Integrated Water Resources Management in the Congo basin based on the development of Earth Observation monitoring systems in the framework of the AMESD Programme in Central Africa

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ABSTRACT

The Congo basin is one of the richest in terms of water resources. These water resources are still under-exploited. However due to the decrease of the Oubangui river discharge since 30 years and the Small Lake Chad current status in the neighbour Lake Chad Basin, the monitoring of water resources in the Congo basin is crucial.

The African Monitoring of Environment for Sustainable Development Programme (AMESD) therefore sets the basis for the development of a regular monitoring system of the Congo Basin water resources.

In 36 months, satellite data reception stations will be installed in 7 Central African countries, regional experts capacities built and alert systems developed. They will inform on low waters in order to improve navigation conditions anticipation and on water cycle to assess the impact on climate change on its water resources. An IWRM decision-support tool will be developed and 28 decision-makers will be sensitised to its use.

Key Words: IWRM, Central Africa, Congo Basin, Congo, Oubangui, Sangha, AMESD, Remote sensing, Earth Observation, environmental monitoring, Lake Chad

INTRODUCTION

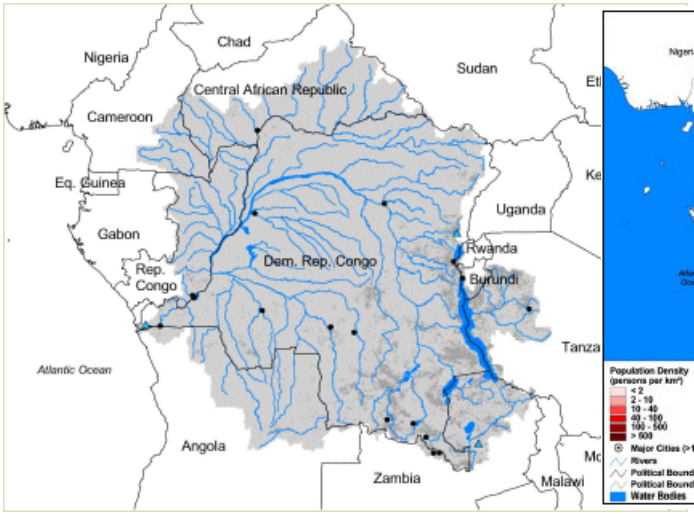
The African Monitoring of Environment for Sustainable Development (AMESD) is an African Union programme funded by the European Union. With a budget of 21 million Euros for the whole Africa, this programme aims at developing operational environmental monitoring systems based on Earth Observation data, field data and ancillary data to regularly inform African decision-makers on the status of their environment. This will enable them to more effectively contribute to international initiatives and comply to international environmental treaties. Five African economic regions have been targeted (ECOWAS, CEMAC/DRC, SADC, IGAD, IOC) with one Thematic topic to be addressed. For Central Africa, the topic is the Management of Water Resources.

1 THE TWO MAIN TRANSBOUNDARY RIVER BASINS IN CENTRAL AFRICA: THE CONGO AND LAKE CHAD BASINS

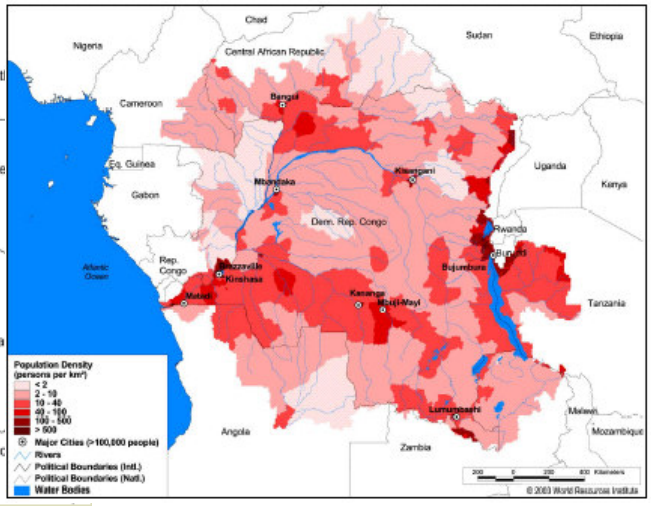
1.1 The Congo Basin

1.1.1 Background

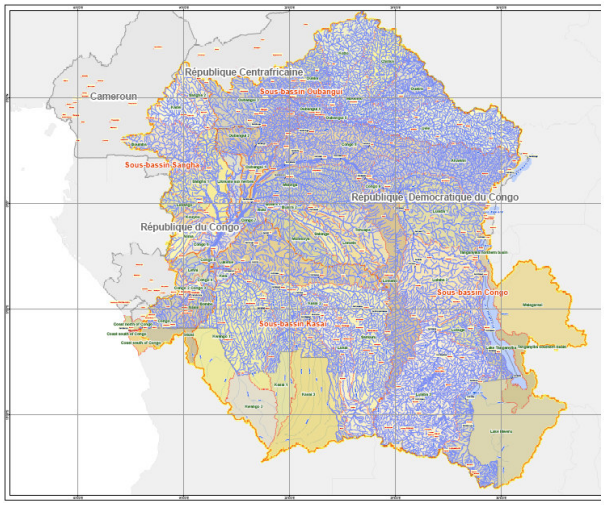
The Congo Basin, located in Central Africa, is the second world river basin by the discharge of its Congo River (average discharge of 42 000 m^3/s), after the Amazon one. Angola, Cameroon, the Central African Republic, the Republic of Congo and the Democratic Republic of Congo make 92% of its total surface of 3 691 000 km^2. The basin comprises a population estimated of 77 344 991 inhabitants in 2005 (Source : Etat des lieux de la gestion des ressources en eau dans le bassin du Congo, African Development Bank, 2006).



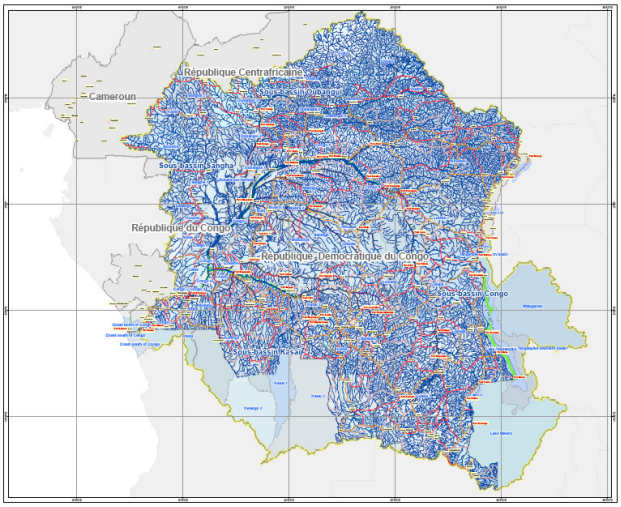
Map of the Congo Basin (Source: World Resources Institute, 2000)



Population density in the Congo basin (Source: WRI, 2000)



Map of the Congo-Oubangui-Sangha-Kasai sub-basins of the Congo basin at 1/3 200 000 (Source: AFC/GTZ, 2007)



Map of the Congo Basin waterways at 1/3 200 000 (Source: AFC/GTZ, 2007)

Extrait de l'article 1er de l'Acte général de Berlin du 26 février 1885

Le bassin du fleuve Congo est délimité par les crêtes des bassins contigus, à savoir : notamment les bassins du Niari, de l'Ogooué, du Chari et du Nil, au Nord par la ligne de partage de faîte orientale des affluents du lac Tanganyika à l'est ; par les crêtes des bassins du Zambèze et de la Logé au sud. Il embrasse, en conséquence, tous les territoires drainés par le Congo et ses affluents, y compris le lac Tanganyika et ses affluents orientaux.

Currently gathered within the International Commission of the Congo-Oubangui-Sangha Basin (CICOS) since November, 6 1999, Cameroon, the Central African Republic, the Republic of Congo and the Democratic Republic of Congo develop their intergovernmental co-operation to enhance interior navigation and Integrated Water Resources Management (IWRM), both for internal and transboundary water resources. Angola is until now an observer of this regional integration process within CICOS. The Agreement establishing a common waterway regime and creating the CICOS Secretariat was signed on November, 6 1999 whereas its additive dates February, 22 2007. The CICOS mandate focusing on IWRM is thus very new.

