WORLD METEOROLOGICAL ORGANIZATION

FRENCH MINISTRY OF FOREIGN AFFAIRS
STATE SECRETARIAT FOR COOPERATION

HYDROLOGICAL CYCLE OBSERVING SYSTEM

FOR WEST AND CENTRAL AFRICA

AOC-HYCOS

DRAFT PROJECT DOCUMENT

BENIN, BURKINA FASO, CAMEROON, CAPE VERDE, CENTRAL AFRICAN REPUBLIC, CHAD, CONGO, COTE D'IVOIRE, EQUATORIAL GUINEA, GABON, GAMBIA, GHANA, GUINEA, GUINEA-BISSAU, LIBERIA, MALI, MAURITANIA, NIGER, NIGERIA, SAO TOME AND PRINCIPE, SENEGAL, SIERRA LEONE, TOGO,

Prepared by the Secretariat of WMO

Geneva, April 1997

Contents

Preamble

The present Draft Project Document on setting up a **Hydrological Cycle Observing System for West and Central Africa (AOC-HYCOS)** was prepared by the World Meteorological Organization at the request of the French Ministry of Cooperation within the framework of a contract signed on 18 July 1996.

In compliance with the terms of this contract, WMO appointed two consultants, namely Mr. Mamadou A. Sakho (Côte d'Ivoire), Deputy Director of Hydrology, President of the Working Group on Hydrology of the WMO Regional Association I (Africa), and Mr. Grégoire Alé (Benin), Head of the Water Resources Department of the National Hydrology Directorate. These two experts visited 16 countries in the subregion and jointly drew up a preliminary report in Cotonou (Benin). The present document is based on this preliminary report.

Missions were undertaken in the following countries (listed alphabetically): Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Gabon, Ghana, Guinea, Mali, Mauriania, Niger, Nigeria, Senegal and Togo. People interviewed by the two consultants during their respective missions are listed in **Annex 10**.

WMO also enlisted the services of Mr. Michel Gautier, Research Engineer at the Institut français de recherche scientifique pour le développement en coopération (ORSTOM) and Head of the West and Central Africa Regional Hydrological Observatory (OHRAOC) at Ouagadougou, Burkina Faso.

The Secretariat of the World Meterological Organization (Geneva) prepared and presented the final document and it was accepted by the French Ministry of Cooperation (Paris).

1. Introduction

One of the main challenges facing humankind at the dawn of the 21st century is meeting the demand for good quality freshwater without degrading the environment, thus ensuring sustainable socioeconomic development. The most obvious way of achieving this goal is by rationalizing water resources management. The United Nations Conference on Environment Environment and Development (1992), in Chapter 18 of Agenda 21, and the report of the International Conference on Water Water and the Environment[1], upon which it was based, recognized that knowledge of the hydrological cycle is essential for efficient sustainable management of water resources (quantity and quality). Moreover, reliable national and regional **hydrological information systems** are necessary for assessment, follow-up and management of these resources. These systems should include data collection and processing, along with dissemination of data and derivative information products products to end-users, ranging from the general public to decision-makers, thus keeping them immediately and reliably informed.

Chapter 18 of the UNCED Agenda mentioned above, along with the ICWE report and WMO/UNESCO Water Resources Assessment report[2], highlighted that these information systems are presently inadequate or have not even been set up in many regions of the world.

The World Hydrological Cycle Observing System (WHYCOS)[3] was thus launched in 1993 with the support of the World Bank. It is based on a global network of reference stations (hydrological observatories) with real-time transmission of data using, when possible, meteorological satellites of the World Weather Watch (WWW) of WMO. The overall aim is to develop nationally distributed databases with consistent, regularly-updated, high-quality data on river discharge, water quality and some climatic parameters, for regional, national and global dissemination.

An integrated approach has been adopted for this programme, contrasting with the highly technological thrust at the outset. The broad objectives are to improve the collection, exchange, dissemination and end-use of consistent reliable data and products concerning the continental hydrological cycle of national river basins, at regional and global levels, by setting up and/or strengthening demand-driven information systems.

The WHYCOS programme has two components:

- a **general conceptual component** - aimed at strengthening cooperative links between participating countries for the assessment and management of essential global freshwater resources, and

- an **operational component** - aimed at implementing WHYCOS components at regional and international basin levels (HYCOS). This involves proportional support for national hydrological information systems, while addressing local concerns within the general framework of the WHYCOS programme. The goal is to promote full involvement of these systems in sustainable national and regional socioeconomic development, and in international activities in the fields of water resources, environment and climate.

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1 WMO (1992) International Conference on Water and the Environment, 26-31 January 1992, Dublin, Ireland. Dublin Declaration and Conference Report

2 WMO/UNESCO (1991) Water Resources Assessment. Progress in the Implementation of the Mar del Plata Action Plan and a Strategy for the 1990s

3 Rodda, J.C., Pieyns, S.A., Sehmi, N.S., & Matthews, G. (1993) Towards a world hydrological cycle observing system. Hydrological Sciences Journal, Vol. 38 no. 5

The conclusions of the Sub-Saharan African Hydrological Assessment Project (SSAHAP)[4], especially with respect to the West and Central African subregion (AOC), were presented in a regional report (December, 1992)[5]. They clearly highlight the current alarming state of hydrological information systems and agencies in charge of these systems. Factors responsible responsible for this situation were widely discussed at the Addis Ababa Conference on Water Resources (20-25 March 1995)[6], jointly organized by WMO and the United Nations Economic Commission for Africa (ECA), financially supported by several countries including France. The SSA Hydrological Assessment and the Addis Ababa Conference Report, which was was endorsed at the 12th WMO Congress and by the ECA Council of Ministers, propose solutions to this situation on a subregional, regional and national scale.

Implementation of a regional hydrological cycle observing system for West and Central Africa (AOC-HYCOS), which is a subregional application of the overall WHYCOS concept, is aimed at modernizing national systems and tailoring them to the actual economic context in AOC countries, while developing regional cooperation to enhance national and global integrated water resources management. AOC-HYCOS is obviously not a universal cure-all, but does promote operational hydrology by integrating it in the socioeconomy of participating countries. Once AOC-HYCOS is set up, it should be able to address defined specific demands of local and external partners through an integrated national-regional-global strategy.

This regional approach should not create conflicts of interest, especially at the expense of funding for national projects listed by SSAHAP. It is actually complementary, and countries in the subregion should benefit through: (i) modernization of some benchmark hydrological stations; (ii) facilitated access to real-time data exchange and dissemination systems such as WMO's Global Telecommunication System (GTS) and Internet; (iii) modernization of national databases; (iv) promoting National Hydrological Services (NHSs) and regional bodies with respect to local decision-makers, international agencies, funding bodies, especially through the development, preparation and rapid dissemination of hydrological products of regional, national and international interest; and (v) training.

2. The subregional context

2.1. Population and economic indices

In the Sub-Saharan African Hydrological Assessment, Africa south of the Sahara was divided into five groups. West and Central Africa (AOC) is considered here as belonging to group III, i.e. "West Africa", and includes 23 countries in an area extending from the right banks of the Congo River to the southern Sahara, between the Atlantic Ocean in the west and the Sudanese border in the east. In addition to the 16 countries visited when preparing the present document (listed in the Preamble), the seven other countries in the AOC subregion are, alphabetically: Cape Verde, Gambia, Guinea-Bissau, Equatorial Guinea, Liberia, Sao Tome and Principe, and Sierra Leone.

Geographically, this is the largest African subregion, covering 9,150,700 km^2 or 30% of the continent. The population in this subregion (more than 236 million inhabitants) represents more than 35% of the entire population of Africa. There is a high annual population growth rate (2.82%) in this subregion, ranging from 1.46% (exceptionally low) to 3.58%.

The per-capita gross national product (GNP) is extremely low. Apart from the unique situation in Gabon which has an annual per-capita GNP of US$3,880, the mean is around US$420 (range US$160-930). Concerning the gross domestic product (GDP), all countries in the subregion belong to category 1 (less than US$795/year), i.e. the lowest in the World Bank four-category classification, except for one country which is in class 2 (US$796-2,895/year) and another in class 3 (US$2,896-8,955/year).

2.2 Climate and hydrological regimes

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4 Conducted by the World Bank and funded by UNDP, the World Bank, AfDB, the French government and the European Community

5 Mott MacDonald Intl./BCEOM/SOGREAH/ORSTOM (1992) Sub-Saharan Africa Hydrological Assessment West African Countries, Regional Report

6 WMO/ECA (1995) African Conference on Water Resources: Policy and Assessment. Addis Ababa (Ethiopia)

The climate of the subregion is highly diversified from north to south and mainly governed by the seasonal movements of the intertropical convergence zone (ITCZ).

