



DEVELOPMENT WORKSHOP
Desenvolvimento Comunitário
Human Settlements & Development

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WATER RESOURCE MANAGEMENT UNDER CHANGING CLIMATE IN ANGOLA'S COASTAL SETTLEMENTS

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DEVELOPMENT WORKSHOP ANGOLA

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1 SYNTHESIS

After 27 years of civil conflict, Angola achieved peace in 2002 and only then has the country begun to address such long-term issues as adaptation to climate variability and its socioeconomic effects. Given the short length of the period in which significant meteorological and hydrological records were collected is short: 1940 to 1975 for meteorological records and 1960 to 1975 for hydrological records, very 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. The lack of such facilities and services makes it difficult for stakeholders to produce improved, even basic, information on rainfall and apply new data collection methods to contribution to the conduct of reliable research and credible knowledge production for better planning. This project was designed to narrow this gap and strengthen capacity building in the assessment of the impact climate variability on water supply and environmental risks in urban areas as a good entry point for practical adaptation planning setting grounds for the design of more medium and long term policy frameworks.

The overall objective of the project is to strengthen Angola's efforts in climate change adaptation by developing tools and providing information that address information gaps about rainfall patterns and hydrology and their likely impact on environmental risks and water-supply issues in Angola's coastal urban areas.

The specific objectives are to:-

- 1 Reconstruct lost data so as to improve knowledge about rainfall patterns and hydrology in coastal areas of Angola and develop a framework for future continuous data collection and analysis
- 2 Improve information about settlement patterns and population in three of Angola's urban coastal areas, and assess the risks, impact and vulnerability from flooding and erosion at present and under future climate scenarios, especially for vulnerable social groups
- 3 To promote the improvement of water access in Angola's urban coastal areas, assess the impact of climate change on water supply issues, especially for vulnerable social groups, and develop options for better water management mechanisms for these areas.

Through these objectives, the project aims to contribute to Angola's efforts to address some of the serious issues related to adaptation to climate change. Angola's water resources will be increasingly important in the southern Africa region (which, according to climate model projections, is likely to become drier). Angola has urbanised rapidly and with little coherent urban planning. There have been a number of recent flooding events in urban areas of Angola that 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 planned activities in the first twenty-four months of the project involved establishing relations with relevant institutions, collecting and archiving existing information, and preparing for and carrying out field-work in the three urban areas. A questionnaire for the household surveys was designed and tested and used in two areas (Luanda and Cabinda) through use of hand-held electronic devices and the results have been analysed. Field-work in the Benguela and Lobito conurbation was carried out after the national census had been completed (the first complete census in Angola since 1971).

Historical rainfall data from more than 100 stations in Angola (and some stations in neighbouring countries) has been obtained and a digital database in Access compiled. A process was set up to analyse the database of monthly rainfall records, taking into account the large number of gaps in the records. A draft report has been completed based on this historic rainfall, including an analysis of patterns of rainfall variability in coastal areas of Angola and the report was presented at the CETAC conference on climate change in Angola. Satellite-based estimates of decadal, monthly and annual rainfall per 8x8 kilometre cell for the whole country have been obtained, covering the years 1996 – 2012 from two sources: these are being calibrated with historic rainfall data before analysis. Field trips to Cabinda and Benguela-Lobito were made in February and March 2013. Case studies of the flooding in various parts of Luanda have been carried out (including the serious flooding in January 2007) using oral histories. Similar case studies are being developed in Cabinda and Benguela and Lobito using oral histories.

This means that good progress has been made with reconstructing lost data about rainfall patterns and variability in Angola from historic rainfall data. This has helped develop relations with a new local institution, CETAC, and with climate scientists who may assist in establishing linkages between rainfall events and features of the Benguela Current and other large-scale circulation features. The data-base of rainfall events is also of interest to scientists in this area. Much less progress has been made in using satellite-based estimates of rainfall, due to poor calibration of the models for this region of Africa. Alternative sources of satellite-based estimates of rainfall are being pursued as well as collaboration with TAMSAT on re-calibrating their model.

Good progress is being made in improving information about settlement patterns and population in Angola's urban coastal areas, and in assessing the risks, impact and vulnerability from flooding and erosion. Satellite images have been obtained for all the urban areas and demographic analysis is underway for each of them. Environmental risk analysis and mapping is underway for each urban area as well as socio-economic analysis and mapping.

Good progress is being made in describing the water supply systems of the coastal urban areas of Angola and assessing the impact of climate change on water supply issues, especially for vulnerable social groups. Information has been collected through questionnaires, observation and key informants. Basic information on supply and prices is being produced and mapped.

2 RESEARCH PROBLEM

The growth of coastal cities in areas which usually have a low rainfall implies constraints on water supply for these settlements. Urban coastal settlements in Angola are supplied through urban water distribution systems with inadequate quantities of low quality water. The functioning of these water systems is incompletely understood, as are the constraints on supply and how these could be overcome. The expansion of coastal cities means that the population has grown in areas with a low but very variable rainfall.

Planning of water management infrastructure requires climate and hydrological information that is lacking, even though water investments should be designed to perform under future climate regimes as well as present-day ones. The lack of data for many areas of Angola during the period since 1975 also creates uncertainties for international scientific research and climate change modelling. The supply of urban services to coastal urban areas has not grown in line with the growth in population for almost all the cities. Most urban water and sanitation infrastructure is immobile and long lasting, making rapid shifts in urban location very costly.

Similarly hydrological information for Angola is scarce. With 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 normal variability or part of a trend. The pace at which mapping of river basins and collection of information on stream flows is developing 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).

Floods have been experienced in recent years in many Angolan urban areas as settlements have developed in an unplanned manner and then unusually high rainfall has flooded these areas. Limited information is available on population and land-use in coastal cities and on the vulnerability of these coastal cities and how they may be affected by climatic hazards. This has 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.

3 RESEARCH FINDINGS

3.1 Improve Knowledge on Rainfall Patterns and Hydrology in Coastal Areas

Summary of activities in this period.

Satellite-based rainfall estimates' data - collaboration with the TAMSAT programme of Reading University (UK) has given access to another source of satellite-based rainfall estimates' data: Development Workshop's historic station data is being used to improve calibration of TAMSAT's data for the Angola region.

Further written records of notable climate events and notable flooding, erosion or drought events have been collected from newspapers, emergency bulletins and food security bulletins.

Oral history collection about notable climate events and notable flooding, erosion or drought events from recent years have been completed in Luanda but are still in progress in Cabinda, Benguela and Lobito.

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, organised and referenced spatially and temporally and with source information) has been created. Good progress has been made with adding information to this database, though some further records may be added.

A draft paper has been completed about annual, seasonal and monthly means of rainfall and about variability of rainfall in Angola. This paper uses station data, both historic and recent. There is still further work to do to be able to use satellite-based estimates of rainfall.

Work has begun on identifying linkages between events (such as droughts and flooding) and fluctuations in the Benguela Current and other circulation trends and outside factors. Some collaboration has been obtained with climate scientists. Further inputs from oral histories and satellite-based rainfall estimates may be needed to take this further forward.

3.1.1 Obtaining and Digitalisation of Existing Rainfall Data

The process of setting up meteorological stations in Angola in the early 20th century was very slow, and it was only in about 1940 that a real effort was made to improve coverage of all areas of Angola and to ensure a continuous record at meteorological stations (reducing the number of gaps in records at any particular station). Up to that date Angola had considerably fewer stations recording rainfall than neighbouring countries and other Portuguese colonies: in 1935 Angola was listed as having 23 stations recording rainfall while Mozambique had 66. The supervision of the collection of rainfall data was poor up until the 1940s (as is admitted in contemporary reports) and there are a considerable number of gaps in the records. The network of stations collecting rainfall data ceased to function in 1975 and there is still not a fully functioning network of stations throughout the country. There is thus only a period of about 30 years (between the early 1940s and 1975) for which there are reasonable rainfall records.

There is only a complete rainfall record for Luanda (where data is available since 1880 save for a one year gap). A number of other stations were set up in a few important cities on the coast and the central plateau in 1913, but after 3 to 5 years these ceased to function. Other stations were set up along the Benguela Railway soon after but, if they continued to collect data, this was not centralised and only a few years of data are available. No scans have as yet been located for the years 1920 to 1926, and the records for this period at the UK Meteorological Office are on crumbling paper. Thus the data pre-1940 for stations outside Luanda have significant gaps, so analysis can be challenging. It is, however, potentially an important database of the rainfall records of Angola.

Historical rainfall data from 109 stations in Angola have been obtained first eighteen-month period of the project. A digital database in Access has been created. The 109 stations selected are throughout Angola though with a bias towards coastal areas of Angola, which is the focus of the project and because there tend to be longer records for areas closer to the coast. Stations have been chosen on the basis of the completeness of the record at that station, coverage of various areas of the country and inclusion in previous analyses (to allow comparison)¹.

The database is being further developed as a tool that might be of use in future for partner organisations, as it could contain (with further development) a unique record of monthly rainfall data in Angola and be programmed to easily add data when available and to provide monthly, seasonal and annual parameters simply.