The CICOS Secretariat produced a map of the Congo basin with its sub-basins and a map of waterways classified by categories of boats' water heights, with the support of the German technical co-operation (GTZ).

1.1.2 Interior navigation

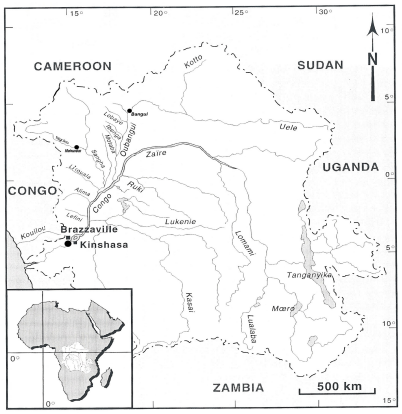
The first CICOS donors, French co-operation DG/CID and the German Technical Co-operation GTZ, respectively present since 2003 and 2006, concentrated first on navigation improvement by developing the CEMAC/DRC Interior Navigation Common Code, capacity building for navvigant staff, a strategic action plan for navigation and the establishment of a sub-regional

navigation school.
Indeed, interior navigation is crucial for the sub-region disenclavement which does not have road and aerial networks so developed and cheap. Waterways represent about 20 000 km of sub-regional network from which 1 600 km are transboundary : the Oubangui and Congo rivers define Central African Republic and the Republic of Congo, and the Congo river the Republic of Congo and the Democratic Republic of Congo downstream. River navigation accounts for respectively annually 223 635t (1985), 100 772t (2000) and 716 431 (1985) tons of merchandises but the current figures are respectively, approximately 40 000 t (2007), 272 818 t (2007) and 428 301t (1991). The traffic severely decreased since 1985 in Central African Republic. This is partly due to the decrease of water level of the Oubangui river and to a certain political instability.

Wood on a boat navigating on Stanley Pool, at Kinshasa arrival.

1.1.3 The hydrometric network

The hydrometric network is only composed of four operational reference stations in the Congo basin. The main limnimetric station is at Brazzaville/Kinshasa on the Congo river which controls a 3.500.000 km^2 basin and for which data exist since 1902. This station is seconded by the Bangui one, on the Oubangui river, which started its functioning in 1912, with stop in data collection until 1936. The Bangui station controls a 480.000 km^2 basin. Then, the Ouesso station on the Sangha river, which controls a 158.000 km^2 basin and which services since 1948. Numbers of the right bank of the Congo river tributaries (Djoué, Djiri, Léfini, Alima, Likouala Mossaka, Likouala aux herbes, Kouyou, ...) have historical data of water levels for more than twenty years- They stopped functioning in 1993 with the departure of ORSTOM (now IRD). Navigation services, respectively GIE-SCEVN and RVF, continue to daily measure water levels at Bangui, Ouesso, Brazzaville and Kinshasa.

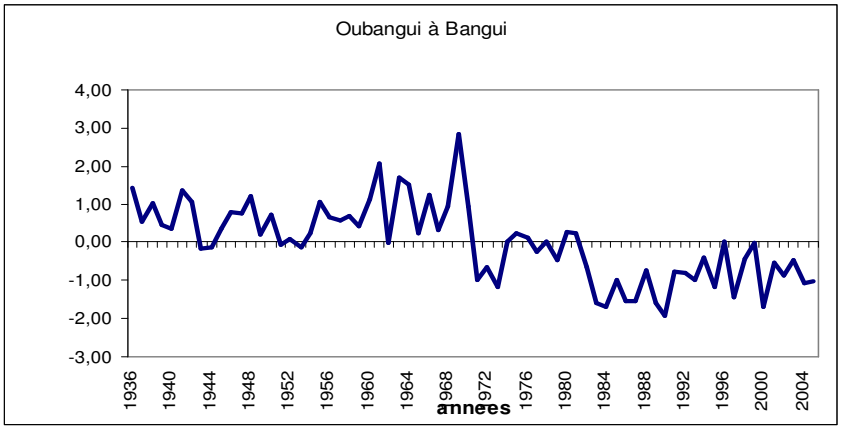


The four reference gauging stations.

Seventeen HYCOS stations are going to be installed in October 2008 in the Congo Basin: 9 on SADC-HYCOS and 8 on Congo-HYCOS projects.

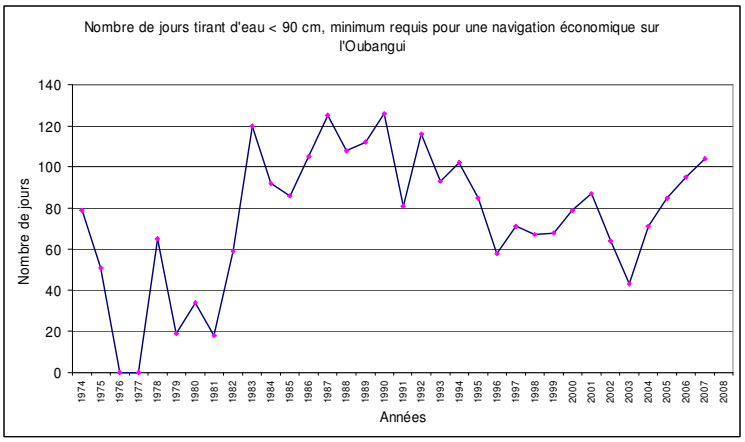
1.2 Main issues at stake in the Congo Basin

Navigation services noted a decrease of about 18% of the Oubangui river's discharge since 30 years.



This decrease is causing increasing days of navigation stopping: 4 days per year from 1935 to 1971 ; 40 days per year from 1972 to 1982 ; 107 days per year from 1983 to 1989, and more than 200 days per year since 2002.

Low waters on the Oubangui river, with increasing sand banks

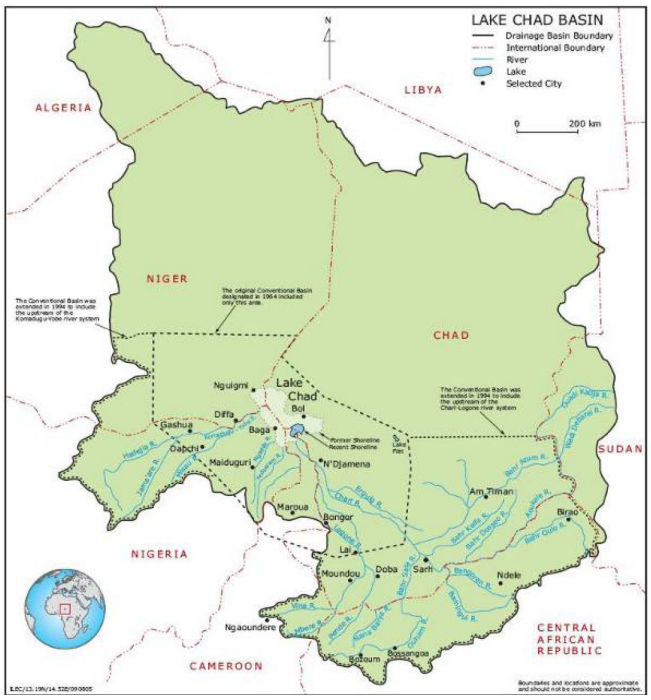


Number of days with a water height of less than 90 cm required for an economic navigation on the Oubangui river.

