)</td>
<td>Informal settlement patterns</td>
<td>Adjacent to industrial district and commercial centre</td>
<td>Water access mainly through public standpoints and private tanks; area partially electrified; lack of integrated infrastructure - high use of dry-latrine latrines Sewers but no rubbish collection. Water supply from standposts.</td>
<td>Ad hoc building structures, precarious houses</td>
</tr>
<tr>
<td>3 Organised Musseque</td>
<td>Older than 40 years, constructed before independence</td>
<td>Self (residents / individuals/low-income families) on a layout created before Independence</td>
<td>Aligned street pattern</td>
<td>Intermediate distance from city centre</td>
<td>Water access mainly through public standpoints and private tanks; area partially electrified; lack of integrated infrastructure - high use of dry-latrine latrines Sewers but no rubbish collection. Water supply from standposts.</td>
<td>Ad hoc building structures, precarious houses</td>
</tr>
<tr>
<td>4 Initially settled before independence</td>
<td>Self (residents / individuals)</td>
<td>Initially informal, gradually being upgraded</td>
<td>Very close to urban area, land considered very valuable</td>
<td>Formal though out-dated system for water, electricity, sewage (flush toilets)</td>
<td>Formal though out-dated system for water, electricity, sewage (flush toilets)</td>
<td>Formal though out-dated system for water, electricity, sewage (flush toilets)</td>
</tr>
<tr>
<td>5 Owner built in planned sites</td>
<td>Built less than 12 years ago, after the end of the war in 2002</td>
<td>Government or designated private agency. Often within Government designated Land Reserves</td>
<td>Formally planned settlement structure</td>
<td>Distant from city centre</td>
<td>Water mainly from neighbours' tanks, supplied by lorry. Some sewerage but also latrines and open-air defecation. No rubbish collection.</td>
<td>houses over time</td>
</tr>
<tr>
<td>6 Social Housing Zones</td>
<td>Built less than 15 years ago, after the end of the war in 2002</td>
<td>Government. Often within Government designated Land Reserves (Reservas Fundiarias)</td>
<td>Aligned street pattern</td>
<td>Long distance and poor public transport to city centre, unsuitable soil conditions</td>
<td>Formal provision of water; electricity with sewage infrastructure (flush toilets)</td>
<td>Mostly block buildings with roofs made of corrugated iron (chapas)</td>
</tr>
<tr>
<td>7 Older than 40 years, constructed before independence</td>
<td>Originally built by government</td>
<td>Aligned street pattern</td>
<td>Intermediate distance from city centre</td>
<td>Piped water (to house or to neighbours' tanks). Sewerage available. Rubbish collection provided.</td>
<td>Mostly block buildings with roofs made of tiles or (less often) corrugated iron. Modern, high-quality construction.</td>
<td></td>
</tr>
<tr>
<td>8 New suburbs - condominiums</td>
<td>Mostly built less than 15 years ago, after the end of the war in 2002</td>
<td>Government and large, private companies. Often within Government designated Land Reserves</td>
<td>Defined street pattern, though not necessarily a grid</td>
<td>Distant from city centre</td>
<td>Formal provision of water; electricity with sewage infrastructure (flush toilets)</td>
<td>Mostly block buildings with roofs made of corrugated iron. Modern, high-quality construction.</td>
</tr>
</tbody>
</table>
Old urban centre

- Older than 40 years, constructed before independence
- Private sector
- Defined street pattern, though not necessarily a grid
- Central, with access to most formal employment

Rural settlements

- Traditional land holders
- Scattered low density
- Very peripheral
- None

Industrial zone

- Private sector
- No housing

New Peripheral Settlements

- Very new, currently being occupied
- Mainly initiated by families with low incomes, some speculative land occupation
- Scattered low density
- Very peripheral
- None
- Provisional structures tin sheets, occupied while house (usually of blocks) being built

Figure 7. Physical location of the different settlement types, Benguela

5.1.2 Estimates of Housing and Population Densities
Recent satellite imagery will be used to do detailed household mapping of the settlements to be studies. In Angola no accurate maps have been published in recent years and GIS has proven to be the most cost effective tool in urban research and planning. DW has developed a technique of "participatory mapping" involving desk-top remote sensing with on-the ground data collection in order to build settlement typology profiles. Physical counts of rooftops from satellite images were used to arrive at estimates of the number of structures within the boundaries of each housing type -- the rooftop counts served as a
proxy for the number of dwelling units in each area, and were used to estimate the housing densities in each housing type.

DW Angola applied the classic “inverse problem” approach that is familiar to remote sensing, namely, 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. Technicians inspected high-resolution satellite images of these cities and, using a system of digital markers, mapped every rooftop. In Luanda alone over 1,300,000 buildings were electronically tagged. Since the data from the eye-in-the-sky is one-dimensional, however, the researchers also employed a team of on-the-ground local informants to supply additional details. DW Angola’s innovative blending of GIS technologies with participatory diagnostic methods is believed to be unique to this project 3.

The rooftop counts were also used as inputs to define the sampling parameters of the household surveys. Data from these surveys provided estimates of the number of people per household, and hence, estimates of population and population densities. These estimates had previously been made in Luanda but were carried out for the first time in Cabinda, Benguela and Lobito. This methodology has proved useful in studying the changing demography of cities. To validate the above methodology, the resulting population estimates were compared with those obtained from the preliminary results of the 2014 National Census conducted by the Angolan Statistics Institute 4. It was found that the data from both sources closely agree, suggesting that the method of estimating population developed by Development Workshop is sound, and that this methodology could be used to obtain population estimates in areas of rapid growth, estimates between censuses, or where it has not been possible to carry out a census for some time such as in Luanda where the evolution of population densities has been tracked between 2008 and 2015.

![Image]

Figure 8. Luanda’s population growth rate between 1960 and 2015

5.1.3 Baseline Household Surveys
Household surveys were conducted to obtain the required socio-economic data for each research area. The physical boundaries of each housing type were used as part of the criteria in defining the sampling framework. An interview schedule for the baseline household survey was constructed and pre-tested,
and the survey enumerators were trained on the use of this research instrument (a copy of the interview schedule is attached as Annex 3).

The numbers of respondents interviewed from each research area are as follows: Luanda - 2,000; Cabinda - 1,000; and Benguela/Lobito - 1,500. Enumerators were trained in the use of Android-based GSMA and GPS enabled tablets that allowed them to rapidly carry out automatically georeferenced household surveys that are loaded through the cell-phone network, avoiding data transfer time and errors. By way of observations, interviews, focus groups, and household surveys, these informants described the buildings and neighbourhoods in terms of such factors as their environmental vulnerabilities, socio-economic conditions, housing quality, access to water services and costs.

The interview schedules were pre-loaded into the tablets and a small programming routine was built in so that the survey enumerators could quickly skip from one section of the instrument to another. This feature was found to be useful and convenient, and greatly simplified the task of data gathering in the field. The tablets significantly reduced the use of paper and considerably speeded up the process of transferring the survey data to a database; it also significantly reduced the amount of time that researchers spent on checking the quality of data from the field. On the other hand, it was observed that the availability and quality of internet connectivity in the field can pose problems in downloading the data from the tablets to the servers for the household survey database.

A consultant was hired to train the core research team in designing the electronic data collection instruments using the Open Data Kit (ODK) application for Android smart phones and tablets. The Development Workshop research staff now has the capability to carry out this task on their own, and to train others as well.
The following statistical packages were used to analyse the data: XLStat, SPSS and Stata.

5.1.4 Surveys on Water and Associated Social Services
As a preliminary component of the household surveys a scoping diagnostic was done in the four cities data was obtained on social indicators, land values, and water access, use and prices. Preliminary field visits to Cabinda and Benguela/Lobito were done in February and March 2013 to collect information on primary water systems, and meetings were held in preparation for the in-depth interviews with key informants. Full household surveys were conducted in all four cities in the later half of 2013 and early 2014.

5.2 Analysis of Rainfall Data
5.2.1 Data Sources
Since no single source could provide reliable climatic data, a variety of sources were used in this study to enable the researchers to cross-check, validate and/or obtain more accurate estimates of the climate parameters.

5.2.1.1 Historical Rainfall Data
Historical rainfall data from 50 stations in Angola was obtained and put into an MS-Access database. Scans of published records were used to create digital records for stations in the north of Angola. Scans of the published records were also obtained from the US National Oceanic and Atmospheric Administration (NOAA) website and from the UK Meteorological Office to check and correct the data in the existing database, and to fill in data gaps. Although the pre-1940 data for stations outside Luanda have significant gaps, this database probably contains the most comprehensive monthly, seasonal and annual rainfall records of Angola.

The 50 stations throughout Angola were selected with a bias towards those stations in the coastal areas of Angola (the focus of the project), and because stations in areas closer to the coast tend to have longer and more complete records. Stations were also chosen based on coverage of various areas of the country and inclusion in previous analyses, as this allows for comparison and cross-validation of data.

The project also collected data from paper records from about 100 stations with the best records and with the fewest gaps. In addition, monthly rainfall data were obtained from places near the border of neighbouring countries (i.e., Namibia, Zambia and southern parts of the Democratic Republic of Congo) and used to produce maps to carry out a first-stage analysis.
5.2.1.2 Satellite-based Measures of Cloud Cover and Precipitation
Satellite-based estimates of decadal, monthly and annual rainfall per 8x8 kilometre cell for the whole country was obtained, covering the years 1996 - 2012. This was used to create a database of monthly, seasonal and annual rainfall totals for the same 50 locations that have been chosen for historic rainfall data cited above. The preliminary analysis of the data from satellite-based estimates of rainfall greatly over-estimated rainfall in the coastal areas of Angola. This is probably because this method infers rainfall measures from cloud cover and cloud temperatures. On the other hand, the coast of Angola has almost continuous cloud cover throughout the year but very low rainfall.

It was found that for Angola, satellite-based rainfall data have never been validated against ground-based observations, and this is probably because station data for Angola have not been generally available for the recent years for which satellite-based measures are available. Work was carried out with the TAMSAT project (Tropical Applications of Meteorology using SATellite data, Reading University) to assist them in re-calibrating satellite-based estimates of rainfall in Angola. Satellite-based estimates were not used to analyse mean rainfall and rainfall variability because of this unreliability. It was also noted that the methodology of satellite-based rainfall estimates has primarily been developed for areas of Africa where rainfall is linked to the passage of the Inter-Tropical Convergence Zone (ITCZ), but the ITCZ does not pass over the coastal areas of Angola. However the examination of the data with the TAMSAT group suggested that the direction of anomalies from the mean rainfall is correct for given time periods, so satellite-based estimates were used in studying the influence of years of low/high Sea Surface Temperatures (SST), and ENSO, on rainfall variability in Angola.

5.2.1.3 Notable Climatic Events
Data on notable water and other climate-related events were extracted from paper documents (newspapers, emergency bulletins, food security bulletins) covering the period from the mid-1980s to recent years. These documents, held in the Development Workshop archives, as well as scanned information from more recent issues of local newspapers, contain qualitative information about droughts and floods in Angola, and were used to pinpoint significant climatic events such as droughts and heavy storms. Although the newspapers and bulletins often do not provide exact meteorological information about these events they provided valuable impact information such as populations or households affected, damage that occurred. The national coverage from journalists is much more extensive and inclusive that the coverage of meteorological stations.
A database of notable water and other climate related activities was created and geo-referenced to contain the type of event (flooding, drought, river or flood erosion, sea erosion from high seas), the date, the location and the source of information. The data can be queried for specific historic information on the events that occurred in specific locations and mapped for spatial analysis purposed.

Figure 10. Map of climatic events recorded from the media 2011 & 2015

5.2.1.4 Oral Histories from Key Informants
For Cabinda and Benguela-Lobito, areas of environmental risk were identified (within the cities, the surrounding areas, and along the rivers that affect those cities) and key informants were then interviewed about the nature of those risks.

Interviews with local residents who witnessed the flooding in Cacuaco (Luanda) in January 2007 were used to reconstruct events leading up to and after the heavy rainstorms that washed away houses and changed the course of a river and the coast. Images from Google Earth before and after the flooding, media reports, photos and videos of
events were also examined to cross-check the information that the key informants provided.

The case studies showed that local people have clearer information than is contained in the press or official reports, and that key informants can assist in the analysis of the factors contributing to environmental risks.

5.2.1.5 Data on Vegetation, Geology and Flows of Relevant River Basins

During field trips to Cabinda and Benguela-Lobito in February and March 2013, observations were made of the vegetation and soils of relevant river basins. Maps of soil and vegetation for all the research areas were also used as references. The National Institute of Water Resources has made available their database that contains good quality digitalised records of river flows from the 1960–1975 period.

5.2.2 Important Parameters

Taking into account the large number of gaps in the historical rainfall records, the data were summarized to obtain monthly, seasonal and annual patterns. The following statistics were calculated: a) Mean, b) Median, c) Difference between mean and median as a percentage of the median, d) 25th percentiles, e) 75th percentiles, f) Coefficient of Variation, g) Anomalies from Conrad’s Normal Relative Variability, and h) Seasonal rainfall as a percentage of annual rainfall. These same statistics were calculated from the satellite-based data.

Particular attention was placed on the indicators of rainfall variability because little work has been done on the variability of rainfall in Angola since the work of Queiroz in 1955, and because it is the variability of rainfall that is an important factor linked to flooding and drought. The Coefficient of Variation (CV) was used as the main indicator of the variability of rainfall.

Rainfall variability was also measured using the anomalies from Conrad’s Normal Relative Variability (Conrad, 1941). This method identifies areas that have rainfall variability higher than expected, for places with that mean rainfall. Conrad’s original work shows the coastal areas of Angola as having rainfall variability that is higher than expected.

The two indices of variability show similar results in terms of detecting general patterns of variability. However, it was observed that the Coefficient of Variation showed very high values in the extremely low rainfall areas in the south-western extremity of Angola, which is a desert area. Anomalies from Conrad’s Normal Relative Variability do not have such high values in extremely arid areas and the values decline less rapidly inland, drawing attention to areas such as those...
along the Kwanza River and some southern inland areas of Angola where rainfall is quite high but there are also notable year-to-year variations.

5.2.3 Correlations of Annual Variations and Notable Events with ENSO and Fluctuations in the Benguela Current
An analysis was conducted on the rainfall patterns from satellite-based data for recent years and information from the local newspapers, emergency bulletins, and food security bulletins to confirm if most areas of Angola are indeed unlikely to be affected by ENSO, as suggested by existing literature. The literature review has indicated that it is possible that the south-east of Angola (which is distant from the coastal areas) may have come into the area affected by ENSO.

An analysis was conducted on the historic rainfall records for coastal areas of Angola to confirm if the pattern of high SST and high rainfall years for coastal areas of Angola coincides with those of Namibia.

While the project attempted to build an ongoing partnership with the Climate Systems Analysis Group, University of Cape Town, the financing necessary for sustaining an on-going linkage with the CSAG was not available. The project team had hoped that a relationship with CSAG could be based on the provision of data from the research in Angola. The lack of a strong institution in Angola capable of carrying out an analysis of data and the affects of ENSO requires a strengthening of regional linkages to institutions with these capacities. The project was not able to insure that these needed long-term relationships were established.