The starting point was an existing digitalised database obtained from Namibia, which was used for analysis of rainfall patterns in Namibia in 1999, but which does not include stations in the north of Angola. The Climate Explorer digital records of monthly rainfall were also used for some stations in the north of Angola. Both sets of digital records were checked against records at the UK Meteorological Office (on paper) or against the scans available on the NOAA² website. Although no scans are available of monthly rainfall data for the years 1920 to 1926, and from 1954 onwards (and this has been confirmed by NOAA) the archive staff at the UK

¹ Such as Serviço Meteorológico de Angola “O clima de Angola”, Luanda (1955). Also Dr Dário X Queiroz “A variabilidade das chuvas em Angola”, as Serviço Meteorológico de Angola, Luanda (1955)

² The National Oceanic and Atmospheric Administration of the United States Government, which has a National Climatic Data Centre responsible for compiling global weather records.

Meteorological Office were able to assist with access to the relevant paper records. Some of the data on Climate Explorer would appear to be unreliable as, for some years where Climate Explorer shows data, no published records could be found and the monthly rainfall factors are all factors of 10; these data have been excluded as there is a lack of clarity of their origin. The data from these 109 stations, along with data from stations near the border of Angola in Namibia, Zambia and southern parts of the Democratic Republic of Congo, have been used to produce maps and carry out an analysis of historic rainfall patterns. (The number of stations included in the database has been increased in the third six-month period of the project, both in Angola and in neighbouring countries, so as to provide a more complete database for other potential users of the data and to improve coverage of the country and neighbouring areas.)

Further rainfall data are being sought where it is of direct relevance to the project. Data for 10-day periods or daily data are available locally for stations in the project area, such as Cabinda. Daily data from other stations (Waco Kungo, Chianga) have been obtained. Data for stations along the Benguela Railway, which have not been centralised, may be available enable a closer analysis to be done of the way in which rainfall, and variability changes with distance from the coast.

3.1.2 Calculation, Mapping and Graphing of Means and Variations of Existing Rainfall Data

A process has been set up to analyse the database of historic rainfall records, taking into account the large number of gaps in the records. This process is being used to calculate monthly, seasonal and annual parameters. The main indicators being calculated are:

- Mean
- Median
- Difference between mean and median as a percentage of the median
- 25th percentiles
- 75th percentiles
- Coefficient of variation
- Anomalies from Conrad's normal Relative Variability³
- Seasonal rainfall as a percentage of annual rainfall.

A draft working paper has been completed. The paper confirms what is known about the mean rainfall in different areas of Angola (that it declines from north to south, that there are large differences between coastal areas and inland areas, and that the rainfall increases rapidly going inland from the coast as the effects of the cool Benguela Current decrease). The analysis of station data also shows, however, that in going inland from Benguela and Lobito, rainfall increases as far inland as the town of Cubal, then declines slightly, then increases again further

³ Conrad V. "The Variability of Precipitation". Monthly Weather Review, January 1941, pp 5 – 11.

inland from the town of Ganda: this phenomenon is not obvious on most rainfall maps of Angola where the smoothing of data has hidden this feature .

The paper pays particular attention to the indicators of variability because little work has been done on the variability of rainfall in Angola since the work of Queiroz in 1955⁴, and because it is the variability of rainfall that is an important factor in flooding (and also in droughts) as it is associated with the occurrence of large amounts of rain in infrequent, and irregular, heavy storms. The results in the working paper show that rainfall is low along the coast but that variability from one year of rainfall to another is high along the coast of Angola (and significantly lower inland). Variability increases from north to south along the coast. This is unsurprising because it has been known since Conrad's analysis in the 1940s that, globally, coastal areas where the weather is influenced by ocean currents tend to have high year-to-year variations: small shifts in the ocean currents can lead to significant changes in rainfall.

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.

As well as using the Coefficient of Variation as an indicator of variability of rainfall, anomalies from Conrad's Normal Relative Variability have been used as an indicator of variability of rainfall. The general pattern of variability revealed is similar using the two indices. However the Coefficient of Variation has 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 values decline less rapidly inland, drawing attention to areas such as 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.

An analysis has also been carried out of the patterns of year to year variation of rainfall. This shows that there is a tendency for stations in the coastal areas of Angola to have rainfall in the same years and to have low rainfall in the same years, and for there to be some linkage with years that have been identified as years of Benguela Niños⁵. Thus there is a period of years in the mid-1970s where rainfall tended to be higher than average in coastal areas of Angola and 1995 was a high rainfall year; these are years considered to be Benguela Niño years. There is no apparent correlation with El Niño itself even in inland areas of Angola which are close to the area of eastern southern Africa where rainfall is related to El Niño. However areas that may be expected to be affected by El Niño, in south-east Angola, has few rainfall stations so with historic data it is difficult to assess the spread of the influence of El Niño.

⁴ Dr Dário X Queiroz (1955) "A variabilidade das chuvas em Angola", Serviço Meteorológico de Angola, Luanda.

⁵ The Benguela Niño is a pattern of variation in sea temperatures in the south Atlantic near the coasts of Namibia and Angola that in some of the literature is said to be similar to El Niño itself, which affects mainly the Pacific and Indian Ocean basins. However the pattern of variation is not the same as El Niño. Some of the literature posits a correlation between higher sea temperatures off the coasts of Angola and Namibia and higher rainfall in western Namibia and Angola. This would not be surprising given that, globally, coastal regions influenced by sea currents have variable rainfall and small changes in the sea currents can have important effects on rainfall.

It should be noted though that there is not a 100% correlation between rainfall patterns at stations in coastal areas of Angola, and that there are other factors in play. The year 2001 is cited as being a Benguela Niño year, but rainfall in Namibe was not high in that year. Rainfall occurs in isolated heavy storms, which may not occur at the place where rainfall is being measured. There was flooding in Namibe in 2001, which probably was due to heavy rainfall inland while no rain occurred at the coast. Recent research suggests that patterns of variability of sea temperatures may be different off the coast of Angola compared to areas of the Benguela Current further south, and that there may be differences in trends in temperature between cool and warm seasons. Thus further study is required of these patterns of variation.

3.1.3 Obtaining of Satellite-based Measures of Cloud Cover and Precipitation for Recent Years

Satellite-based estimates of decadal, monthly and annual rainfall per 8x8 kilometre cell for the whole country have been obtained, covering the years 1996 – 2012, from FEWS. This was used to create a database of monthly, seasonal and annual rainfall totals for the first 55 locations that have been chosen for historic rainfall data (as in section 1.2). A preliminary analysis of the data indicated that there may be particular difficulties in using satellite-based measures for estimating rainfall in coastal areas of Angola: for some of the locations the estimates from satellite-based measures of cloud cover and precipitation for recent years do not correspond with the historic station data. This may be because this method infers rainfall measures from cloud cover and cloud temperatures: the coast of Angola has almost continuous cloud cover throughout the year but very low rainfall. The methodology of satellite-based estimates has 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 and rainfall is linked to changes in air temperature and sea surface temperatures. These difficulties were investigated and revised data have been obtained from FEWS. The utility of these data for investigation of coastal rainfall patterns in Angola in the last 30 years are being studied.

Contact has also been made with the TAMSAT research group at the University of Reading in the UK to discuss the use of satellite-based measures in this project.

<http://www.met.reading.ac.uk/tamsat/about/>

It has emerged that there has been no checking of satellite-based measures against station data in Angola because station data for Angola has not been generally available for the recent years for which satellite-based measures are available. Development Workshop has some post-1975 monthly station data for Angola and a database of historic pre-1975 monthly station data. TAMSAT studied satellite-based rainfall measures for the Southern Africa region and showed that estimates for Angola were poorly calibrated compared to the rest of the region due to the lack of station data. TAMSAT is at present recalibrating estimates for Angola, using station data made available by Development Workshop. For interior regions of Angola this would involve an extension of the methodology used in the rest of the Southern Africa region, as interior regions of Africa have rainfall linked to the passage of the ITCZ. For coastal regions of Angola some methodological innovation is required as rainfall is linked to other mechanisms.

3.1.4 Rainfall Means and Variability Mapping from Satellite-based Measures of Cloud Cover and Precipitation

The plan is to calculate from these data the same indicators as from historic rainfall data, and to look at year-to-year variations. The fit of the satellite-based measures (from two sources) with historic data is currently being checked and, when this has been completed, a database will be created and analysis of rainfall means and variability will be carried out (in a similar fashion to that used for historic rainfall data records).