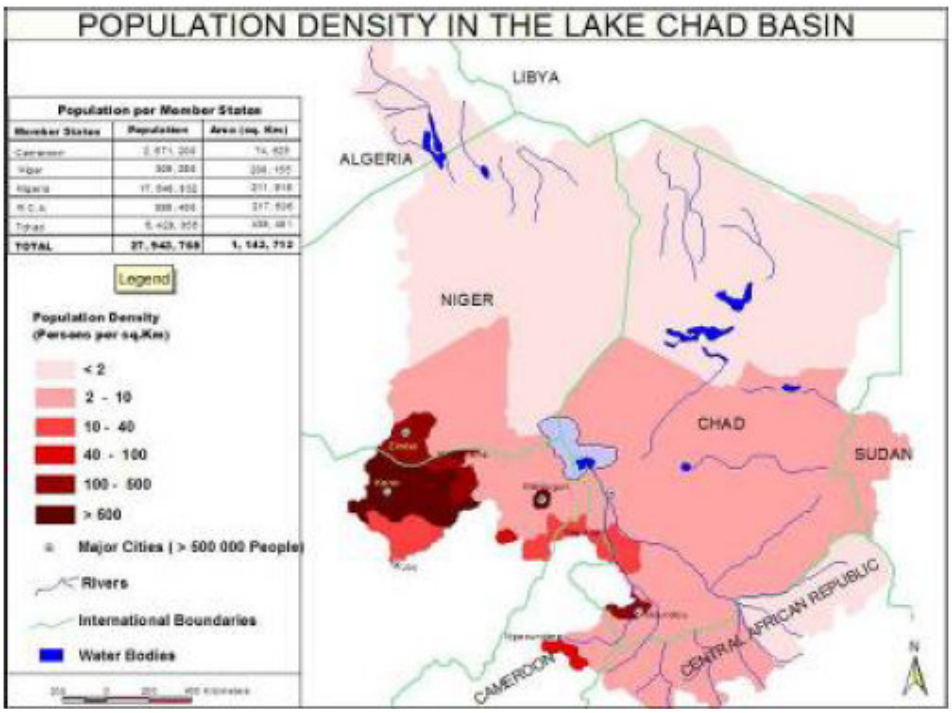
2 THE LAKE CHAD BASIN

2.1 Background

Lake Chad Basin is the other transboundary basin of the Central African sub-region. It is spread over 2 397 423 km^2 in Chad, the Central African Republic, Niger and Nigeria Algeria, Sudan, Cameroon and Libya, by decreasing surface ratio.Its population is around 29 million inhabitants, by extrapolating the census data obtained in 1991.

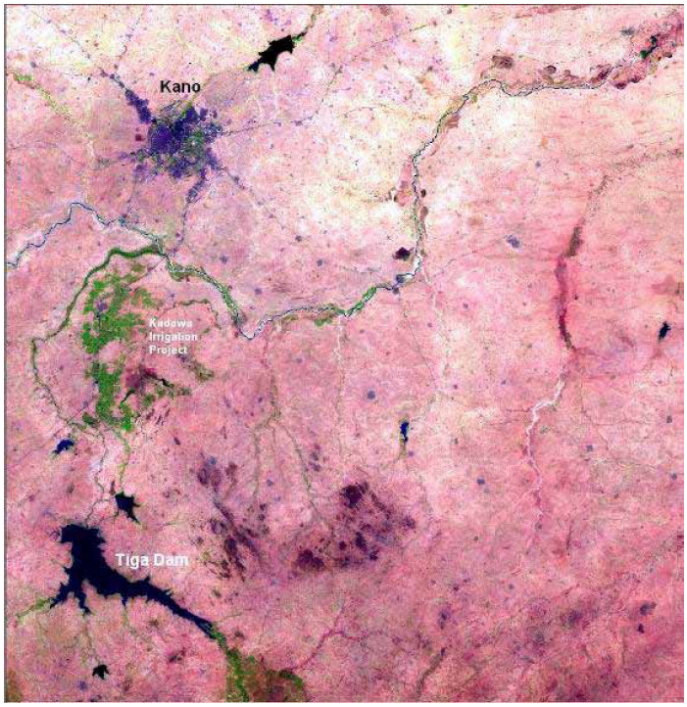


Lake Chad Basin map



Population density (Source: WRI, 2000)

The Nigerian part is highly populated with Kano, the main city of the region with more than 1 million inhabitants. Kano is located close to the Komadugu-Yobe river bank with two dams (Tiga and Challawa dams) supplying it and a vast irrigation project feeding it: the Kaduna Irrigation Project.

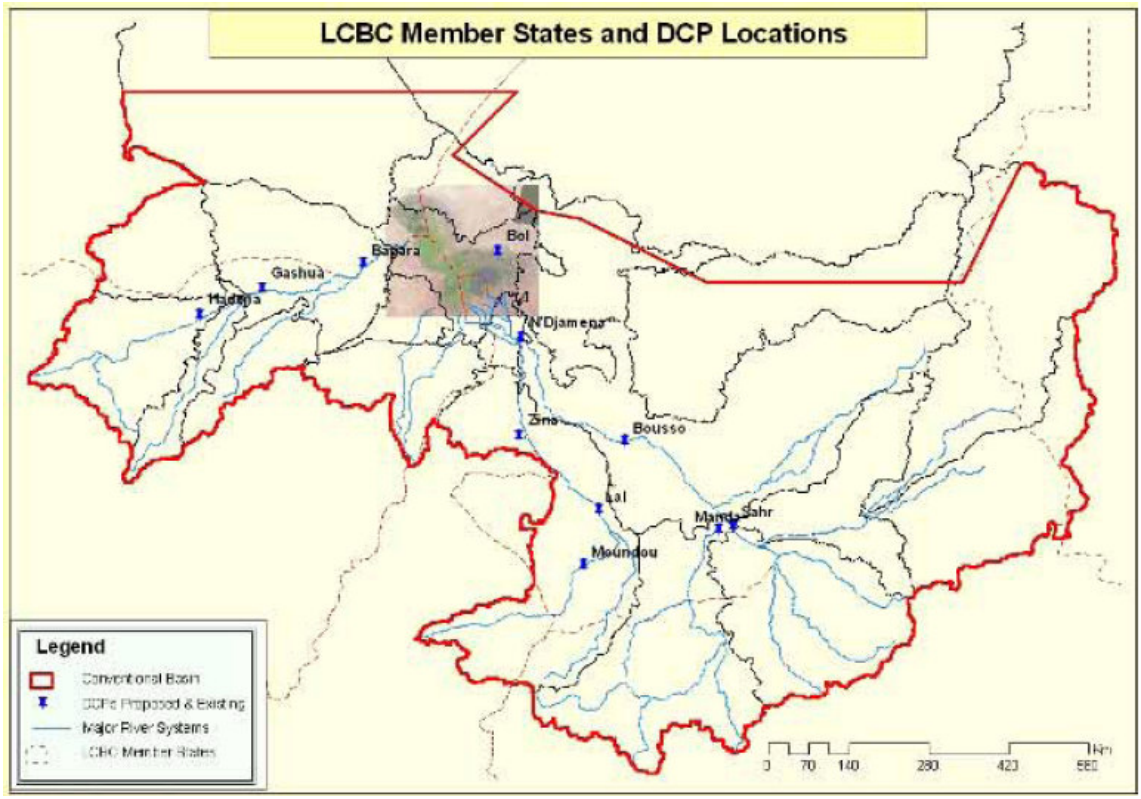


1.2.1 The hydrometric network

76 limnimetric stations compose the Lake Chad basin network (Chad : 30 stations; Cameroon : 11 stations ; Niger : 4 stations with one planned on Lake Chad ; Nigeria : 22 stations ; RCA : 9 stations ; Libye : 0 station)

DREM-Chad informed that the 4 current DCP installed in Chad at N'Djamena, Sahr, Bongor and Moundou) are not functioning since 2003 due to vandalism.