5.2.4 Temperature
Although it is clear that temperature is directly related to cloud cover and rainfall, the initial research design of this project did not focus much on temperature because the debate is still ongoing as to whether and how temperatures are changing in Africa. Data on average temperatures for the whole of Angola was obtained from the World Bank climate change portal (see Figure 1111 below) but it is not clear how these average temperatures were arrived at, considering that many meteorological stations in the country have not been functional for more than 30 years. It can only be speculated that the values may have been extrapolated from data from the few stations that were functional over the respective years. Where possible, information on temperatures was collected from functioning meteorological stations in areas relevant to the study and comparisons were made with average historic information from the same stations.
Figure 11. Average temperatures for Angola

The latest IPCC report shows that annual average temperatures in the region of Africa in which Angola is located have increased by about 1°C over the last 100 years (IPCC, 2014) and this seems to be consistent with the trend in the above figure.

The project has obtained temperature data from Cabinda and the initial analysis shows that for most months, the maximum temperature recorded in each month and the monthly average of daily maximum temperatures has increased between 1943-52 and 1984-97. For most months, there has been at least a 1.0 degree Celsius increase in these measures. The monthly average of daily minimum temperatures and the lowest recorded temperature per month have increased slightly, but these increases are not statistically significant. Maximum temperatures have therefore increased while the increase in minimum temperatures is less clear.

5.2.5 Risk Maps
Risk maps and physical planning information were co-produced and validated with the participation of local communities and municipal government administrations on-the-ground. The risk maps are available for downloading on the project website at http://www.dw.angonet.org/content/climate-change.
5.2.6 Media Scans and Information Mapping
Information on environmental issues were extracted from the local media (i.e., the public, independent and community media) and archived. Data on records of sea surges, which identify the areas that are vulnerable to the effects of high tides and high waves (and when) were used to map risks from higher sea levels while information on incidents of flooding and erosion in urban areas were extracted and used as inputs into environmental risk maps. The maps that display data on important variables were then overlaid to gain more insights into the relationships and interactions between key variables such as measures of environmental risk (inundation, slope, etc.), socio-economic vulnerability (settlement typology and poverty levels), and population density.

5.3 Institutional Relationships
An important component of the project approach is to establish strong working relationships with relevant institutions at the local, national and international levels.

5.3.1 South-South Exchanges and Visiting Scholar Programme
Linkages were established with the Climate Systems Analysis Group (CSAG) at the University of Cape Town, the project made it possible for a staff member from a partner institution, CETAC (Centre for Tropical Ecology and Climate Change in Huambo Angola) to attend the July 2014 course.

CSAG are interested in daily meteorological data for any station in Angola for a recent 10 year continuous period as an input into their climate models and Development Workshop has provided data from INAMET (the Angolan meteorological service) and from the Chianga Agricultural Station near Huambo (Huambo Province, central highlands of Angola).

5.3.2 Relationships with Relevant Government and Angolan Civil Society Institutions
Good working relationship were developed with the Ministry of the Environment (Ministério do Ambiente), and in particular with the National Environment Directorate (Direcção Nacional do Ambiente) and the Climate Change Adaptation Department in that Directorate. DW had shared the findings and results of this project with the Ministry on a regular basis, and had participated in all of the Ministry’s workshops and training events. Inputs from DW are being used in setting up an early warning system for the drought/flood situation in South-West Angola.

Similar relationships were also developed with the National Water and Sanitation Department of the Ministry of Energy and Water (Direcção Nacional
de Abastecimento de Água e Saneamento), which is responsible for domestic and industrial water supply throughout the country, as well as with the National Institute of Water Resources (Instituto Nacional de Recursos Hídricos), which is responsible for river basins, and their management and use. The Ministry of Energy and Water has appointed DW as the lead institution in the implementation of the MoGeCA (Modelo de Gestão Comunitária da Água or Community Water Management Model); the manual jointly produced by Development Workshop and the Direcção Nacional de Abastecimento de Água e Saneamento is available at:  
http://dw.angonet.org/sites/default/files/online_lib_files/AGUA-MoGeCa_0.pdf

DW has also provided assistance in the implementation of SISAS (Sistema de Informação Sectorial de Água e Saneamento or Sector Information System for Water and Sanitation). This included collaboration with the Canadian software development firm Hatfield Consultants in developing the open-source national data platform as well as implementing the base-line data collection in the provinces of Cabinda, Luanda and Huambo.

In Cabinda, linkages have been established with the Provincial Directorates for Water (Direção Provincial das Águas), the Territorial Administration, Urbanism and Environment (Direção Provincial de Ordenamento do Território, Urbanismo e Ambiente), the Provincial Office of the Meteorological Institute (Gabinete provincial do INAMET), and the Provincial Division of the Civil Protection (Comando Provincial da Proteção Civil) as well as with various civil society organizations that deal with issues of interest to the project.

In Benguela, contacts have been established with similar institutions and conversations with the Rapid Response Team of the Civil Protection Department have focused on data sharing on disaster preparedness and response, as well as other related issues.

Strong working relationships have been established with CETAC (Centro de Ecologia Tropical e Alterações Climáticas or Centre for Tropical Ecology and Climate Change) based in the central highland province of Huambo. This institution is responsible for research on climate change (analysis of climate and meteorological data) and the preservation of natural resources and ecosystems. Its focus is on geographic areas or regions experiencing climate-related or environmental disasters. CETAC has provided funding to enable a member of the Development Workshop climate change research team to attend the 2015 Climate Systems Analysis Group winter training course in Cape Town, South Africa.
5.3.3 Capacity-building for Research Students
Linkages have been established with the Research Centre of the Catholic University, the Faculty of Science at the Augustinho Neto University, as well as with the Faculty of Architecture and Environmental Studies at the Methodist University.

Each year, four (4) university students were recruited as interns in the research team. They participated in various project activities such as rooftop counting for population estimates, media monitoring, mapping of water and drainage channels, and field research (e.g., interviewing respondents in the relevant research areas).

6 Project Results & Research Findings

In compliance with the requirements of the IDRC Open Access Policy, all project outputs have been posted in the DW website (i.e., the Climate Change Project page --- see http://www.dw.angonet.org/content/climate-change). This site is accessible to the general public, and materials can be downloaded for free. All other project outputs that will subsequently be completed shall likewise be posted in the same location. A list of the project outputs is in Annex 2.

6.1 Rainfall Variability and River Basins
The objectives of this component of the project were:
a) Collect and digitise historic monthly rainfall data (there appears to be no database of historic rainfall data for Angola)
b) Collect and create a database of recent extreme rainfall events such as droughts and heavy storms (such information might fill the gaps for the post-1975 period for which there are limited data)
c) Write up case studies of recent high rainfall events (such information might help fill the gaps for the post-1975 period for which there are limited data)
d) Collect historic data on maximum rainfall values in 24 hours (to be used as a proxy for rainfall intensity)
e) Calculate and map mean values
f) Calculate and map rainfall variability (there has been little work on rainfall variability in Angola, and because of its importance in understanding the important issues of droughts and floods)
g) Identify links between ENSO, sea surface temperatures (SST), etc. (it has been hypothesised that there are links between ENSO and SST, but little detailed analysis)
h) Identify trends
i) Examine the potential of using satellite-based estimates of rainfall (such information might fill the gaps for the post-1975 period for which there are limited data)
The main outputs are as follows:

1. Historical rainfall data from 200 stations in Angola and neighbouring border regions was obtained and put into an MS-Access database and Excel spreadsheets. The database is now available as a tool that can be used by the National Meteorological Institute (INAMET), other partner organisations and researchers, as it contains a unique record of monthly rainfall data in Angola that can provide monthly, seasonal and annual rainfall parameters. Although the pre-1940 data for stations outside Luanda have significant gaps, this database probably contains the most comprehensive rainfall records of Angola. The median annual rainfall for Angola is shown below in Figure 12. It demonstrates clearly that precipitation is highest in the north-east interior of the country and declines in the coastal belt and in the southern provinces.
2 The analysis of mean annual rainfall data from the project database shows no difference from the standard analyses of rainfall in Angola. The results of the analysis of the project data is consistent with the general observation that rainfall increases from the coast towards the interior, and also increases from north to south.

3 As mentioned in the section on the project methodology, the Coefficient of Variation (CV) was used as the main indicator of the variability of rainfall. The only previous work on the variability of rainfall in Angola was done by Queiroz in the 1950s, who calculated the CV of data from a very limited number of stations and for a limited number of years. The calculations using the data from the project show that the variability of rainfall from one year to
the next is moderate in the interior of the country but high in the coastal areas. The CV is very high in the southern coastal regions, suggesting very high variability in rainfall patterns, and decreases northwards along the coast. These results do not differ greatly from those obtained by Queiroz.

4 As mentioned in the section on the project methodology, Conrad’s method (Conrad, 1941) was replicated using the data in the project database, and the results show that the coastal regions of Angola (and coastal regions in countries to the north) and all the south of Angola have a rainfall variability higher than expected, for places with their mean rainfall. This is similar to the results obtained by Conrad, although Conrad’s map does not show the south of Angola as an area of higher than expected rainfall variability. Figure 13 below shows the coefficient of variation of annual rainfall in different geographic locations in Angola.

5 Most existing maps of mean rainfall and variability interpolate their results from data from a limited number of stations, and use summarized or generalized data for a large area. This suggests that such maps are not able to show local variations in rainfall patterns. For instance, although most maps show a linear trend of rainfall increasing inland, an analysis of data obtained by the project show that inland from Lobito and Benguela, rainfall increases to Ganda (annual mean = 1503 mm, 12.95 South, 14.62 East) then is lower further inland such as at Caála (annual mean = 1235 mm, 12.85 South, 15.55 East). Rainfall increases markedly going inland from the coast, though there may be similar local variations that are undetected due to lack of station data.
Inland from Lobito and Benguela, the amount of rainfall increases and variability decreases, although variability decreases more slowly than increases in the average amount of rainfall. Thus there are places inland with both high variability of rainfall and high mean annual rainfall. For example, Cubal (13.00 South, 14.33 East) has annual mean rainfalls of 1259mm with a Coefficient of Variation = 0.44. Rainfall variability then
declines rapidly inland from Cubal. There are inland areas west of Cubal with high rainfall and variability, where there are some years with very high, and probably intense rainfall.

7 Rainfall Intensity -- in the coastal areas of Angola, rainstorms are infrequent but intense, and heavy rain does not occur in all years. Complete historic data are not available on rainfall intensity (total amount of rainfall divided by the number of rainy days) but historic data from 1940 – 1975 are available to show the highest 24-hour rainfall in each year at each station. Data from a limited number of stations were analysed, and it was found that the coastal areas of Angola do experience occurrences of daily rainfall of more than 100 mm. On the other hand, despite their higher mean rainfall, it was observed that the inland areas rarely experienced occurrences of daily rainfalls of more than 100 mm. The only inland areas with occurrences of daily rainfall of more than 100 mm are the very high rainfall areas of the extreme north and east of Angola.

8 The data show that rainfall of more than 200 mm in a 24-hour period can occur in coastal cities of Angola, and this needs to be taken into account in urban drainage planning.

9 The station with the most frequent occurrence of years with a daily rainfall over 100 mm is Catengue (50 km south-east of the city of Benguela). While intense rainfall can occur on the coast itself, areas further inland (where the cooling effect of the ocean is less and where there are steep escarpments) have more frequent intense rains.

10 Inland from Benguela, places such as Catengue have sparse vegetation because of the low mean rainfall. There has been further removal of vegetation cover due to charcoal making (due to the proximity of the cities where demand is high, and lack of alternative fuels especially during the war years) and the decline of sisal cultivation and its subsequent replacement with cattle rearing. These are the areas of the headwaters of rivers that flow into the sea near the cities of Benguela, Lobito and Dombe Grande and there are a number of steep slopes associated with the escarpments. These factors combine to create a high flood risk in these cities.

11 There have never been many rainfall stations in the areas a few kilometres from the coast (25 km to 100 km). Historically, there were stations at the coast but rarely in the immediate hinterland, and it is probable that these areas are where the most intense storms occur.
It is interesting to note that there are places a few kilometres inland where rainfall is significantly higher than along the coast but where variability is also high. This suggests that occasional very heavy rainfall a short distance inland may be linked to episodes of flooding in the coastal river basins. For instance, the flood in the city of Namibe in March – April 2001 was due to storms inland, but no intense rain was recorded in the city itself (there are no stations in the immediate hinterland). Where the availability of station data was limited, satellite data was used to augment the rainfall analysis and in this particular case, the satellite data appear to support the above hypothesis – the satellite data for the period March – April 2001 show that there was heavy rainfall inland from the city of Namibe but at the same time, it shows no rainfall at the coast.

12 The rainiest months on the coast of Angola are February to March. In the interior the rainy season is October to April though it is shorter in the south than in the north.

13 In the north of Angola there are some areas with two peaks of rainfall (November and March) with a comparatively dry period between. This has no practical effect in the extreme north of the country (because rainfall continues to be significant between the peak months) there are areas in Kwanza Norte and Malange provinces where there can be a noticeable dry-spell at some point between December and February. In some years the phenomenon of a dry-spell in the middle of the rainy season also occurs further south (e.g., in inland Kwanza Sul and Huambo provinces), with important implications for agriculture (especially in maize cultivation where the mid-season dry-spell reduces yield significantly). There are practical reasons to try to understand which years are more likely to have this mid-season dry-spell in the centre-north inland: one hypothesis is that it occurs when the Inter-Tropical Convergence Zone reaches further south in mid-summer, and in some years it has occurred in dry years in coastal areas.

14 ENSO (El Niño – La Niña) is the main factor responsible for the variability of rainfall in the south-eastern parts of Southern Africa, leading to drought years and years of flooding depending on the phase of ENSO. Although Angola is geographically a part of Southern Africa, ENSO only has direct implications for the extreme south-east of Angola (for which rainfall data are scarce). However if one of the effects of climate change is that ENSO becomes stronger, the areas of Angola affected by ENSO may expand and larger areas of southern and eastern Angola may be affected by drought in some years and high rainfall in other years.
15 There is evidence that years with low Sea Surface Temperatures (SST) in the Atlantic Ocean near Angola are years of low rainfall and drought in coastal Angola. Years of low SST in the Atlantic Ocean near Angola were shown to be: a) years of reported drought in the database of reports of extreme rainfall events, b) years of low rainfall in the database of historic monthly rainfall in the 1940s – 1970s, and c) years of negative rainfall anomalies (years of no unusually high or intense rainfall) in satellite-based rainfall estimates for more recent years.

16 Conversely, years with high SST in the Atlantic Ocean near Angola are years of higher than average rainfall and years in which intense rainstorms occur in coastal Angola. It must be noted though, that intense rainstorms can also occur in years of average SST. Thus, early warning of fluxes of warm water from the north towards the coast of Angola may give some indication of the risk of intense storms in coastal areas of Angola, but it should be noted that intense storms can occur in other years as well.

17 More research is required about the geographical distribution of SST variations along the coast of Angola. There are data from the Nansen ship cruises that suggest that there are important spatial and temporal variations in this parameter, and that changes in temperature do not occur evenly along the coast.

18 The analysis of historic rainfall data showed that: a) there is a clear pattern of high rainfall and low rainfall years for coastal areas of Angola but that this pattern does not apply to the inland areas of the country, b) the same years are not necessarily the high rainfall years on all parts of the coast of Angola, and c) high rainfall years in coastal Angola do not necessarily coincide with high rainfall years further south in Namibia. This is different from the effect of ENSO on the coast of Eastern Africa, where the same variability occurs on all parts of the coast. Further research is required about the local rainfall variability.

