DEVELOPMENT WORKSHOP
Desenvolvimento Comunitário
Human Settlements & Development

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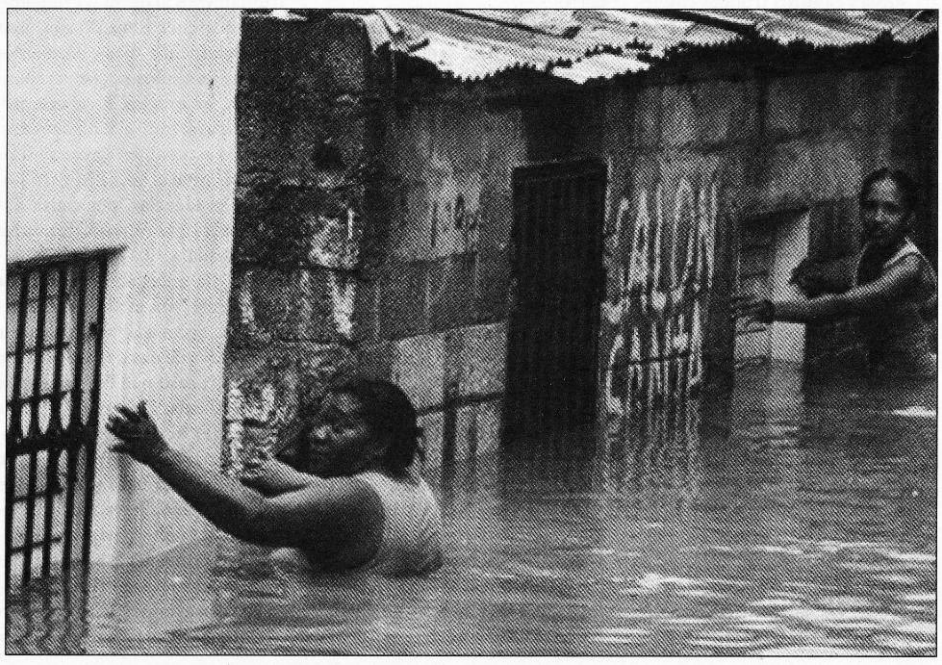
WATER RESOURCE MANAGEMENT UNDER CHANGING CLIMATE IN ANGOLA'S COASTAL SETTLEMENTS

IDRC PROJECT NUMBER: 107025

2ND PROGRESS REPORT



NOVEMBER 2012 TO OCTOBER 2013

DEVELOPMENT WORKSHOP ANGOLA

Luanda - 31st October 2013

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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 de 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 year of the project involved establishing relations with relevant institutions, collecting and archiving existing information, and preparing for and carrying out field-work in two of the three urban areas. A questionnaire for the household surveys has been designed and tested and used in these two areas through use of hand-held electronic devices. Historical rainfall data from 50 stations in Angola has been obtained and put into a digital database in Access. A process has been set up to analyse the database of rainfall records, taking into account the large number of gaps in the records and a preliminary analysis has been carried out. 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. Field trips to Cabinda and Benguela-Lobito were made in February and March 2013. A case study of the flooding in Cacuaco (Luanda) in January 2007 has been carried out using oral histories, and this has been extended to similar events in the urban area of Luanda as a whole.

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

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 55 stations in Angola were obtained in the first six-month period and entered into a digital database in Access. The 55 stations that have been 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. However both sets of digital records were checked against records at the UK Meteorological Office (on paper) or

[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)

against the scans available on the NOAA[2] 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 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 55 stations, along with some data from places 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 a first stage analysis (see below).

Historical monthly rainfall data from about another 50 stations in Angola are being digitalised, using the same sources. Further monthly rainfall data from the Democratic Republic of the Congo are also being digitalised, as data were lacking in the first analysis along the northern boundary of Angola. Mapping and analysis will then be updated using these further stations. The database will potentially be an important database of the rainfall records of Angola and 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.

When data have been obtained and digitalised for about 100 stations, this will mean that about 40% of the functioning station from the 1940-1975 period will be in a database. This will include the main meteorological stations in the country with the most complete records and will provide a reasonable geographical coverage. It isn't considered to be useful at this stage to collect and digitalise the records of the other stations, whose records are irregular or of short duration. The information on the database will also include a high percentage of the information from the pre-1940 and post-1975 periods; it would seem that almost all reliable information has been collected.