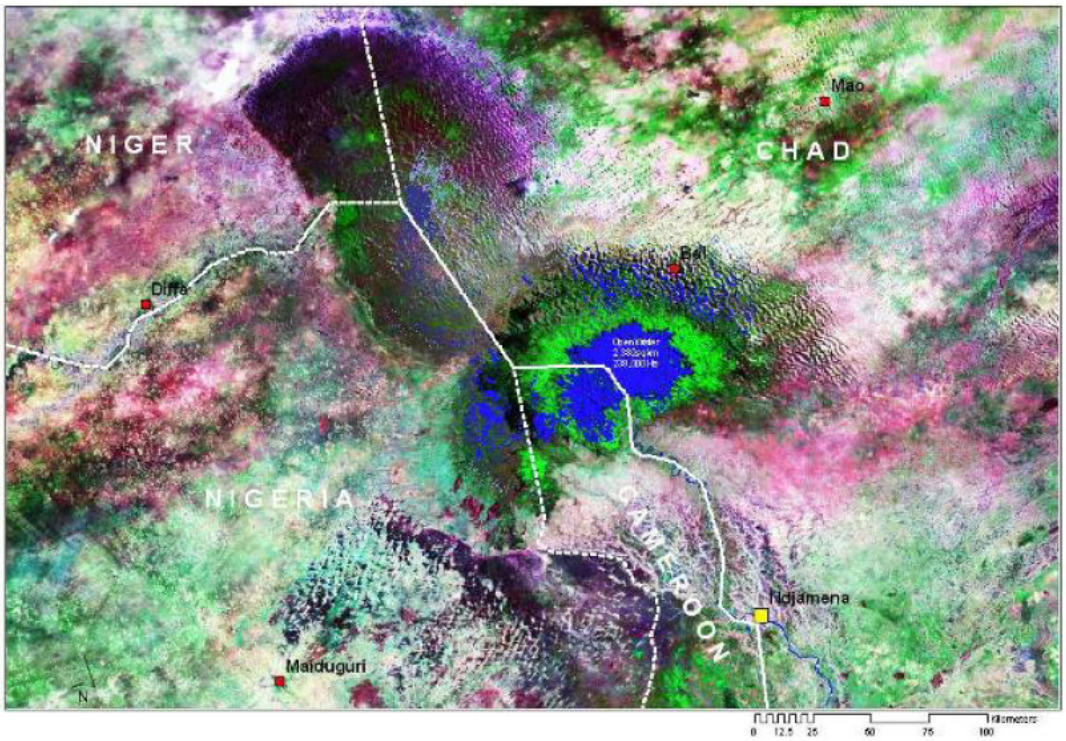
Twelve HYCOS stations are going to be installed. The planned locations are hereafter:



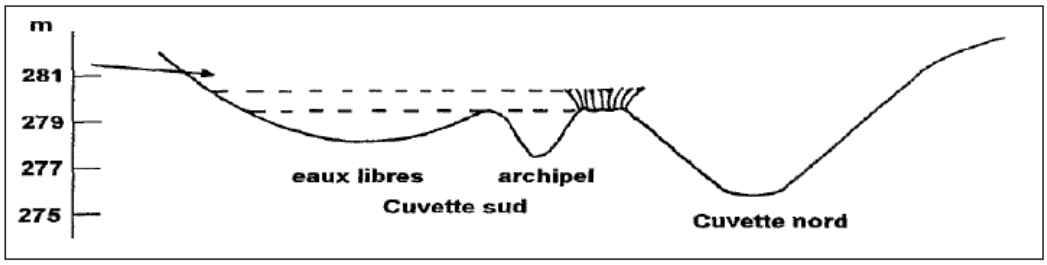
Planned location of HYCOS Data collection Platforms in the Lake Chad Basin.

2.2 Drying of Lake Chad

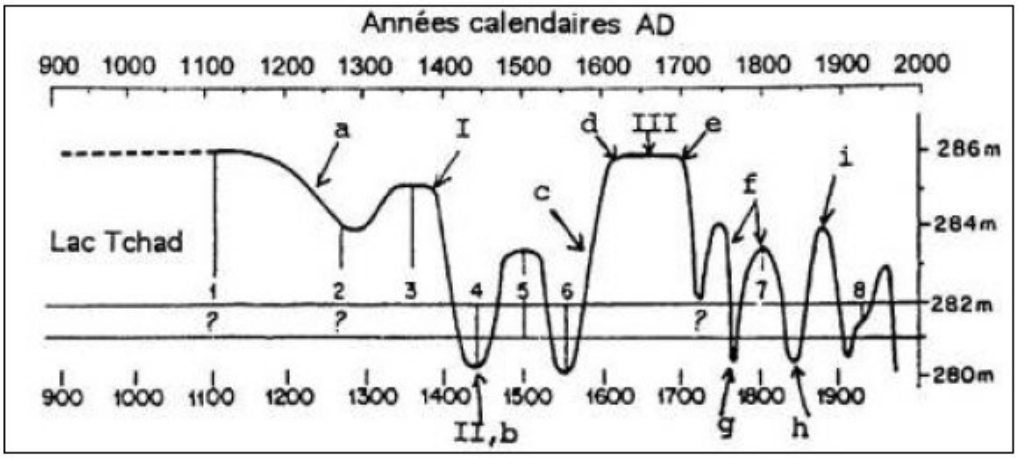
Since the 1970s and 1980s droughts, Lake Chad surface has decreased from 25 000 km^2 to 2300 km^2. Its depth varied from 4 in the Southern Pool to 7 m in the Northern Pool.



Satellite image of Lake Chad in March 2007 with a total surface of 2300 km^2
(Source: LCBC, 2007)



Lake Chad Profile and depth



Historical variations of Lake Chad water level (Source : Maley, IRD, 1981)

From Maley studies, the Lake Chad water level was already very low in the past (near 1440, 1550, 1770, 1850 and currently) and reached a maximum between 1580 and 1700. The variations of its level could be due to climatic factors such as the decrease in rainfall since the

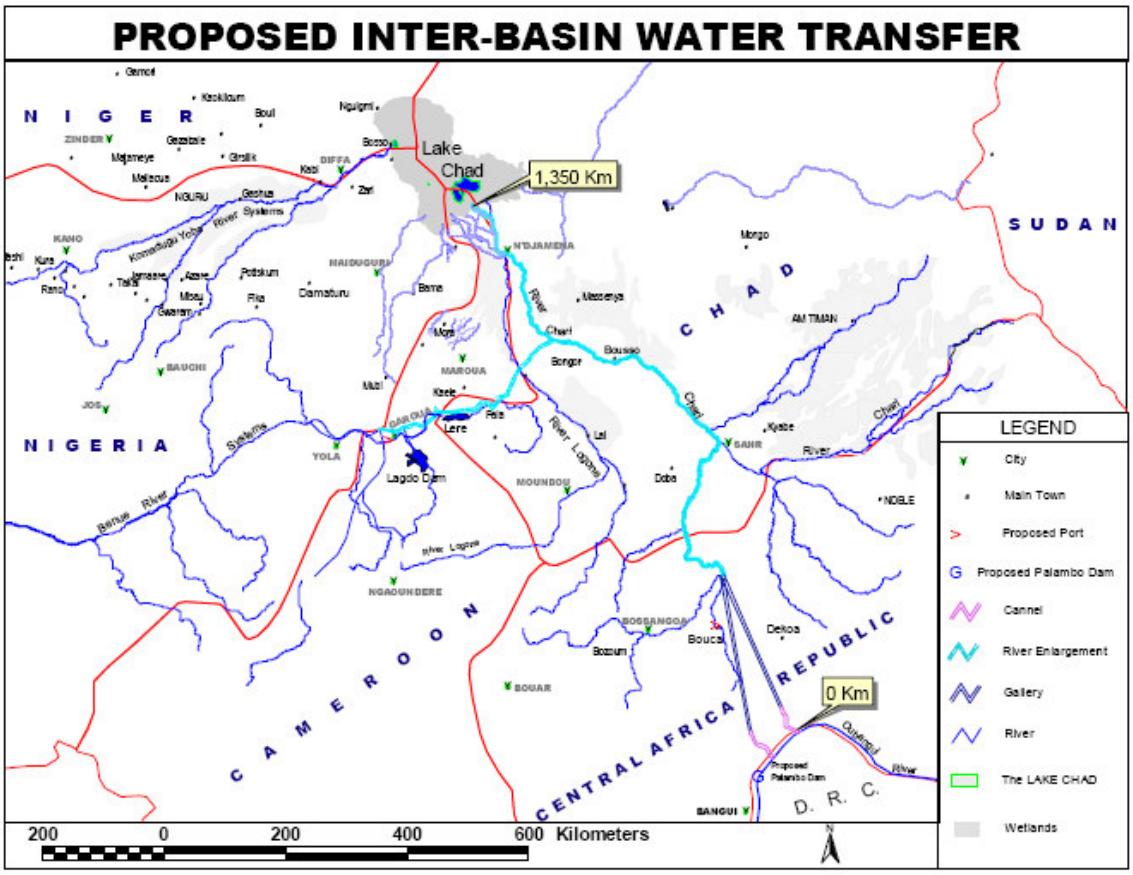
1970s in the region (the isohyete shifted by 200 km southward) but also anthropogenic with the development of Kano city and its influence on the Komadugu-Yobe river flow to Lake Chad.