On a north to south gradient, a wide range of different climatic types and corresponding hydrological regimes can be noted[7]: noted[7]:

- desert
- subdesert
- Sahelian
- humid tropical
- equatorial.

Desert and subdesert regimes prevail along the northernmost rim of the subregion: mainly in Mauritania, northern Senegal, Mali, Niger and Chad. The desert regime is characterized by precipitation levels of 100-150 mm/year, with 150-300 mm/year under the subdesert climate. Day temperatures are high, reaching and even surpassing a mean 40EC from May to September, with marked day-temperature deviations (10-12EC). Temperatures are much lower (24-30EC) from late September to late February, with high day-temperature deviations (12-16EC) and absolute lows of about 0EC in flat areas and lower in higher zones. Morning relative humidity ranges from 20% to 30% throughout most of the year in desert conditions, and from 40% to 45% under the subdesert regime, where the rainy season (July-August) has a marked effect, with morning means ranging from 40% to 50%. There is substantial interannual variability in precipitation (i.e. resources), with no perennial runoff and flash floods occur in small basins during summer. In addition, evaporation rates are very high (more than 4 m/year).

The Sahelian regime is located between the 300 mm isohyet and 750 mm isohyet in the south. The heavier rains, especially especially in the southern part of the area under the Sahelian regime, lead to cooler summer temperatures, annual evaporation ranging from 2.5 m to 3 m, and morning relative humidity levels ranging from 30% to 50% in the dry season and and from 65% to 75% during the rainy season. The rainy season lasts 3 months (July-September) on average. Throughout the Sahelian zone, widespread flooding occurs as a result of the marked hydrographical degradation, relatively high runoff and lack of slope. Many tropical rivers (e.g. Niger, Senegal, Logone and Chari Rivers) flow into the Sahelian zone and regulate flood discharge, but enormous quantities of water are still lost. There is even greater interannual variability under this climatic regime and perennial flooding is exceptional, apart from the large rivers flowing out of southern zones that receive more rainfall.

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7 Rodier J. (1964) Régimes hydrologiques de l'Afrique noire à l'ouest du Congo, Mémoires Orstom

Table 1

Statistics and forecasts on population, GNP and GDP patterns in the subregion.

		1995				**2025**		
1	2	3	4	5	6	7	8	9
Country	Area (km²)	Population (millions)	Annual growth rate (%)	GNP per capita US$	GDP World Bank class	Population (millions)	GNP per capita US$	GDP World Bank class
Benin	112,620	5,409	3.33	370	1	11,358	656	1
Burkina Faso	274,200	10,319	2.79	300	1	21,668	532	1
Cameroon	475,440	13,233	2.92	680	1	27,787	1,205	2
Cape Verde	4,030	0.392	2.98	930	2	0.823	1,648	2
CAR	622,980	3,315	2.10	370	1	6,961	656	1
Chad	1,284,000	6,361	2.18	180	1	13,357	319	1
Congo	342,000	2,590	2.32	620	1	5,439	1,099	2
Côte d□Ivoire	322,460	14,253	3.38	610	1	29,929	1,081	2
Equatorial Guinea	28,050	0.400	2.59	430	1	0.840	762	2
Gabon	267,670	1,320	1.46	3,880	3	2,772	6,876	3
Gambia	11,300	1,118	3.08	330	1	2,348	585	1
Ghana	238,540	17,453	3.06	410	1	36,648	727	2
Guinea	245,860	6,700	2.43	520	1	14,069	922	2
Guinea-Bissau	36,120	1,073	2.36	240	1	2,253	425	1
Liberia	111,370	3,039	3.22	500	1	6,381	886	2
Mali	1,240,000	10,795	2.83	250	1	22,668	443	1
Mautitania	1,030,700	2,274	3.17	480	1	4,775	851	2
Niger	1,267,000	9,151	3.40	230	1	19,215	408	1
Nigeria	910,770	111,721	3.16	280	1	234,594	496	1
Senegal	196,190	8,312	3.12	600	1	17,454	1,063	2
Sierra Leone	71,740	4,509	2.63	160	1	9,468	284	1
Togo	56,790	4,138	3.58	320	1	8,689	567	1

The "pure" tropical and transitional tropical regimes extend from 750 mm to 1,200 mm isohyet and beyond 1,200 mm isohyet, respectively. There is a "cool" period of 1-1.5 months spanning December and January, with very marked temperature deviations. Day temperatures are around 30EC, while night temperatures are within the 15-17EC range. Day and night temperatures then promptly increase, peaking diurnally at 40EC in April, or May further north. With the arrival of the monsoon season, day temperatures slowly decrease to a low of 30-35EC in August when rainfall is heaviest. Relative humidity can reach as high as 85-95% in the morning during the rainy season, and drops to 40-45% in the dry season. Evaporation levels are around 2 m/year. There are two distinct seasons: the high-water season from July to early October and the low-water season from early December to early June. There is often no low-water flow in basins smaller than 1,000 km^2, while runoff is generally steady in larger basins.

There is an equatorial regime in the south-southwestern part of the subregion, with two low-water and two high-water periods. Under the "pure" equatorial regime, the two dry seasons are of equal length and the two high-water seasons are also almost equal. The climate is relatively uniform throughout the year, with morning relative humidity almost steady at 85-95%. Evaporation is 1.5 m/year on average. There is very little interannual variability and low-water flows are quite substantial.

There is a wide range of transitional climatic regimes, depending on the prevailing orographic and drainage basin features.

In addition to the high spatial precipitation variations within the subregion, there has been very marked interannual variability. variability. The overall decrease in precipitation after 1970, with a concomitant southward shift of the interannual isohyets[8] (sometimes more than 200 km) is a spectacular illustration of this trend.

2.3 Water resources and uses

2.3.1 Quantitative assessment of these resources and uses

This marked climatic variability, especially precipitation, incurs high variability in the distribution of water resources throughout the subregion.

Table 2 presents data that were collected by the Stockholm Environment Institute, WMO and other UN bodies concerned about water issues and pooled for a report on global water resources (in press). These data were based on the research of I.A. Shiklomanov[9], FAO statistics[10] and a monograph edited by P. Gleick[11].
In Table 2, the key information for each country listed in column 1 is as follows:

- column 2: endogenous resources, including groundwater resources (GR), expressed in millions of m^3;
- column 3: endogenous resources (GR) for the surface area of the relevant country (S), expressed in millions of m^3/km^2;
- column 4: total endogenous and exogenous resources (TR), expressed in millions of m^3;
- columns 5 and 13: population in 1995 and a projected figure for 2025 (P), expressed in millions of inhabitants based on a given mean population growth;
- columns 6 and 14: ratio of withdrawal (W) to total resources (TR) for 1995 and the forecasted level in 2025, expressed in %;
- columns 7 and 15: per-capita resources supplies (RS) for 1995 and 2025, expressed in m^3/capita/year;

A number of indices developed by the Stockholm Environment Institute are shown in columns 8-12 for the situation in 1995, with a forecast for 2025. These indices highlight the extent of the stress and impact on water resources.

8 L'Hôte Y. and Mahé G. (1996) Afrique de l'Ouest et Centrale. Carte des précipitations moyennes annuelles (période 1951-1989), ORSTOM

9 Shiklomanov I.A. (1996) Assessment of Water Resources and Water Availability in the World (Scientific and Technical Report), State Hydrological Institute, St. Petersburg, Russia

10 FAO (1995) Statistics of water resources of African countries

11 Gleick P. (1993) Water in Crisis

- columns 8 and 16: ratio of total storage capacity (S) to total resources (TR). As this ratio increases, potential annual water supplies decrease;
- columns 9 and 17: coefficient of variation for annual precipitation (VAP). This indicates water-supply variability within the country and the impact on agriculture. A high coefficient reflects high variability;
- columns 10 and 18: resource reliability (RR). This is a composite index that combines the two previous indices with another index, that is not on the table, which determines the extent of a country's dependance on exogenous resources. As RR increases resource reliability decreases;
- columns 11 and 19: the ratio of resource use to supplies (W/TR) assesses a country's ability to meet the demand for resources when they are temporally and spatially variable. As the ratio increases the ability decreases;
- columns 12 and 20: stress index, based on the two prior indices (weighted). As the index increases the stress increases.

In the first analysis, the data presented in Table 2 indicate that the current situation regarding water supplies (per capita/year) is only serious in Burkina Faso and Cape Verde. By 2025, four other countries (Ghana, Niger, Nigeria and Togo) will fall into the category of countries with low renewable water resources, as defined by M. Falkenmark in 1989 (per-capita water supplies less than 1,700 m^3/year).