Further rainfall data will be sought where it is of direct relevance to the project. Data for 10-day periods or daily data may be available locally for stations in the project area. 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.

[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.

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 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 Variability[3]
- Seasonal rainfall as a percentage of annual rainfall.

A working paper is being finalised. It is intended to seek publication in peer-reviewed journals. There are two journals that have shown a particular interest in publication. The first is Environment and Urbanisation (http://eau.sagepub.com/). The second is Regional Development Dialogue, which is the journal of the UN Centre for Regional Development. (http://www.uncrd.or.jp/pub/rdd.htm). The editor of a special issue on climate adaptation (Jean D'Aragon, who is the coordinator Disaster Management Planning Unit of the UNCRD) has invited a contribution based on this paper.

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 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 1955[4], 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

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

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

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.

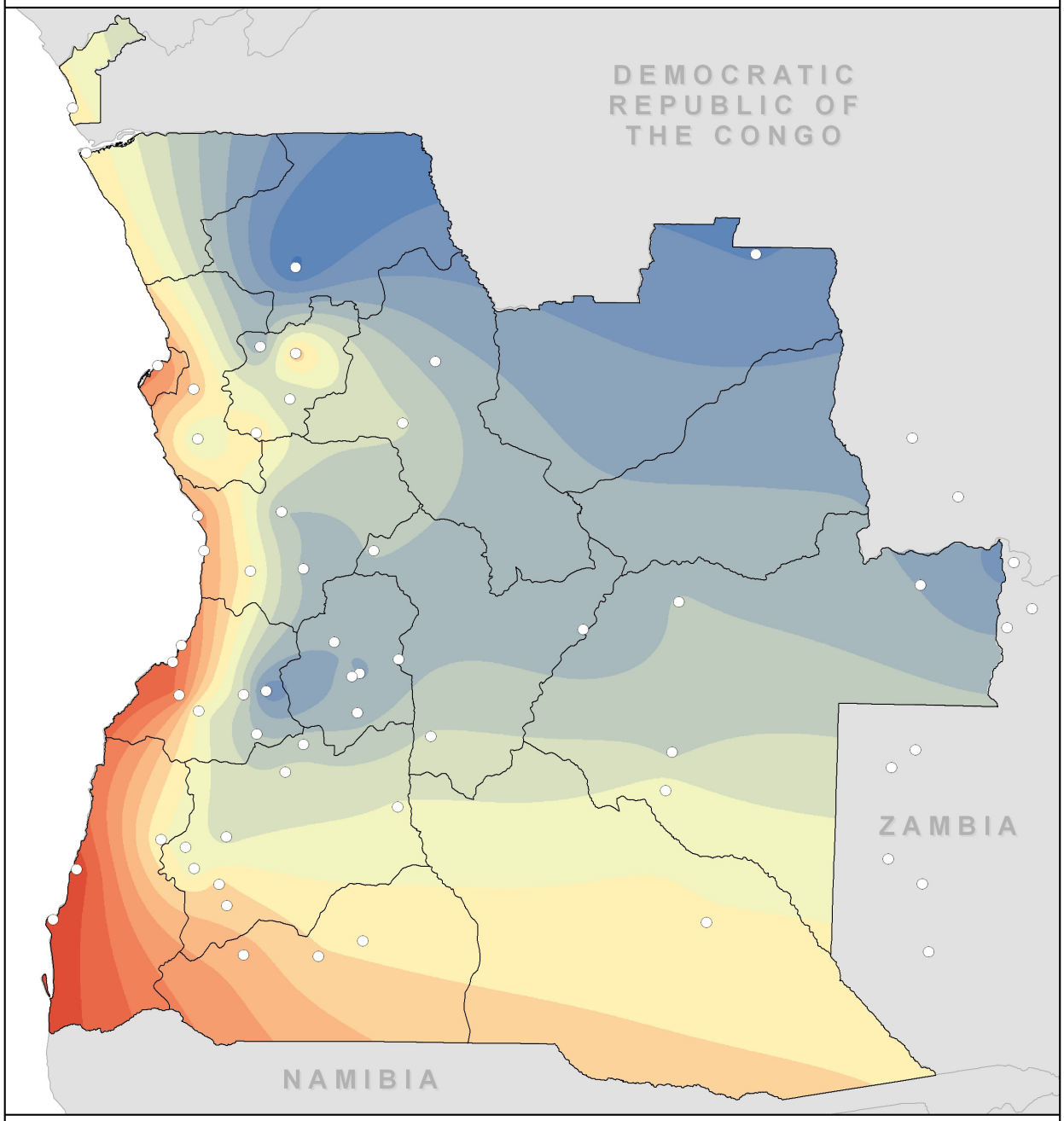
As well as using the Coefficient of Variation as an indicator of variability of rainfall, anomalies from Conrad's Normal Relative Variability have been used as an indicator of variability of rainfall. The general pattern of variability revealed is similar using the two indices. However the Coefficient 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.