19 Further research is required about what triggers intense storms at particular locations. The flux of rain-bearing winds in this region is from the Indian Ocean in the east. Rainfall occurs when rain-bearing winds cross into the Atlantic and then turn back on the coast of Angola, and then convection occurs (rising air and clouds may lead to the formation of thunderstorms). Higher SST is one of the triggers in this sequence of events, and the presence of escarpment slopes is possibly another factor. However more research is required to characterize the other factors that lead to this sequence.
20 So far it has not been possible to detect trends in rainfall in the coast areas of Angola. Detecting trends is difficult when rainfall variability is high and when there is limited data. Satellite-based estimates have proved to be unreliable to make up for the lack of post-1975 rainfall data, hence the full use of satellite-based rainfall estimates has not been possible. It has proven difficult to correlate satellite estimates with metrological data collected on the ground by INAMET stations.

However written reports and satellite-based estimates do suggest that droughts and floods continue to be very common in this region. It is generally accepted that climate change will lead to higher rainfall variability. SST data for this region of the Atlantic Ocean show a warming trend and this is probably one of the factors in the occurrence of intense rainfall events. Urban planning therefore needs to take into account the possible occurrence of rainstorms of 100 mm or more in cities or in the drainage basins that flow into them (particularly in the case of coastal cities in Benguela province).

21 A paper has been completed on the variability of the average annual, seasonal and monthly rainfall data for Angola. This monograph “Analysis of Historic Precipitation Data for Angola” uses both historic and recent station data, and has been made available to Angolan partner institutions in Portuguese.

6.2 Population, Social Indicators and Environmental Vulnerability

The objectives of this component of the project were:

a) Conduct a demographic analysis of the four urban coastal settlements and describe the changes in the geography of coastal cities

b) Conduct a socio-economic analysis of the three urban coastal areas of Angola, and describe and map socio-economic patterns and indicators

c) Conduct an environmental vulnerability analysis in urban coastal areas of Angola, and describe and map areas of environmental risk and their impacts

The main findings are as follows:

1 The population of the urban coastal cities increased rapidly during the years of civil conflict (1975 to 2002), the annual rate of increase being approximately 7% in Luanda and 4% in other cities. There was a significant

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5 Monograph - Análise dos Dados históricos da precipitação para Angola- CETAC 16 Junho 2014
migration of people from rural areas to the cities, and from other cities to
Luanda.

Today, approximately 70% of Angola’s population of 25.8 million (or an
estimated 17.5 million people) live in the vulnerable coastal regions
(National Statistics Institute, 2016).

2 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
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 persons per household were about eight (8). As families found
land in areas further from the city centre, they moved out to these new
areas (peripheral 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.

Since 2002, the rate of increase of the population of the coastal cities has
decreased from the 7 to 8% annual growth during the war years, as
apparently the rate of migration into the cities has decreased. However the
overall population of the cities still continues to grow annually at 4 – 6% due
to migration -- this is well above the natural annual growth rate of about 3%.

3 Figure 14 below shows that the population growth rate for Luanda steadily
grew from about 5% in 1950 to almost 8% in 1985, and then sharply
declined to about 4.75% in the year 2000 when conflict was intense and
many roads became inaccessible. With the end of the war in 2002, the
population growth once more markedly increased to 6.5% in 2005 and then
showed a slow but steady growth to 6.6% in 2015. While all coastal cities
studied had increased population flows following similar trajectories, the
detailed estimates of growth do not exist.
Data from the project, calculated using remote sensing tools\(^6\), was found to correlate highly with data from the recently-released national census, and provide the following population estimates: 594,000 for Cabinda; 7,020,000 for Luanda and 1,428,000 for Benguela/Lobito.

Another result of demographic mobility has been a reduction in population density in old musseques areas, and overall, a declining number of people per household (from 8 to an average of 5.29 for the whole of Luanda). The lowest average household size is five (5), while the highest average size is 6.33 persons per household in the Rural Settlements. It is hypothesized that the relatively smaller household sizes in each settlement type is a function of the relatively fewer migrants to the city, and the reduced number of several families living together in one dwelling unit. In areas close to the city centres (both the formally-constituted concrete city and the old musseques) some dwellings have been converted, or reconverted, to shops or offices as formal economic activity has increased and trading on the street has become less common and several of the informal markets have been closed. Error! Reference source not found. below shows the population statistics by settlement type in Luanda as of 2015. It shows that the peripheral musseques have the greatest number of people -- about 1.9 million people or less than one-third (28%) of the slightly more than seven (7) million Luanda residents. Although the population in the old musseques has declined, a significant number of people (about 1.7 million people or

\(^6\) See: http://www.idrc.ca/EN/Programs/Agriculture_and_the_Environment/Climate_Change_and_Wat/er/ Pages/ArticleDetails.aspx?PublicationID=1144)
25% of the population of Luanda) still live in these areas, closely followed by homes in the apartment blocks (about 1.6 million or 23% of the population of Luanda). Together, these three types of settlements are home to slightly more than three-fourths (76%) of the population of Luanda. While these three settlement types have the most number of people, the average household sizes in each settlement type are smaller than the average household size of 5.29 persons per household.

<table>
<thead>
<tr>
<th>Settlement Type</th>
<th>Number of Households</th>
<th>Average household size</th>
<th>Estimated population</th>
<th>% of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Settlements</td>
<td>37,453</td>
<td>6.33</td>
<td>237,161</td>
<td>3%</td>
</tr>
<tr>
<td>Directed Self-help Housing</td>
<td>28,444</td>
<td>6.08</td>
<td>172,951</td>
<td>2%</td>
</tr>
<tr>
<td>Bairro Popular (Township)</td>
<td>9,492</td>
<td>5.63</td>
<td>53,450</td>
<td>1%</td>
</tr>
<tr>
<td>Social Housing</td>
<td>36,915</td>
<td>5.69</td>
<td>209,909</td>
<td>3%</td>
</tr>
<tr>
<td>Old Musseques (slums)</td>
<td>336,493</td>
<td>5.17</td>
<td>1,739,443</td>
<td>25%</td>
</tr>
<tr>
<td>Structured Musseques</td>
<td>107,156</td>
<td>6.05</td>
<td>648,088</td>
<td>9%</td>
</tr>
<tr>
<td>Peripheral Musseques</td>
<td>387,842</td>
<td>5.13</td>
<td>1,990,922</td>
<td>28%</td>
</tr>
<tr>
<td>Upgraded Musseques</td>
<td>24,247</td>
<td>6.22</td>
<td>150,721</td>
<td>2%</td>
</tr>
<tr>
<td>Old Urban Centres</td>
<td>14,860</td>
<td>5.7</td>
<td>84,746</td>
<td>1%</td>
</tr>
<tr>
<td>New Suburbanization</td>
<td>18,868</td>
<td>5.5</td>
<td>103,774</td>
<td>1%</td>
</tr>
<tr>
<td>Industrial Zone</td>
<td>2,358</td>
<td>5</td>
<td>11,790</td>
<td>0%</td>
</tr>
<tr>
<td>Apartments in Blocks</td>
<td>322,953</td>
<td>5</td>
<td>1,614,767</td>
<td>23%</td>
</tr>
<tr>
<td>Other</td>
<td>463</td>
<td>5</td>
<td>2,315</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,327,081</strong></td>
<td></td>
<td><strong>7,020,038</strong></td>
<td><strong>100%</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td><strong>5.29</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Population statistics by settlement type: Luanda (2015)

Figure 15 below shows the change in patterns of areas occupied by each settlement type in Luanda. From 2008 to 2015, the areas occupied by the old musseques (areas shaded in light pink) have been reduced (particularly in areas near the city centre), but have spread further inland towards the southeast. On the other hand, the areas occupied by the peripheral musseques (areas shaded in bright pink) have markedly grown and spread towards the northeast, southeast, and southwest of the city centre. This settlement type now occupies the largest area in Luanda, and this is consistent with the data in Error! Reference source not found. which shows that the largest number of the population (28% or almost 2 million) now live in peripheral musseques. Likewise, the areas occupied by the bairro popular, new urban areas, and self-construction settlement types have grown and spread. It is interesting to note that the areas occupied by the self-construction settlement type have shifted and grown, from the outlying areas in the southeast to the south of the city centre above the municipality of Samba.
In Benguela, the neighbourhoods were classified into five (5) settlement types: *Formal de Habitacao* (Formal Housing), *Auto-constrocao Dirigida* (Self-help housing), *Musseque* (informal settlements), *Zona Industrial* (Industrial Zone), and *Assentamentos Rurais* (Rural Settlements). The same typology classification system (Table 2) was used for all of the cities studied, however in Benguela, Lobito and Cabinda the settlements were less differentiated and the classifications were simplified as much as possible while continuing to distinguish formal and informal typologies.

In 2015, Benguela had an estimated population of about 550,000 residing in 108,000 homes. About 92% of these homes are in *musseques*, in low-income and informal housing areas (see Figure 16 below; the houses are represented as blue dots). The socio-economic vulnerability is mainly a consequence of income insecurity, low social status, insecure land tenure, and lack of public services, particularly sewage disposal, garbage collection, potable water supply, and electricity.
The neighbourhoods in Lobito demonstrate four (4) settlement types – Musseques em auto-construção dirigida (self-build informal settlements), Formal urbano (formal urban construction), Zona industrial (Industrial Zone), and Assentamentos rurais (Rural settlements). These settlement typologies use the same classification system as described in the Methodology section 5.1.1, but the neighbourhoods in Lobito are also less differentiated.

Figure 16. Settlement types and distribution of homes, Benguela (2015)
In 2015, 108,000 homes were mapped by the project team in Lobito with an estimated population of more than 400,000. In 2014, about 90.2% of all households mapped by the project team were poor and are located in informal housing areas, in slums and areas of self-construction; the highest concentrations of the population live in the slums near the old town and
Lobito Bay (see Figure 17 below; the houses are represented as blue dots). (the map shows that the majority of the houses are clustered near a somewhat diagonal line running from the northeast towards the southwest – running southwest from Lobito bay. The old town extends around the low-lying port area and the spit (protecting the harbour). The city is expanding up the cliffs into the high-plateau to the east of the city and to the south along the road to Benguela 30 km away.

The geographical area covered by cities has expanded rapidly since 2002 especially in the case of Luanda. This is partly due to the greater feeling of security which encourages people to construct homes in what were previously considered rural areas. It is also partly due to deliberate planning policies. The building of expressway roads, such as a road around Luanda to the east and south and associated spurs towards the city centre, has encouraged the outward movement of housing areas. Direct government intervention in housing provision, such as the construction of large blocks of flats (centralidades), construction of high-quality low-rise housing in walled communities, provision of sites-and-services for lower income groups (auto-construção dirigida) and some direct housing provision for lower income groups (habitação social) has led to the spread of the occupied area (particularly in the case of Luanda -- see Figure 18 below).

Figure 18. The growth of Luanda in the last 50 years (2015)

The destruction of the large Roque Santeiro informal market in Luanda (and similar informal markets close to the city centre in Cabinda, Benguela and Lobito) has led to redistribution of trading activity to other markets further from the city centre and to shops; a knock-on effect of this has been that families who depended on these markets for their livelihoods have moved to
other locations in the city with access to other economic activities (usually further from the city centre).

9 One result of this “urban sprawl” has been increased traffic congestion and long journeys to work, as places of residence and work become more widely separated. There has been little effective investment in public transport and families have been obliged to invest in private transport in order to cover the greater distances they have to travel. It is only recently that planning for a Bus Rapid Transit system has begun.

10 The rapid geographical spread of the city of Luanda has led to the occupation of land in two basins (both previously sparsely occupied) that drain into the Atlantic Ocean -- one in Cacuaco (north-east of the city centre) at and the other in Benfica, located south-west of the city centre. The increase in the proportion of hard surfaces relative to the total the surface area of these drainage basins has created a risk of more rapid discharge of water if heavy rainfall occurs within these drainage basins. The housing areas close to the exit points to the sea are particularly at risk if there is a heavy rain storm. For example, the heavy rains of January 2007 caused extensive damage to housing in the flood plain at Cacuaco.

11 Incidents of heavy rain in the 1960s in Luanda led to water and silt draining down into the lower-lying areas of the city centre, causing severe damage to offices and shops in these parts. This led to the construction of improved drainage in the early 1970s so that water would not flow down on the surface into the city centre. The urbanisation of areas above the city centre led to a lesser expanse of exposed surface and less risk of silt being eroded and deposited into the lower city centre. Figure 19 below shows Luanda’s storm-water drainage system and the natural basins.
When there were intense rainstorms in the 1970s to 1990s, the flood risk in Luanda was highest in informal housing areas that were on steep slopes and in gullies (i.e., risk of housing collapse through soil erosion) and the development of ponds and lakes in certain musseque areas where the subsoil was impermeable and drainage was impeded. In these areas, standing water could remain for considerable periods of time. Since 2002 the density of population on steep slopes and on areas of impermeable soil in Luanda has decreased but there are still significant amounts of housing in these risk areas and, despite some improvements, drainage is still inadequate.

Figure 20 and Figure 21 below are examples of maps that can be overlaid with other variables such as population density and poverty levels to show areas and populations at risk from flooding and erosion.

The highest concentrations of people live in musseques near the old town and the bay of Luanda and in 2015, the data show that about 85% of all the homes are located in slum areas. An increasing number of people live in newly-built apartments, of which there are now over 250,000.

Figure 20 shows the location of all households and apartments mapped in
2014 and 2015 – many poor families have built houses in areas subject to flooding, erosion and landslides.

Figure 21 shows the areas prone to erosion, and the locations of houses in those zones. More than 13,000 homes are located in elevations of less than 4 meters above sea level, about 22,500 homes are in flood-risk areas located about 20 meters from the water and about 1,600 houses are built on land with slopes greater than 15 degrees.
Figure 20. Map showing slopes and elevations in Luanda (2015)
Although Luanda has a relatively dry climate, occasional heavy rains lead to flooding in stagnant pools and lakes, flooding of houses built in drainage channels and fast flowing water down steep slopes where informal housing have been built. The overall result is flooding of homes and commercial properties, roads being closed (or difficult to use) for extended periods, and an increase in disease incidence due to conditions suitable to the spread of malaria (see Figure 22) and gastro-intestinal diseases. Torrents of water undermine houses and damage roads, and sewage and drainage infrastructure.
Figure 22. Malaria Map of Luanda showing critical hot spots

Figure 23. Percentage of populations living in risk zones in Luanda

<table>
<thead>
<tr>
<th>Settlement Typologies</th>
<th>Flood Risk Areas</th>
<th>Malaria Risk</th>
<th>Erosion Risk Slope&gt;10°</th>
<th>Erosion Risk Slope 3° &gt;10°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old central business district</td>
<td>0.06%</td>
<td>1.63%</td>
<td>0.97%</td>
<td>14.85%</td>
</tr>
<tr>
<td>New suburbs condominiums</td>
<td>1.77%</td>
<td>32.68%</td>
<td>0.31%</td>
<td>5.19%</td>
</tr>
<tr>
<td>Bairro Popular</td>
<td>0.12%</td>
<td>13.57%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Social Housing</td>
<td>1.10%</td>
<td>16.47%</td>
<td>0.00%</td>
<td>2.03%</td>
</tr>
<tr>
<td>Owner-built on planned sites</td>
<td>2.47%</td>
<td>46.38%</td>
<td>0.00%</td>
<td>1.01%</td>
</tr>
<tr>
<td>Transitional musseques</td>
<td>0.88%</td>
<td>30.50%</td>
<td>0.18%</td>
<td>2.65%</td>
</tr>
<tr>
<td>Organized musseques</td>
<td>1.00%</td>
<td>33.27%</td>
<td>0.10%</td>
<td>3.49%</td>
</tr>
<tr>
<td>Old musseques</td>
<td>2.29%</td>
<td>38.96%</td>
<td>0.99%</td>
<td>12.19%</td>
</tr>
<tr>
<td>Peripheral musseques</td>
<td>3.48%</td>
<td>49.55%</td>
<td>0.30%</td>
<td>15.85%</td>
</tr>
<tr>
<td>Rural settlements</td>
<td>4.38%</td>
<td>27.30%</td>
<td>0.83%</td>
<td>10.88%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2.25%</td>
<td>37.79%</td>
<td>0.56%</td>
<td>9.91%</td>
</tr>
</tbody>
</table>
14 A total population of over 131,200 people were living within potential flood risk areas surrounding rivers, pools and borrow pits. Of these people, approximately 106,400 live in musseque housing which is characterized by its informal nature and high population density, flimsy building construction and general absence of services, such as safe water, sanitation and refuse removal. Almost 600,000 people are estimated to live in the gradient zone between 3 and 10 degrees while over 30,000 people to live in steep gradient zones of greater than 10 degrees. About two and a half million people live in areas with a high risk of malaria. Most of these inhabitants of informal low-income musseque areas. Since these areas are also within proximity of flood and standing water, they are also places where other water-borne diseases are prevalent.

