

**Republic of Angola
Ministry of Energy and Water Affairs**

National Directorate of Water (DNA)



FINAL REPORT

National Water Sector Management Project, Activity C

**A Rapid Water Resources and Water Use
Assessment for Angola**

March 2005

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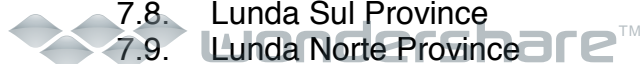
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1. INTRODUCTION

1.1 Study Background

The potential of renewable water resources of Angola is not known with sufficient accuracy, mostly due to lack of data. Almost all of the 189 hydrometric stations in operation at independence in 1975 were abandoned during the years of civil war. The same is the case for data on total water use, water consumption, and future water demand. Proper water development planning is thus almost impossible.

This project “A Rapid Water Resources and Water Use Assessment for Angola” is undertaken to start moving in the direction of establishing a sufficiently accurate assessment of the renewable water resources and water use that can be further elaborated and updated as data become available. As such it forms one of the steps towards achieving the goals of the Strategy for the Development of the Water Sector in Angola.

The project is Activity C of the National Water Sector Management Project (NAWASMA) being carried out as institutional co-operation between the Angolan National Directorate of Water, (DNA) (Direcção Nacional de Águas) and the Norwegian Water Resources and Energy Directorate, NVE under the financing of NORAD and covering the entire country. SWECO Grøner carried out the assessment for and in collaboration with DNA under the Ministry of Energy and Water. The development objective of the NAWASMA project is improved water sector management in Angola through a strengthened institutional capacity of DNA. Proper water management requires solid knowledge. The specific development objective of Activity C is therefore to assess rapidly the water resources, water use, and future water demand in Angola.

In addition to providing up-dated estimates of water resources and water use, the future capacity for managing and planning water resources was improved through the project by transfer of knowledge and capability to DNA. This final report of the project has been designed to enable DNA and other Angolan authorities to move on in their work with national master plans for the water sector, identifying bottlenecks for further planning and management in terms of data quality and availability. The full Terms of Reference for the assessment is included in the Appendices.

1.2 Assessment Methodology

A consultative approach was applied to the assessment in which relevant authorities and stakeholders in the water resources sector were involved in the study in order to attempt to include their knowledge and possible data. DNA was the facilitator in this respect, providing the link between the Consultant and the various authorities and bodies. Although most of this consultation work was carried out in Luanda, limited field trips were also made to some provinces where meetings were held with relevant authorities, available data collected, and some water resources developments inspected.

The challenges to obtaining reliable data on water resources and water use in Angola are many. In some sectors in fact no data is freely available at all. The importance of identifying and addressing these bottlenecks in the development of assessments for the sector cannot therefore be overestimated and has been a major activity during the assessment.

1.2.1 Establishment of clear assumptions and methodologies to be applied in assessment estimates

At the outset of the assessment the methodologies to be used as suggested in the consultant's proposal were firmed up and necessary points discussed and agreed with DNA.

An important point was the aerial resolution to be used in the study. In concurrence with the advice of Angolan experts during the project kick-off seminar in the Royal Norwegian Embassy in Luanda, the established boundaries of regions of Angola to be identified and used were adopted. These are the major river drainage basins draining to the international rivers and the coastal rivers draining to the Atlantic:

- Zaire
- Zambezi
- Okavango
- Etosha
- Coastal rivers draining to the Atlantic (including the Luando-Kwanza (Cuanza) system)

These were, however, further disaggregated into individual catchments for both the water resources and the water use assessment.

1.2.2 Estimation of Angola's renewable water resources (surface and groundwater) by river basins and aquifers

For surface water mean monthly data from the hydrology records of the NAWASMA database in DNA were transferred, assessed and used, supplemented by regional data. Monthly and yearly means were used to generate a simplified runoff map for those parts of Angola covered within the hydrometeorological network. This data was subjected to further checks before comparison with regional runoff and rainfall distribution, especially with a view to compensation for the lack of data from the eastern parts of Angola.

Meetings were held with INAMET and data was received for a selection of stations. Quality control of this data was carried out and several corrections were made, especially with respect to obvious punching errors and location of stations. Some data appears to be incorrectly punched but the values lie within probable limits. Such data values have not been adjusted. This data was then subjected to further checks before comparison with regional figures for rainfall distribution.