A preliminary 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 Niños[5]. 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.

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. Thus further study is required of these patterns of variation.

[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.

ANGOLA
Median annual rainfall
Mediana de precipitação anual



Milimetres

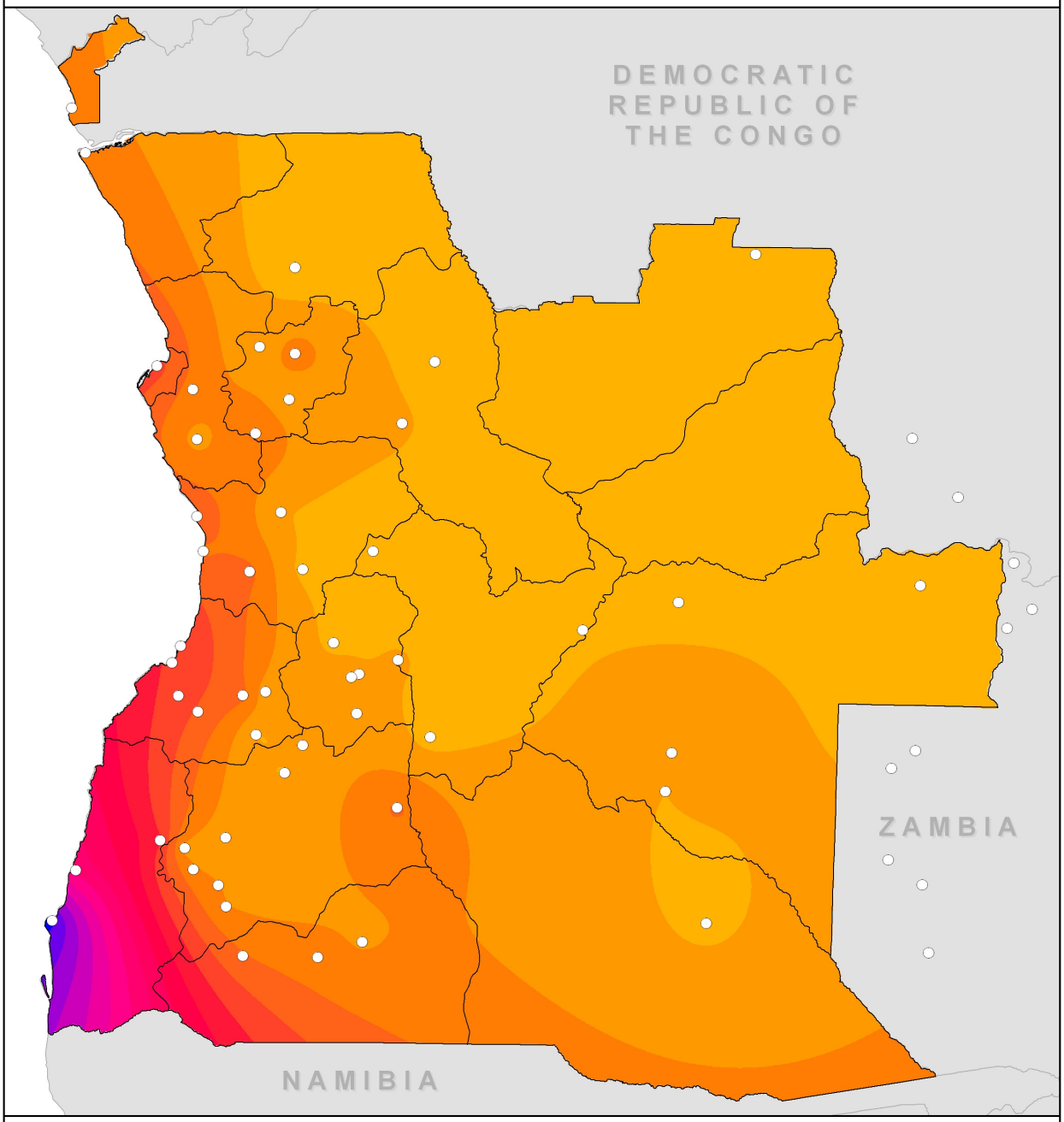
≤ 1	> 360 - 480	> 840 - 960	> 1,320 - 1,440	Weather Station
> 1 - 120	> 480 - 600	> 960 - 1,080	> 1,440 - 1,560	
> 120 - 240	> 600 - 720	> 1,080 - 1,200	> 1,560 - 1,680	Province
> 240 - 360	> 720 - 840	> 1,200 - 1,320	> 1,680	