3.1.5 Collection of Written Records of Notable Water and other Climate Related Activities

Information has continued to be extracted from paper documents held by Development Workshop from the post-Independence period (newspapers, emergency bulletins, food security bulletins). These cover the period from the mid-1980s to recent years, and have qualitative information about droughts and floods in Angola. More recent information from local newspapers, held as scanned information, has also been extracted, and this is continuing as more sources of information are identified. Examination of the information shows that it can be used to pinpoint significant events and, although these newspapers and bulletins do not provide exact information about these events (often being vague about the exact location or importance of an event) they provide a starting point for investigation through other methods. More information is available for recent years, for which station rainfall data are less readily available; however comparison with satellite-based measurements will be attempted when this is available

3.1.6 Collection of Oral Histories from Key Informants of Notable Water and other Climate Related Activities

The case study of the flooding in Cacuaco (Luanda) in January 2007, reported in the first six-month report, was followed-up with a wider study of flooding and storm-damage in Luanda as a whole. There was a very heavy rain storm in Luanda in late January 2007, which caused serious disruption. Some houses in Cacuaco were washed away and there were changes to the course of a river and the coast. The area of interest has been extended as has the time-frame. The study suggests that, despite recent significant improvements to drainage in Luanda, there are still frequently flooding issues. Collection of similar case-studies in Cabinda and the Benguela – Lobito conurbation is being carried out.

The use of oral histories from key informants, local residents who witnessed the flooding, is linked to other methods such as extracting images from Google Earth before and after the flooding, and collection of media reports and photos and videos of events. Case studies of this type show that local people have clearer information than is contained in press reports or official reports, and that this can assist analysis of the factors contributing to environmental risks.

3.1.7 Creation of a Database of Notable Water and other Climate Related Events

Information that has been collected from various sources about important water and climate-related events is being inputted into a database for each year. The database shows the type of event (flooding, drought, river or flood erosion, sea erosion from high seas), the date, the location and the source of information. This is on-going as more information becomes available.

3.1.8 Correlations of Events from Annual Variations and Notable Events to ENSO and Fluctuations in the Benguela Current.

A literature review has shown that most areas of Angola are unlikely to be affected by ENSO, though 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. Analysis of the rainfall patterns from satellite-based data for recent years (and from the local newspapers, emergency bulletins, food security bulletins) should show whether this is the case.

A literature review has shown that the years of high sea temperatures (and high rainfall) along the coast of Angola are different from years of high sea temperatures (and high rainfall) along the coast of Namibia. A preliminary analysis of the historic rainfall records for coastal areas of Angola shows that there is a clear pattern of high rainfall and low rainfall years for coastal areas of Angola (and that this pattern does not apply in inland areas of the country). The analysis confirms the pattern in previous literature (from the 1980s) about coastal rainfall patterns in Angola and confirms that the pattern in Angola is different from the pattern in Namibia (though in recent years that have been some years in which high rainfall in coastal Angola coincided with high rainfall in coastal Namibia).

A more thorough analysis will be possible when there is more information in the database of notable events and from satellite-based measures of cloud cover and precipitation for recent years.

3.1.9 Obtaining of Existing Data on Vegetation, Geology and Flows of Relevant River Basins

The National Institute of Water Resources has a database that contains good quality digitalised records of river flows from the 1960–1975 period, and is making it available for use in this project.

During the 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 Cabinda and Luanda have been obtained, and maps for Benguela/Lobito are being sought.

3.2 Production and Dissemination of Information about Settlement Patterns, Population Densities and Water Resource Management Relative to Policy, Socioeconomic and Climatic Dynamics

Summary of activities in this period.

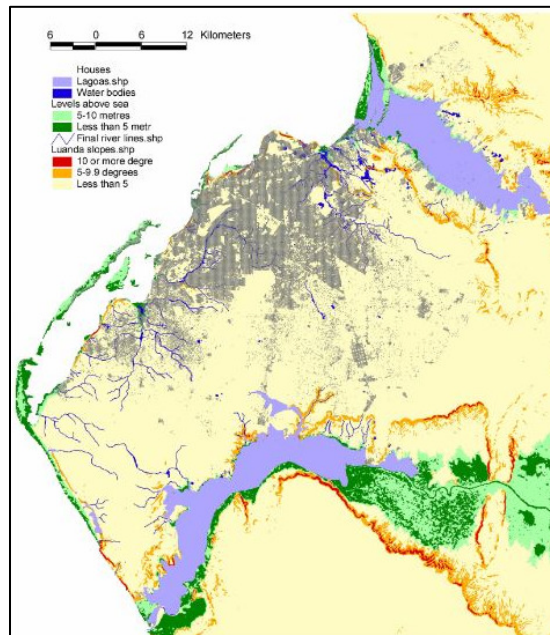
Up-to-date satellite images of Luanda have become available and the definition and delimitation of zones of the urban area have been completed, including new areas of the city. Definition of the urban areas of Cabinda, Benguela and Lobito was carried out previously as recent images were more easily available and growth of these cities appears to be slower.

The present urban area of Luanda has been mapped and information on the past urban area is being collected. Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas.

Data on the number of people per structure in Luanda are available from the household survey carried out earlier. Structures in each zone have been counted and estimates of population have been made. Estimates of population agree closely with the preliminary results from the recent National Census (the first since 1971), which suggests that the method of population estimate from the methodology developed by Development Workshop provides good estimates of population.

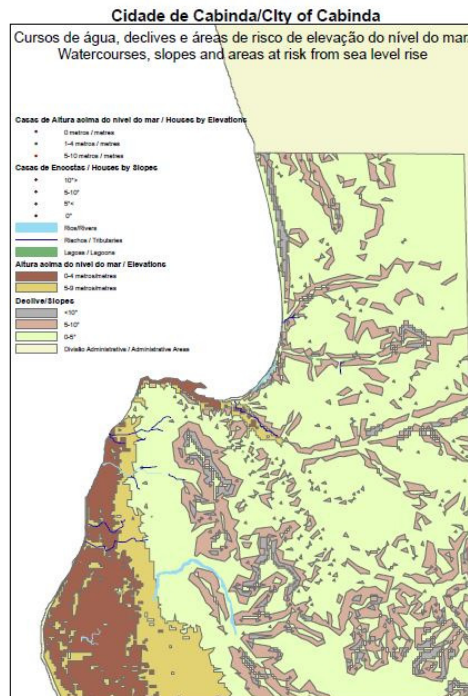
The satellite images and field observation have been used to prepare a map of Luanda that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators. For Luanda, areas that are at risk from flooding and erosion under plausible range of future changes, areas at risk from sea-level rise and salt-water intrusion (under present and possible future conditions) are being mapped.

For Luanda description of, and mapping of, environmental vulnerability is in progress. Satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.



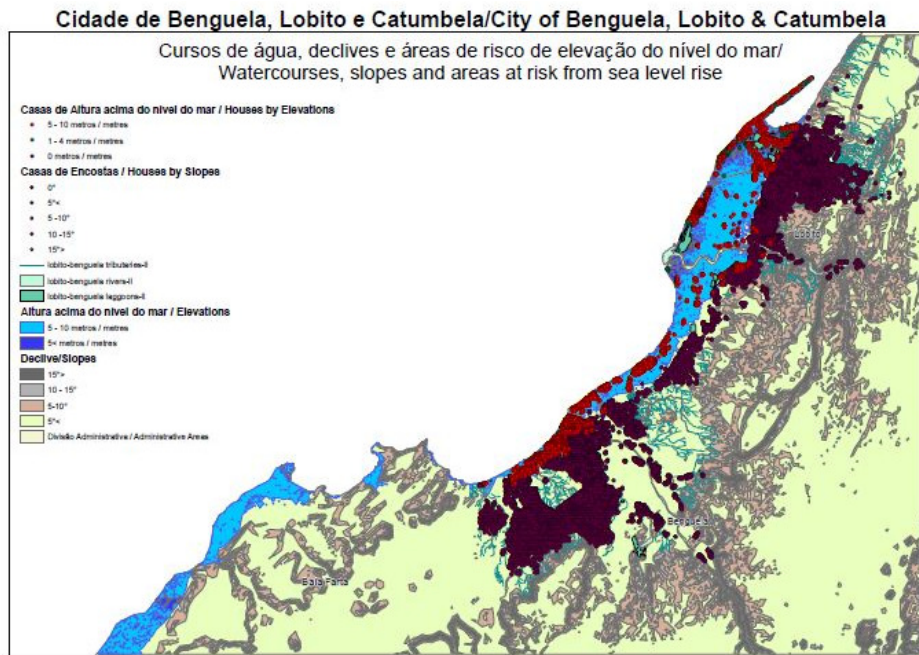
For Luanda, a working paper is being prepared on how water is being supplied, describing the supply chains, prices at various stages of the supply chains, organisation of water markets, quality, reliability and price (and variation of these attributes by season and by year).

For Cabinda demographic analysis is underway. Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas. Roof-top counting has been carried out. Population estimates are being made. Information from the household questionnaire survey has been analysed for this purpose and a working paper on the social characteristics of Cabinda, the distribution of population and poverty levels is being prepared. The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas of Cabinda and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators. A base map has been prepared for examining the correlation between different hazards and between hazards and socio-economic vulnerability.



For Benguela and Lobito demographic analysis is underway. Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas. Roof-top counting has been carried out. Population estimates are being made.

In Benguela and Lobito a household surveys has been carried out providing information on the number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price. The household surveys in Benguela and Lobito took place soon after the national census has been completed, with a sample size of 1500. A questionnaire was used with questions about number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price. Data have been analysed and a working paper is being prepared on socio-economic indicators, social characteristics, distribution of population and poverty levels. Description of, and mapping of, environmental vulnerability is in progress. The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.