![Traditional house - Cabinda (2014)](image)

15 Cabinda has a wetter climate and there are some occurrences of intense storms. These storms pose a threat to some housing areas that are on steep slopes but more comprehensive drainage and erosion control have limited damage. Error! Reference source not found. above shows water courses, slopes and areas at risk from a rise in sea levels in Cabinda. The map shows the houses at risk, and provides the local governments with concrete data and information to upgrade social infrastructure and develop plans for environmental adaptation. The houses built within areas of environmental risk can be found in elevations close to sea level (wetlands and steep slopes). These homes are particularly vulnerable to shocks and damage because the owners/occupants normally belong to the lower socio-economic strata.
Houses at risk due to flooding, erosion & collapse

- Green: Areas 4 meters above sea level
- Light green: Houses less than 4 meters above sea level
- Blue: Areas within 20 meters of water courses or rivers
- Light blue: Houses within 20 meters of water courses or rivers
- Red: Areas with slopes greater than 15 degrees
- Light red: Houses in areas with slopes greater than 15 degrees

0 5 kilometres

Figure 24. Cabinda (2015) Water courses, slopes and areas at risk from sea level rise
Houses built at low elevations near the seashore can be damaged when the sea levels rise. About 4,200 homes in Cabinda are in areas less than 4 meters above sea level. Between 2012 and 2015 the number of houses increased and these were built closer and closer to the sea. In Cabinda, the main area at risk from sea-level rise is between the airport and the sea -- this area has been occupied in the last 15 years as the city has spread southwards (see Figure 25 below).

![Figure 25. Houses on the Cabinda coastal plain (2012, 2015)](image)

An increasing number of houses are built between 2012 and 2015 on the banks of the river and drainage course are likely to be flooded when the rains are intense. There are examples of newly built houses erected in the marshy margins shown in Figure 26. There are a total of about 2,300 homes in Cabinda within 20 meters of water courses.
The coastal zone where the cities of Benguela and Lobito are located is a low rainfall zone, but also a high variability zone. On the few occasions when it does rain, it can rain very heavily.

In the escarpment to the east of the city of Lobito, there has been a significant amount of growth of housing areas on steep slopes and in gullies since the 1970s. The area occupied by the city expanded since 2002 and this has involved further occupation eastwards in the slopes and gullies associated with the escarpment. Rainfall is generally low in Lobito, but there are occasional heavy storms. A storm in March 2015 was centred on the escarpment area to the east of the city of Lobito, and did considerable damage by flooding houses constructed in gullies and by bringing mud down into low-lying areas.

Although there are about 360 homes are built on elevations below 4 meters above sea level (therefore at risk from rising sea levels) in the city of
Benguela, the main environmental risk is flooding from the River Cavaco (which almost always has water flow but where the flow is very variable) and flooding from the dry rivers to the south of the city. Heavy storms can occur inland of the city of Benguela and the rain water flow rapidly down these rivers (as there are steep slopes and little vegetation to impede flow). Housing has spread into the area south of the city, and this area is affected by strong flows that breached the banks of the normally dry streams in these areas. The areas close to the River Cavaco near the centre of Benguela are also often affected by flooding, as what occurred in March 2015. There appear to be mechanisms by which the civil authorities warn people of approaching flood risk when heavy rains cause flood surges in the River Cavaco, but in spite of this, damage to property still occur.

Figure 28. Water courses, slopes and areas at risk from sea level rise, Benguela and Lobito

18 The most vulnerable people are those who are socio-economically weak and live in places where their homes may be damaged by flood, erosion
and landslides. In Benguela and Lobito, the areas at risk can be found near water (lakes and rivers), at elevations near sea level (i.e., below 4 meters above sea level), and at slopes greater than 15 degrees. Figure 28 above shows water courses, slopes and areas at risk from a rise in sea levels; the houses in these areas are shown as points.

![Figure 29. Example of homes built on steep slopes (Lobito 2015)](image)

About 2,200 homes are in areas below 4 meters above sea level, about 10,200 houses are located at a distance of 20 meters from the lagoon and river, and about 6,400 homes are built on land with slopes greater than 15 degrees (see Figure 27 for an example of homes built on very steep slopes).

19 Due to climate change, the sea level is expected to rise 1 metre or more in this area of the Atlantic Coast by the year 2100. This part of the coast is affected by high waves of up 2 metres or more (*calemas*) especially between May and August. Areas that are up to 4 metres above sea level have therefore been mapped in the four cities. All cities have built-up areas that are less than four metres above sea level and are therefore at risk from flooding from sea-level rise over the next century (see Figure 2 below for an example of sea-level rise affecting a coastal settlement in Lobito). In Cabinda, the main area at risk from sea-level rise is between the airport and the sea (this area has been occupied in the last 15 years as the city has spread southwards).

20 In all cities, flood risk is heightened by rubbish being deposited in drainage channels due to the inadequacy of the rubbish collection system. When heavy rains occur, flood waters cannot readily drain into the sea and instead
back up, causing flooding. There is also the risk that the rubbish that temporarily dam the drainage channels may give way and the sudden surge of water then damages structures lower down the water course. Rubbish collection has, in general, improved in the last 10 years in all cities but there are still blocked channels that can cause flooding problems.

21 Risk maps in the form of posters (see below) and physical planning information were co-produced and validated with the participation of local communities and municipal government administrations on-the-ground. The posters are essential tools now being used to plan adaptation strategies to reduce climate risks in vulnerable urban communities.

Risk Map Posters for Cabinda, Luanda, Lobito & Benguela (March 2016)
6.3 Water Supply Systems

1. Potentially, Angola can exploit 140 billion m$^3$ of surface (river) water and 72 billion m$^3$ of sustainable ground water. In the years following the end of the civil war the country has committed itself to invest the resources to build the infrastructure that can 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.

2. The growth of coastal cities in areas with increasingly variable rainfall implies constraints on water supply for these settlements. Urban coastal settlements in Angola are therefore 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 are the constraints on management and how these could be overcome.

Figure 30. Map of Angola water resources and most important coastal settlements
3. 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 the 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, find that access to water from shallow wells (a common source of water for poorer communities in inland cities) is increasingly unavailable for 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 (see Figure 30 below) has developed to meet essential needs. Informal water markets predominate in the other coastal urban areas, which have a growing population but are located in areas with variable rainfall. There are indications that future water availability, accessibility and reliability will be constrained by supply factors, particular under a changed climate, that the informal water market in these areas charges high prices, varying with the season, and that consequently low water consumption per person per day is reduced to a minimum for poor quality water.

Figure 31. Photo of water market in Luanda (2014)

4. The project has supplied climate and hydrological information required for master-planning of water management infrastructure that was unavailable before. Water investments need to be adapted 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).

5. Rapid surveys of water prices were carried out in all four urban areas, and the data were mapped to show where water was most and least expensive. Overlaying this map with the maps of other variables such as poverty levels or settlement types provide greater insights into the interactions between variables and allow us to understand better the different dimensions of each variable. For instance it allows us to answer such questions as, “Is the price of water higher in more affluent neighbourhoods, or are the poor paying much higher prices?”

6. More than 50% of Luanda's residents depend on water trucks, or purchase-from private sellers. Costs are generally higher where private providers sell water to the poorest families in the slum areas. Consumers in the formal residential areas of Luanda and those in the more rural districts pay relatively little for water (see the dark blue and blue areas in Figure 31 below).
7. Water resources in Cabinda

Climate change has a major impact on water supply and sanitation in the coastal city of Cabinda. In the coastal zone of the city, water tables are very deep and most ground water is saline and often polluted from seepage from latrines and the inefficient, poorly-maintained sewage systems. Water is drawn from surface sources, mainly from the near-by Lucolo River, to supply Cabinda's water distribution system. Rapid urban population growth has meant that the government's post-war investments through the Water for All Program still has not achieved the target of providing water for 90% of the urban populations. In fact, more than 50% of Cabinda's urban population still purchase water mainly from households who do have piped water. Water in Cabinda is usually sold to households in 20-litre buckets (bidons) and the price of a bucket of water is a useful indicator of water supply and access. Figure 33 shows that the price varies from less than US$ 0.20 (20 kz) to US$ 1.00 (100 Kz) depending on the source, quantity available, distance from the source, quality of water and the time it takes to fetch or deliver the water.

Figure 33. Water prices in Cabinda (2014)
8. Increasing climatic variation is one of the factors that affects water price. When bairros are flooded, road access for water delivery becomes problematic. Flooding also affects the water collection points such as standposts and storage tanks and may cause contamination of the water supply. Poor rubbish collection, particularly in the rainy season, contributes to the accumulation of rubbish in drainage channels and cause blockages. These exacerbate the incidence and severity of flooding, and erode the service distribution networks. Climate adaptation planning requires bairro-level improvements in water-supply delivery and parallel local community actions to improve sanitation.

6.4 Water Governance Policy Influencing

1. Development Workshop’s research presented to the Ministry of Water and Energy\(^7\) showed that in many communities, the Water for All program 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% were functional. This study also found that local capacity for operation and maintenance of water systems is very weak, 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”, these technological solutions were rarely discussed with the communities and usually do not respond to the preferences of users.

2. DW worked with the Ministry of Water and Energy to support their commitment to achieve the Millennium Development Goals and bring water services to 80% of the country’s population, wherever they live, including in high risk zones. Building on the research and evidence-based demonstration work with communities on service provision, DW developed a strategy of community management of local water standposts that involved the election of water caretakers by consumers and the creation of legally constituted water associations that collected user-fees, managed maintenance, and bought water in bulk from the parastatal provincial water companies. DW together with the Ministry tested this model of water governance in Luanda and several other provinces and proposed it as a remedial tool for incorporation into the

\(^7\) Development Workshop and Cowater International implemented this project.
“Water for All” program. In late February 2014 the Secretary of State for Water announced that the community water model (Modelo de Gestão Comunitária de Água - MoGeCA) was adopted as national policy and the training manual developed by DW was distributed to municipalities across the country. 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, ten-year strategy for sustainable community water to be piloted in provinces across the country. The program will draw on the evaluation of the Water for All experience and incorporate the water governance lessons from the community management model.

3. The project’s experience illustrates that research and evidence based policy advocacy is an effective long term development strategy that can achieve outcomes at a national scale.

4. Development Workshop advocated for raising sustainable local government financing for rubbish management through local service charges, rather than depending on subsidies from the dwindling state central budget. The project engaged with students and youth in affected communities in the use of social media advocacy by promoting the “Selfi-Rubbish” campaign (http://cazenga.forum.angonet.org/campanha-selfie-lixo/) as well as policy influencing through the press, radio and TV. DW’s director participated in several radio and prime-time television debates on the issues of urban sanitation and climate change risks. A feature article in Angola’s principal Financial Weekly based on his
interview on the theme of Urban Sanitation and Environmental Risks was published on 18th September 2015⁸.

Figure 35. "Selfi-Rubbish" campaign on Facebook⁹

Figure 36. Drainage channels clogged with rubbish increase risk of flooding

5. On April 15, 2016 the government of the province of Luanda adopted one of the project’s key policy recommendations on raising sustainable local government financing for rubbish management through local service charges. This will create an autonomous, local-level financing


⁹ Selfie-Lixo: http://cazenga.forum.angonet.org/campanha-selfie-lixo/
mechanism for sanitation (i.e., rubbish collection) by cross-financing on municipal service bills (for electricity). A more efficient rubbish collection service is essential for Municipal Adaptation Planning in that it will help keep drainage channels open, thereby greatly reducing the risk of flooding.
6.5 Knowledge-Sharing

Disseminating information about the project objectives, activities, and its outputs is another important component of the project approach and methodology. This creates awareness of and generates interest in climate change issues, and facilitates policy-influencing and advocacy initiatives. Below are the main knowledge-sharing activities:

1. A presentation was made by Afonso Cupi Baptista, the Development Workshop Water Sector Manager, entitled “Alterações Climáticas e Água Urbana” at the Annual Symposium on Water in Portuguese-speaking Countries in Maputo, Mozambique, May 27-30, 2013. The presentation can be found at: http://www.dw.angonet.org/forumitem/500. Another presentation was made for the same symposium in Lisbon in 2014.

2. Two of the university-student project interns, Ana Julante and Weba Quirimba, shared their field experiences and discussed the impact of climate change on the environment relative to floods and storm water runoff/drainage on July 19, 2013 at the Development Workshop Library in Luanda. The PowerPoint and audio files can be found at: http://dw.angonet.org/forumitem/762

3. A presentation entitled, “Urbanisation, Environment and Climate Variability in Angola” was made by a member of the DW research team at the International Conference on Development and the Environment held in Lobito on October 1 and 2, 2013.

4. A member of the DW research team participated in a conference convened by the Southern Africa Regional University Association at the Universidade Agostinho Neto Faculty of Science to address issues on enhancing Climate Compatible Development capacities.

5. The Project Leader provided two, 2-hour long radio interviews\(^\text{10}\) in the National Radio (24 September 2015) and the Catholic Radio stations (16 January 2016), and discussed the interrelationships and interactions between rubbish accumulation, climate risk, and flooding.

6. Development Workshop presented the aims and scope of this project at a conference on climate change and sustainable development in Angola.

in the city of Huambo in June 2014. A second presentation was made on the project’s preliminary findings about variability and trends in rainfall in Angola. This event was organized by CETAC, who indicated interest in the DW approach and methodology, and noted that these may form the basis for future climate analysis by CETAC.

7 On December 5, 2014 project results were presented at the National Workshop on Urban Studies in Luanda (see http://www.dw.angonet.org/forumitem/workshop-de-estudos-urbanos-em-angola-0.

8 Development Workshop participated in the National Conference on Climate Change held in Luanda on December 6, 2014. This event was organised by the Angolan Council of Churches and attended by civil society organizations (see photo of participants in Figure 37 below).

Figure 37. Participants in the National Conference on Climate Change, December 6, 2014

9 The findings of the research were presented at the 2nd National Conference on Environment and Sustainable Development at Mandume University in the southern coastal city of Namibe (an area severely affected by climatic variation).

10 Preliminary project results were presented to CETAC (the Centre of Tropical Ecology and Climate Change) and to the National Institute of Water Resources on 16 June 2014.