N

0 100 200

Kilometres

ANGOLA
Coefficient of variation of annual rainfall
Coeficiente de variação de precipitação anual



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.

These difficulties were investigated, though little direct information about this difficult could be identified. Contact was 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 so, although ideally decadal or daily data should be used for comparison, TAMSAT will compare station and satellite-based data for recent years. If this is successful, it should allow better estimates of rainfall from satellite-based measures.

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. This will only proceed when fit of satellite-based measures with historic data has been checked and this is still in progress because, as noted above.

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

Further information has been 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, has been 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.

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 Activities

A database template has been prepared. The information that has been collected continues to be inputted into a database of 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 are available, and maps for Benguela/Lobito are being sought.

There is no information available for river-flow from the pre-1960 period and very little available from the post-1975 period. There is also very little information available on changes in vegetation. The collection of oral histories and information from is expected to provide qualitative information about high or low river flows in particular years, and on changes in vegetation, that could be linked to particular rainfall events.

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

3.2.1 Obtaining of Satellite Images of Relevant Research Areas

Satellite images of Cabinda and Benguela/Lobito have been obtained. Satellite images of Luanda have been commissioned (a 2013 update of the images for Luanda), though the images available at the beginning of the dry season in May and June 2013 (when there is less risk of cloud cover) were not suitable and suitable images are still being awaited. The images presently available for Luanda were suitable for beginning household surveys, but new images will be required in order to count households and begin population estimates. .

These are being used to produce maps that will show features such as slopes, low-lying ground, areas at risk from flooding and the geographical distribution of social variables. The intention is that these maps will be a central part of the dissemination of information in later stages of the project, as they will give policy-makers a clear visualisation of important information such as populations at risk.

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 the relevant research areas with similar dates of construction and social characteristics, creating a housing and neighbourhood typology. Updating has been carried out for Luanda through on-site observation and interviews with key informants, in the absence of updated satellite images. In the case of the other cities, satellite images became 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 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. When analysis of the household surveys has been completed, this will provide information on the number of persons per household and will provide information to construct a better model of estimation of population and population densities in each settlement type.

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 and in Cabinda in September 2013. 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 and 1000 interviews in Cabinda.

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 both Luanda and Cabinda are now available, though cleaning of the database for Cabinda is still in progress. First analyses of the data from Luanda have been carried out.

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

This survey was meant to provide information on the number of people per household, social indicators, land values, water access, use and prices. During preliminary field visits to Cabinda