3 ENVISAGED REMEDIATIAL ACTION: THE OUBANGUI-CHARI IBWT

3.1 IBWT Oubangui-Chari

The context of the Lake Chad drying led some engineers to propose to transfer water from the Oubangui river in the Congo Basin to the Chari river system flowing to Lake Chad in the Lake Chad Basin. 920 m3/s have been assessed as possible waters from the Oubangui river to transfer to the Chari by the 1370 km route highlighted below.

An Italian Consulting firm BONIFICA proposed a first project in 1988 and a second project was designed by NEPA (Nigeria National Electric Power Authority). The IBWT project studies the possibility to transfer water from the Congo basin (through the Oubangui river) through a 184 km tunnel which would link Oubangui river to Fafa river and Ouham river (Bahr Sara river in Chad) until Chari river until Lake Chad. A liaison would be established between Chari and Benoue river linking Congo, Lake Chad and Niger basins and Bangui to N'Djamena and Port Hartcourt.



The feasibility study funded by the Nigerian government is planned for this year.

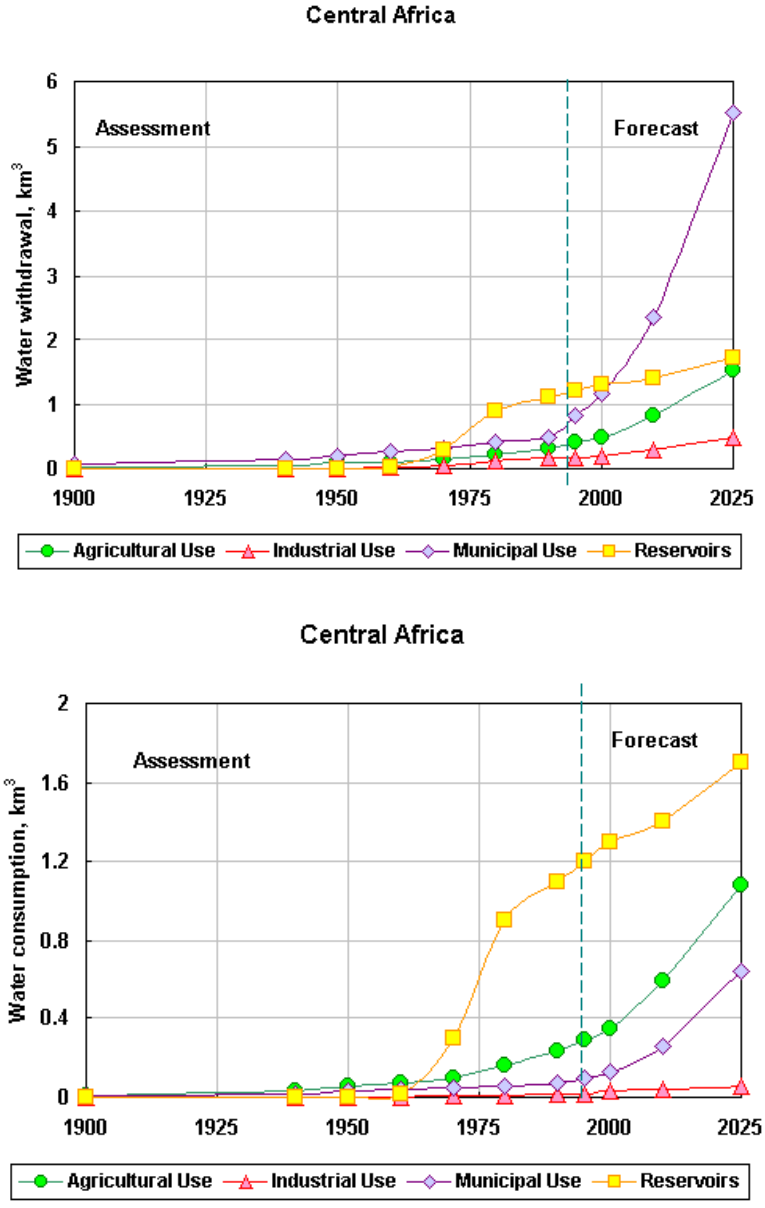
The proposed Interbasin Water Transfer questions the lack of available data regarding the giving basin : the Congo Basin. Therefore, an environmental monitoring system is required to better assess the actual Congo basin water resources and their sensitivity to climate and anthropogenic changes.

4 IWRM IN CENTRAL AFRICA

The drying of Lake Chad and the lack of knowledge of water resources in the Congo basin advocate for a better water resources management in the sub-region, using the principles of Integrated Water Resources Management (IWRM).

4.1 IWRM in Central Africa: background

From Shiklomanov World Water Resources Assessment in 1999, the Central African region appears to withdraw and consume less than 3 km^3/year. The main increase will be withdrawal for domestic use (Water supply) and consumption for dams.



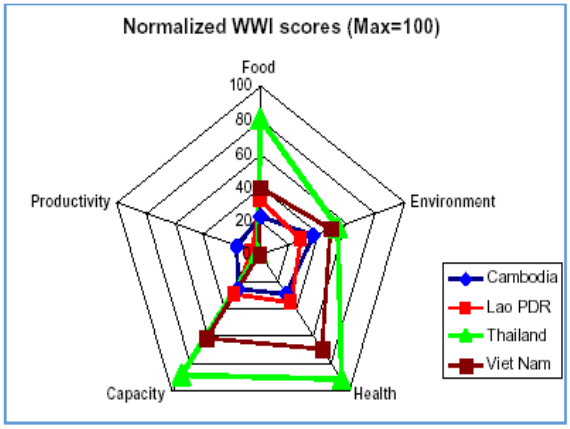
Dynamics of water resources uses in Central Africa by economic activities types (Source: Shiklomanov, 1999, UNESCO/PHI).

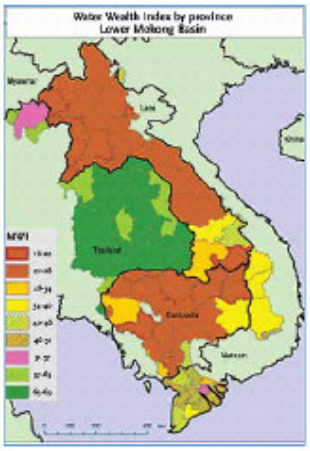
4.2 IWRM in the Congo Basin

Despite its important availability (22 752 m^3/inhabitant/year), much more than 1000 m^3/inhabitant/year water stress, Integrated Water Resources Management is necessary in the Congo basin due to conflicting uses and water scarce neighboring basins. Moreover the climate change context that changes the environmental conditions in Africa justify it. IWRM in the Congo basin is since February 22 2007 part of the CICOS mandate.

GTZ initiated the development of a Congo Basin information system (SIBCO). Moreover, a IWRM state-of-the-art study was done in November 2006 by the African Development Bank. The development of a Strategic Action Plan for the water resources management of the Congo Basin funded by the African Water Facility will start in August 2008 until December 2009 to elaborate strategies.

IWRM tools are still required. Example could be taken from NBA and Mekong river basin.



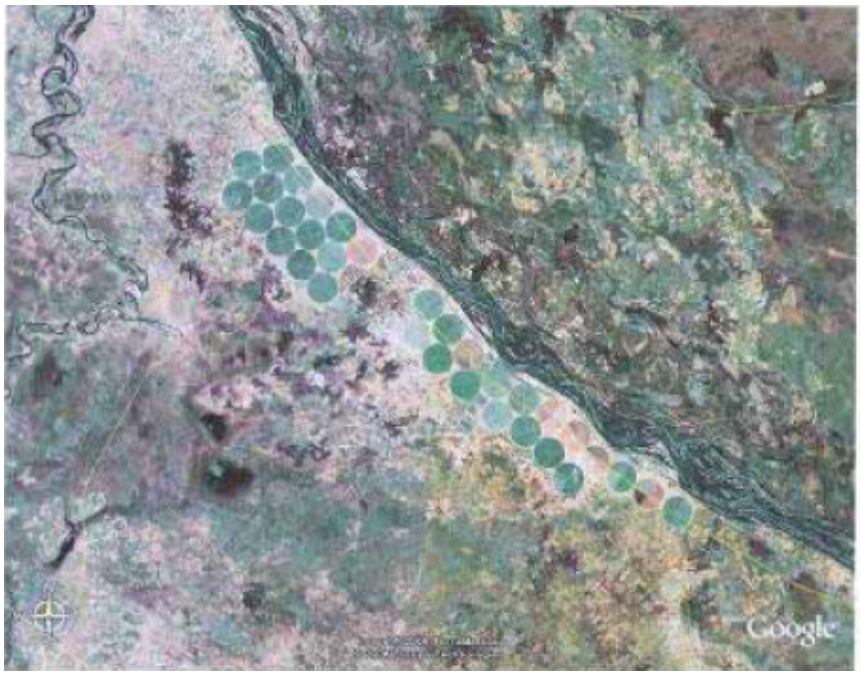


Water wealth index in the lower Mekong basin

4.3 IWRM in the Lake Chad Basin

The GEF, GTZ and European Union projects aim at combining their effects to the IWRM of Lake Chad Basin. The GEF programme tackle the reversing of land and water degradation in Lake Chad Basin. GTZ is developing an information system for Lake Chad Basin and data exchange protocols. GTZ/AHT also mapped the Lake Chad Basin hydrographic system and studied the planned development such as Palambo dam in Central African Republic.