The data sources for the evaluation of the hydrogeology and groundwater resources of Angola are mainly the Hydrogeological map of Angola at scale 1:1.500.000 and the Geological map of Angola at scale 1:1.000.000. In addition geological and hydrogeological maps and interpretations produced as the UK contribution to the International Hydrological Programme (IHP) of UNESCO Southern Africa, and the FRIEND Phase II project were accessed. Meetings were held with HYDROMINAS, UNICEF and Direcção Provincial de Águas in Lubango, and information on groundwater registers and some groundwater data was collected. These data sources gave the possibility to indicate probable groundwater yields in most of the common aquifers, but data for estimation of the volumes of renewable groundwater resources were not accessible.

1.2.3 Preliminary estimation of sediment transport in the different river basins, and the identification of river basins where soil erosion problems are most severe

Data on sediment transport is virtually non-existent in Angola. Consequently, this is one of the major bottlenecks, which needs to be prioritised in DNA's further work on water resources.

Fortunately the Consultants were successful in obtaining a copy of a study of the sedimentation of the Cambambe Dam reservoir on the important Cuanza River¹. The study is based on bathymetric field surveys carried out and gives estimates of the sediment volume that has accumulated in the reservoir since its implementation. Although of course not representative for other basins in Angola, it does give one data point for the important Cuanza River. Contacts were also made with institutions in neighbouring countries to seek out further possible data sources, in particular for the Okavango Delta. Internet resources were extensively researched to find any further existing relevant studies. Some limited information was found on soil erosion caused by human activity in the catchments draining to the Atlantic Ocean.

1.2.4 Development of scenarios for urban, peri-urban, and rural population growth in Angola up to the year 2025

This was one of the most complex parts of the assessment due to the lack of firm population data in Angola. The methodology was developed by gathering and comparing various available sources of population data and estimates as detailed in Chapter 4, discussing and assessing the merits and shortfalls of each one, and applying international experience combined with local knowledge. The provincial breakdown of population estimates was even more challenging. A description of the methodology and results is given in Chapter 4.

Finally, the population estimates for each province were again disaggregated into catchments populations and entered into the GIS water resources database on a catchment basis by first splitting each province up into its various catchments and, using the satellite maps of the locations of the towns, villages and settlements in each catchment, allocating first the urban and periurban figures to the correct catchment in the province. The rural population figures were then distributed to the various catchments proportionately to the intensity of settlements in each catchment as indicated by the satellite imagery. The result is a catchment distribution of the forecasts within each province. Catchments that straddle province boundaries were dealt with as sub catchments within each province, the total of the various provincial sub catchments then being summed by the GIS system to arrive at total catchment figures. Further details are given in Chapter 7.

1.2.5 Development of scenarios for growth of water intensive industrial and mining activities

Updated information on water intensive industrial and mining activities is very difficult to obtain in Angola. There is some information on the government website Angola.org, this is, however, dated from 1995. In order to secure more detailed and up-to-date information and data, meetings were planned with three main institutions:

- Ministry of Industry
- Ministry of Geology and Mines
- Endiama, the national diamond mining company

¹ Estudo de Avaliação da Sedimentação da Albufeira da Barragem de Cambambe no Rio Cuanza, PM Consultoria Obras Hidráulicas, Luanda, February 2002

At the time of writing this report, the meetings with the Ministry of Industry and Endiama were still pending. A meeting was held with the Geological Services of the Ministry of Geology and Mines but no information could be given. This was due to the Geological Services request for payment for supplying such information for which there is no facility under the Consultant's contract. This has been brought to the attention of DNA and it is hoped that this matter can be resolved in the future development of the assessment by DNA.

As a result of the general lack of data on this issue, it has not been possible to develop firm scenarios of the growth of industrial and mining industries. This is a bottleneck that should be prioritised in the further development of the assessment. One line of action for achieving this could be ministerial collaboration between the Ministry of Energy and Water and the Ministry of Geology and Mines. Mutual exchange of information and data could be beneficial to both parties in this respect.