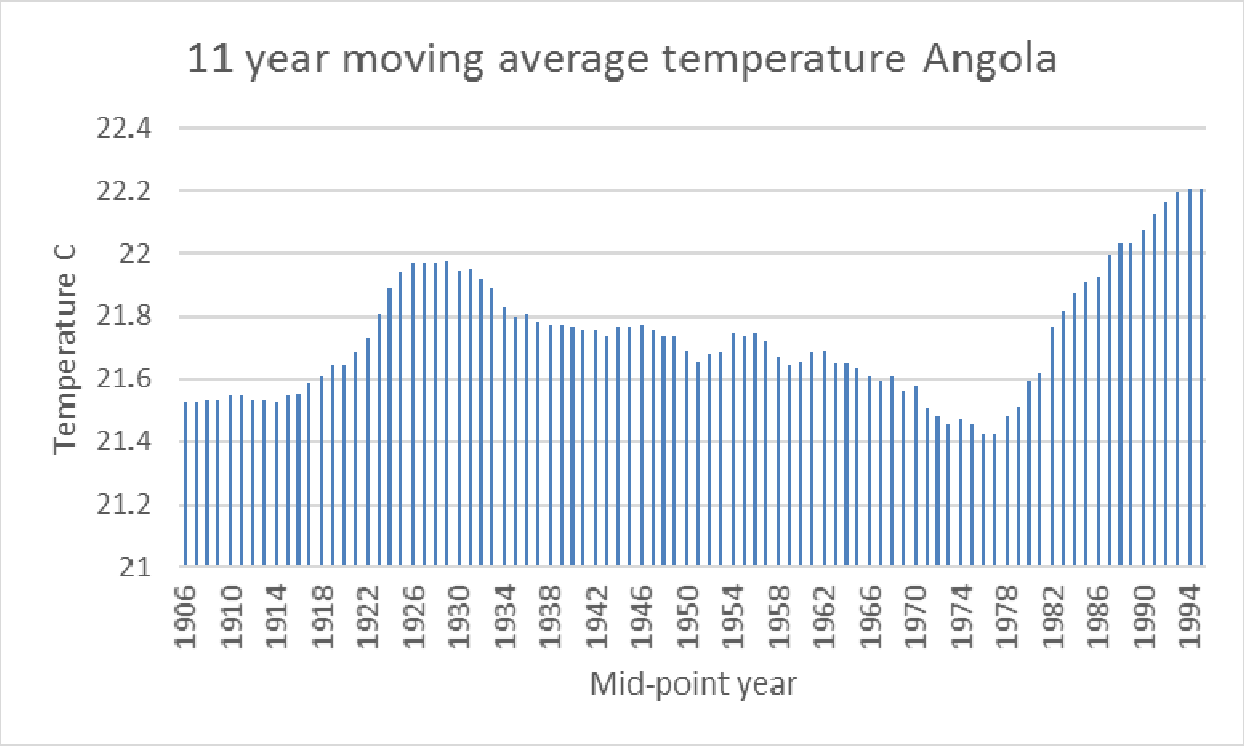
and Benguela/Lobito in February and March 2013 information was collected about primary water systems in those cities and the areas that they serve. A number of meetings were held with key informants in both regions to set out platforms for in-depth key informant interviews and household surveys on these 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.

Temperature

The initial design of this research project did not focus much on temperature, as there is debate about whether and how temperatures are changing in Africa. It is clear, however, that temperature is directly related to cloud cover and rainfall. 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. How these averages were arrived at is not stated. It can only be speculated that these may have resulted from the few that were functional over the respective years.

Extracting large amounts of data about temperatures would be very time-consuming. Where opportunities arise, however, information on temperatures will be collected from functioning meteorological stations in areas relevant to the study and comparisons made with average historic information from the same stations.



Source: *the World Bank climate change portal*

4 PROJECT IMPLEMENTATION AND MANAGEMENT

4.0. Progress Summary

The scope of the project remains unchanged and progress continues to be made in the second 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 are being analysed and the first working paper is being finalised. Field-work (household questionnaire surveys) has been carried out in Luanda and Cabinda and analysis of data from Luanda has begun. Progress with analysis of rainfall data is ahead of schedule. Progress with activities dependent on the household questionnaire survey from Luanda and on the use of satellite images from Luanda are 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 have not been available.

In the next six-month period the main activities will be field-work in Benguela and Lobito and analysis of data collected in Luanda and Cabinda. Analysis of rainfall data will continue.

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, and it was planned that some Development Workshop staff would attend the winter school in July 2013 (http://www.csag.uct.ac.za/winterschool/). However, it was not possible to have these plans implemented due to lack of availability of our partner in indicating a suitable candidate. We have asked our new partner CETAC (Centre for Tropical Ecology ad Climate Change in Huambo Angola) to chose a candidate for the 2014 course and CSAG have agreed to hold a place for an Angolan participant.