However, assessing the situation solely on the basis of per-capita water supplies gives only a very rough notion of the actual situation and likely outcome, and as a result interpretations can be completely false. It is also essential to take into consideration problems related to interannual variability, resources distribution between different zones within the same country, and annual precipitation patterns.

The resource reliability index is a much better indicator. It highlights that 13 countries in the subregion could be considered as having relatively unreliable resources in 1995, and an identical situation is predicted for 2025.

In terms of the composite stress index, only Mauritania reaches level 3 on a scale of 4, whereas nine countries showed no stress, and 12 countries showed minimal stress. Forecasts for 2025 indicate a very slight declining trend, with the index only increasing for one country (from 1 to 2). By comparison, France is currently classified as having a stress level of 2, which should increase to level 3 by 2025.

In calculating the stress index, more importance is given to the volume of water withdrawn than to the water supply. Moreover, water withdrawal rates are extremely low, i.e. current (less than 5% for 20 countries) and predicted (less than 5% for 19 countries) for 2025, thus explaining the very low stress on water resources.

With the exception of Gabon, this very low withdrawal rate is associated with the fact that incomes are extremely low throughout the region. Countries are therefore unable to develop their water resources, especially drinking water supplies for local inhabitants and crop irrigation systems.

The notions of water resource scarcity and abundance are much more complex than the simple per-capita water supply concept, even when the resource reliability notion is introduced. Water scarcity and abundance can only be assessed in terms of meeting the demand of, in M. Falkenmark's terms, "the human and social sphere and the natural sphere".

2.3.2 Transnational distribution of water resources

The transnational distribution of water resources in sub-Saharan Africa (SSA) should also be considered. As noted in a World Bank report[12], most surface-water resources in continental SSA are supplied by large international basins. The 17 main basins (each more than 100,000 km^2) in the area are shared by at least 35 of the 41 countries present. Three of these these large basins are shared by nine countries, a situation which, with the exception of the Danube River basin, is not found found elsewhere in the globe. There are six international basins larger than 100,000 km^2 in the AOC subregion, and six others with a surface area of 30,000-100,000 km^2. Five large basins account for most of the water resources of the region.

[12] World Bank (1995) International river basin organizations in sub-Saharan Africa. Technical Paper No. 250, African Technical Department series, provisional version

In addition, as noted in a CIDA report[13], large African rivers have six important common features that influence potential ways they can be developed, with a concomitant impact on international cooperation:

i) runoff mainly concentrated in small mountainous zones with marked seasonal and annual rainfall variations. This means that neigbouring countries located downstream, where the climate is often dry, are often affected by measures taken by upstream countries, in terms water quantity and quality;

ii) there are very marked variations in seasonal and annual discharges in hydrographic systems. These variations are are further increased after a series of dry years, as occurred during the 1979-1988 period, when the rate of groundwater discharge to replenish surface water bodies decreased. A study conducted in 1970 revealed that for the Niger River at Niamey, the discharge rate decreases once every 10 years to 15 m^3/s. Values were then lower for 15 years, which has had a predictable impact on watercourse sharing between neighbouring countries[14];

13 Berthelot R. (1988) Overview of international rivers and lakes in Africa, Canada, CIDA

14 Sircoulon J. (1992) Evolution des climats et des ressources en eau. Afrique contemporaine, l'environnement, No 61 (special)

Table 2

Statistics on water resources in the subregion and their uses in 1995 and forecasts for 2025

	1995											2025							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Country	GR 10^6 m^3	GR/S 10^3 m^3/km^2	TR 10^6 m^3	P 10^6 m^3	P/TR %	RS m^3/h/an	S/TR class	VAP class	RR class	P/T class	Stress class	P 10^6 m^3	P/TR %	RS m^3/h/an	S/TR class	VAP class	RR class	P/T class	Stress class
Benin	10,300	91	25,800	154	0.6	4,770	4	1	2	1	1	200	0.8	2,272	4	1	2	1	1
Burkina Faso	14,700	54	16,700	412	2.5	1,618	4	1	2	1	1	535	3.2	771	4	1	2	1	1
Cameroon	268,000	564	268,000	500	0.2	20,252	4	1	2	1	1	648	0.2	9,645	4	1	2	1	1
Cape Verde	300	74	300	30	10.0	765	4	1	2	1	1	39	12.9	364	4	1	2	2	2
CAR	141,000	226	141,000	85	0.1	42,534	4	1	2	1	1	110	0.1	20,256	4	1	2	1	1
Chad	15,800	12	44,100	218	0.5	6,933	4	2	3	1	2	282	0.6	3,302	4	2	3	1	2
Congo	222,000	688	832,000	51	< 0.1	321,236	4	1	2	1	1	66	0,00	159,982	4	1	2	1	1
Côte d□Ivoire	76,700	238	77,700	941	1.2	5,451	2	1	1	1	1	1,222	1.6	2,596	2	1	1	1	1
Equatorial Guinea	30,000	1,069	30,000	12	< 0.1	75,000	4	2	3	1	2	16	0.1	35,717	4	2	3	1	2
Gabon	164,000	613	164,000	78	< 0.1	124,242	4	1	2	1	1	101	0.1	59,168	4	1	2	1	1
Gambia	3,200	283	7,900	36	0.5	7,066	4	2	3	1	2	47	0.6	3,365	4	2	3	1	2
Ghana	30,300	127	53,200	300	0.6	3,408	1	1	1	1	1	422	0.8	1,452	1	1	1	1	1
Guinea	226,000	919	226,000	936	0.4	33,731	4	2	3	1	2	1,215	0.5	16,064	4	2	3	1	2
Guinea Bissau	16,000	443	27,000	22	0.1	25,163	4	3	4	1	2	28	0.1	11,983	4	3	4	1	2
Liberia	200,000	1,796	232,000	168	0.1	76,341	4	2	3	1	2	218	0.1	36,356	4	2	3	1	2
Mali	50,000	40	94,000	1,746	1.9	8,708	4	3	4	1	2	2,266	2.4	4,147	4	3	4	1	2
Mautitania	400	0,4	11,400	1,851	16.2	5,013	4	3	4	2	3	2,402	21.1	2,387	4	3	4	3	3
Niger	3,500	2,8	33,400	628	1.9	3,650	4	3	4	1	2	815	2.4	1,738	4	3	4	1	2
Nigeria	274,000	301	317,600	4,648	1.5	2,843	4	2	3	1	2	6,031	1.9	1,354	4	2	3	1	2
Senegal	14,400	73	34,800	1.702	4.9	4,187	3	3	3	1	2	2,202	6.3	1,994	3	3	3	1	2
Sierra Leone	160,000	2,230	160,000	445	0.3	35,485	4	2	3	1	2	578	0.4	16,889	4	2	3	1	2
Togo	11,500	202	12,000	115	1.0	2,900	4	2	3	1	2	150	1.2	1,381	4	2	3	1	2

iii) great distances between perennial streams in SSA. This limits the use of river water for domestic, industrial and agricultural purposes due to the long-distance haulage required, especially for low-income countries such as those in this subregion;

iv) the water quality is generally good, with low salinity and still very little localized pollution;

v) except for the inner Niger delta, there are no irrigable areas that could be developed. The irrigation potential is very low;

vi) as water resources are concentrated in the main rivers, water resources development often requires high investment, generally beyond the financial means of a single country.

There are currently very few problems between states with respect to equitable sharing of water resources. However, it should be borne in mind that a significant increase in water usage could lead to conflicts focusing on national and international rights concerning water quantity and quality.

2.4 Regional organizations

Of the 16 countries visited, the 10 West African countries belong to the Economic Community of West African States (ECWAS), while the 6 in Central Africa are part of the Economic Community of Central African States (ECCAS).

These organizations promote coordination of national sectoral policies through implementation of common projects, and even common policies, in particular for the environment, health, agriculture, energy, industry and mining. In contrast with other regional organizations such as the Southern African Development Community (SADC), a group of 11 countries of southern continental Africa and Mauritius, and with the Intergovernmental Authority on Development (IGAD) for East African countries, neither ECWAS nor ECCAS have developed a common regional policy for water resources management. However, a project to reinforce meteorological services in West African countries was recently endorsed by the ECWAS Council of Ministers.