1.2.6 Estimation of Angola's water demand for the different sub-sectors, with special emphasis on consumptive water use, and particularly the demand for full or supplementary irrigation

For estimation of the consumptive water use in the Agriculture sector, the following factors were taken into consideration: the existing and the planned irrigation schemes; the main crops grown under irrigation; and the net annual irrigation requirement. Watering of animals was also considered. For irrigation activities, year round irrigated agriculture was assumed with 365 days, while for dried periods 182 days was used. The volume of water for 2005 was assumed to be as of 2004, i.e. at the time of the study. For those irrigation schemes partially operational, it was assumed that in 2005 they would be working at 20% to 40% of their capacity, whereas in 2015 these schemes will be working at 50% to 75% of their capacity. For 2025 it was assumed that all planned irrigation schemes would be constructed and that all irrigation schemes, be they planned, partially operational or operational, would be working at 100% of their capacity.

In relation to animal watering, projections were made based on figures provided by the Department of Animal Production of the National Directorate of Livestock, a government body under MINADER, the Ministry of Agriculture and Rural Development. As the figures provided on animals are concentrated in the southern region of Angola, a certain re-distribution of animals was made for the whole country, considering those provinces with natural conditions for livestock development. In relation to poultry development it was assumed that this activity would be revitalised in those provinces where, in the recent past, a certain level of development had been reached. The annual growth of cattle was assumed to be 3%, while the annual growth of pigs, sheep and goats was assumed to be 4%. The same annual growth was assumed for poultry. The AGRODOK Series recommendations were used for daily consumptions of water for cattle, pigs, sheep and goats was taken by. The Department of Animal Production of the National Directorate for Livestock recommendations were used for daily consumptions of water for poultry.

The sum of water volumes for irrigation and water volumes for animal watering was assumed to be the total of water demand for the Agriculture sector.

For estimation of the consumptive water use in the domestic water supply sector, water use estimates and projections were developed on a per capita basis and applied to the population estimates. The methodology of this process is described in Chapter 6. The information in the existing water master plans for towns in Angola were used in this analysis.

1.2.7 Establishment of criteria and recommendations for future water resources and water use and demand assessment activities

Key to the establishment of criteria and the formulation of outline plans for maintaining and developing water resources and water use assessments is the system sustainability. It was realised at an early stage that the capacity of DNA in this respect is limited, as were the resources available to this project. Consequently focus was put on developing and handing over a system that could easily be used and updated for water resources, as well as a system that could be useful in DNA's other activities. The resulting Water Resources and Water User database and tools chosen are therefore based on the GIS system that can be easily adapted to almost any other use, and is well known in Angola, being used by NGO's in de-mining activities, the oil industry etc.

Focus was also placed on the identification of bottlenecks and gaps in the assessments due to lack of data or lack of institutional cooperation, which is addressed in the final chapter of this report, where recommendations for the dissemination of information and involvement of stakeholders in the further development of the assessments are given.

1.3 Water Resources/GIS Software and Database Tools Applied

The available hydrometeorological, meteorological and other types of data for use as input to the system are detailed in some areas and sparse or non-existent in other areas of the country. The most appropriate and sustainable methodology for establishing the water resources and water use database with such constraints was to implement an Arc-GIS database system for the entire country. The database system is raster based and the entire country is broken down into rectangular units or rasters, their size depending on the data availability for each type of data (for example with 1 km raster for rainfall data). Each data type could then be represented by one layer of rasters and the different data layers combined using mathematical algorithms to arrive at the desired data sets for use in the water resources and water use assessment.

The advantage of this system is its flexibility in that it can easily be extended or updated as new data becomes available. In addition DNA has been provided with a powerful and useful Arc-GIS software tool which will undoubtedly also be found useful in its other activities and projects. In order to obtain maximum benefit from this system a dedicated plotter for producing large-scale printouts and visualisations from the system is advisable. Consequently the Consultant has used funds from its budget for office equipment to provide such an A1 size plotter to DNA.

Recommendations have been made to immediately follow up the assessment by a stakeholder seminar in Luanda, in which the GIS database and the assessment report can be presented to key stakeholders. Such a venue would encourage the further use and development of the assessments achieved during this study.

1.4 Acknowledgements

The Consultants would like to take this opportunity to extend their appreciation and thanks to the management and staff of DNA and the Ministry of Energy and Water, without whose support this assessment would not have been possible. DNA has been the vital link between the Consultants and the stakeholders and sources of information and data in the water resources and water use sector in Angola, and has been facilitator in the stakeholder meetings held.

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