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. 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. CSAG has communicated, indicating that the data that DW provided was adequate for incorporation in their modelling. DW will therefore collect metrological data in this format so that CSAG will be able to fill in the Angolan gaps in their modelling for the Southern African region. DW is in regulat contact with the GEF regional team based in Pretoria to explore other opportunities that will enhance skills in the DW research team and strengthen institutional cooperation with our new partner CETAC.

4.2 Consolidation of Relationships with Relevant Government and Civil Society Institutions

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 six 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 and Sanitation Department of the Ministry of Energy and Water (Direcção Nacional de Abastecimento de Água e Saneamento), which is responsible for domestic and industrial water supply throughout the country, 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).

The manual jointly produced by Development Workshop and the Direcção Nacional de Abastecimento de Água e Saneamento is available here.

http://dw.angonet.org/sites/default/files/online_lib_files/AGUA-MoGeCa_0.pdf

Relationships are being developed with INAMET, the national meteorological institute. This will be important for on-going data collection systems and longer-term analysis of present and past data. INAMET appears to be aware of the commercial value of meteorological data and have been reluctant to release their own information, though may be interested in greater collaboration when information from this project becomes available. INAMET has a programme of gradual extension of the network of stations and are reluctant to expand too quickly if they are unsure of their capacity to maintain the network. The strategy in this programme will be to demonstrate the interest and usefulness of continuing with the expansion programmer.

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 Provinvcial 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 ad 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

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 Luanda and Cabinda and first level mapping has begun for Benguela.

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. Together with the Government and UNDP a submission is being prepared to the Global Environment Facility (GEF) and Climate Adaptation Fund. Explorations are also underway with several potential bilateral and corporate donors. The commitment from IDRC to support the project provides potential project financers with confidence in the quality and pertinence of the proposal and has opened doors for future support.

4.5 Budget Forecast Variance

As reflected on the expense and forecast summary sheet (FR3), the overall balance shows and overdraft of $78.72 on the travel budget line. However, the balance on the rest of the budget items is either positive or zero. A few expenses have already been incurred on media monitoring and on the document and archive research lines (FR2) though these have not been reflected in the financial system as yet. About 10 tablets were also bought, expenses of which have not yet been reflected on the balance sheet (FR2).

5 PROJECT OUTPUTS AND DISSEMINATION

A consultant was hired to train the core research team on designing electronic data collection instruments using the Open Data Kit (ODK) application which can be loaded on Android smart phones and tablets for field data collection. These will in turn train the rest of the research and field data collection teams on the same. Three interns have been recruited and are part of the research team. They are participating in various project activities including rooftop counting for population modelling to constitute the sample frame in Bueguela, mapping of water and drainage channels and conducting primary interviews with people living in relevant research areas in Luanda and Cabinda whose results will be presented in the next report

A presentation was made by Afonso Cupi Baptista, Development Workshop's water sector manager entitled Alteraçôas 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.

Achievement of Milestones

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

Satellite images- Images for Cabinda and Benguela/Lobito have been obtained. Up-to-date Luanda images (2013) have been ordered and should be available soon.

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

Satellite data - Data for Angola 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. Cooperation with the TAMSAT programme should permit more access to more reliable satellite data.

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 is available 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

***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 ad 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.

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

Information in the local media on environmental issues is being extracted and copied, with a view to future analysis

***Zones of the urban area defined and delimited. Structures in each zone counted and mapping of current area and urban growth completed for Luanda*:**

Up-to-date images will be available later in 2013. Older images have been used to define and delimit zones for more than 95% of the city area. The definition of the new areas of the city will be completed as soon as new images become available. Meanwhile defining the urban areas of Cabinda, Benguela and Lobito is being carried out as recent images are available and growth of these cities appears to be slower.

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.

Analysis is still in progress.

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 not been available so this is still pending.

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 not been available so this is still pending.

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 is being 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 is at present being analysed for this purpose.

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.

This is not yet underway.

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 is at present being analysed for this purpose. Up-to-date good quality satellite images are not yet available for the roof-top counting that is necessary for this purpose.

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 is at present being analysed for this purpose.

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 not yet available to allow this to proceed.

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.

6 IMPACT

7 RECOMMENDATIONS

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

	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

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)?

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.

Program Fluxogram