Many interstate organizations which deal with water resources issues have, on the other hand, been set up in the subregion, especially in West Africa. Some of the main ones are:

- *The Inter-State Committee on Drought Control in the Sahel (CILSS)* was created in 1973 with 9 member-countries from the northern part of the subregion (Burkina Faso, Cape Verde, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal and Chad);

- *The AGRHYMET Regional Centre*, a CILSS technical agency, was founded in 1974. It specializes in scientific and technical agro-hydrometeorological applications for the purposes of rural development and environmental protection, while promoting information dissemination and training in these sectors. It is supported by CILSS member-countries and many sponsors such as USAID, along with French, Italian, Dutch and Swiss government agencies;

- *The African Centre of Meteorological Applications for Development (ACMAD)* is a regionally-oriented Centre with all member-countries of the WMO Regional Association I (Africa) participating. The aim of the Centre is to monitor the meteorological and climatic situation throughout Africa, promote the use of new techniques to forecast social and economic development on the continent, and train African professional staff and researchers in the fields of meteorology and climatology;

- *The Niger Basin Authority (NBA)* was initially founded in 1964 as the Niger Basin Commission. NBA is a river basin authority comprising nine countries within the Niger River basin (Niger, Nigeria, Mali, Guinea, Burkina Faso, Côte d'Ivoire, Benin, Cameroon and Chad). Its initial mandate was very broad, including data collection, planning, water-use regulation, navigation, environmental issues, as well as promoting and running projects of common interest. The mandate was then expanded to include implementation of the Hydroniger Project (see below). A number of problems have hampered NBA activities, which are now at a standstill;

- *The Hydroniger Project* was set up in 1979 with the aim of collecting hydrological data that could be used to forecast dangerous flooding, of providing expert advice concerning farming practices under drought conditions, and facilitating operations of hydroelectrical stations. The Hydroniger International Forecasting Centre (IFC) is a technical institution which received Hydroniger Project support until 1992. Since then its activities have been funded by participating countries. Despite reduced resources it has continued its institutional activities, especially retrieval of hydrological data transmitted by stations equipped with ARGOS DCPs, installed within the scope of the project, management and updating of databases (raw, historical, operational), and production of some hydrological products such as flood forecasts. NBA can be called upon for support on hydrological and hydraulic elements, as part of an integrated project on desertification problems in Burkina Faso, Mali and Niger, funded ($20 million) by the Japan Agricultural Land Development Agency (JALDA);

- *The Organization for the Development of the Senegal River (OMVS)* was created in 1972, bringing together neighbouring countries, including Mali, Mauritania and Senegal. This river basin authority conducts hydraulic projects that are considered as joint property or "common hydraulic structures" (Manantali dam and power station, and Diama dam). OMVS is now responsible for operating and maintaining hydraulic structures;

- *Organization for the Development of the River Gambia (OMVG)* was jointly created by Senegal and Gambia in 1975, and Guinea and Guinea Bissau subsequently became members. This river basin authority was initially modelled on OMVS. Later it adopted a more practical approach, with priority given to drawing up master plans for basins under its authority (Gambia, Kayanga-Geba and Koliba-Corubal);

- *Lake Chad Basin Commission (CBLT)* was formed in 1964 by the four countries bordering the Lake Chad (Cameroon, Niger, Nigeria and Chad). Although the Commission has a very broad mandate, ranging from project promotion and coordination to the regulation and control of water resource use, it is now relatively inactive.

The Inter-African Committee for Hydraulic Studies (ICHS) should be mentioned to complete the present review of the main interstate institutions. For 35 years ICHS (which finally included 14 member countries) aimed at strengthening collaborations in the field of hydrology and other water-related areas.

ICHS no longer exists, and several other interstate bodies mentioned above are having difficulties. Hence, there has been a a proposal to create a regional organization for sustainable water resources management[15].

This potential regional organization could consolidate fields such as data collection, storage and processing, training, development of sound methods, and streamlining monitoring networks for integrated regional (rather than national) water resources management.

2.5 Operational services and the institutional framework

Each country in the subregion has its own National Hydrological Service. Central African Republic, Chad and Gambia have joint hydrometeorological services.

The Sub-Saharan African Hydrological Assessment mentioned earlier was carried out from 1988 to 1992 and applied to all countries in the AOC subregion. This project was launched at the request of the African governments to investigate deficiencies in SSA hydrological services following the serious drought that occurred in the 1980s. It was aimed at assessing available information, controlling its quality and setting up reliable hydrological monitoring systems to facilitate planning and assessment of water resources development projects. The results of this subregional assessment were presented in the form of 22 national reports (no report for Liberia) and a regional report which was published in December 1992. The final project document, which was presented by the World Bank at Ouagadougou (Burkina Faso) in July 1996, reviews the main hydrological deficiencies noted in SSA:

- a reduction in the quality and coverage of hydrological networks;

15 Tiercelin (1995) Report for the French Ministry of Cooperation

- a lack of qualified staff and thus a high dependence on expatriate advisors;
- poor equipment maintenance;
- security problems in a few countries;
- few studies on groundwater systems have been undertaken.

Figures 1 and 2, based on WMO data collected for the INFOHYDRO Manual (1995 edition)[16], illustrate the hydrological situation on the African continent (WMO Region I). Unfortunately, the above-described situation prevails throughout the AOC AOC subregion. The situation concerning hydrological services, staff, networks and databases has not improved since 1992. 1992. Indeed, it has actually worsened, as observed in most of the 16 (out of a total of 23) countries visited in the subregion subregion when preparing the present project document.

Although AOC countries have made some progress with respect to formulating and implementing integrated global water management policies, through new laws and regulations, the institutional framework is still generally in a premature state[17]. As pointed out in the Addis Ababa Conference on Water Resources Report mentioned earlier, it is not surprising that policy and decision-makers are unaware of the urgent need to set up efficient hydrological information systems and to develop regional collaboration in this field.

2.6 Current state of knowledge

A very large set of historical data on water resources has been built up over the last several decades in AOC countries. Most of these data are available on computer files, conventional hydrological yearbooks, original survey sheets and reports. They are archived in AOC countries and some European countries, particularly France at the Institut français de recherche scientifique pour le développement en coopération (ORSTOM). The Global Runoff Data Centre (GRDC), founded in Koblenz under the auspices WMO with German government support, has also compiled many data obtained from countries in the subregion.

Many summary documents have been published, for instance:

- hydrological monographs for the Senegal, Chari, Logone, Sanaga, Volta, Niger and Gambia River basins, for Cameroonian rivers and streams, and on surface-water resources in the Republic of Benin. Monographs for the Ubangi River and Gabonese rivers and streams are currently in press;

- daily rainfall charts available for the whole period since the stations became operational (1980) for 14 AOC countries, summary prepared for ICHS;

- regional comprehensive assessment studies on annual runoff, urban rainwater purification, surface-runoff modelling, regional water resources assessment, or small-basin flood modelling.

Several studies have been carried out in collaboration with AOC scientists to investigate hydrological cycles, rainfall/discharge relationships, flood genesis and propagation, etc. The aim is to extrapolate the results for drainage basins that have not yet been gauged and enhance the overall understanding of desertification processes. Mathematical hydrological forecasting and management models have been developed, and some of these are based on remote-sensing data. All of this information and expertise can be used to promote socioeconomic development of the subregion and protection of its environment.

2.7 Training and education in hydrology

Regional training centres have been set up in the AOC subregion. These include the National Water Resources Institute of Kaduna (Nigeria), the Water Resources Research Institute of Accra (Ghana), the Interstate School of Rural Equipment Engineers (EIER) and the Ecole Inter-Etats de Techniciens Supérieurs de l'Hydraulique et de l'Equipement Rural (ESTHER),

[16] WMO (1995) Hydrological Information Referral Service - INFOHYDRO. Operational Hydrology Report No. 28. WMO-No. 683

[17] World Bank (1996) African Water Resources. Challenges and Opportunities for Sustainable Development

(ESTHER), both based in Ouagadougou (Burkina Faso). Training courses on hydrology and connected fields are also given at the AGRHYMET Research Centre in Niamey (Niger). University training is also available in the subregion, e.g. a postgraduate hydrological sciences programme at the University of Dakar, a predoctoral environmental sciences programme programme at the University of Abobo-Adjame (Côte d'Ivoire), an environmental sciences engineering programme at the National University of Benin, and a predoctoral earth sciences programme at the University of Yaoundé. In addition, head scientific and technical personnel in most AOC countries have been (and are still being) trained within the scope of many north-south cooperative agreements.

2.8 Hydrological observing systems and ongoing hydrological information projects

Irrespective of conventional observing networks (cf. 2.6), West and Central Africa is the African subregion that has benefitted the soonest, and the most, from telemetry systems designed to collect hydrological data. For instance, Hydroniger (set up in 1984) is the most long-lived African network for the collection of real-time data. **Annex 1** gives a detailed summary of these networks, showing that 87 stations still currently have telemetering capability, mainly using the ARGOS satellite system. However, the future of these networks is uncertain for various reasons, i.e. some might be shut down due to financial problems and others because specific projects are terminating, as is the case for the WHO Onchocerosis Control Programme.

Besides these telemetry networks, two major projects concerning hydrological information systems in the subregion should be noted: the West and Central Africa Regional Hydrological Observatory (OHRAOC) and the FRIEND AOC project.