Information about the water-supply system of Benguela and Lobito has been collected and a working paper on the system is being produced. A rapid survey of water prices has been carried out. The resulting information is being written up and mapped. Testing of water quality is still being planned. A working paper is being prepared describing the water system and key indicators of water supply in Cabinda.

3.2.1 Obtaining of Satellite Images of Relevant Research Areas

Satellite images of all three urban areas have been obtained. Satellite images of Luanda became available (without cloud cover) when cloud cover decreased after April 2014. (Rainfall is highest in April in Luanda but is much less from May onwards.)

3.2.2 Delimitation and Housing Typology Mapping from Satellite Images

Satellite images, coupled with information from on-site observations and interviews with key informants have been used to delimit zones of all the relevant research areas with similar dates of construction and social characteristics, creating a housing and neighbourhood typology. In all the cities, satellite images were available and the delimitation of zones was carried out using remote sensing techniques as well as on-site observations and interviews with key informants.

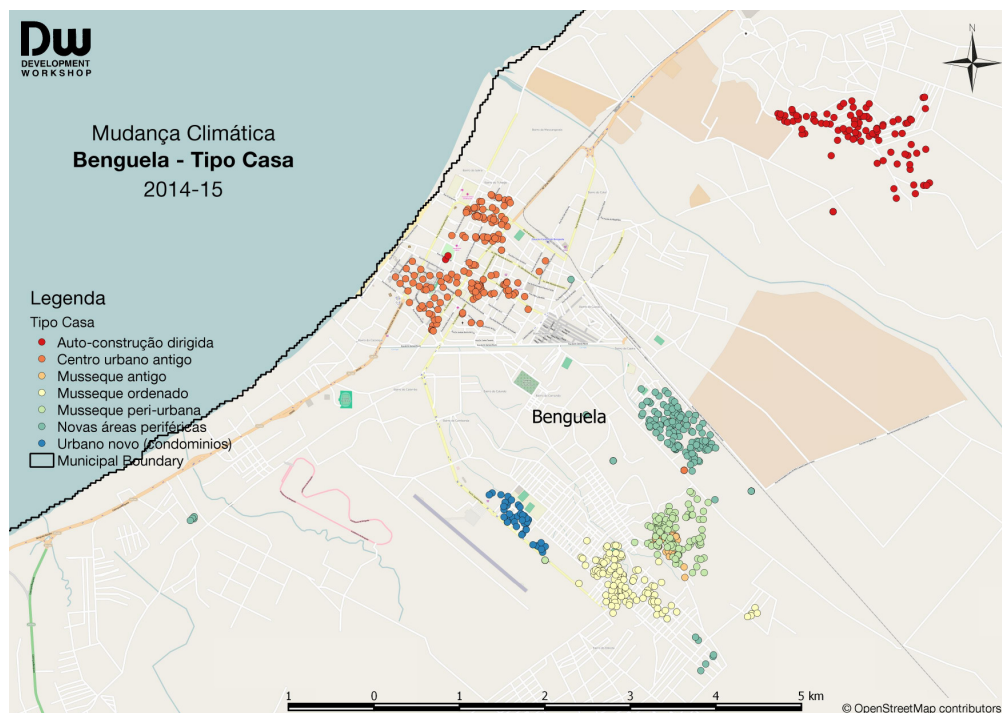
Mapping of rooftops on the satellite images to make a count of the number of structures in each delimited zone (to be then used in conjunction with data on number of people per structure to estimate population numbers and densities of an area) has been carried out for Luanda, Cabinda and Benguela/Lobito: rooftops on the satellite images have been identified and marked as well as counting of rooftops per area after the delimitation of zones had been completed. The household survey in Cabinda has been completed, and this has provided information on the number of persons per household. It is therefore estimated that the total population in Cabinda is approximately 400,000. Population densities in each settlement type are being calculated.

3.2.3 Household Surveys on Relevant Variables

A questionnaire for the household surveys was designed and tested in the first six-month period. A decision was taken to use hand-held electronic devices (Android tablets) for administering the household surveys; this would reduce paper use and speed up considerably the process of transferring survey data to a database. This would then also allow more rapid checking of the quality of the data through examination of the database while under construction. The pre-loading of the questionnaire skip-pattern into the questionnaire on the devices simplifies the task of the interviewers in finding their way through the questionnaire in the field.

The hand-held devices were acquired and loaded with the program that allows loading of the questionnaire and transfer of the data to the database after data collection (and subsequent download to XL, SPSS or Stata for data analysis). A server was prepared for holding the databases. A consultant was hired for training in these processes and Development Workshop staff can now carry them out on their own. The use of hand-held devices with the questionnaire was tested in the field, checking the logic and the skip pattern as well as the ease of use of the tablets and the questionnaire.

Preparations were made for starting fieldwork in Luanda and Cabinda during the second six-month period, with further amendments made to the questionnaire, as well as further amendments to the field-work and data-retrieval processes to take account of the special characters used in the Portuguese language. Field-workers were then trained and instructions finalised. Field-work took place in Luanda in July 2013, in Cabinda in September 2013 and in Benguela/Lobito in June 2014. The division of the urban areas into a typology of housing types was used as the sample frame and points at which interviews should be carried out were defined. More than 2000 interviews were carried out in Luanda, 1000 interviews in Cabinda and 1500 interviews in Benguela/Lobito.



It was found that the use of hand-held Android devices did simplify field-work for this kind of questionnaire survey. The pre-loading of the questionnaire skip-pattern into the questionnaire on the devices simplifies the task of the interviewers in finding their way through the questionnaire in the field. Uploading of completed questionnaires to the database was carried out successfully, though this uploading from Cabinda did sometimes have to wait for internet capacity to be available. This is because uploading of the questionnaires on the tablets and downloading of completed questionnaires to the server database depended on internet connectivity. Since the team in Cabinda only depended on 3G internet services, oscillation in the 3G signal affected the progress of the process.

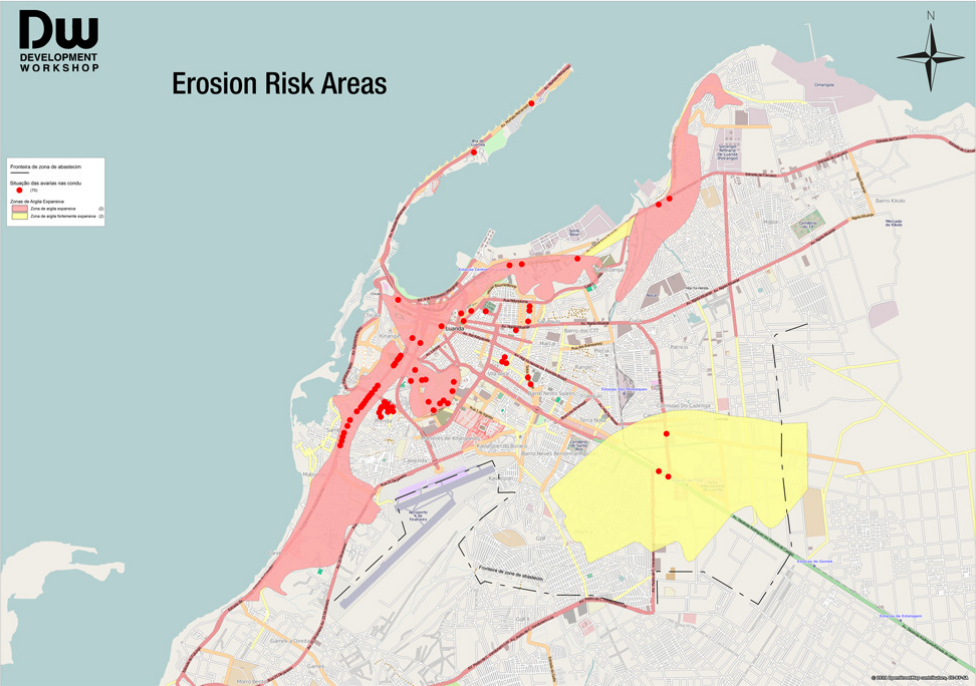
The databases for all three cities have been cleaned and analyses of the data have been carried out.

3.2.4 Counting of rooftops on satellite images and population estimates

Counting of rooftops has been carried out for all three urban areas. The household surveys in all three urban areas provide an estimate of the size of household. Population estimates are being made for all three urban areas.

3.2.5 Mapping of flood risk areas and erosion risk areas.

Maps are being compiled for all three urban areas to show populated and urbanised areas, flooding zones, flood risk zones and erosion risk zones.