11 A presentation was made to the IDRC workshop on climate change and water held in Pretoria in September 2014
12 A paper and presentation on the findings of the project were made at the Climate Systems’ Analysis Group at the University of Cape Town. A similar paper and presentation were made to the Ministry of Environment of Angola in the context of the preparation of the Global Environment Facility project on adaptation in coastal regions of Angola. The presentation materials can be found in the Development Workshop website: http://www.dw.angonet.org/content/climate-change

13 The findings from this research were presented by the Project Leader at the World Bank Conference on Land and Poverty held in Washington, DC from March 23 to 27, 2015. Subsequently, the paper “Climate Change and Land Markets in Coastal Cities of Angola – the case of Luanda”, was published by the World Bank (see http://www.dw.angonet.org/forumitem/climate-change-and-land-markets-angola)

14 The IDRC Water & Climate Change program in Ottawa requested the Project Leader to prepare two presentations on its current and past research programs for the May 2015 World Water Congress in Edinburgh; the Project Leader also served as the keynote speaker for one of the themes on Water Governance and Markets in this Congress.

15 Training Course National Adaptation Plan - July 2015
The DW Director was one of the expert trainers in a UNEP/GEF training course targeting the national and provincial staff of the Ministry of Environment responsible for developing Angola’s National Adaptation Plan. The theme of the component presented focused on evaluation methods for assessing the vulnerability of human settlements.

16 A peer-reviewed paper was prepared for a special journal issue on the IDRC Water & Climate Change research titled: Water Resource Management Under Changing Climate in Angolan Coastal Cities - for Water International Journal (forthcoming)

17 Information from media scans have been uploaded into the database on unusual climate events (the information is sourced daily from the public, private and community media, journals, and newspapers). DW publishes a monthly media scan which includes a section on Climate Change and Environmental issues; annual compilations of these thematic areas are published and made available through the internet (http://dw.angonet.org/pt-pt/cedoc). Figure 38 below is a sample cover of an annual compilation on the environment and climate change.
Figure 38. Sample cover of an annual compilation of media scans on the environment and climate change

18 A website on the DW Climate Change program was launched in (please see [http://www.dw.angonet.org/content/climate-change](http://www.dw.angonet.org/content/climate-change)). The site contains project documents, information on project events such as workshops and debates, and other related documentation.
A monograph is being prepared on the variability of the average annual, seasonal and monthly rainfall data for Angola. This paper (“Characterization of observed rainfall in Angola and surrounding countries” is to be published by PREFACE by the University of Bergen, Norway) uses both historic and recent station data.

The project director has been invited by the Rockefeller Foundation for a fellowship at the Bellagio Center in Italy in October and November 2016 to write a monograph on “Participatory Risk Mapping Africa’s Vulnerable Coastal Settlements”. The monograph will be submitted for peer review to the International Institute for Environment and Development.
7 Problems and Challenges

Several notable problems were encountered in the implementation of the project:

1) Funding Shortfall
In the initial budget design it was foreseen that Development Workshop would need to mobilise a further US$200,000 in order to carry out the project as planned. It became evident in the first reporting period that this ambitious research project will require more financial resources than anticipated. The weak existing climatic data and the actual scale of the accelerating growth of Angolan coastal cities meant that the project team would need an additional funding of US$ 500,000 to fully carry out the planned project activities. To this end, the Angolan Ministries of Environment and Water & Energy have provided assistance in mobilizing additional resources for the project. Together with the Government and the UNDP (United Nations Development Programme) a submission was prepared and submitted to the Global Environment Facility (GEF) and Climate Adaptation Fund. Several potential bilateral and corporate donors were also approached for funding.

We are disappointed that the GEF counterpart funding for the project did not materialize before the completion of this project. Had the funding been available earlier on in the implementation of the project, the planned tasks would have been completed in a more timely manner and the partnership with the Climate System Analysis Group (CSAG) at the University of Cape Town to engage them in using Angolan data to update their climate models for Southern Africa would have been implemented. The CSAG had required additional financing in order to process Angolan data.

While we are disappointed that the GEF project approval process has been so lengthy and time consuming, there is little that we could have done to expedite it. The application for GEF financing that DW had contributed to developing had to be channelled through the Angolan Ministry of Environment and the UNDP office, since UNEP (United Nations Environment Program) has no permanent representation in Luanda. Perhaps a relationship with UNEP’s headquarters in Nairobi could have been facilitated through IDRC’s African office in Nairobi, but it is unlikely that the formal channels could have been bypassed.

Due to the lack of counterpart funding to supplement the IDRC project financing, some opportunities to present findings of the project and exchange experiences with other institutions in the Southern African region were missed.
2) Devaluation of the Canadian Dollar
The budget was seriously constrained by the currency exchange losses due to
the unexpected devaluation of the Canadian dollar during the project
implementation phase. In real terms, this has effectively reduced the budget by
about 25%. In hindsight, it would have been prudent to have included a line item
in the budget that would address and attenuate the effects of contingencies
such as this.

3) Unreliable Internet Connectivity
The low reliability of internet connectivity posed difficulties for the research team
-- programming and loading applications on mobile PDAs (Personal Digital
Assistant), uploading and downloading data and other information became
cumbersome and time consuming.

4) Delays in Project Implementation
The project encountered unexpected delays in the implementation of some
planned activities due to the departure of one of the project’s principal
researchers. While new staff were recruited a no-cost extension of six months
was requested and subsequently granted.

Although the project was constrained by the fact that expected counterpart
funding did not materialize, and that the budget was seriously constrained by
the currency exchange losses due to the devaluation of the Canadian dollar, the
project has achieved its principal planned objectives. It is anticipated that further
policy outcomes will be evident after the end of the current program.

8 Administrative Reflections and Recommendations
It is a concern that IDRC has recently begun to limit geographical interventions,
based on what we assume to be Canadian Government priority countries. We
hope that this policy will be reconsidered in the future and that decision making
on programming would be determined by research priorities and opportunities
for policy influencing, institutional capacity and partnership building.

As pointed out in the previous section, it might be advisable to include a
Contingency line item in the budget of future projects to attenuate the effects of
unexpected events such as the devaluation of the Canadian dollar. In this
particular case, the problem with the currency exchange rate has effectively
reduced the budget by about 25%, hence severely constraining the
implementation of planned project activities.
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ANNEXES
ANNEX 1. Questions for CCW-Supported Project Teams

**Water quality/availability, adaptive capacity, and risk**

1. Within the scope of your project activities, have there been improvements in the quality and/or availability of water, especially for vulnerable communities? Have risks associated with climate change (e.g. flooding, drought, sea-level rise, storms, etc.) been reduced? If so, please describe how.

The three year timeline of the project has coincided with an adjustment of the Angolan economy (particularly from 2014) due to falling commodity prices and a subsequent reduction of the Angolan State Budget. The implementation of the State sponsored Water for All program, which the current project is linked with, has been affected and is being implemented more slowly. The State’s plan to install household water connections in urban areas is behind-schedule. Urban communities in all four cities remain largely dependent on community standposts. These standposts are delivering more sustained services and are well maintained due to the project’s promotion of community management.

The last two years of the project have seen major flooding events in Lobito in April 2015 and in Luanda in February & March 2016. The project has been able to provide early warning alerts in the form of maps to the Civil Protection Departments of both cities as a contribution to mitigation to local adaptation actions. The crisis situations provided opportunities to advocate with central government and local municipal officials for the importance of good updated information. The project has created a demand for information and evidence of the need to develop adaptation plans.

2. Has the project put in place strategies for building adaptive capacity of people and institutions? Have you observed a measurable change in the adaptive capacity of the communities or institutions associated with your project? Please describe. *(Note: Building adaptive capacity implies that the project has improved the ability of people (through access to resources, such as financial, human, social and natural capital) to modify practices to cope with and manage the negative impacts of climate change.)*

The success of the Community Water Management Model (MoGeCA) has had an important impact on the outcome of the project. The model builds sustainable water systems that recover costs at levels affordable to the urban poor and ensures maintenance of systems when in place. The number of municipalities that have implemented the model has grown to substantially to at least 20. The Ministry of Water and Energy has asked DW to support their role-out of MoGeCA nationally. Presently we are working on implementing the model in four provinces with funds from USAID. DW is preparing the curriculum for a
national training program.

3. Has the project identified barriers that are impeding the uptake of existing technologies and strategies for improving water resources management? If so, please describe these barriers.

As mentioned above, the restrictions in State budgets since 2014 has delayed the implementation of plans to provide individual water connections to households. However DW’s strategy to date has focused on community water supplied through standposts and other point-sources of water. The water management tools promoted by the project remain applicable and are increasingly valuable in this context.

**Climate change adaptation research methods**

4. Did researchers involved in the project apply relevant social research methods (e.g. economic analysis, social vulnerability assessment, gender analysis, etc.) to improve water management in the context of climate change? Which methods were particularly valuable or innovative?

The project introduced a number of innovative social research methods.

a) the use of GSMA and GIS enabled Android Tablets reduced research time, cost and increased accuracy in collecting geo-referenced household data and implementing questionnaires.

b) The co-production of information by involving local community associations, government actors and students in data collection, means that these stakeholders also have a sense of co-ownership of the information produced by the research. Data is therefore validated by all partners and can be used in public-policy advocacy more readily.

c) The use of media monitoring of climatic events and oral histories are both non-formal methods that produce useful data that has been used to fill in the information gaps that occurred during Angola’s war years.

d) Participatory mapping is a tool used by DW that uses qualitative rapid diagnostic methods in conjunction with GIS remote-sensing to produce demographic, environmental and service data maps that are useful for planners and local communities.

5. Were researchers involved in the project trained to use methods to conduct economic analysis? How did they apply these methods?

The researchers involved in the project were engaged in using poverty assessment ranking using a tool (Poverty Scorecard) developed by the World Bank’s CGAP program. The tool used national poverty line data collected by the Angolan Statistical Institute. The Poverty Scorecard is used to rank households in a 10 percentile scale against the national poverty-line.

**Engagement of research users and policy influence**
6. How did researchers work with policy makers in the project? What worked well, and what challenges did the team encounter?

The co-production model of research involved Government stakeholders who are targeted as policy-makers, in the process of collecting and validating data. This approach facilitates greatly the use of research findings and data in public-policy influencing.

Development Workshop has a very good record on policy influencing using this model over a number of years.

7. Did project team members improve their ability to communicate research results to diverse audiences? How?

The project team members prepared posters and presented project results in a number of workshops and conferences (please see Annex 2 – List of Project Outputs). These have given them additional experience and confidence in speaking before large audiences. The project has provided numerous opportunities for the project team members to interact formally and informally with government officials at the local, regional and national levels. These experiences will provide the project team with the skills and confidence not only in communicating research results, but in networking and effectively working with other organizations.

8. Were any policy options identified through the research? Have any of the policy options developed through the project influenced policy change at the local/regional or national level?

On April 15, 2016 the government of the province of Luanda adopted one of the project’s key policy recommendations on raising sustainable local government financing for rubbish management through local service charges, rather than depending on subsidies from the dwindling state central budget (see www.dw.angonet.org/....and/or relevant sources). This will create an autonomous, local-level financing mechanism for sanitation (i.e., rubbish collection) by cross-financing on municipal service bills (for electricity). A more efficient rubbish collection service will help keep drainage channels open, thereby greatly reducing the risk of flooding.

The MoGeCA water model based on community management as an outcome related to the project, that is currently being scaled up at the national level.
Future research plans

9. Have you or your partners been able to secure additional resources to carry out further research related to adaptation to climate change and/or water resources?

Development Workshop is seeking additional funding for taking the project to scale and adapting the materials for municipal adaptation planning.

To date, no additional funding sources have been secured to carry out further research related to adaptation to climate change and/or water resources. However, the application for GEF funding that was submitted during project implementation is still in the pipeline. If this funding application is successful, DW shall revive its plans to partner with the Climate System Analysis Group (CSAG) at the University of Cape Town to engage them in using Angolan data to update their climate models for Southern Africa.

The opportunities afforded by the project to exchange ideas, share research approaches and policy influencing strategies with other IDRC partners, as well as other interested institutions is extremely valuable. Development Workshop is keen to explore the possibility of scaling up the current research and policy development program on coastal urban settlements on a regional basis, involving at least one other country (ideally more than one).

It is Development Workshop’s plan to scale up the current research to a national level and also promote adaptation planning at local municipal levels across the country. This will involve transforming many of the tools developed through the project into training materials that can form the basis of a course for local administrators and municipal planners at the National Institute for the Formation of Local Government IFAL. DW has obtained a small fellowship from Rockefeller Foundation to work on the preparation of a monograph that can be used in training.

A proposal is currently being prepared for presentation to the Global Resilience Partnership. The project is designed to increase the capacity of Angolan communities to engage with local municipal governments in participatory planning and in developing adaptation strategies for highly-vulnerable coastal settlements at risk of the adverse effects of climate change. This project will use information produced by the IDRC supported project, such as the Risk Maps of the principal environmental hazards in the targeted municipal communities, to develop multi-stakeholder mechanisms that will allow civil society to engage local government authorities on environmental protection and other salient issues, and develop participatory municipal adaptation plans that address and mitigate the key environmental risks associated with climate change.
ANNEX 2. Household Survey Interview Schedule

CLIMATE CHANGE, FLOODING AND WATER SUPPLY
LUANDA, CABINDA, BENGUELA AND LOBITO

29 de Dezembro 2012

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<thead>
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<tr>
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<td>CIDADE</td>
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<td>3</td>
<td>Benguela</td>
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<td>4</td>
<td>Lobito</td>
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<td><strong>A2</strong></td>
<td>COORDENADAS DA CASA DO ENTREVISTADO</td>
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<tr>
<td>Long</td>
<td>..................</td>
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<td>Lat</td>
<td>..................</td>
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<td><strong>A3</strong></td>
<td>TIPO DE HABITAÇÃO</td>
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<tr>
<td><strong>A4</strong></td>
<td>NUMERO DO QUESTIONÁRIO</td>
</tr>
<tr>
<td><strong>A5</strong></td>
<td>CÓDIGO DO INQUIRIDOR</td>
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<td><strong>A6</strong></td>
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<td><strong>A8</strong></td>
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</tr>
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<td><strong>A9</strong></td>
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</tr>
<tr>
<td><strong>A10</strong></td>
<td>NO. DE DIVISÕES DA CASA</td>
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<td><strong>A11</strong></td>
<td>O CHÃO DA HABITAÇÃO E DE</td>
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<td>Cimento</td>
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<td>Mármore</td>
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<td>4</td>
<td>Tijolo</td>
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<td>5</td>
<td>Madeira ou taco</td>
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<td>6</td>
<td>Adobe</td>
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<tr>
<td>7</td>
<td>Terra batida</td>
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<td>8</td>
<td>Outros</td>
</tr>
<tr>
<td><strong>A12</strong></td>
<td>O MATERIAL DE CONSTRUÇÃO DA CASA É</td>
</tr>
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<td>1</td>
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<tr>
<td>2</td>
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<td>3</td>
<td>Adobes</td>
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<tr>
<td>4</td>
<td>Pau-a-pique</td>
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<td>5</td>
<td>Capim</td>
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<td>6</td>
<td>Chapa</td>
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<td>7</td>
<td>Madeira</td>
</tr>
<tr>
<td>8</td>
<td>Outros</td>
</tr>
</tbody>
</table>
A13 QUE TIPO DE COMBUSTÍVEL UTILIZA PRINCIPALMENTE PARA COZINHAR?

1 Electricidade
2 Gás
3 Petróleo

4 Carvão
5 Lenha
6 Bosta animal
7 Restos de cultivo agrícola
8 Outros
9 Não cozinha

A14 OUTRO TIPO DE COMBUSTÍVEL QUE UTILIZA PARA COZINHAR?