The regional hydrological observatory concept was initially put forward in 1992 during the preliminary phase of a WMO-World Bank project to set up a system that was first called HYCOS-Africa. The concept was then secured in a large-scale ORSTOM research programme (GP 222) entitled "Spatiotemporal variability - Regionalization". The programme, which was in some ways a prelude to the AOC-HYCOS project, is briefly presented in **Annex 2**.

FRIEND[18] is a UNESCO programme that was created in northern Europe in 1985. It is a regional hydrology research programme based on international cooperation. The main thrust of the programme is to investigate spatial hydrological patterns, and describe hydrological features of different regions in full detail in order to simulate conditions in yet unexplored unexplored drainage basins. FRIEND is involved in building a database with historical hydrological data which participating countries have accepted to share. The programme is constantly expanding through the development of projects for other global regions: Mediterranean and Alpine countries (FRIEND AMHY), Southern Africa (FRIEND SADC), and the Nile River basin (FRIEND NIL). FRIEND AOC was officially launched in November 1992 but actually got off the ground in October 1994 following a meeting in Abidjan (Côte d'Ivoire) when a Steering Committee was appointed, with the participation of UNESCO, WMO, ORSTOM and EIER. The project, funded by the French Ministry of Cooperation, is coordinated from headquarters in Abidjan, and the Base de Données Inter-Etats (BADOIE) compiled by ORSTOM was presented at the FRIEND AOC meeting in Ouagadougou (Burkina Faso) in July 1996. As is the case with other regional components of FRIEND, FRIEND AOC, which requires large sets of good quality hydrological data, and the potential AOC-HYCOS project, project, which is partially aimed at facilitating and perpetuating collection of such data, are clearly complementary.

3. Overview of the situation

- The AOC subregion has a wide range of climates and hydrological regimes, with arid to semiarid zones in the north shifting to equatorial rainforests in the Congo River basin in the southeast. In addition to this spatial variability, which also occurs intra-nationally, there is marked seasonal and interannual variability throughout the subregion;

- Drought is an endemic phenomenon in this subregion. The last Sahelian drought was extremely serious and persisted for a whole generation; it spread considerably during the 1972-73 and 1983-84 crises when the reduced precipitation was even noted in equatorial zones;

- Desertification is also a problem in the subregion, especially in arid and semiarid zones, but it also affects the subhumid zones. Human activities in zones that receive the most rainfall also incur major problems, with a

[18] Flow Regimes from International Experimental and Network Data

negative impact on aquatic ecosystems, on the quantity and quality of water supplies and on biogenetic resources;

- Water resources are distributed transnationally, with almost all countries sharing one or several basins with neighbours;

- There is a high population growth rate in the subregion (mean 2.82%);

- The per-capita GNP is low (around US$420);

- Thirteen AOC countries have highly unreliable water resources;

- There is a very low water resources usage rate, i.e. currently lower than 5% for 20 AOC countries. This suggests that there are no serious water supply problems, except in Mauritania and Cape Verde. Apart from the problems highlighted earlier concerning spatiotemporal water resources distribution, economic insufficiency with respect to water storage, protection and distribution, and the transnational nature of these resources, it should be noted that:

    - currently less than a third of the population has reliable access to water, and an even lower proportion benefits from water purification systems;

    - the percentage of irrigated land relative to the actual potential (which is quite low because of the geomorphology of the subregion) is no higher than 40%;

    - there is very little industrial development in the subregion and the hydroelectrical development potential is extremely low;

    - many ecosystems in the subregion are very fragile - it is essential to protect them while conserving biogenetic diversity, which means addressing the needs of both the biosphere and mankind.

These physical and economic elements, combined with social factors (water resources in terms of supply and demand, quantity, scarcity, and ecological value are generally overlooked by most of the social system), **make managing the hydraulic resources or, more generally, the hydrological cycle very complex for most AOC countries.** As is the case case worldwide, AOC countries are highly dependent on the hydrological cycle, and marked fluctuations therefore have an impact on people living in the subregion and on the environment (Fig. 3)[19].

Moreover:

- national hydrological information systems are not operating properly;

- there is insufficient regional cooperation on water resources, and many interstate organizations are faltering. ICHS, one of the main regional instigators of water resources collaboration, has disappeared, mainly due to a lack of political and financial support from AOC countries;

- the subregion has a long hydrological history, a considerable body of baseline information is available;

- many real-time data exchange and dissemination systems were operational in the past, some stations are still running;

- projects such as the Regional Hydrological Observatory and FRIEND AOC are developing within the framework of relatively formal regional cooperation arrangements.

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19 M Falkenmark (1995) Coping with water scarcity under rapid population growth. A vision for the future. Conference of SADC Ministers responsible for water resources management. Pretoria, South Africa (23-24 November 1995).

4. Problems, causes, demand and proposed solutions

4.1 Problems to be addressed

When water resources management and protection is complex with respect to environmental interactions, these resources have to be fully understood in terms of water quantity, quality, distribution, seasonal and interannual dynamics. As recommended in Chapter 18 of the Dublin Conference report and the global freshwater resources assessment report mentioned earlier, water resources issues have to be dealt with on a drainage-basin scale, i.e. the basic unit for integrated water resources management. This is particularly applicable when resources are distributed transnationally, which is the case in the AOC subregion.

Obtaining and continually updating this knowledge is dependent mainly:

- on the quality of national information systems with capacity for data collection (measuring and transmission), quality control, storage, processing, preparation and dissemination (Fig. 4)[20];

- on institutionalized integration of these national systems at the subregional level.

As noted above, none of these conditions have been met in the AOC subregion.

4.2 Causes

The causes of this situation are known and were fully discussed at the Addis Ababa Conference in March 1995 (excerpts of the Conference Report are presented in **Annex 3**).

The fundamental cause of the decline of national hydrological information systems and relevant regional bodies is the slowdown and even reversal of socioeconomic progress in most AOC countries. However, this is not the sole reason.

Besides the economic situation, there are several other long-standing historical and structural causes. The adverse economic situation highlighted and aggravated the problems.

The poor level of institutional planning in the water sector is a major cause of this situation. In the AOC subregion, as in most areas worldwide, water-related issues are generally handled by the public sector. Policy and decision-makers in AOC countries, who generally have an overwhelming number of problems to deal with, do not always understand the importance of the water sector, and especially the need for its sustainable integrated development. Moreover, they are often unaware of the direct and indirect economic value of water resources information systems. They also have no access to information tailored to their needs or to decision-making tools which would enable them to utilize this information efficiently. Finally, they are not inclined to invest even part their scant government budgets in funding water resources information and monitoring.

They are not the only ones accountable for the situation; national services running information systems and external donor agencies also bear their share of the responsibility. Due to a lack of resources and initiatives, these national services are generally reactive in their response and manage *de facto* situations; no innovative efforts are made, e.g. seeking outlets or tailoring their products to these potential regional, national or international outlets. External donor agencies usually do not coordinate their financial efforts and they are generally oriented towards short-term projects; neither of which foster sustainable activities in this sector. Furthermore, they do not promote the use of local capabilities, even though they themselves were often instrumental in creating them. This forces national water resources services into the unrewarding role of data suppliers.

Past and recent experience has obviously shown that AOC countries have not taken over water resources information systems, which were often founded before their independence and have been artificially maintained with external subsidies.

[20] World Bank (1995) A guide to the formulation of water resources strategy. Technical document No. 263, Chapter 4.

subsidies. However, many donors are now tired of this situation, and very few national projects surveyed during the hydrological assessment are sponsored, highlighting the extent of donor fatigue.

4.3 Demand

The next issue to address is that of □demand□ and □users□. No information system can be economically sustainable if it does not address an explicit, analysed and ultimately solvent demand. However, this solvency should not be limited to the purely tangible financial element of the market. In many developed countries, hydrological information systems are considered to be key elements in the national infrastructure, supported by public authorities through various fees and taxes.

It should be noted that this demand (public and private) is now generally too low in the AOC subregion to justify developing large monitoring networks and overstaffed National Services. It would be a serious error to claim otherwise and continue believing in the illusions of the past. There is also a major risk that water resources assessment and monitoring activities will be restricted to specific short-term problems. Indeed, medium- and long-term problems should be the focus of considerable attention in order to achieve sustainable development.

It would also be quite risky to adopt an all-or-nothing policy, i.e. waiting for the right time or political and socioeconomic conditions to set up sustainable hydrological cycle information systems. This policy of adopting the worst possible line to achieve one's ends would result in the loss of a large share of several decades of investments in this field, particularly in human resources development. It would also mark the end of African hydrology, with an enormous loss of information on the globe and its climate, development, and protection of its environment and biodiversity.