3.2.6 Household and Key Informant Surveys on Water and Associated Social Services

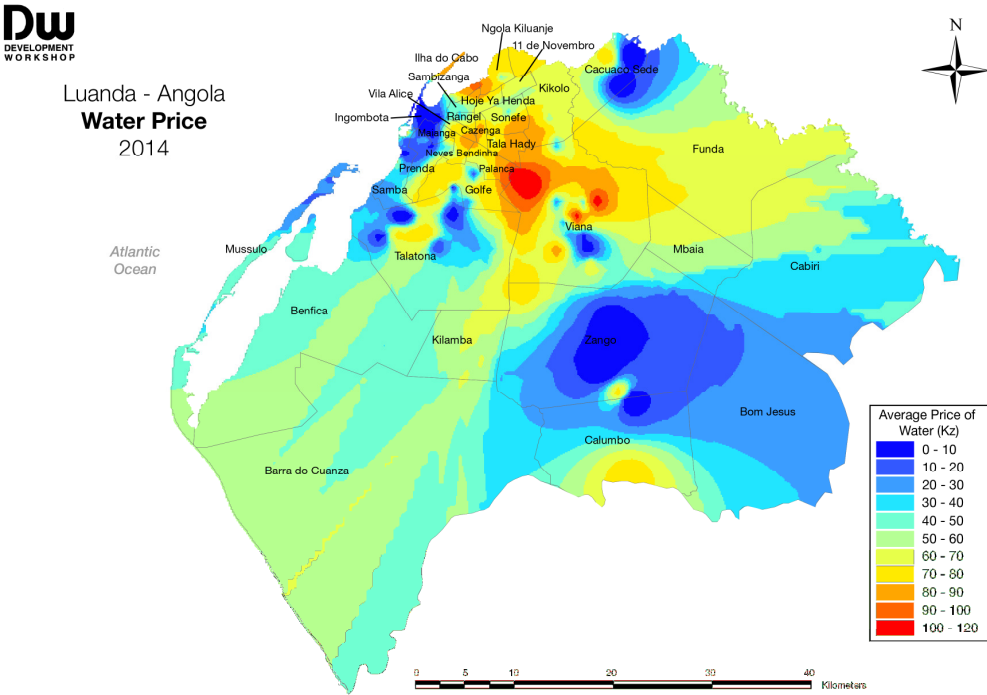
During preliminary field visits to Cabinda and Benguela/Lobito in February and March 2013 information was collected about primary water systems in those cities and the areas that they serve. A number of meetings were held with key informants in both regions to set out platforms for in-depth key informant interviews and household surveys on these variables in the next reporting periods. These will be triangulated with information from the household surveys.

In Luanda the collection of this information using key informant interviews was carried out and is being analysed.

3.2.7 Rapid surveys of water prices

Rapid surveys of water process have been carried out in all three urban areas as part of the preparation for the household surveys.

Luanda Water Prices:

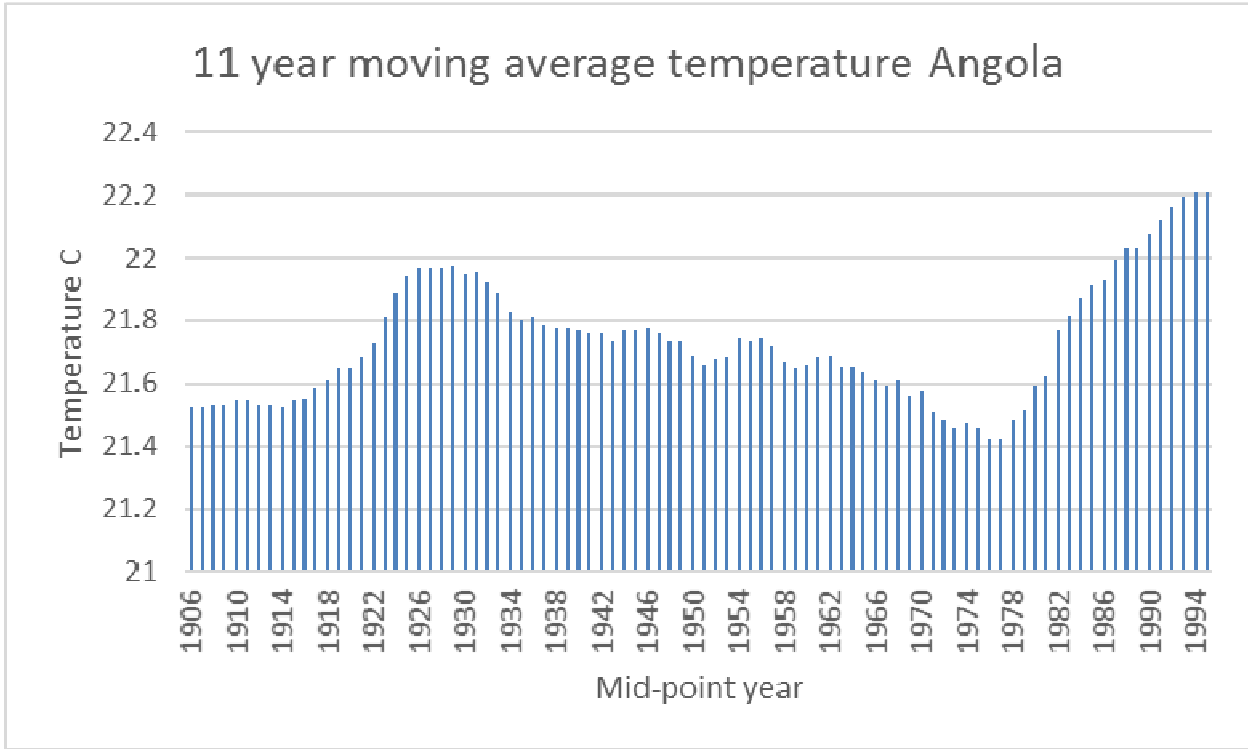


3.2.8 Tests of the quality of water will have been carried out.

Testing of water quality is still being planned.

Temperature

The initial design of this research project did not focus much on temperature, although it is clear that temperature is directly related to cloud cover and rainfall. 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 years⁶. To give a general picture, the graph below shows the variation of annual average temperature for the whole of Angola as drawn from the World Bank’s climate change portal. As indicated in several sections of this interim technical report, many meteorological stations have not been functional for more than 30 years.



Source: the World Bank climate change portal

The project has obtained temperature data from Cabinda and these have been analysed. The 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.

⁶ IPCC. Climate Change 2014: Impacts, Adaptation and Vulnerability. Technical Summary (Figure TS5, pp 64-65).

4 PROJECT IMPLEMENTATION AND MANAGEMENT

4.0. Progress Summary

The scope of the project remains unchanged and progress continues to be made in the fourth six-month period. There has been no change in the approach or methodology, and the fact that the examination of the available rainfall and hydrological data show gaps and raise questions confirms the rationale of applying the methodology of using field surveys, key informant interviews and oral histories to complement the patchy “hard data”.

There is no reason to expect that the project will not be completed on time. Relations have been and more are still being established with relevant institutions. Existing rainfall and other relevant data have been collected, databases are being created, data have been analysed and a working papers has been completed. Field-work (household questionnaire surveys) has been carried out in all three urban areas and the data from these has been analysed. Progress with analysis of rainfall data is ahead of schedule. Progress with activities dependent on the household questionnaire surveys and on the use of satellite images from Luanda was behind schedule; time has been invested in setting up a system of data collection using electronic devices, which delayed the field-work but will make future data-collection easier and faster. Also suitable up-to-date satellite images for Luanda were not been available for some time but are now available.

Some Progress and achievement were made during the last 6 months of the project:

- 1) There was good progress with creating a database of gauge rainfall data for Angola and surrounding areas and analyzing rainfall variability. There were difficulties in using satellite-based estimates of rainfall, but the University of Reading (UK) has agreed to try to adapt the methodology and there are therefore good prospects of using these estimates in the final year of the project.
- 2) The holding of the first full census in post-independence Angola delayed some of the questionnaire-based fieldwork. There were also difficulties in obtaining adequate satellite images of Luanda. However questionnaire-based fieldwork has now been carried out in all urban areas of this project and satellite images obtained for all urban areas. Population estimates for all urban areas are being made, as well as mapping of environmental risks and socio-economic analysis.
- 3) Following the completion of questionnaire-based fieldwork in all the urban areas of this project, there was good progress with analyzing the water systems of all the relevant areas.

In the next six-month period the main activities will be continued analysis of satellite-derived rainfall data, the preparation of outputs suitable for presentation to local institutions and preparation of reports.

4.1 South-South Exchanges and Visiting Scholar Programme

A relationship has been developed with the Climate Systems Analysis Group at the University of Cape Town. CSAG are interested in daily meteorological data for any station in Angola for a recent 10 year continuous period as an input to modelling, and Development Workshop is seeking this data from a number of stations. This is not yet available centrally from INAMET (the Angolan meteorological service) and is being sought at individual stations. Development

Workshop has obtained data from Chianga Agricultural Station near Huambo (Huambo Province, central highlands of Angola) and has made it available to CSAG, who are evaluating the data and transforming it into a standard format and will advise the team on future data collection and formatting. Although CSAG has not as yet communicated how useful the data provided from Angola is to the modelling, prospects are that this and a few other South-South programmes yet to be implemented will enhance skills in the DW research team and strengthen institutional cooperation.

On-going collaboration with the Climate System Analysis Group at the university of Cape Town on modelling will depend on Development Workshop being able to secure additional financing for the project. Funding is being sought for this but there is no guarantee that funding can be raised for this purpose.

4.2 Consolidation of Relationships with Relevant Government and Civil Society Institutions

Summary of activities in this period.