1 Electricidade
2 Gás
3 Petróleo

4 Carvão
5 Lenha
6 Bosta animal
7 Restos de cultivo agrícola
8 Outros
9 Não cozinha

A15 NO AGREGADO FAMILIAR TEM UMA VENTOINHA?

1 Sim
2 Não

A16 NO AGREGADO FAMILIAR TEM UM TELEFONE (FIXO OU MÓVEL)?

1 Sim
2 Não

A17 NO AGREGADO FAMILIAR TEM UM RÁDIO?

1 Sim
2 Não

A18 NO AGREGADO FAMILIAR TEM UM TELEVISOR?

1 Sim
2 Não

A19 NO AGREGADO FAMILIAR TEM UMA BICICLETA?

1 Sim
2 Não

A20 NO AGREGADO FAMILIAR TEM UMA MOTORIZADA?

1 Sim
2 Não

A21 NO AGREGADO FAMILIAR TEM UMA VIATURA?

1 Sim
2 Não

A22 QUANDO FOI A ULTIMA VEZ QUE UM MEMBRO DO AGREGADO FAMILIAR LEU UM JORNAL?

1 Hoje ou ontem
2 Durante os últimos 7 dias
3 Durante o último mês
4 Durante o último ano
5 Anteriormente
6 Nunca

B ÁGUA GERAL

B1 PARA BEBER, O AGREGADO USA PRINCIPALMENTE ÁGUA DE

1 Torneira na residência ligada à rede
2 Torneira no prédio ou do vizinho
3 Tanque do vizinho
4 Chafariz public
5 Furo com bomba
6 Cacimba protegida
7 Cacimba desprotegida
8 Nascente protegida
9 Nascente desprotegida
10 Água de chuva, chimpucas
11 Charco, rio, riacho, lagoa
12 Cisterna de água
13 Água mineral em garrafa
14 Outro .........................................................

B2 A ÁGUA E TRATADA DE ALGUMA FORMA PARA FICAR MAIS SEGURA PARA BEBER?
1 Sim 2 Não

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA B4

B3 QUE TIPO DE TRATAMENTO DA ÁGUA USA HABITUALMENTE?
1 Fervura
2 Adicionar lixivia/cloro
3 Passar através dum tecido
4 Filtro de água (cerâmica, areia, compósito)
5 Desinfecção solar
6 Deixar pousar/reposar
7 Outro ...........................................

B4 PARA OS OUTROS USOS (COZINHAR, HIGIENE ETC) O AGREGADO USA PRINCIPALMENTE ÁGUA DE
1 Torneira na residência ligada à rede
2 Torneira no prédio ou do vizinho
3 Tanque do vizinho
4 Chafariz public
5 Furo com bomba
6 Cacimba protegida
7 Cacimba desprotegida
8 Nascente protegida
9 Nascente desprotegida
10 Água de chuva, chimpacas
11 Charco, rio, riacho, lagoa
12 Cisterna de água
13 Água mineral em garrafa
14 Outro .........................................................

B5 QUANTO O AGREGADO PAGOU NO MÊS PASSADA PELA COMPRA DE ÁGUA?

C Torneira na residência ligada à rede

C1 A CASA TEM LIGAÇÃO À REDE PÚBLICA DE ÁGUA?
1 Sim 2 Não

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA D1

C2 SE TIVER LIGAÇÃO, HAVIA ÁGUA NA TORNEIRA NO MÊS PASSADO?
1 Sim 2 Não

C3 QUAL É A FREQUÊNCIA DE FORNECIMENTO DE ÁGUA CANALIZADA EM CASA
1 nunca
2 poucas vezes
3 algumas vezes
4 muitas vezes
5 sempre

C4 A TORNEIRA NA RESIDÊNCIA É A FONTE PRINCIPAL DE ÁGUA?
1 Sim 2 Não

C5 O AGREGADO UTILIZA OUTRAS FONTES DE ÁGUA?
1 Sim 2 Não

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA C8
C6 QUANDO UTILIZA OUTRAS FONTES DE ÁGUA?  
1 Quando falta água da torneira  
2 Porque água da torneira é cara  
3 Outro  

C7 PARA QUAIS FINS UTILIZAM OUTRAS FONTES DE ÁGUA?  

C8 QUAL É O PREÇO DE Água Canalizada Por Metro Cúbico?  

Kwanzas  

C9 SE TIVER LIGAÇÃO, QUAL É O CONSUMO NORMAL MENSAL?  

metros cúbicos  

C10 SE TIVER LIGAÇÃO, NORMALMENTE QUANTO É A FACTURA MENSAL?  

Kwanzas  

C11 ACHA O PREÇO JUSTO?  
1 Sim 2 Não  

C12 QUAL É A QUALIDADE DA Água Canalizada?  
1 péssima  
2 mediocre  
3 suficiente  
4 boa  
5 excelente  

C13 QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DA Água Canalizada EM CASA?  
1 Cheiro  
2 Cor  
3 Sabor  
4 Outro (especificar)  

D Torneira no prédio ou do vizinho  

D1 ÀS VEZES USA A TORNEIRA NO PRÉDIO  
1 Sim 2 Não  

OU DO VIZINHO PARA TER ACESSO À ÁGUA?  

▶ SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA E1  

D2 A TORNEIRA NO PRÉDIO OU DO VIZINHO É A FONTE PRINCIPAL DE Água?  
1 Sim 2 Não  

D3 EM QUE CIRCUMSTÂNCIA USA A TORNEIRA NO PRÉDIO OU DO VIZINHO?  
1 Quando não há outras fontes de água  
2 Quando o preço é alto nas outras fontes de água  
3 Quando o agregado precisa de muita água  
4 Só para certos fins  
5 Sempre  
6 Outro  

D4 O QUE É O FIM PRINCIPAL PARA QUAL USA A ÁGUA DA TORNEIRA NO PRÉDIO OU DO VIZINHO?  
1 Todos os efeitos  
2 Beber  
3 Limpeza da casa  
4 Tomar banho  
5 Outros  

D5 QUANTO TEMPO LEVA DE CASA PARÁ
A TORNEIRA DO PRÉDIO OU DO VIZINHO?

D6 QUANTO TEMPO FICA NA FILA A ESPERA PARA ACARRETAR ÁGUA NA TORNEIRA DO PRÉDIO OU DO VIZINHO? minutos

D7 QUAL É O PREÇO NORMAL DE UM BALDE/BIDON DE 20 LITROS NA TORNEIRA DO PRÉDIO OU DO VIZINHO? Kwanzas

D8 ACHA O PREÇO JUSTO? 1 Sim 2 Não

D9 A CERTAS ALTURAS EM QUE O PREÇO NA TORNEIRA NO PRÉDIO OU DO VIZINHO É MAIS ALTO?

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA D13

D10 QUANDO É QUE O PREÇO É MAIS ALTO?
1 Quando não há água canalizada
2 Na época chuvosa
3 Na época seca
4 Outras alturas

D11 QUAL É O PREÇO MAIS ALTO DE UM BALDE/BIDON DE 20 LITROS QUE JÁ PAGOU NA TORNEIRA NO PRÉDIO OU DO VIZINHO? Kwanzas

D12 ACHA O PREÇO JUSTO? 1 Sim 2 Não

D13 QUANTOS BALDES DE ÁGUA DE 20 LITROS ACARRETA DA TORNEIRA DO VIZINHO POR DIA? Baldes

D14 QUAL É A FREQUÊNCIA DE FORNECIMENTO DA ÁGUA NA TORNEIRA DO VIZINHO?
1 nunca
2 poucas vezes
3 algumas vezes
4 muitas vezes
5 sempre

D15 QUAL É A QUALIDADE DE ÁGUA NA TORNEIRA DO VIZINHO
1 péssima
2 mediocre
3 suficiente
4 boa
5 excelente

D16 QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DE ÁGUA NA TORNEIRA DO VIZINHO?
1 Cheiro
2 Cor
3 Sabor
4 Outro (especificar)

D17 A QUEM PERTENCE A TORNEIRA?
1 Empresa de Águas
2 Uma empresa
3 A Coordenação do bairro
4 Um vizinho
5 Outro

E Tanque do vizinho

E1 ÀS VEZES USA O TANQUE DO VIZINHO PARA TER ACESSO À ÁGUA?
1 Sim 2 Não

► SE RESPONDER "NÃO", PASSA PARA A PERGUNTA E1

E2 O TANQUE DO VIZINHO É A FONTE PRINCIPAL DE ÁGUA?
1 Sim 2 Não

E3 EM QUE CIRCUMSTÂNCIA USA O TANQUE DO VIZINHO?
1 Quando não há outras fontes de água
2 Quando o preço é alto nas outras fontes de água
3 Quando o agregado precisa de muita água
4 Só para certos fins
5 Sempre
6 Outro

E4 O QUE É O FIM PRINCIPAL PARA QUAL USA A ÁGUA DO TANQUE DO VIZINHO?
1 Todos os efeitos
2 Beber
3 Limpeza da casa
4 Tomar banho
5 Outros
6 Outro

E5 QUANTO TEMPO LEVA DA CASA AO TANQUE DO VIZINHO?

minutos

E6 QUANTO TEMPO FICA NA FILA A ESPERAR PARA ACARRETAR ÁGUA NO TANQUE DO VIZINHO?

minutos

E7 QUAL É O PREÇO DE UM BALDE/BIDON DE 20 LITROS NO TANQUE DO VIZINHO?

Kwanzas

E8 ACHA O PREÇO JUSTO?
1 Sim 2 Não

E9 A CERTAS ALTURAS O PREÇO NO TANQUE DO VIZINHO É MAIS ALTO?
1 Sim 2 Não

► SE RESPONDER "NÃO", PASSA PARA A PERGUNTA E13

E10 QUANDO É QUE O PREÇO É MAIS ALTO?
1 Quando não há água canalizada
2 Na época chuvosa
3 Na época seca
4 Outras alturas

E11 QUAL É O PREÇO ALTO DE UM BALDE/BIDON DE 20 LITROS NO TANQUE DO VIZINHO?

Kwanzas

E12 ACHA O PREÇO JUSTO?
1 Sim 2 Não

E13 QUANTOS BALDES DE ÁGUA DE 20 LITROS ACARRETA DO TANQUE DO VIZINHO POR DIA?

Baldes

E14 QUAL É A FREQUÊNCIA DE FORNECIMENTO
1 nunca
### Water & Changing Climate in Angola’s Coastal Settlements Final Technical Report to IDRC

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<td>Cor</td>
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<td>3</td>
<td>Sabor</td>
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| F   | Chafariz público |

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<th>F1</th>
<th>ÀS VEZES USA UM CHAFARIZ PÚBLICO PARA TER ACESSO À ÁGUA?</th>
<th>1</th>
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<tr>
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► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA G1

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<tr>
<td>3</td>
<td>Quando o agregado precisa de muita água</td>
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<td>4</td>
<td>Só para certos fins</td>
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<td>5</td>
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<tr>
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<td>Outro</td>
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<tr>
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<td>Todos os efeitos</td>
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<tr>
<td>2</td>
<td>Beber</td>
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<td>3</td>
<td>Limpeza da casa</td>
</tr>
<tr>
<td>4</td>
<td>Tomar banho</td>
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<tr>
<td>5</td>
<td>Outros</td>
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| F5  | QUANTO TEMPO LEVA DO CHAFARIZ PARA CASA? | Minutos |

| F6  | A QUE HORAS ABRE O CHAFARIZ? | ........... | horas |

| F7  | A QUE HORAS EBCERRA O CHAFARIZ? | ...... | horas |

| F8  | GERALMENTE QUANTO TEMPO ESPERA NA BICHA? | Minutos |

| F9  | QUANTO PAGA POR UM BALDE DE 20 LITROS? |

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<tr>
<th>F10</th>
<th>ACHA O PREÇO JUSTO?</th>
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<tbody>
<tr>
<td></td>
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<td>2</td>
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► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA F15
F12  QUANDO É QUE O PREÇO É MAIS ALTO?
1 Quando não há água canalizada
2 Na época chuvosa
3 Na época seca
4 Outras alturas

F13  O QUE É O PREÇO DUM BALDE DE 20 LITROS QUANDO O PREÇO É MAIS ALTO?  Kwanzas

F14  ACHA O PREÇO JUSTO?
1 Sim
2 Não

F15  QUANTOS BALDES DE 20 LITROS O AGREGADO CARTA DO CHAFARIZ POR DIA?  Baldes

F16  QUAL É A FREQUÊNCIA DE FORNECIMENTO DA ÁGUA NO CHAFARIZ?
1 nunca
2 poucas vezes
3 algumas vezes
4 muitas vezes
5 sempre

F17  QUAL É A QUALIDADE DE ÁGUA NO CHAFARIZ?
1 péssima
2 mediocre
3 suficiente
4 boa
5 excelente

F18  QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DE ÁGUA NO CHAFARIZ?
1 Cheiro
2 Cor
3 Sabor
4 Outro (especificar)

F19  QUEM TEM A RESPONSABILIDADE DE GESTÃO E MANUTENÇÃO DO CHAFARIZ?
1 Um indivíduo do bairro
2 Um individ. fora do bairro
3 Uma empresa privada
4 Uma ONG
5 Empresa de água
6 Administração local
7 Comité comunitário (ACA, GAS etc)
8 Outro (especificar)

F20  QUAL É A QUALIDADE DE GESTÃO E MANUTENÇÃO DO CHAFARIZ?
1 Boa
2 Razoável
3 Mau
4 Muito mau

F21  QUais SÃO OS PROBLEMAS COM A GESTÃO E A MANUTENÇÃO DO CHAFARIZ?

G  Furo com manivela

G1  ÀS VEZES USA UM FURO COM MANIVELA PARA TER ACESSO À ÁGUA?
1 Sim
2 Não

G2  O FURO É A FONTE PRINCIPAL DE ÁGUA?
1 Sim
2 Não

G3  QUANDO USA O FURO?
QUANDO NÃO HÁ OUTRAS FONTES DE ÁGUA
2 Quando o preço é alto nas outras fontes de água
3 Quando o agregado precisa de muita água
4 Só para certos fins
5 Sempre
6 Outro

O QUE É O FIM PRINCIPAL PARA QUAL USA A ÁGUA DO FURO?
1 Todos os efeitos
2 Beber
3 Limpeza da casa
4 Tomar banho
5 Outros

QUANTO TEMPO LEVA DE CASA PARA O FURO?

GERALMENTE QUANTO TEMPO ESPERA NA FILA?

QUAL É O PREÇO DUM BALDE/BIDÃO DE 20 LITROS?

Kwanzas

ACHA O PREÇO JUSTO?
1 Sim
2 Não

A CERTAS ALTURAS O PREÇO NO FURO É MAIS ALTO?
1 Sim
2 Não

SE RESPONDER "NÃO", PASSA PARA A PERGUNTA G13

QUANDO É QUE O PREÇO É MAIS ALTO?
1 Quando não há água canalizada
2 Na época chuvosa
3 Na época seca
4 Outras alturas

O QUE É O PREÇO DUM BALDE DE 20 LITROS QUANDO O PREÇO É MAIS ALTO?

Kwanzas

ACHA O PREÇO JUSTO?
1 Sim
2 Não

QUANTOS BALDES DE 20 LITROS O AGREGADO CARTA DO FURO POR DIA?