4.4 Proposed solutions

The AOC-HYCOS project proposes a reasonable solution to the above-described problem. The aim is to provide a logical framework for sustainable reactivation of operational hydrology in the subregion, and give users access to hydrological information in different applied areas, such as: assessing water resources (quantity and quality), the potential for water-related development, the ability to supply actual and foreseeable demands; planning, designing and implementing water projects; assessing the environmental, economic and social impacts of current and proposed water resources management management practices, and adopting sound policies and strategies; assessing the impacts of activities such as urbanization urbanization and forest harvesting on water resources; providing security for people and property against water-related hazards, particularly floods and droughts[21].
Reactivating the hydrology sector should involve decision-makers from the participating countries, information users (even those not residing in the subregion) and funding agencies. The process has to be proportional to the actual short- and medium-term potentials of the relevant countries, while utilizing existing resources, i.e. manpower, expertise and equipment. This reactivation process should also be in line with other ongoing or proposed projects in this field, or associated areas such as health, famine control and poverty eradication.

This process should develop within an environment of modern open communication, based on data dissemination and information access, while focusing on user awareness and training in order to create a "market".

Finally, the hydrology sector should be reactivated within a regionalized environment to deal with problems of assessment, management and protection of water resources and the environment in the subregion, with particular emphasis on cost-effectiveness, sustainability and prevention of water-use conflicts.

5. Project objectives

5.1 Broad objectives

The hydrological cycle, i.e. both terrestrial and atmospheric phases, is a constraint for life on earth, the social sphere (socioeconomic development) and the biosphere within which this development takes place. It is essential to understand this

[21] WMO (1994) Guide to Hydrological Practices. Chapter 3, Hydrological Services, WMO-No. 168.

this cycle and monitor it regularly on different spatiotemporal levels. Comprehensive information systems which can handle all operations, from collection to dissemination of data and derivative information, are needed to understand and monitor the the cycle.

National hydrological information systems in AOC countries are generally unable to supply this information, and there is very little regional cooperation in this field. AOC-HYCOS development objectives are therefore to promote sustainable reactivation of these regional and national information systems so that they can ultimately be handed over to and run by AOC countries. In this way, hydrological concerns could be integrated in regional and national sustainable development and environmental protection policies.

5.2 Targets

The following targets could be reached through implementation of the AOC-HYCOS project:

i) setting up a regional, operational and reliable system for the collection, transmission and storage of hydrological and environmental real-time data or near real-time data, based on a network of hydrological reference stations (hydrological observatories);

ii) enhancing long-term development/reinforcement of regional and national services involved in water resources assessment, monitoring and management for the purposes of sustainable development, environmental protection and biodiversity conservation;

iii) promoting hydrological data/information exchange and dissemination, as well as subregional technical and scientific collaborations.

6. Expected results

6.1 Real-time data collection and transmission system (Fig. 5)

The basic network of 125 data collection platforms (DCPs) will be installed at nationally and regionally important benchmark stations (most already exist). During the project implementation phase, these stations will be selected from a list provided by participating countries on the basis of their compliance with standards established for the WMO WHYCOS programme, especially:

- expressed demand;
- significant historical database available;
- stable routing curve;
- relatively easy site access;
- representive data collected;
- transnational aspect of available information.

A preliminary list of 158 stations proposed by AOC countries is given in **Annex 4**. The final list and priorities will be reviewed and endorsed by the Regional Technical Committee (RTC) for the project.

Variables to be recorded at the stations are listed in **Table 3**, with the measurement frequency given for each variable. Water levels will be determined using a piezometric pressure probe placed in the river. Rainfall will be recorded using a tipping bucket rain sensor. Air temperature, relative humidity, wind speed and net radiation will be recorded to calculate potential evapotranspiration using a standard formula adjusted to prevailing environmental conditions. These data could also supplement information collected by National Meteorological Services. In addition, water temperature, electrical conductivity, dissolved oxygen and turbidity will be measured at 25 of the 125 potential stations to determine the physical and chemical characteristics of the water. This will mark the beginning of regular sampling to assess water quality relative to environmental, health and ocean-protection programmes.

The measurement frequencies given in Table 3 are provided for reference. They can be higher at some stations, depending on the recording equipment and features of the stations.

Each DCP will be equipped with a transmitter to convey data through the METEOSAT satellite using its data collection system (DCS). METEOSTAT is a geostationary meteorological satellite that is located about 36,000 km above the Gulf of Guinea, over the Equator, and thus capable of transmitting data from anywhere in the AOC subregion. Data transmission via DCS is currently free for any projects which come under the auspices of WMO, e.g. programmes such as WHYCOS, but the DCP first has to be admitted into the DCS.

For each METEOSAT DCP installed in this project, Permanent Representatives of each country with WMO should, with WMO backing, contact the satellite (EUMETSAT) to request admission of the DCP and attribution of one or several transmission time slots. To avoid potential problems caused by the drift in the DCP-clock, which could cause stations to transmit outside of their attributed time slots resulting in deactivation of the station by the satellite operator, DCPs installed for this project will be equipped with an automatic system, based on the satellite global positioning system (GPS), which readjusts the clock after each transmission.

All stations (sensors and DCPs) will be powered from solar panels, with a backup battery. They will also be equipped with an in-situ data logger which logs data in case of transmission failures.

As data will be retrieved by the ground stations in real time from METEOSAT, the performance and reliability of the system can be easily monitored regularly. The Pilot Regional Centre (PRC) (see 6.7) and host National Hydrological Services will keep a record of any incidents occurring in the data acquisition and transmission system. As part of the project, the hydrological services will also conduct routine field visits to inspect and maintain the stations.

6.2 Data retrieval and dissemination system

A highly flexible and open approach will be adopted to facilitate implementation and development of the regional data exchange and dissemination system. The idea is to utilize countries' existing possibilities for retrieving data from DCPs (raw data) in real time or near real time (same day). To take full advantage of the existing potential in the subregion, the Global Telecommunication System (GTC) of WMO will be used as much as possible, combined with Internet connections. This approach is also aimed at strengthening cooperation between National Hydrological and Meteorological Services as a means of reducing expenses and increasing efficiency in water resources assessment and management and environmental protection, as these fields are closely linked and complementary.

Table 3

Data collected and measurement frequency

Environmental variable	**Daily measurement frequency**
Water level upstream	1-6 (depending on river size)
Water level downstream	1-6 (depending on river size)
Water conductivity	1
Water temperature	1
Dissolved oxygen	1
Turbidity	1
Air temperature	8 (synoptic hours - main and intermediate)
Rainfall	24, plus daily total
Relative humidity	8 (synoptic hours - main and intermediate)
Wind speed	8 (synoptic hours - main and intermediate)
Wind direction	8 (synoptic hours - main and intermediate)
Net radiation	8 (synoptic hours - main and intermediate)
Housekeeping variables	**Daily measurement frequency**
Battery voltage	1

Solar panel voltage	1
Memory status	1
Temperature inside instrument housing	1

Raw data received by METEOSAT via DCPs are in turn transmitted to Darmstadt (Germany). These data are downloaded, reformatted and sent back through the satellite and received by METEOSAT Direct Receiving Stations (MDRS, PDUS) or Meteorological Data Distribution stations (MDD) which are equipped with a third channel which is currently being installed at the different meteorological services in the subregion. If EUMETSAT agrees, the data could also be injected through the GTS via Offenbach or through specialized networks (TRANSPAC, X25).

Agreements will have to be reached, particularly with the National Meteorological Services (NMS), concerning the use of regional GTS segments while complying with established international WMO codes. Moreover, data exchanges between NMSs and NHSs should be authorized through endorsed agreements. Data transmitted through GTS will be received by NMSs via more or less automated procedures, depending on available communication resources.

A key efficiency indicator for the data exchange and dissemination system will be the volume of data available in the national and regional databases, along with the ease of access to these databases.

6.3 Regional communication network

The regional electronic telecommunication network will link NHSs of relevant countries and the PRC, as well as other regional and global databases and information systems for the exchange of verified data and information.
The main functions of this network will be as follows:

- electronic mail, to facilitate information exchanges on operation and maintenance of AOC-HYCOS stations;
- file and document transmission, especially to transfer verified data from the subregional database to national hydrological agencies and vice-versa;
- database access;
- electronic fora, to enhance cooperation and collaborations between hydrologists of the region.

Benin, Chad and Nigeria are now equipped with operational Internet servers, and one was to be installed in Burkina Faso in early 1997. Servers could also soon be installed in the other AOC countries, especially Niger. Meanwhile, countries that are not yet connected to Internet can gain access through RIO, a network managed by ORSTOM, via its server in Montpellier (France).