Strong relations have also been established with the Centre for Tropical Ecology and Climate Change (Centro de Ecologia Tropical e Alterações Climáticas –CETAC) based in Huambo. This institution is charged with analyzing climate and meteorological information for Angola. Previously there has been no institution with this remit and INAMET did not consider it part of its duties.

A CETAC conference was organized to take place in the town of Huambo in mid-2014 aimed at assessing the current situation and prospects with respect to climate change and sustainable development in Angola. Development Workshop's draft paper using relevant station data was presented at the conference. This aroused interest and may the paper and its analysis may form the basis for future climate analysis by CETAC.

Previous activities

A good relationship has been 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 staff in that Directorate. In the last twelve months DW has engaged more with the Climate Change Section of this Directorate as they sought to understand how best they would utilise DW's contribution to the effort to set up an early warning system to the drought/flood situation in South-West Angola.

A good relationship has also been developed with the National Water Department (Direcção Nacional de Águas - DNA), which is responsible for domestic and industrial water supply throughout the country, and with the National Institute of Water Resources (Instituto Nacional de Recursos Hídricos), which is responsible for river basins and their management and use throughout the country. Besides the application of the Community Water Management Model (Modelo de Gestão Comunitária da Água) in which DW has been taking the lead, there has also been engagement over the last few months with the same institutions in the optimisation of the

Sector Information System for Water and Sanitation (Sistema de Informação Sectorial de Água e Saneamento - SISAS).

In Cabinda meetings have been held and relationships established with Provincial Directorates for Water (Direção Provincial das Águas); Territorial Administration, Urbanism and Environment (Direção Provincial de Ordenamento do Território, Urbanismo e Ambiente); Provincial Office for the Meteorological Institute (Gabinete provincial do INAMET); and the Provincial Division for the Fire Department (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 made with similar institutions but relations are yet to be built, although conversations on disaster and other data sharing with the Rapid Response Team of the Fire Department are quite advanced. These provincial government sectors sent two representatives to participate in the household survey data collection in the last six months.

Relationships have also been established with the Catholic University's Research Centre and more are yet to be established with Augustinho Neto University's Faculty of Science as well as the Methodist University's Faculty of Architecture and Environmental Studies.

Strong relations have been established with the Centre for Tropical Ecology and Climate Change (Centro de Ecologia Tropical e Alterações Climáticas –CETAC) based in Huambo. This centre was inaugurated in November 2012 with the aim of carrying out studies and research in general on climate change, the preservation of natural resources and ecosystems. It addresses such issues across the country with special focus on areas or regions experiencing current climate related or environmental disasters. With regards to this, a conference is being organized to take place in the town of Huambo at the end of January 2014 aimed at assessing the current situation and prospects with respect to climate change and sustainable development in Angola.

4.3 Relevant Media Scan and Information Mapping for Correlations

Summary of activities in this period.

Information from media scanning has been inputted into the data-base on unusual climate events.

Previous activities

Information in the local media on environmental issues continues to be extracted and archived. This has been used as part of an analysis of sea surges showing which places are vulnerable to the effects of high tides and high waves (and when): this will be important for mapping of risks from higher sea levels at a later stage in the project. The collection of Information from the local media has also been used as part of an analysis of incidents of flooding and erosion in urban areas.

We are studying which mapped information will be required and how this will be overlaid when later stages of the project are reached. Variables likely to be overlaid: measures of environmental risk (inundation, slope etc), socio-economic vulnerability (typology and poverty levels) and population density. A settlement typology matrix has been developed and is being projected using remote sensing, and on-the-ground truthing. Typologies are being developed for all three urban areas.

4.4 Financial Mobilisation

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 has become evident in the first reporting period of the project 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 means that the project team needs to re-assess budget requirements. DW is therefore seeking a further \$500,000 for the project. The Angolan Ministries of Environment and Water & Energy have committed to assist us in mobilizing additional resources for the project. A Global Environment Facility (GEF) Project Identification Form (PIF) was developed some time ago entitled "Addressing Urgent Coastal Adaptation Needs and Capacity Gaps in Angola". This was eventually recommended for clearance by the GEF CEO in the second half of 2013, and was approved by the GEF council during the first part of 2014 (GEF identification number 5230). Discussion have begun regarding the implementation of this project with the strong expectation that the work already carried out and in progress by Development Workshop will feed into this project. This is a full size project. The United Nations Environment Programme (UNEP) is the lead agency with the United Nations Development Programme (UNDP) as the secondary UN agency.

<http://d7.thegef.org/geffsp>

Applications have continued to be made to potential bilateral and corporate donors. The commitment from IDRC to support the project provides potential project financiers with confidence in the quality and pertinence of the proposal and has opened doors for future support. In March 2014 DW made an application to the NEPAD Climate Change Fund for Euros 200,000 but this was unsuccessful.

An application was made in September 2014 to the Climate and Development Knowledge Network's Climate Compatible Development Impact Research Fund (in the UK).

4.5 Budget Forecast Variance

It had been anticipated that DW would have been able to secure additional counterpart funds which would have been applied to the budget lines where expenditures have been the greatest such as Travel. New funds have not yet been secured, which may mean that DW will request permission from IDRC to readjust some of the lines in the budget.

5 PROJECT OUTPUTS AND DISSEMINATION

A presentation was made by Afonso Cupi Baptista, Development Workshop's water sector manager entitled 'Alterações Climáticas e Água Urbana' at the Symposium on Water in Portuguese – Speaking Countries in Maputo Mozambique between 27th and 30th of May 2013. The presentation is found at: <http://www.dw.angonet.org/forumitem/500>

Another presentation was made on July 19, 2013 in Luanda where two of the University student interns taking part in the project, 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. The ppt material and audio file can be found at: <http://dw.angonet.org/forumitem/762>

Another presentation was sent to the International Conference on Development and the Environment that took place in Lobito on October 1 and 2, 2013 with the title: "Urbanisation, Environment and Climate Variability in Angola". In the meantime, a member of the DW research team attended another conference convened by the Southern Africa Regional University Association at Universidade Agostinho Neto's Faculty of Science to address issues on enhancing Climate Compatible Development capacities.

Two presentations were made to the conference of CEITAC (Centro de Ecologia Tropical e Alterações Climáticas)⁷ in Huambo. The first was an overall presentation of the aims and scope of the project. The second was a presentation of findings about variability and trends in rainfall in Angola based on the preliminary findings of this research.

A presentation was made to the IDRC workshop in Pretoria on climate change and water.

A paper and presentation were made at the Climate Systems' Analysis Group of the University of Cape Town based on the findings of the project. 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.

Presentation materials are on the Development Workshop website.
<http://www.dw.angonet.org/content/climate-change>

⁷ Centro for Tropical Ecology and Climate Change

Achievement of Milestones

Satellite images, rainfall data, vegetation, geology and hydrology data obtained:

Satellite images- Images for Luanda, Cabinda and Benguela/Lobito have been obtained.

Rainfall data – historic data has been obtained for 109 stations and parameters calculated. Data for new stations will be added. A working paper based on data from the first 55 station has been completed.

Satellite-based rainfall estimates' data - Data for Angola from FEWS were extracted from 1996 to 2012, but this is still being checked as calibration and validation have not been previously carried out for most of the Angola region. There is also a collaboration with the TAMSAT programme which has given access to another source of satellite-based rainfall estimates' data: Development Workshop's historic station data is being used to improve calibration of TAMSAT's data for the Angola region.

Vegetation and geology data for the Luanda and Cabinda areas has been obtained. More detailed data for Benguela and Lobito river basins is still being obtained.

Hydrology data for 1960 to 1975 has been obtained from the Institute of Water Resources.

Relations with partner institutions outside Angola established:

A relationship has been developed with the Climate Systems Analysis Group at the University of Cape Town

Forum on Water in Portuguese – Speaking Countries – presented papers at annual conferences in 2013 in Maputo and 2014 in Lisbon.

Relationships with national government and local government institutions established:

A good relationship has been developed with the Ministry of the Environment (National Environment Directorate), National Water Department (Direcção Nacional de Águas-DNA), National Institute of Water Resources (Instituto Nacional de Recursos Hídricos). Good relations have been established with the relevant local institutions in Cabinda.

Strong relations have also been established with the Centre for Tropical Ecology and Climate Change (Centro de Ecologia Tropical e Alterações Climáticas –CETAC) based in Huambo. This centre was inaugurated in November 2012 with the aim of carrying out studies and research in general on climate change, the preservation of natural resources and ecosystems. It addresses such issues across the country with special focus on areas or regions experiencing current climate related or environmental disasters. A conference was organized to take place in the town of Huambo in mid-2014 aimed at assessing the current situation and prospects with respect to climate change and sustainable development in Angola.

Scanning the public, independent and community media being put in place:

Information in the local media on environmental issues has been extracted and copied, and is being analysed

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 will have been collected.

These have been collected.

Oral histories from key informants 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, along with information on contextual information such as changes in vegetation and settlement patterns will have been collected.

Oral history collection has been completed in Luanda but is still in progress in Cabinda, Benguela and Lobito.