QUAL É A FREQUÊNCIA DE FORNECIMENTO DA ÁGUA NO FURO?
1 nunca
2 poucas vezes
3 algumas vezes
4 muitas vezes
5 sempre

QUAL É A QUALIDADE DE ÁGUA NO FURO?
1 pessima
2 mediocre
3 suficiente
4 boa
5 excelente

QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DE ÁGUA NO FURO?
1 Cheiro
2 Cor
G17 QUEM TEM A RESPONSABILIDADE DE GESTÃO E MANUTENÇÃO DO FURO?
1 Um indivíduo do bairro
2 Um indivíduo fora do bairro
3 Uma empresa privada
4 Uma ONG
5 Empresa de água
6 Administração local
7 Comitê comunitário (ACA, GAS etc)
8 Outro (especificar)

G18 QUAL É A QUALIDADE DE GESTÃO E MANUTENÇÃO DO FURO?
1 Boa
2 Razoável
3 Mau
4 Muito mau

G19 QUAL SÃO OS PROBLEMAS COM A GESTÃO E A MANUTENÇÃO DO FURO?

H Cacimba ou nascente

H1 ÀS VEZES USA UMA CACIMBA OU NASCENTE PARA TER ACESSO À ÁGUA?
1 Sim
2 Não

►SE RESPONDER "NÃO", PASSA PARA A PERGUNTA J1

H2 A CACIMBA OU NASCENTE É A FONTE PRINCIPAL DE ÁGUA?
1 Sim
2 Não

H3 SE NÃO, QUANDO USA A CACIMBA OU NASCENTE?
1 Quando não há outras fontes de água
2 Quando o preço é alto nas outras fontes de água
3 Quando o agregado precisa de muita água
4 Só para certos fins
5 Sempre
6 Outro

H4 O QUE É O FIM PRINCIPAL PARA QUAL USA A ÁGUA DA CACIMBA OU NASCENTE?
1 Todos os efeitos
2 Beber
3 Limpeza da casa
4 Tomar banho
5 Outros

H5 A CACIMBA OU NASCENTE ESTÁ LOCALIZADA EM CASA?
1 Sim
2 Não

►SE RESPONDER "SIM", PASSA PARA A PERGUNTA H17

H6 A QUEM PERTENCE A CACIMBA OU NASCENTE?
1 Um indivíduo do bairro
2 Um indivíduo fora do bairro
3 Uma empresa privada
4 Uma ONG
5 Empresa de água
6 Administração local
### H7: Qual é a qualidade de gestão e manutenção?
1. Boa
2. Razoável
3. Mau
4. Muito mau

### H8: Quais são os problemas com a gestão e a manutenção da cacimba ou nascente?
- [...]

### H9: Quanto tempo leva da casa a cacimba ou nascente?
- Minutos

### H10: Geralmente quanto tempo espera na bicha?
- Minutos

### H11: Quanto custa um balde de 20 litros?
- Kwanzas

### H12: Acha o preço justo?
1. Sim
2. Não

### H13: A certas alturas o preço
1. Sim
2. Não

#### Se responder “não”, passe para a pergunta H17

### H14: Quando é que o preço é mais alto?
1. Quando não há água canalizada
2. Na época chuvosa
3. Na época seca
4. Outras alturas

### H15: O que é o preço dum balde de 20 litros quando o preço é mais alto?
- Kwanzas

### H16: Acha o preço justo?
1. Sim
2. Não

### H17: Quantos baldes de 20 litros o agregado carta da cacimba ou nascente por dia?
- Baldes

### H18: Qual é a frequência de fornecimento da água na cacimba ou nascente?
1. Nunca
2. Poucas vezes
3. Algumas vezes
4. Muitas vezes
5. Sempre

### H19: Qual é a qualidade de água da cacimba ou nascente?
1. Pésima
2. Mediocre
3. Suficiente
4. Boa
5. Excelente

### H20: Qual é o problema principal com a qualidade de água da cacimba ou nascente?
1. Cheiro
2. Cor
3. Sabor
4. Outro (especificar)
J  Charco, rio, riacho, lagoa

J1  ÀS VEZES USA UM CHARCO, RIO, RIacho OU LAGOA PARA TER ACESSO À ÁGUA?  
1  Sim  
2  Não  
▶ SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA  K1

J2  COMO TIRA A ÁGUA DO RIO, RIACho, LAGoa OU CHARCO?  
1  Balde  
2  Motobomba  
3  Bomba manual  
4  Outro tipo bomba  
▶ SE RESPONDER “DIRECTAMENTE”, PASSA PARA A PERGUNTA  J4

J3  A QUEM PERTENCE A BOMBA?  
1  Um indivíduo do bairro  
2  Um individ. fora do bairro  
3  Uma empresa privada  
4  Uma ONG  
5  Empresa de água  
6  Administração local  
7  Comité comunitário (ACA, GAS etc)  
8  Outro (especificar)  

J4  O RIO, RIACho OU LAGOA É A FONTE PRINCIPAL DE ÁGUA?  
1  Sim  
2  Não  

J5  QUANDO USA RIO, RIACho OU LAGOA?  
1  Quando não há outras fontes de água  
2  Quando o preço é alto nas outras fontes de água  
3  Quando o agregado precisa de muita água  
4  Só para certos fins  
5  Sempre  
6  Outro  

J6  O QUE É O FIM PRINCIPAL PARA QUAL USA A ÁGUA DO RIO, RIACho OU LAGOA?  
1  Todos os efeitos  
2  Beber  
3  Limpeza da casa  
4  Tomar banho  
5  Outros  

J7  QUANTO TEMPO LEVA DA CASA AO RIO, RIACho OU LAGOA?  

Minutos

J8  GERALMENTE QUANTO TEMPO ESPERA NA BICHA?  

Minutos

J9  PAGA PARA CARTAR ÁGUA NESTE SÍTIO?  
1  Sim  
2  Não  
▶ SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA  J16

J10  SE PAGAR, QUAL É O PREÇO DE UM BALDE DE 20 LITROS NO RIO, LAGOA OU RIACho?  

Kwanzas

J11  ACHA O PREÇO JUSTO?  
1  Sim  
2  Não
J12  A CERTAS ALTURAS O PREÇO NO RIO, RIACHO OU LAGOA É MAIS ALTO?
1  Sim
2  Não
► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA  J16

J13  QUANDO É QUE O PREÇO É MAIS ALTO?
1  Quando não há água canalizada
2  Na época chuvosa
3  Na época seca
4  Outras alturas

J14  O QUE É O PREÇO DUM BALDE DE 20 LITROS QUANDO O PREÇO É MAIS ALTO?
Kwanzas

J15  ACHA O PREÇO JUSTO?
1  Sim
2  Não

J16  QUANTOS BALDES DE 20 LITROS O AGREGADO CARTA DO RIO, RIACHO OU LAGOA?

J17  QUAL É A FREQUÊNCIA DE FORNECIMENTO DA ÁGUA NO RIO, RIACHO OU LAGOA?
1  nunca
2  poucas vezes
3  algumas vezes
4  muitas vezes
5  sempre

J18  QUAL É A QUALIDADE DE ÁGUA DO RIO, RIACHO OU LAGOA?
1  péssima
2  mediocre
3  suficiente
4  boa
5  excelente

J19  QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DE ÁGUA DO RIO, RIACHO OU LAGOA?
1  Cheiro
2  Cor
3  Sabor
4  Outro (especificar)

K  Cisterna de água privada
K1  ÀS VEZES USA UMA CISTERNA PRIVADA PARA TER ACESSO À ÁGUA?
1  Sim
2  Não
► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA  L1

K2  A SUA CASA TEM TANQUE DE ÁGUA?
1  Sim
2  Não
► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA  K5

K3  QUAL A CAPACIDADE DO SEU TANQUE?
mil litros
Water & Changing Climate in Angola’s Coastal Settlements Final Technical Report to IDRC

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<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Response</th>
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<tr>
<td>K5</td>
<td>COMPRA A ÁGUA SEMPRE DO MESMO CAMIÃO CISTERNA?</td>
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<td>K8</td>
<td>QUANTO CUSTA PARA ENCHER O TANQUE?</td>
<td>Kwanzas</td>
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► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA K14

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<tr>
<td>K14</td>
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<th>Options</th>
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<td>QUAL É A QUALIDADE DE ÁGUA DO CAMIÃO CISTERNA?</td>
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<td>Outro (especificar)</td>
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<td>Cisterna de água pública</td>
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<td>ÀS VEZES USA UMA CISTERNA PRIVADA PARA TER ACESSO À ÁGUA?</td>
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<tr>
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<td>►SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA M1</td>
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<td>COMO AS FAMÍLIAS SABEM QUE VAI CHEGAR O CAMIÃO CISTERNA?</td>
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<td>QUANDO COMEÇOU A PASSAR O CAMIÃO CISTERNA PÚBLICO?</td>
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<tr>
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<td>PAGA PARA RECEBER ÁGUA?</td>
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<tr>
<td>2</td>
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<td>SE PAGAR, QUAL É O PREÇO DE UM BALDE DE 20 LITROS?</td>
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<td>ACHA O PREÇO JUSTO?</td>
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<td>2</td>
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<td>L9</td>
<td>QUANDO É QUE O PREÇO É MAIS ALTO?</td>
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<td>1</td>
<td>Quando não há água canalizada</td>
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<td>2</td>
<td>Na época chuvosa</td>
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<td>L11</td>
<td>ACHA O PREÇO JUSTO?</td>
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<td>péssima</td>
</tr>
<tr>
<td>2</td>
<td>mediocre</td>
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</table>
QUAL É O PROBLEMA PRINCIPAL COM A QUALIDADE DE AGUA DO CAMIÃO CISTERNA?

1. Cheiro
2. Cor
3. Sabor
4. Outro (especificar)

M SANEAMENTO

M1 ONDE HABITUALMENTE OS MEMBROS FAZEM SUAS NECESSIDADES

1. Sistema de esgotos (pia, sanita)
2. Fossa Sépica e Poço roto
3. Latrina Seca ou com descarga manual
4. Vaia negra/aberta
5. Poço roto somente
6. Directamente no rio ou no lago
7. Balde
8. Capim/ ar livre
9. Outro

M2 ONDE SE ENCONTRA ESTE SANITÁRIO?

1. Na casa
2. No quintal
3. Fora do quintal

M3 DIVIDE ESTE SANITÁRIO COM OUTROS AGREGADOS?

1. Sim
2. Não

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA M5

M4 QUANTOS OUTROS AGREGADOS USAM ESTE SANITÁRIO?

M5 EXISTE SISTEMA DE RECOLHA DE LIXO ONDE MORA?

1. Sim
2. Não

► SE RESPONDER “NÃO”, PASSA PARA A PERGUNTA M7

M6 SE EXISTE UM SISTEMA DE RECOLHA DE LIXO, QUAL É A FREQUÊNCIA DE RECOLHA?

1. Diariamente
2. Algumas vezes por semana
3. Semanalmente
4. Quinzenalmente
5. Mensalmente

M7 QUE DESTINO DÁ AO LIXO DA CASA?

1. Deixar num contentor
2. Deixar ao ar livre
3. Deixar no chão para recolha
4. Enterrar
5. Deixar numa Lixeira
6. Queimar

M8 EXISTE UM SISTEMA DE ESGOTOS ONDE MORA?

1. Sim
2. Não

M9 QUAL É O DESTINO DAS AGUAS RESIDUAIS DA CASA

1. Nos esgotos
2. No quintal
3. Na rua
4 Numa vala
5 Outro

N MERCADO DE TERRA E HABITAÇÃO

<table>
<thead>
<tr>
<th>N1 A CASA ONDE VIVE É</th>
<th>1 Própria</th>
<th>2 Arrendada</th>
<th>3 Da família</th>
<th>4 Outro</th>
</tr>
</thead>
</table>

N2 COMO CONSEGUIU A CASA OU O TALHÃO/TERRENO?
1 Ocupação de terreno vazio
2 Ocupação de casa vazia
3 Compra da casa
4 Compra de terreno
5 Herança
6 Cedência entre família
7 Cedência do Estado
8 Outra

N3 PAGOU POR ESTA OCUPAÇÃO?
1 Sim
2 Não

N4 TEM ALGUMA PROVA DO DIREITO DE OCUPAÇÃO?
1 Sim
2 Não

N5 SENTE-SE SEGURO NA POSSE DO TALHÃO?
1 Não
2 Não sabe
3 Sim

P MEIO AMBIENTE

<table>
<thead>
<tr>
<th>P1 A ESTRADA DE ACESSO A CASA É</th>
<th>1 Asfaltada</th>
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<tbody>
<tr>
<td>2 Terra planada</td>
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<tr>
<td>3 Terra com buracos</td>
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<table>
<thead>
<tr>
<th>P2 DEPOIS DA CHUVA COMO E O ESTADO DA RUA DE ACESSO A CASA?</th>
<th>1 Bom</th>
<th>2 Mau</th>
<th>3 Intransitável</th>
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► SE RESPONDER “BOM”, PASSA PARA A PERGUNTA P5

P3 QUANDO FOI A ULTIMA VEZ QUE A ESTRADA FICOU EM MAU ESTADO OU INTRANSITAVEL DEPOIS DA CHUVA?
5 Desde Setembro 2012
6 Entre Setembro 2011 e Agosto 2012
7 Entre Setembro 2010 e Agosto 2011
8 Entre Setembro 2009 e Agosto 2010
5 Entre 2005 e 2009
6 Entre 2000 e 2004
7 AnTES de 2000

P4 QUANTOS DIAS A ESTRADA FICOU EM MAU OU INTRANSITAVEL ESTADO NAQUELA ALTURA?

P5 ESTA ÁREA ALGUMA VEZ FOI AFECTADA PELAS INUNDAÇÕES OU PELA EROSÃO?
1 Sim
Não

P6  QUANDO FOI A ULTIMA VEZ QUE A ÁREA FOI AFECTADA PELAS INUNDAÇÕES OU PELA EROSÃO?
1  Desde Setembro 2012
2  Entre Setembro 2011 e Agosto 2012
3  Entre Setembro 2010 e Agosto 2011
4  Entre Setembro 2009 e Agosto 2010
5  Entre 2005 e 2009
6  Entre 2000 e 2004
7  Antes de 2000

P7  NA ÁREA QUAIS CONSTRUÇÕES FORAM AFECTADAS?
1  Algumas construções da área foram afectadas?
2  A maior parte das construções da área foi afectada?
3  Todas as construções da área foram afectadas?

P8  A VOSSA CASA FOI AFECTADA?  
1  Sim
2  Não

P9  FOI NECESSARIO ABANDONAR A CASA DURANTE ALGUM TEMPO NAQUELA ALTURA?
1  Sim
2  Não

P10  SE SIM, DURANTE QUANTOS DIAS? ..................

P11  AONDE FOI VIVER QUANDO FOI NECESSARIO ABANDONAR A CASA?
1  Com familiares
2  Com amigos
3  Num centro de acolhimento?
4  Em tendas fornecidas pelo Governo
5  Em tendas fornecidas por uma outra organização (ONG, igreja)?
6  Outro (especificar) .................................