The European Union project revised its activities to match with on-going implementation and develop socio-economic strategies on navigation and multiple uses developments comprising hydropower.



Sugarcanne irrigation near Sahr along the Chari river, Chad (Google, 2006)

Transboundary area between Cameroon and Chad with the artificial Maga lake in Cameroon and its SEMRY northern paddy fields and the transboundary Logone river, the border between Cameroon and Chad (Google, 2007)

5 THE AMESD THEMATIC ACTION IN THE CONGO BASIN

Since the decrease of the Oubangui river discharge and the pressing needs of Lake Chad basin, the monitoring of water resources in the Congo basin is to be improved. The AMESD programme proposes to focus on the development of a preliminary water resources management

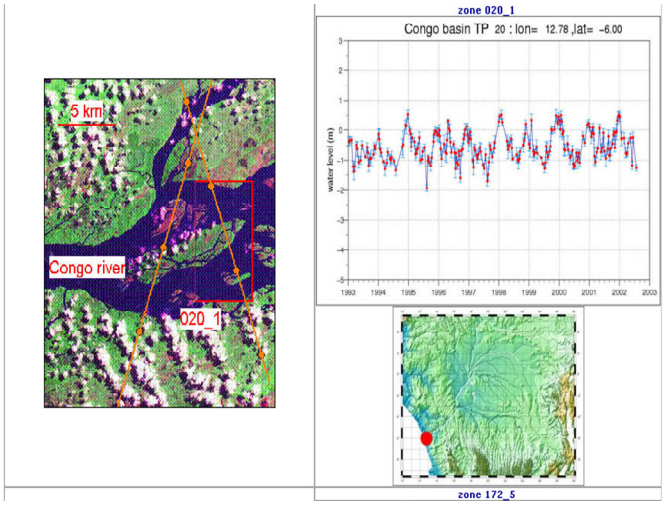
tool with an operational environmental monitoring system of the Congo basin water resources based on Earth Observation data.

5.1 The Use of Space Technology for Water Management in the Congo Basin

5.1.1 Background

Good correlations have been observed between in situ water level measurements and spatial altimetry water level assessments in the Congo basin by the LEGOS laboratory at Toulouse, France. Spatial altimetry can improve the spatial coverage of these kind of measurements.

Regional needs in environmental monitoring include meteorological ones (rainfall, ETP), hydrological ones (water levels, discharges, water balance) and environmental ones (sand banks, deforestation impact on water resources monitoring).

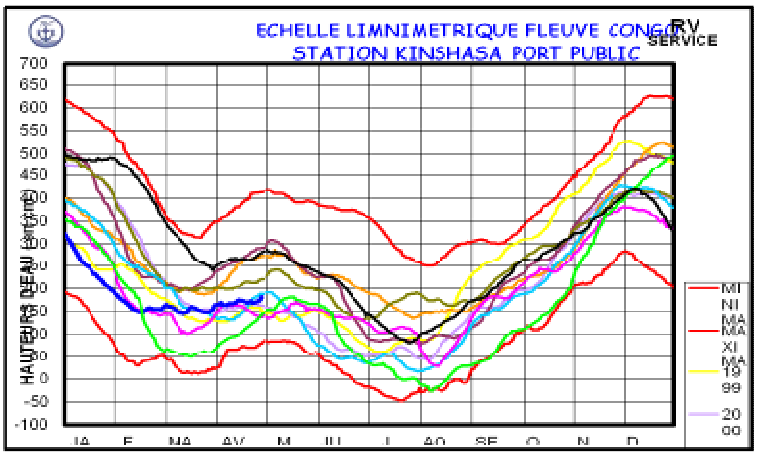


Source : LEGOS, Anny Cazenave & Marie-Claude Gennero, http://www.legos.obs-mip.fr/en/equipes/gohs/resultats/i_hydroweb

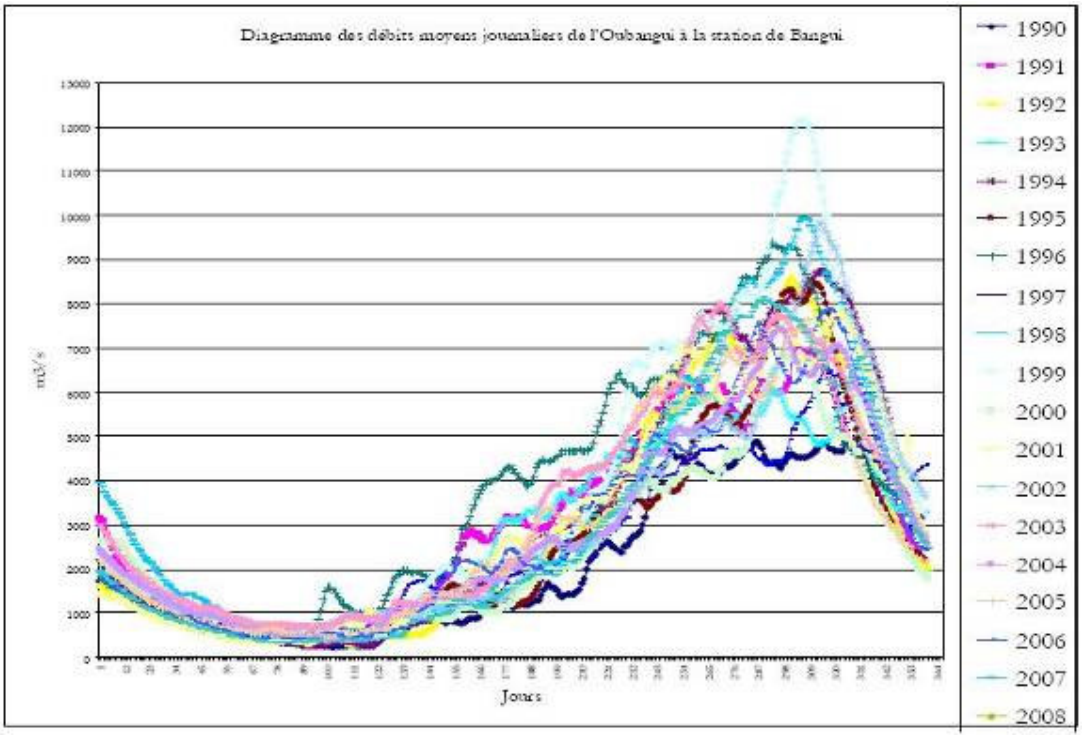
5.1.2 Assets

The assets of spatial altimetry is to multiply the virtual stations on the waterways. This would allow the characterization of sensitive navigation areas such as Zinga step, on Ounbangui river in Central African Republic. There are some unconsistencies observed now between the Bangui limnimetric station and Zinga one that could be explored.
The output will be the issuing of upgraded navigants bulletins by navigation services (RVF, GIE-SCEVN).