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, organised and referenced spatially and temporally and with source information) will have been created.

The database has been constructed through there are still further records to be added.

Annual, seasonal and monthly means and variability of rainfall for each relevant station will have been calculated and mapped from existing rainfall data and satellite-based measures of cloud cover and precipitation. Graphs of annual variations will have been made.

A draft paper using relevant station data has been completed. There is still further work to do to be able to use satellite-based estimates of rainfall.

Information on annual variations and database of notable events will have been used to identify linkages between events (such as high rainfall events and flooding) linkages to ENSO and fluctuations in the Benguela Current. (This will involve looking for trends and, in cooperation with climate scientists, seeking correlations with outside factors).

This activity has been initiated but awaits further inputs of oral histories and satellite-based rainfall estimates to be taken forward.

Using existing river flow data, oral histories and written records, trends and variability in key river basin parameters will have been analysed. A description of key river basin parameters of basins affecting urban coastal areas of Angola, and possible implications of climate change on these basins, will have been made.

This activity has been initiated but awaits further inputs of oral histories and satellite-based rainfall estimates to be taken forward. We also need the river flow data.

Luanda: Satellite images of Luanda will have been obtained. Zones of the urban area with similar dates of construction and social characteristics will have been defined and delimited using examination of satellite images, local observation and interviews with key informants.

Up-to-date images of Luanda have become available and the definition and delimitation of zones of the urban area have been completed, including new areas of the city. Definition of the urban areas of Cabinda, Benguela and Lobito was carried out previously as recent images were more easily available and growth of these cities appears to be slower.

Luanda: The data on number of structures and on number of people per structure will have been used to make an estimate of population, population densities and population trends.

Good quality up-to-date satellite images have become available, and data on the number of people per structure are available from the household survey. Structures in each zone have been counted and estimates of population have been made. Estimates of population agree closely with the preliminary results from the recent National Census (the first since 1971), which suggests that the method of population estimate from the methodology developed by Development Workshop provides good estimates of population, and that this methodology could be of importance for population estimates in areas of rapid growth between censuses or where it has not been possible to carry out a census for some time.

Luanda: Present-day satellite images and any previous mapping of the urban area will have been used to map the current urban area and past growth of the area.

The present urban area has been mapped and information on the past urban area is being collected.

Luanda: Demographic analysis will have been completed, including population figures by area and figures on trends and future scenarios maps of the urban areas, the extent of urban areas at different dates, and maps of growth and densities of population.

Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas. Up-to-date good

quality satellite images are now available for the roof-top counting. Population estimates are being made.

Luanda: Household surveys will have been carried out, ensuring that each identified zone is covered. This will provide information on the number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

The household survey has been carried out with a sample size of 2000, using a questionnaire with questions about number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

Luanda: The clustering of socio-economic indicators in the defined areas will have been checked statistically to refine the definition of zones.

Data have been analysed and a working paper is being prepared.

Luanda: Socio-economic description and mapping of, social characteristics and indicators, distribution of population and poverty levels will have been completed.

Information from the household questionnaire survey has been analysed for this purpose and a working paper on the social characteristics of Luanda, the distribution of population and poverty levels is being prepared.

Luanda: Satellite images and field observation will have been used to map the main and critical features, and to delimit and map flood areas that have experienced flooding, slopes that have experienced erosion in the past.

The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Luanda: Areas that are at risk from flooding and erosion under plausible range of future changes, areas at risk from sea-level rise and salt-water intrusion (under present and possible future conditions) will have been mapped. This will have been cross-checked with oral history of past events and their impact.

Good quality up-to-date satellite images have become available and areas at risk are being mapped.

Luanda: Description of, and mapping of, environmental vulnerability will have been completed, which will include maps of risk zones under present and future conditions and descriptions of events and risks and impacts; .also a comparison with population distributions and social conditions.

Up-to-date good quality satellite images are now available and this is in progress. The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Luanda: Key informant surveys about water supply systems in the relevant coastal urban areas will have been carried out. The structure and use of the water supply system will have been observed, noted and mapped. .

The relevant information has been collected about the water system.

Luanda: A rapid survey of prices of water in various areas will have been carried out and this information will have been mapped.

The survey of water prices has been carried out and data have been analysed.

Luanda: Tests of the quality of water will have been carried out.

Testing of water quality is still being planned.

Luanda: From the household survey, key informant interviews, observation, water quality data and price mapping, how water is supplied will have been documented, describing the supply chains, prices at various stages of the supply chains, organisation of water markets, quality, reliability and price (and variation of these attributes by season and by year).

Information from the household questionnaire survey has been analysed and a working paper has been prepared.

Luanda: An assessment will have been made of how present and possible future climatic conditions (variability and possible trends) impact on water supply systems for urban areas and thus on water markets, water access and affordability.

This has not yet been started.

Luanda: The existing water supply systems will have been examined and options proposed for better water systems governance, analysing how technical and policy innovations could improve access and affordability and ease adaptation to possible future conditions.

This has not yet been started.

Luanda: Mapped information will have been superimposed to examine correlations, in each urban area, between different variables. A series of maps will have been produced, that combine the maps that form part of the other outputs, using the maps as layers, to

allow analysis of the possible geographical overlap between different hazards and between hazards and socio-economic vulnerability.

A base map is being prepared and the data for the various layers have been compiled and analysed.

Cabinda: Satellite images of Cabinda will have been obtained. Zones of the urban area with similar dates of construction and social characteristics will have been defined and delimited using examination of satellite images, local observation and interviews with key informants.

Defining the typology of urban areas of Cabinda has been carried out as recent images are available. Mapping of current areas and urban growth has been completed, and structures have been counted.

Cabinda: Counting of rooftops on the satellite images will have been carried out, to make a count of the number of structures in each delimited zone

Roof-top counting has been carried out, by zone.

Cabinda: Present-day satellite images and any previous mapping of the urban area will have been used to map the current urban area and past growth of the area.

The present urban area has been mapped and information on the past urban area is being collected.

Cabinda: Demographic analysis will have been completed, including population figures by area and figures on trends and future scenarios maps of the urban areas, the extent of urban areas at different dates, and maps of growth and densities of population.

Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas. Roof-top counting has been carried out. Population estimates are being made.

Cabinda: Household surveys will have been carried out, ensuring that each identified zone is covered. This will provide information on the number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

The household survey has been carried out with a sample size of 2000, using a questionnaire with questions about number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

Cabinda: The clustering of socio-economic indicators in the defined areas will have been checked statistically to refine the definition of zones.

Data have been analysed and a working paper is being prepared.

Cabinda: Socio-economic description and mapping of, social characteristics and indicators, distribution of population and poverty levels will have been completed.

Information from the household questionnaire survey has been analysed for this purpose and a working paper on the social characteristics of Luanda, the distribution of population and poverty levels is being prepared.

Cabinda: Satellite images and field observation will have been used to map the main and critical features, and to delimit and map flood areas that have experienced flooding, slopes that have experienced erosion in the past.

The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Cabinda: Areas that are at risk from flooding and erosion under plausible range of future changes, areas at risk from sea-level rise and salt-water intrusion (under present and possible future conditions) will have been mapped. This will have been cross-checked with oral history of past events and their impact.

The above map has been used to show areas that are at risk from future flooding and sea-level rise.

Cabinda: Description of, and mapping of, environmental vulnerability will have been completed, which will include maps of risk zones under present and future conditions and descriptions of events and risks and impacts; .also a comparison with population distributions and social conditions.

This is in progress. The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Cabinda: Key informant surveys about water supply systems in the relevant coastal urban areas will have been carried out. The structure and use of the water supply system will have been observed, noted and mapped.

Information about the water-supply system has been collected and a working paper on the system is being produced.

Cabinda: A rapid survey of prices of water in various areas will have been carried out and this information will have been mapped.

A rapid survey of water prices has been carried out. The resulting information is being written up and mapped.

Cabinda: Tests of the quality of water will have been carried out.

Testing of water quality is still being planned.

Cabinda: From the household survey, key informant interviews, observation, water quality data and price mapping, how water is supplied will have been documented, describing the supply chains, prices at various stages of the supply chains, organisation of water markets, quality, reliability and price (and variation of these attributes by season and by year).

A working paper is being prepared describing the water system and key indicators of water supply in Cabinda.

Cabinda: The existing water supply systems will have been examined and options proposed for better water systems governance, analysing how technical and policy innovations could improve access and affordability and ease adaptation to possible future conditions. A description of, and mapping of, access to and affordability of potable water in coastal urban areas of Angola, together with an assessment of the impact of climatic conditions on water supply and a description of possible innovations and adaptations. This will show, among other information, areas of scarcity of water and high prices and the geographical characteristics of the supply chain.

This has not yet been started.

Cabinda: An assessment will have been made of how present and possible future climatic conditions (variability and possible trends) impact on water supply systems for urban areas and thus on water markets, water access and affordability.

This has not yet been started.

Cabinda: Mapped information will have been superimposed to examine correlations, in each urban area, between different variables. A series of maps that combine the maps that form part of the other outputs, using the maps as layers, to allow analysis of the possible geographical overlap between different hazards and between hazards and socio-economic vulnerability.