All National Hydrological Services will thus be equipped with PCs, modems and the appropriate communication software required to access the local telecommunication network.

As the project partners will thus be able to communicate with one another and disseminate information to users, it will be easy to assess the status and performance of the regional network.

6.4 Subregional database

A database of reliable and regularly-updated hydrological data will be archived at the PRC. Users will have access to data in real time or near real time for the purposes of water resources assessment. This database will also help in strengthening cooperative ties between hydrological services and agencies within and outside the subregion.

This database will be modular, interactive and user-friendly, thus providing ready access to all potential users. The possibility of archiving data in an Oracle database with an integrated Web server has also been proposed, and in this way baseline data could be disseminated via Web pages. Users could also access information by e-mail on a query basis.

The exact content and format of the database will be jointly decided by the PRC and hydrological services involved in the project according to the following criteria: existing databases (OCP, Hydroniger, OMVS, OMVG, CBLT, BADOIE of FRIEND

FRIEND AOC, national databases, GRDC, etc.), and current and potential regional and national uses. The following general categories of data could be included in this subregional database:

- geometrical and geomorphological basin information;
- dynamic real-time or near real-time data;
- historical data.

At the end of the project, the subregional database could remain at the initial PRC or be decentralized with links between national databases through the subregional electronic network set up within the project.

Database access rights and criteria will be agreed upon by participating countries, in accordance with national regulations, users' needs, and international guidelines and recommendations on this subject, e.g. Resolution 40 of the Twelfth World Meteorological Conference concerning meteorological data exchange, and the equivalent recommendation on hydrological data exchange (in preparation).
Regardless of the future of this subregional database, the initial centralized phase is essential as many of the countries are not yet connected to Internet, and also to facilitate training of national database coordinators, standardizing procedures and formats, and developing regional cooperation under the umbrella of a unifying physical entity.

The number of database queries will be a good indicator of the success of this project component.

6.5 Hydrological products of regional and national interest

These products will be prepared from data contained in the AOC database and from other national, subregional and international databases.

In the first phase, the PRC, in agreement with national services participating in the project, and in conjunction with other projects and programmes in the subregion, will prepare a number of standardized regionally-oriented products such as hydrological yearbooks (per region and basin), forecast bulletins (per basin), runoff maps, etc. These products will be disseminated in various ways, such as: through the World Wide Web via the hydrological server (with information presented in a dynamic format), e-mail, CD-ROM and standard publications. These products will be sent to as many users as possible. Users will be surveyed to assess the impact of these products. New products will subsequently be developed on the basis of expressed needs in a wide range of fields, such as agriculture, navigation, energy and environmental protection, and on the condition that at least part of the costs can be recovered.

AOC hydrologists will be trained at the PRC on developing, formulating and disseminating hydrological products. They will then be responsible for these tasks in their own countries.

The extent of the market which develops for regional and national hydological information products, both within and outside of the subregion, will be an indicator of the impact of this activity and the scope of its success.

6.6 Training

Training of National Hydrological Service staff on various aspects of the project is crucial for the sustainability of the hydrological information system being set up and for enhancing regional cooperation.

The training programme will be part of the plan of activities prepared by the technical assistance after review and endorsment by the Regional Technical Committee (RTC) (cf. 6.7). Training courses will be conducted by PRC staff with, when necessary, the assistance of other, preferably local, experts.

Several training modules could be proposed in different areas within the scope of the project:

- DCP installation, operation and maintenance (two 2-week courses)
- E-mail and GTS operation (two 1-week courses)

- database management (two 2-week courses)
- hydrological expertise, and hydrological product development, formulation and dissemination (two 2-week courses)
- marketing and public relations (two 1-week courses)
- national and global water resources management (two 1-week courses).

Other training activities are planned, such as training trainers in the fields of hydrometeorology and topography on criteria for WHYCOS station installation, control and maintenance, as specified in **Annex 5**, as a means of certifying that these criteria will be met by all participating countries.

Staff to be trained will be proposed by the National Hydrological Services and selected by the PRC in collaboration with the national services. These training activities will be organized in different ways, including: group training at the PRC or in the countries, and training sessions during PRC support missions in the countries.

In addition to group training, individual attachment programmes of about 2 months are planned for representatives to work at the PRC on activities associated with the development of hydrological products of national interest.

6.7 Creation of a regional cooperation base

The Pilot Regional Centre (PRC) is set up to implement the regional hydrological information system. It can, upon the request of decision-makers in the participating countries and assuming they provide sufficient resources, be transformed into a regional centre to facilitate cooperation and collaborations between regional institutions on water resources.

7. Implementation

7.1 Institutional framework (Fig. 6)

7.1.1 Preliminary comments

There are three major problems which have to be dealt with in implementing regional projects such as AOC-HYCOS:

- The lack of a single regional economic/political institution which could serve as the silent partner and beneficiary of the project;

- The poor levels of human and financial resources of operational institutions (NHSs, interstate organizations) in the subregion which would potentially qualify to host the PRC for implementation of the project;

- The diversity of the potential funding sources (bilateral, international etc.).

The first problem implies that the project needs to be approved by each participating country. A Regional Technical Committee (RTC) of representatives from each country, appointed by the parent ministry of the National Hydrological or Hydrometeorological Service, could ensure regional cohesiveness and national commitment. A longer term strategy would be to try to fit the project, and especially the possible resulting regional structure, within the framework of ECWAS and ECCAS.

The second problem implies that the **technical assistance** will take care of setting up and operating the PRC and this will be completely funded by the project. This means that the PRC could conceivably be shut down at the end of the project. Should this centre be sustainable, and in what form? The answer to this question will generally depend on the attitude of decision-makers in AOC countries. The project will have to be operational long enough to become entrenched and thus demonstrate its potential to decision-makers, users and funding agencies. The potential advantages of setting up a "subregional water resources organization", based on the hydrological information system developed in this project, should be objectively assessed. The type of organization, its role and long-term financing would have to be determined thereafter.

The third problem refers to the actual implementation of the project. If several sources are involved in funding the project, there will almost certainly be a wide range of regulations stipulating exactly how the funds should be used. This situation, combined with the first problem (lack of a single contracting authority for the subregion), could considerably complicate implementation of the project and jeopardize its consistency. A fund should thus be created and managed by a **single executing agency**. This agency could manage all financial contributions, according to the regulations set out in contracts signed with each financial partner of the project, concerning fund usage, control and information disclosure.

7.1.2 Proposed institutional framework and stakeholders' roles

Host countries ***23 countries in the AOC subregion***

- installing the national segment of the AOC-HYCOS DCP network;
- providing sufficient support for PRC missions and technical assistance;
- performing routine hydrological activities, especially river gauging, regularly updating stage-discharge relations, assessing sediment discharge and measuring physicochemical variables;
- performing network maintenance operations, i.e. routine, at the request of the PRC, and after an incident is detected;
- controlling the quality of received raw data;
- regularly sending verified data to the PRC;
- running the project with already existing equipment, particularly equipment required for data transmission, exchange and dissemination;
- participating in workshops, attachment and training programmes;
- disseminating data and other products of the project to users, in line with the arrangements agreed upon by participating countries.

Sponsors ***Unidentified***

- defining project strategies and roles;
- integrating the project within subregional development aid policies, especially in discussions with decision-makers;
- monitoring the results;
- financial control.

Proposed executing agency ***WMO***

- administrative and financial control for the project and preparing annual progress reports;
- drawing up proposals for selecting an institution to host the PRC;
- selecting the technical assistance after the terms of reference are defined;
- purchasing equipment;
- budget updating;
- monitoring the results.

Pilot Regional Centre (PRC) ***Hosted by an existing but not yet selected regional agency***

- implementing the project (proposed PRC activities described in **Annex 6**);
- drawing up 6-monthly progress reports.

Technical Assistance ***Selected according to the terms of reference set out by the executing agency in collaboration with the participating countries***

- managing and operating the PRC through seconded staff;
- supporting countries for developing national AOC-HYCOS components;

- preparing and conducting training activities;

- setting up tools for information dissemination, especially on the World Wide Web

Regional Technical Committee (RTC) ***1 representative appointed per participating country***

- revising and approving the implementation plan and the list of stations for the AOC-HYCOS network;
- selecting the PRC location;
- technical monitoring for the project;
- national-regional harmonization;
- approving the 6-monthly and annual progress reports and revising the assessment report.

Steering Committee (SC) ***Representatives from sponsors, executing agency and participating countries (President and Vice-President of the RTC)***

- defining the broad policies of the project;
- orienting and controlling the financial and budgetary policies of the project;
- interactions with other projects.