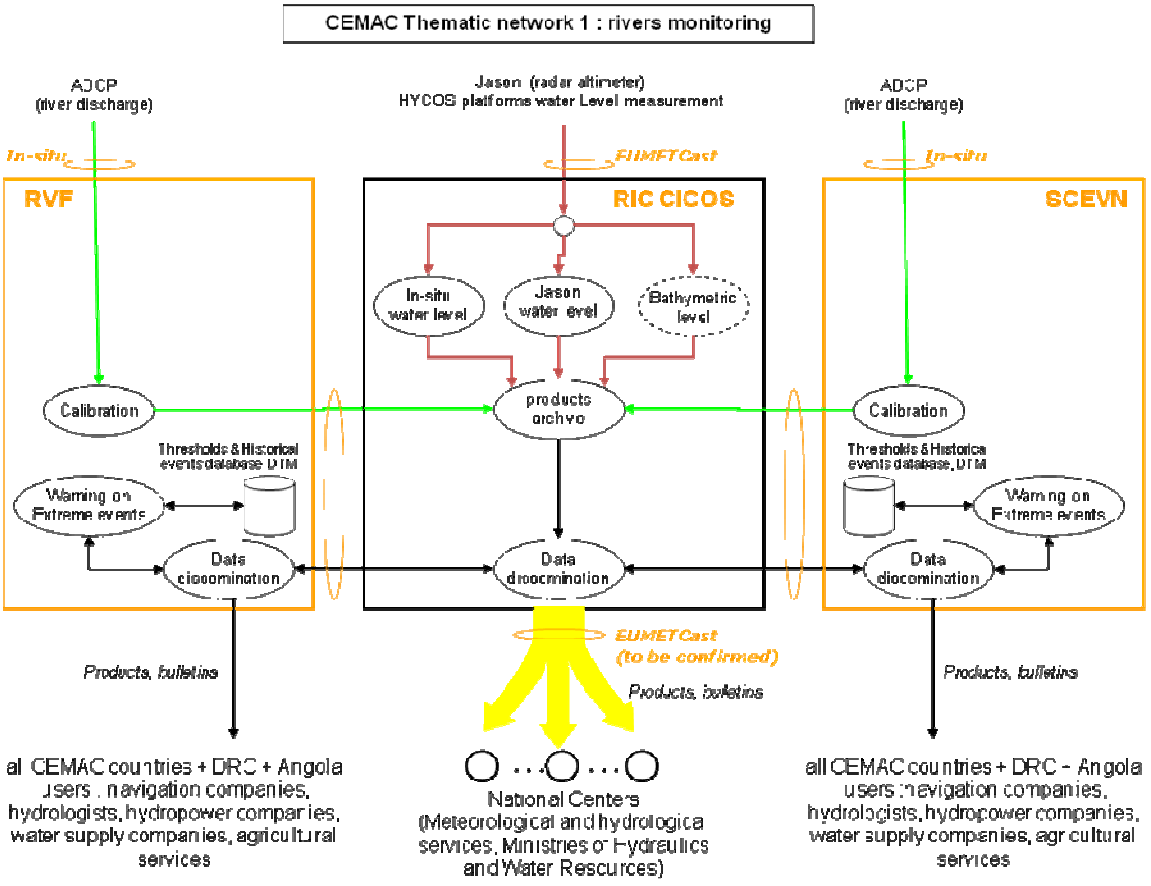
5.2 Towards rivers monitoring

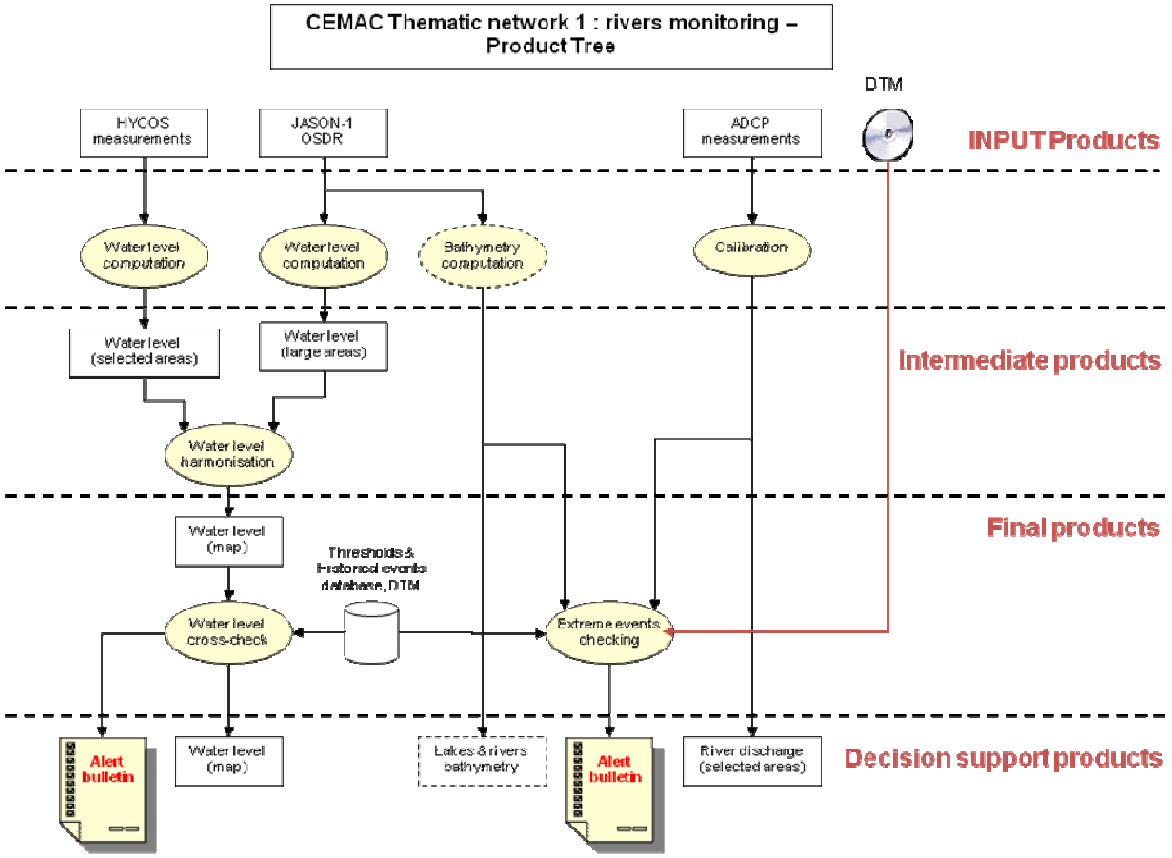


Water levels at Kinshasa, measured by RVF, 1999-2006.