A base map is being prepared and the data for the various layers have been compiled and analysed.

Benguela and Lobito: - Satellite images of Benguela and Lobito will have been obtained. Zones of the urban area with similar dates of construction and social characteristics will have been defined and delimited using examination of satellite images, local observation and interviews with key informants.

Defining the typology of urban areas of Benguela and Lobito has been carried out as recent images are available. Mapping of current areas and urban growth has been completed, and structures have been counted.

Benguela and Lobito: - Counting of rooftops on the satellite images will have been carried out to make a count of the number of structures in each delimited zone

Roof-top counting has been carried out, by zone.

Benguela and Lobito: - Present-day satellite images and any previous mapping of the urban area will have been used to map the current urban area and past growth of the area.

The present urban area has been mapped and information on the past urban area is being collected.

Benguela and Lobito:- Demographic analysis will have been completed, including population figures by area and figures on trends and future scenarios maps of the urban areas, the extent of urban areas at different dates, and maps of growth and densities of population.

Information from the household questionnaire survey has been analysed and data are now available on average household size in different housing areas. Roof-top counting has been carried out. Population estimates are being made.

Benguela and Lobito: - Household surveys will have been carried out, ensuring that each identified zone is covered. This will provide information on the number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

The household surveys in Benguela and Lobito took place soon after the national census has been completed, with a sample size of 1500. A questionnaire was used with questions about number of people per household, social indicators, land values, and experience of flooding and climate variation, water access, use and price.

Benguela and Lobito: - The clustering of socio-economic indicators in the defined areas will have been checked statistically to refine the definition of zones.

Data have been analysed and a working paper is being prepared.

Benguela and Lobito: Socio-economic description and mapping of, social characteristics and indicators, distribution of population and poverty levels will have been completed.

Information from the household questionnaire survey has been analysed for this purpose and a working paper on the social characteristics of Luanda, the distribution of population and poverty levels is being prepared.

Benguela and Lobito: Satellite images and field observation will have been used to map the main and critical features, and to delimit and map flood areas that have experienced flooding, slopes that have experienced erosion in the past.

The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Benguela and Lobito: - Areas that are at risk from flooding and erosion under plausible range of future changes, areas at risk from sea-level rise and salt-water intrusion (under present and possible future conditions) will have been mapped. This will have been cross-checked with oral history of past events and their impact.

The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Benguela and Lobito: Description of, and mapping of, environmental vulnerability will have been completed, which will include maps of risk zones under present and future conditions and descriptions of events and risks and impacts; .also a comparison with population distributions and social conditions.

This is in progress. The satellite images and field observation have been used to prepare a map that shows important physical features. This has been used to map flood risk areas and areas that have experienced flooding, and urbanised areas that are on slopes. This map has layers that allow viewing of different combinations of indicators.

Benguela and Lobito: - Key informant surveys about water supply systems in the relevant coastal urban areas will have been carried out. The structure and use of the water supply system will have been observed, noted and mapped.

Information about the water-supply system has been collected and a working paper on the system is being produced.

Benguela and Lobito: - A rapid survey of prices of water in various areas will have been carried out and this information will have been mapped.

A rapid survey of water prices has been carried out. The resulting information is being written up and mapped.

Benguela and Lobito: - Tests of the quality of water will have been carried out.

Testing of water quality is still being planned.

Benguela and Lobito: - From the household survey, key informant interviews, observation, water quality data and price mapping, how water is supplied will have been

documented, describing the supply chains, prices at various stages of the supply chains, organisation of water markets, quality, reliability and price (and variation of these attributes by season and by year).

A working paper is being prepared describing the water system and key indicators of water supply in Cabinda.

Benguela and Lobito: - The existing water supply systems will have been examined and options proposed for better water systems governance, analysing how technical and policy innovations could improve access and affordability and ease adaptation to possible future conditions. A description of, and mapping of, access to and affordability of potable water in coastal urban areas of Angola, together with an assessment of the impact of climatic conditions on water supply and a description of possible innovations and adaptations. This will show, among other information, areas of scarcity of water and high prices and the geographical characteristics of the supply chain.

This has not yet been started.

Benguela and Lobito: - An assessment will have been made of how present and possible future climatic conditions (variability and possible trends) impact on water supply systems for urban areas and thus on water markets, water access and affordability.
Benguela and Lobito: -

This has not yet been started.

Benguela and Lobito: Mapped information will have been superimposed to examine correlations, in each urban area, between different variables. A series of maps that combine the maps that form part of the other outputs, using the maps as layers, to allow analysis of the possible geographical overlap between different hazards and between hazards and socio-economic vulnerability.

A base map is being prepared and the data for the various layers have been compiled and analysed.

	Months 1 – 6	Months 7 - 12	Months 13- 18	Months 19 - 24	Months 25- 30	Months 31 – 36
Preparation. Obtaining satellite images. Obtaining rainfall data Obtaining river flow and vegetation data	XXXXXX					
Rainfall and river-flow activities (specific objective 1)		XXXXXX	XXXXXX	XXXXXX		
Activities in Luanda (in specific objectives 2 and 3)	XX	XXXXXX				
Activities in Cabinda (in specific objectives 2 and 3)	XX	XXXX	XXXXXX	XX		
Activities in Benguela and Lobito (in specific objectives 2 and 3)	XX		XXXXXX	XXXXXX		
Finalisation of outputs and dissemination					XXXXXX	XXXXXX
End of project Evaluation					XX	XX

6 IMPACT

7 RECOMMENDATIONS

There are no recommendations to make in this report, in agreement with the statements in 4.0 above.

Appendix 1: Interim Technical Report Guidelines **(for CCW-supported projects)**

As set out in its Prospectus, the goal of IDRC's Climate Change and Water (CCW) program is to support applied, policy relevant research to help people adapt to the water-related impacts of climate change. We are therefore interested to know how specific project results improve access to water for communities, increase adaptive capacity, and reduce risks to build resilience in the face of climate variability and change. We are also interested in how CCW-funded projects are using climate change adaptation research methods and engaging the end-users of research. To complement the general research findings and results described in your Interim Technical Report, the following Annex asks targeted questions related to CCW's specific areas of interest. The questions may not all be applicable to your research project. Please answer, directly in this Word template, only those questions that are relevant to the project topic and objectives. Answers should reflect all project results to date and include concrete numbers or examples where possible. Thank you for taking the time to complete these questions.

Questions for CCW-supported project teams:

Water quality, water 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 project is not yet in a position to assess and/or measure any improvements in the quality and/or the extent of climate change in Angola and its possible impact on availability of water or risks associated with climate change.

2. Has the project put in place strategies for building adaptive capacity of people and institutions? If so, please describe the strategies. (*Note: Building adaptive capacity implies that the project is improving 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.*)

This will be done after an assessment is made of the risks associated with climate change and other socioeconomic factors and will be reflected, earliest, in the third interim report.

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.

The only barrier identified so far in this regard is the low reliability of internet connectivity leading to difficulties of programming and loading applications on mobile Android tablets at times from researcher point of view. From the point of view of the target communities, oscillating internet connectivity makes it difficult to view areas in which they live or others of their interest and/or concern on programs like Google earth and/or Google maps among other internet based research and technology products.

Among the barriers to improved water resource management remains the lack of adequate information on rainfall and river-flows, which this project aims to go some way to address.

Climate change adaptation research methods

4. Are researchers involved in the project applying 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 are proving to be particularly valuable?

Insofar as data collection is concerned, a variety of social research methods are being used including social and environmental risk vulnerability assessment, economic analysis, gender analysis, population density estimate correlations, historical documented and oral discourse analysis, among others. However, it is not plausible to state which methods are proving to be particularly valuable until substantial data analysis is done.

5. Have researchers involved in this project been trained to use methods to conduct economic analysis? How are they applying these methods?

Economic analytical methods are integrated in the professional training of most of the researchers. However, a number of in-house training sessions have been conducted to enhance capacity building in, and promote, the uptake of technology in research and policy influencing. This is ongoing.

Engagement of research users and policy influence

6. How are researchers working with policy makers in the project? How has this changed since the start of the project (i.e. more or less interaction with policy makers)?

DW worked with the Ministry of Water and Energy 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, were ever they live, including in high risk zones. 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 “Water for All” program. The program draws on DW’s experience and incorporate the water governance lessons from the community management model.

Currently there is some interaction between researchers and policy makers. The latter also show a lot of interest and willingness to collaborate and participate in the research and corresponding technology uptake including transfer of skills and data sharing among project researchers and relevant and interested public and private entities.

Project staff have attend meetings and seminars on climate change, which is beginning to come up the agenda in Angola. It is planned to hold a significant Development Workshop seminar on this subject in the third reporting period.

7. Have project team members improved their ability to communicate research results to diverse audiences? How?

Communication of research results is yet to happen after some satisfactory level of analysis of the data so far collected is reached.

8. Have any policy options been identified through the research? How have these policy options been validated and communicated to potential users or what plans are in place?

Given the fact that the research project is still at its initial stage, policy options are yet to be identified. As such it is immaterial to discuss their validation and communication to potential users at this stage.