P12  A CASA FICOU DANIFICADA?
1  Sim
2  Não

P13  SE SIM, QUAIS FORAM OS PIORES DANOS?
1  Fendas nas paredes
2  As paredes caíram
3  O tecto caiu
4  Outro (especificar)

P14  RECEBEU ALGUM APOIO PARA A REPARAÇÃO DA VOSSA CASA DEPOIS DA INUNDAÇÃO?
1  Sim
2  Não

P15  SE SIM, QUEM DEU O APOIO PRINCIPAL?
1  Familiares
2  Amigos
3  Vizinhos
4  O Governo
5  Outras organizações

P16  A SAÚDE DE MEMBROS DO AGREGADO FOI AFECTADA PELAS INUNDAÇÕES?
<table>
<thead>
<tr>
<th>P17</th>
<th>QUAL FOI A DOENÇA PRINCIPAL?</th>
<th>.........................................................</th>
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<tbody>
<tr>
<td></td>
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<th>QUAL FOI A SEGUNDA DOENÇA (EM ORDEM DE IMPORTÂNCIA)?</th>
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<th>QUAL FOI A TERCEIRA DOENÇA (EM ORDEM DE IMPORTÂNCIA)?</th>
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<th>O SISTEMA DE AGUA DA ÁREA FOI DANIFICADO?</th>
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<tr>
<td></td>
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<tr>
<th>P24</th>
<th>O QUE CAUSOU A INUNDAÇÃO?</th>
<th>.........................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Acumulação de água das chuvas na rua</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Água dum lago ou dum logoa</td>
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<td></td>
<td>3 Água dum rio próximo</td>
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<td></td>
<td>4 Água do mar</td>
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<tr>
<td></td>
<td>5 Erosão ou deslizamento da terra</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 Outro (especificar)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P25</th>
<th>ISSO ACONTECEU RAPIDAMENTE?</th>
<th>.........................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 As águas chegaram rapidamente</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 As águas subiram gradualmente</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Outro (especificar)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P26</th>
<th>O GOVERNO IMPLEMENTOU MEDIDAS PARA REDUZIR O IMPACTO DAS INUNDAÇÕES?</th>
<th>.........................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Sim</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Não</td>
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</table>

<table>
<thead>
<tr>
<th>P27</th>
<th>QUAL É A MEDIDA MAIS IMPORTANTE QUE IMPLEMENTOU?</th>
<th>.........................................................</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>P28</th>
<th>QUAL É A SEGUNDA MEDIDA QUE IMPLEMENTOU (EM TERMOS DE IMPORTÂNCIA)?</th>
<th>.........................................................</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>P29</th>
<th>QUAL É A TERCEIRA MEDIDA QUE IMPLEMENTOU (EM TERMOS DE IMPORTÂNCIA)?</th>
<th>.........................................................</th>
</tr>
</thead>
</table>
ANNEX 3. List of Project Research Outputs

This is a list of all project-related documents are also filed into their respective project file electronically, and have been sent for filing to IDRC. Some of them, which have academic or research value, may also be captured for IDRC Digital Library.

<table>
<thead>
<tr>
<th>Type of research output</th>
<th>Description</th>
<th>Document type</th>
<th>IDRC Digital Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress or interim report</td>
<td>a) 1st Interim Report - April 2013</td>
<td>IRT</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>b) 2nd Interim Report - Oct 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) 3rd Interim Report - April 2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) 4th Interim Report - Nov 2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) 5th Interim Report - May 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final technical report</td>
<td>Composed of a final project narrative and a final scientific report (see below for description)</td>
<td>FTR</td>
<td>Y (once approved by Program Officer)</td>
</tr>
<tr>
<td>Journal article, book or chapter of a book</td>
<td>Published copy or final version of the text produced for publication in a scientific journal or as a book</td>
<td>PUB</td>
<td>Y</td>
</tr>
<tr>
<td>Newspaper articles</td>
<td>Final version of the text produced for publication in a newspaper or</td>
<td>PUB</td>
<td>N</td>
</tr>
<tr>
<td>Type of research output</td>
<td>Description</td>
<td>Document type</td>
<td>IDRC Digital Library</td>
</tr>
<tr>
<td>---------------------------------</td>
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</tr>
<tr>
<td>scanned copy of a newspaper article</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulletin, newsletter, pamphlets</td>
<td>Communication material produced to inform the community about a project or IDRC activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Media Dossier Ambiente 2010 2011</td>
<td></td>
<td>PUB</td>
<td>Y (if produced for external audience)</td>
</tr>
<tr>
<td>b) Media Dossier Ambiente 2012</td>
<td></td>
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</tr>
<tr>
<td>c) Media Dossier Ambiente 2013</td>
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<td></td>
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</tr>
<tr>
<td>d) Media Dossier Ambiente 2014</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) Media Dossier Ambiente 2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policy briefs</td>
<td>Climate-adaptive planning for Angola's coastal cities</td>
<td>PUB</td>
<td>Y</td>
</tr>
<tr>
<td>Post-project synthesis normally published providing lessons, recommendations and key research results on research fields or programs</td>
<td>Planeamento de Adaptação Climática das Cidades Costeiras - (versão portuguesa)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project briefs, project profiles</td>
<td>Water Governance Article for IDRC on significant policy achievements - May 2014</td>
<td>PBF</td>
<td>N</td>
</tr>
<tr>
<td>Project briefs, project profiles</td>
<td>Highlighting the project in journalistic style normally produced by Communication Division or the Program Initiative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop report</td>
<td>Notes on a workshop, the program and the list of participants and presenters</td>
<td>PPT Video</td>
<td>Y</td>
</tr>
<tr>
<td>Workshop report</td>
<td>Workshop sobre Impactos da variação climática sobre inundações e escoamento pluvial em Luanda - 19 Julho 2013</td>
<td></td>
<td></td>
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</tbody>
</table>

http://www.dw.angonet.org/content/ana-julante-e-weba-quirimba-
<table>
<thead>
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<th>Type of research output</th>
<th>Description</th>
<th>Document type</th>
<th>IDRC Digital Library</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thesis, essay, paper</strong></td>
<td><strong>Composition or dissertation embodying IDRC research results</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>impactos-da-varia%C3%A7%C3%A3o-clim%C3%A1tica-sobre-inunda%C3%A7%C3%B5es-e-escoamento-plu Workshop on Planning of Coastal Cities of Angola for Climate Adaptation – UNDP Luanda 31 March 2016</td>
<td>WKR</td>
<td></td>
</tr>
<tr>
<td>Type of research output</td>
<td>Description</td>
<td>Document type</td>
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</tr>
<tr>
<td>Type of research output</td>
<td>Description</td>
<td>Document type</td>
<td>IDRC Digital Library</td>
</tr>
<tr>
<td>------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Photograph, film</td>
<td>Pictures or moving images relating project activities or use as a document supporting the project</td>
<td>IMG</td>
<td>Y</td>
</tr>
<tr>
<td>Scoping study, exploratory report</td>
<td><em>Case study on a situation that looks back on a specific research field, program or project and presents some recommendations to support the design and programming of a project or to develop future research projects</em></td>
<td>SDY</td>
<td>Y (if produced for external audience)</td>
</tr>
<tr>
<td>Evaluation report</td>
<td>Mission Report from the IDRC team that visited the project and participated in the Final Workshop in April 2016</td>
<td>EVR</td>
<td>Y (in most cases)</td>
</tr>
</tbody>
</table>
## ANNEX 4. Milestones, Achievements and Recommendations

<table>
<thead>
<tr>
<th>KEY OBJECTIVE</th>
<th>MILESTONE RESULTS</th>
<th>ACHIEVEMENTS</th>
<th>LESSONS LEARNED &amp; RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFIC OBJECTIVE 1: Improve information about rainfall patterns and hydrology in coastal areas of Angola, which is essential information for understanding trends and variability and also for adaptation planning.</td>
<td>1.1 Collected &amp; digitalised existing rainfall data for coastal and nearby areas of Angola.</td>
<td>Data collected was mainly from the 1930 to 1975 but some for the post-independence period, and scans of data for all stations from 1937 to 1974; data for the few stations operating pre-1937 were obtained from the archive of the UK Meteorological Office and Angolan sources. These will characterise the spatial and temporal variability of annual, seasonal and monthly rainfall in Angola.</td>
<td>The seasonal monthly rainfall data collected will assist the Angolan meteorological office fill in the gaps between existing stations and make comparisons with available rainfall data for past periods and satellite-based measures of cloud cover and precipitation for 1980 to the present.</td>
</tr>
<tr>
<td></td>
<td>1.2 Calculated annual, seasonal and monthly means and variability of rainfall for each relevant station and map this information from existing rainfall data. Make graphs of annual variations.</td>
<td>A Variability Map was produced demonstrating the spatial and temporal analysis of rainfall and its variability for Angola (including high, low and unusually distributed rainfall patterns in recent years). This included an analysis of rainfall trends, and of correlations of historical rainfall variability.</td>
<td>Angola’s first Variability Map produced by the research project demonstrated that variability increases as one moves from North to South along the coast while precipitation intensity increases as one moves from South to North.</td>
</tr>
<tr>
<td></td>
<td>1.3 Obtained for coastal and nearby areas of Angola satellite-based measures of cloud cover and rainfall events for recent years (usually available from the 1980s onwards)</td>
<td>Satellite Imagery was obtained for specific flooding and rainfall events in the highly vulnerable urban coastal areas and adjacent river basins.</td>
<td>Satellite Imagery was proven to be most useful in tracking and monitoring real-time and specific historic critical events (flooding disasters). The value of this tracking was demonstrated to local authorities in Benguela Province in 2015 and to the Civil Protection Department at the National level.</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
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<tr>
<td>1.4</td>
<td>Calculated annual, seasonal and monthly means and variability of rainfall for each relevant station and map this information from satellite-based measures of cloud cover and precipitation. Make graphs of annual variations. The river basins affecting the four urban settlements, were mapped and the risk factors were projected. The four risk maps produced improved understanding of, the characteristics of river basins that affect urban areas in these coastal regions. The risk map for Benguela which proved to be the most vulnerable urban area was developed more extensively and demonstrated the reduction of vegetation coverage which caused erosion and contributed to severe flooding.</td>
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<tr>
<td>1.5</td>
<td>Collected written records of notable climate events and notable flooding, erosion or drought events (newspapers, emergency bulletins, food security bulletins) from post-Independence period in the relevant coastal urban areas and the relevant river basins. Climate events were tracked by DW’s Documentation Centre through Media Scan process every year of the project. A database of events was compiled and geo-referenced and mapped. The importance of geo-referencing data has been demonstrated by this component of the project. The maps produced give a clear picture of the high-risk districts of the country and present information in a form that is directly useful to policy makers and planners.</td>
<td></td>
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<tr>
<td>1.6</td>
<td>Collect oral histories from key informants of notable climate events and notable flooding, erosion or drought events from recent years. Oral histories were collected from the disastrous flooding events in Benguela and Luanda. Oral histories were written up and presented in project workshops and posted on the project website as material for future researchers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>Create a database of notable climate events and notable flooding, erosion or drought events from recent years in the relevant coastal urban areas and the relevant river basins (from the collected oral histories and written records) As per section 1.5 above the climate events were tracked by DW’s Documentation Centre through Media Scan process every year of the project. A database of events was compiled and geo-referenced and mapped. The importance of geo-referencing data has been demonstrated by this component of the project. The maps produced give a clear picture of the high-risk districts of the country and present information in a form that is directly useful to policy makers and planners.</td>
<td></td>
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<tr>
<td>1.8</td>
<td>Use information on annual variations and database of notable events to identify linkages between events (such as high rainfall events and flooding) linkages to ENSO and fluctuations in the Benguela Current. Annual variation data was collated a presented in the form of a map of climatic variation. The project did not have the resources of capacity to assess the linkages with ENSO and the Benguela Current. This component will require the development of relationships with institutions outside of Angola who have the technical capacity to do this kind of assessment.</td>
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<tr>
<td>1.9</td>
<td>Obtain existing data (which is mainly from the colonial period) on flows in the relevant river basins. Data was collected and archived from previous studies. It is being posted on the project website. Hydraulic data remains to be analysed in relationship to river flows and flooding.</td>
<td></td>
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</tbody>
</table>
### SPECIFIC OBJECTIVE 2: Improve information about settlement patterns and population in Angola’s urban coastal areas and assess the risks from flooding and erosion at present and under future climate scenarios, especially for vulnerable social groups

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Obtain satellite images of the relevant urban areas covered by the research</td>
<td>A demographic analysis of all four urban coastal areas was collected and analysed by DW’s Geographic Information System team. This permitted the determination of population figures by area and figures. It permitted the mapping of the urban areas, the extent of urban areas at different dates, and maps of growth and densities of population.</td>
</tr>
<tr>
<td>2.2</td>
<td>Household surveys were conducted in the urban areas covered by the research. This provided information on the number of people per household, social indicators, land values, and experience of flooding and climate variation.</td>
<td>The innovative use of satellite imagery and the results of the rooftop mapping provide an invaluable tool for urban planners and policy makers. We propose that these materials are incorporated into a training manual that will be used by IFAL for the formation of municipal planners and decision makers in local governments.</td>
</tr>
<tr>
<td>2.3</td>
<td>The examination of satellite images, local observation and interviews with key informants allowed the research team to delimit zones of the urban relevant areas with similar dates of construction and social characteristics. Settlement Typology Maps for each of the four urban areas demonstrating indicators and the distribution of population were produced and incorporated into city posters and risk maps.</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>The counting of rooftops on the satellite images permitted the accurate calculation of number of structures in each delimited zone (that were used in conjunction with data on number of people per structure to calculate population of an area)</td>
<td>The environmental vulnerability of the four coastal urban areas of Angola and its impacts of climate change have been clearly demonstrated. This included maps of risk zones and descriptions of impacts. This included a comparison with population distributions and social conditions in outputs 1 and 2, to produce estimates of numbers of people affected and the social conditions of those most affected. The geographic datasets for risk zones, urban footprints and populations affected.</td>
</tr>
<tr>
<td>2.5</td>
<td>Present-day satellite images and previous mapping of the relevant urban areas covered by the research allowed the project team to map the past and current growth of the different settlement</td>
<td></td>
</tr>
<tr>
<td>Typology areas.</td>
<td>Cross-checking was made with oral histories of past events and their impacts (e.g., on health).</td>
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<td>----------------</td>
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<tr>
<td>2.6 The socio-economic characteristics of different settlement typologies have been demonstrated statistically.</td>
<td></td>
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</tr>
<tr>
<td>2.7 The counting of the number of structures and data on the number of people per structure allowed the research team to make an estimate of population and population densities in each city. Use this to make an estimate of population trends if past data are available.</td>
<td></td>
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</tr>
<tr>
<td>2.8 The use of satellite images and field observation permitted the mapping of critical features and delimit and map flood risk areas and slopes (including erosion risk), areas at risk from sea-level rise and salt-water intrusion (under present and possible future conditions).</td>
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</table>

**SPECIFIC OBJECTIVE 3:**
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 propose better water governance mechanisms for these areas.

<table>
<thead>
<tr>
<th>3.1 Satellite images of the relevant urban areas covered by the research were obtained.</th>
<th>Mapping was made for each coastal urban area of the affordability of potable water. Maps were incorporated into the posters for the four urban areas. High prices demonstrated the scarcity of water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2 Household surveys in the four urban areas covered by the research were conducted to provide information on the number of people per household, social indicators, land values, water access, use and price of water.</td>
<td></td>
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<tr>
<td>3.3 Key informant surveys were conducted to gather information on water supply systems.</td>
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<tr>
<td>3.4 A rapid survey of prices of water in the relevant coastal settlements was collected annually and data was mapped.</td>
<td>Water price mapping provides a valuable tool to water supply companies in the four cities in identifying critical problem supply areas where shortages have produced high prices. Mapping provided the municipal or provincial water companies with opportunities for planning their technical investments in locations where cost recovery potential can be maximized.</td>
</tr>
</tbody>
</table>
3.5 Carry out rapid tests of the quality of water.

3.6 Water quality data was collected (and variation of these attributes by season of the year).

3.7 Mapping proves projection critical areas where future climatic change (variability and possible trends) could impact on water supply systems for urban areas and thus on water markets, water access and affordability.

Mapping of water prices provides policy makers and decision makers an opportunity to monitor the impact of public investments and technical improvements.