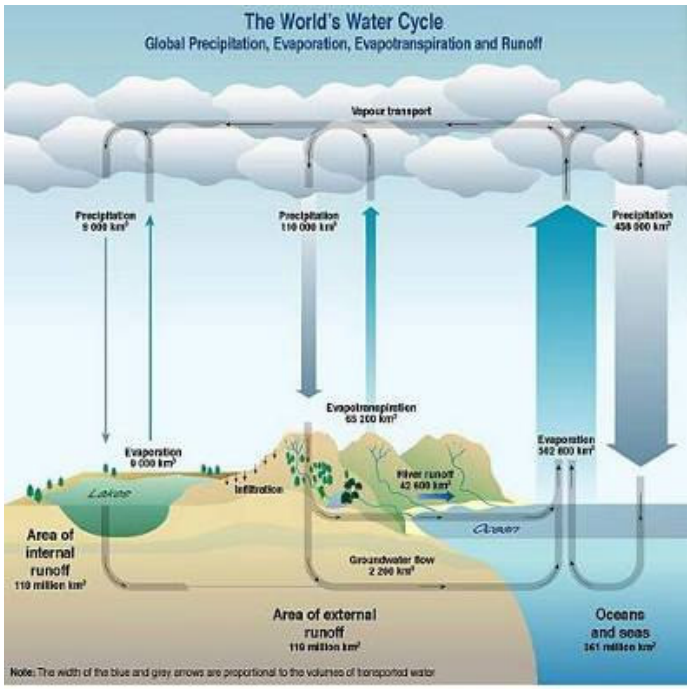


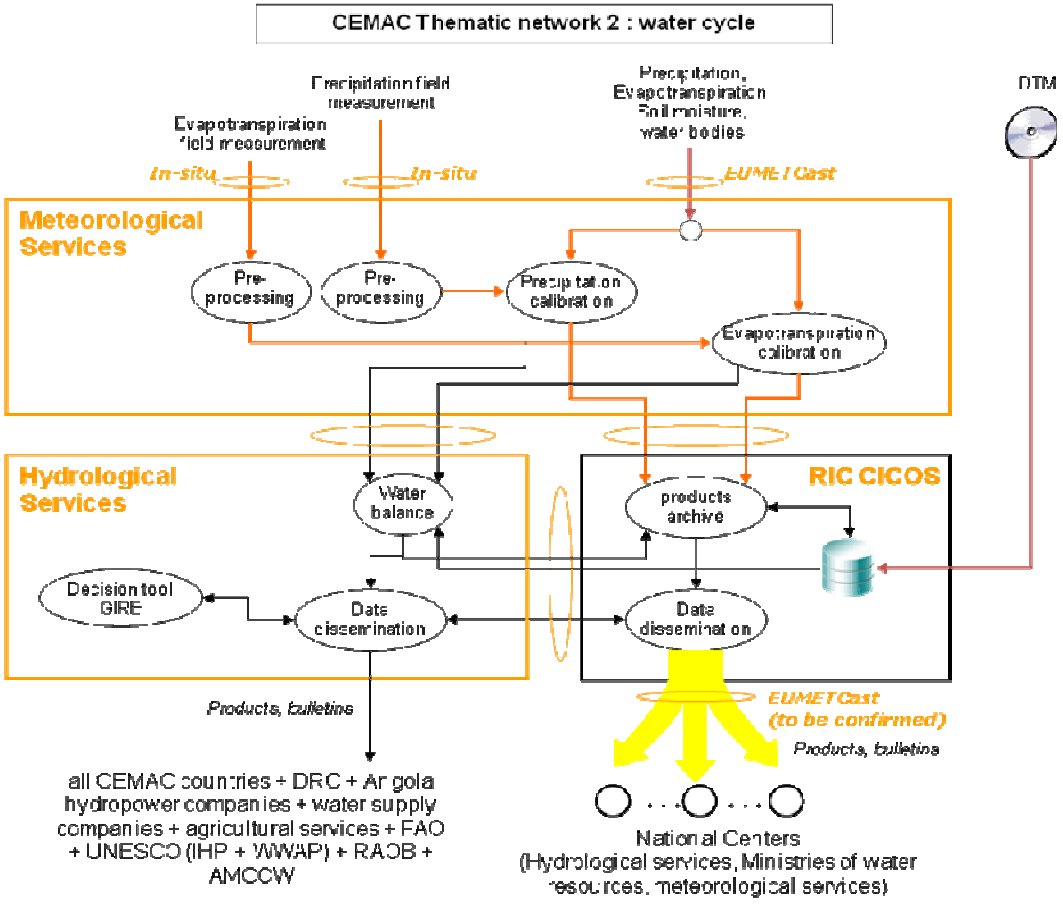
A relationship water level – discharge can usually be established for some river sections. However, on the Oubangui river, no relationship can be found between the measurements made at Bangui and the ones made at the Zinga step.

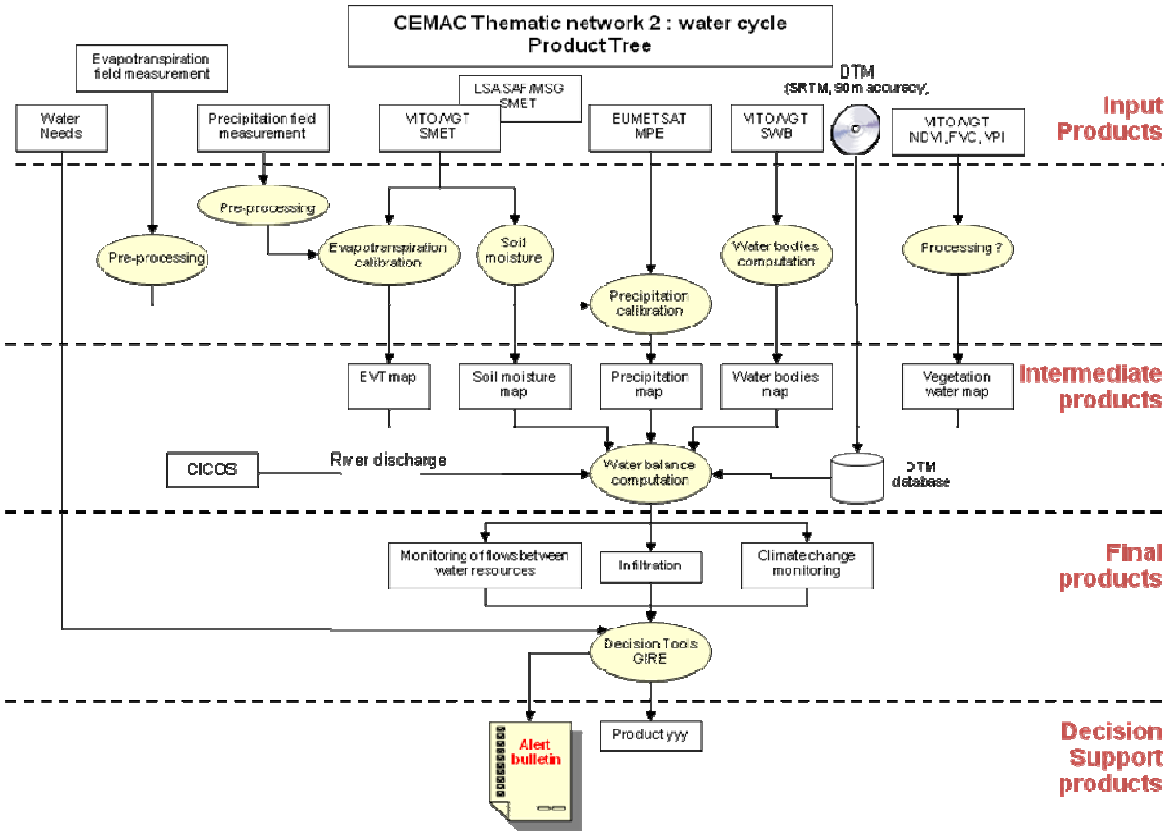

CEMAC Thematic network 1 : rivers monitoring
ADCP (river discharge)
In-situ
Jason (radar altimeter) HYCOS platforms water Level measurement
EUMETCast
ADCP (river discharge)
In-situ
RVF
RIC CICOS
SCEVN
In-situ water level
Jason water level
Bathymetric level
Calibration
products archive
Calibration
Thresholds & Historical events database, DTM
Thresholds & Historical events database, DTM
Warning on Extreme events
Warning on Extreme events
Data dissemination
Data dissemination
Data dissemination
EUMETCast (to be confirmed)
Products, bulletins
Products, bulletins
Products, bulletins
all CEMAC countries + DRC + Angola users : navigation companies, hydrologists, hydropower companies, water supply companies, agricultural services
National Centers (Meteorological and hydrological services, Ministries of Hydraulics and Water Resources)
all CEMAC countries + DRC + Angola users : navigation companies, hydrologists, hydropower companies, water supply companies, agricultural services


CEMAC Thematic network 1 : rivers monitoring – Product Tree
DTM
HYCOS measurements
JASON-1 OSDR
ADCP measurements
INPUT Products
Water level computation
Water level computation
Bathymetry computation
Calibration
Water level (selected areas)
Water level (large areas)
Intermediate products
Water level harmonisation
Water level (map)
Thresholds & Historical events database, DTM
Final products
Water level cross-check
Extreme events checking
Alert bulletin
Water level (map)
Lakes & rivers bathymetry
Alert bulletin
River discharge (selected areas)
Decision support products

5.3 Towards Water balance monitoring







5.4 Training needs

Capacity building will target GIS, the use and analysis of EumetCast products (www.eumetsat/products), data management, and the use of remote sensing for water management.

5.5 Thematic Network building and Partnerships

Partners of the Thematic Action are data or service providers such as navigation services and meteorological/hydrological services.

Beneficiaries are users of the navigation services, hydropower and drinking water producers, as well as regional experts and decision-makers.

CONCLUSION

The AMESD programme in Central Africa aims at developing two services: one for water level monitoring and one for rainfall monitoring by catchments. It is an operational programme involving regional navigation, meteorological and hydrological services.

Navigation on the Congo river

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ACRONYMS

AMESD African Monitoring of Environment for Sustainable Development

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