7.2 Activities

An institutional/financial framework is essential before implementing the project. The project should thus be officially endorsed by the AOC countries and allotted a budget. However, as many countries could be involved and implementation costs high, it might be difficult to apply a broad implementation strategy due to the many potential obstacles, consequently delaying the actual start of the project.

A global conceptual approach is essential. Nevertheless, it would be more realistic to set up the project on the basis of existing geographical (river basins) and/or institutional (interstate organizations) units, having taken into consideration any request for targeting the allocated funds.

In addition, the project should be implemented with efficient use of existing resources, as described in part 3 of the present report "Overview of the situation", including telemetering networks, interstate organizations, the Regional Observatory and the FRIEND AOC project.

The project could thus be implemented in four main phases: a preliminary phase, a starting phase, a development phase and a project stabilization phase.

The Pilot Regional Centre (PRC), hosted by a subregional institution, will coordinate implementation of the project. The PRC will be set up, managed and operated by the technical assistance, which will in turn provide scientific and technical support for the project in the form of staff seconded to the PRC and expert missions.

The responsibilities of the PRC are presented in Annex 6, with staff, office and equipment requirements listed in Annex 7.

Three regional institutions based in Niamey (Niger) have already expressed their interest in hosting the PRC:

- the AGRHYMET Centre, which is equipped to capture satellite data with a primary data user station (PDUS), which can retrieve data transmitted by METEOSAT, and a station equipped to receive NOAA high resolution picture transmission (HRPT) data. The Centre also has a training room equipped with PCs, along with most other equipment required for the PRC;

- the Hydroniger-IFC, which is equipped with an ARGOS receiving station and staff with experience which would be useful for the PRC, but there is not sufficient technical equipment, or it is in poor order;

- the ACMAD Centre, which has a PDUS METEOSAT receiving station, a computerized meteorological information processing system, along with most other equipment required for the PRC.

The cost of hosting the PRC was estimated for the present project document. However, the exact costs, together with the terms of the agreement which will have to be signed with one or several of these institutions, will have to be defined much more accurately before a valid proposal can be made to the RTC and the Steering Committee.

Before the beginning of the preliminary phase, it is proposed that the executing agency will, in collaboration with the countries and potential sponsors, be responsible for: (i) defining criteria for selecting the institution which will host the PRC; (ii) making the necessary contacts with interested institutions, and; (iii) putting forward accurate proposals based on surveys of these institutions.

7.2.1 Preliminary phase (6 months)

7.2.1.1 Technical assistance selection

The executing agency would prepare the terms of reference for selecting the technical assistance, based on the project document (endorsed by the countries) and within the scope of available funding. A selection committee, made up of sponsors representatives, AOC countries and the executing agency, would select the technical assistance after evaluating the tender proposals.

The technical assistance would then be responsible for drawing up a detailed schedule of activities and a list of stations for the AOC-HYCOS network.

These proposals would be assessed and approved by the RTC and the Steering Committee during their (possibly joint) formative meetings.

7.2.1.2 Observatory transfer

Once the PRC is set up, the Regional Hydrological Observatory would be transferred, after the necessary equipment is installed, from Ouagadougou to Niamey. This would mark the beginning of the starting phase of the project. For this operation, an expert would be assigned to the PRC to provide short-term support (one month). During the equipment installation period, local agents running the PRC could be given further specific training sessions on data collection and dissemination procedures.

7.2.2 Starting phase (1 year)

7.2.2.1 Ongoing Observatory activities

Hydrological stations officially selected for the AOC-HYCOS network would be monitored. At this stage, data would be transmitted via Argos to WHO-OCP and Hydroniger stations, by METEOSAT to stations in Chad, and by conventional channels to other stations not yet equipped for transmission which were previously monitored within the context of the Observatory. Decisions would then be made on the fate of data from other stations which were monitored (**Annex 8**), but which were not officially selected for the AOC-HYCOS network. It is quite likely that these could be easily monitored if the automatic data acquisition system is functional.

During this starting period, NHSs supplying the data could be asked to begin controlling the quality of archival and recent data from WHYCOS stations.

7.2.2.2 Ordering AOC-HYCOS DCPs

During this phase, the executing agency, in collaboration with the PRC, would call for equipment tenders, especially for DCPs. A figure of 125 DCPs equipped to transmit data through METEOSAT was put forward for the budget estimate. A real-time hydrological information system large enough to meet the project objectives could be set up with this number of DCPs. The actual number of DCPs ordered and the acquisition schedule would obviously depend on the extent of secured funding. There would probably have to be tradeoffs in setting priorities with respect to the list of PRC-approved stations.

Running the project on a geographical and/or institutional unit basis could also be useful in orienting the priorities. At this stage, a schedule should be drawn up to install HYCOS DCPs in the highest priority stations, even if they are already equipped for telemetering within the framework of WHO-OCP and Hydroniger projects (but there are few such cases). It should be possible for the two types of facilities to coexist separately within the same stations. The current facilities would be be operational for a limited period of time and the operating requirements are not the same for all the different users. Moreover, because of the additional sensors, modern DCPs would have to be installed at priority AOC-HYCOS sites.

7.2.2.3 Progressive upgrading of existing and soon-to-be-equipped stations to hydrological standards

Operations to upgrade stations to AOC-HYCOS standards could be started at this stage, beginning with those which have been classed as top priority. On-site field work would be necessary at this stage, including a topographical survey of gauging sections. The field work would determine the exact positioning of the DCPs on the basis of the hydraulic characteristics of the river, while taking into account prior extreme flooding and low streamflow periods, along with new constructions which could be built upstream. This information would be essential for ordering DCPs and preparing installation estimates.

7.2.2.4 Retrieval of previous datasets and developing an official dataset

During this phase, data processing equipment would be ordered and delivered to the national operators. The data quality control operations could then begin.

7.2.2.5 Establishing electronic links between the PRC and NHSs

During this phase, all operators should be equipped with E-mail so that they can communicate and exchange data with the PRC.

7.2.2.6 Training

The first training sessions on equipment operation and data processing would be offered to NHS staff during this phase. Once the PRC receives the DCPs, training sessions will be organized to help teams from participating countries to install, maintain and manage this equipment. Training sessions will also be proposed on E-mail and GTS use, with emphasis on their potential.

7.2.2.7 Interim progress report and publications

At the end of the first phase, the PRC would assess the situation and present a complete report to the RTC describing the different implementation phases. The report should also review the initial hydrological results, highlighting actual noted improvements in data quality, in communications between services, and points requiring special attention. At this stage, it would be advisable to publish a bulletin presenting the results obtained at the main stations, along with a summary of the initial results, a list of a few simple hydrological products, a chart of the equipment to be installed in each country, and the objectives. The report should also be used by each NHS as a guideline for their reports.

7.2.3 Development phase (24 months)

7.2.3.1 Installation of AOC-HYCOS DCPs

During this phase, DCPs would be installed at the different sites selected during the starting phase. As a supplement to operations for upgrading stations to hydrological standards, field missions would be undertaken to conduct surveys and make additional installations, e.g. change staff gauge elements or defective supports, installing benchmarks, and drawing up complimentary cross-sections and longitudinal sections, etc.

7.2.3.2 Installation of a raw data retrieval and storage system

Raw data from DCPs would be retrieved by the PRC and the different national operators. Depending on the type of equipment available and agreements with NMSs connected to the GTS, national operators would receive data via the GTS in slightly differed time through the NMSs by E-mail or from the PRC. When data is transited through the GTS, it would be captured more or less automatically, depending on available communication resources.

The executing agency should thus contact EUMETSAT to request admission of AOC-HYCOS DCPs, the request forms should be filled out and signed by the Permanent Representatives for each country with WMO. The executing agency would also facilitate exchanges between NMSs and NHSs so that the latter would actually be able to receive raw data through the GTS.

All messages transmitted through AOC-HYCOS DCPs would be received by the PRC. Copies of each message should be stored so that the data can be processed at a later date, as necessary. The PRC would also monitor the DCPs and quickly notify the NHSs of any incidents which have gone undetected in order to solve problems on-site as swiftly as possible.

7.2.3.3 Installation of a quality controlled data dissemination system

The raw data would be verified by the NHSs and then transmitted to the PRC by E-mail. The PRC would build up a regional database with all data received from NHSs involved in the project. The PRC should not have to process the messages, except in cases when it takes over from an NHS because it is out of order or having equipment problems. The PRC, therefore, should be equipped for processing any information received from DCPs. This would require installation of a data processing system such that mean daily discharges at stations could be derived automatically from measurements received in METEOSAT messages and rating curves supplied by the NHSs.

7.2.3.4 Development of the subregional database and supporting NHSs for national databases

The contents and format of the database should be jointly decided by the PRC and the hydrological services involved in the project in terms of existing databases (OCP, Hydroniger, OMVS, OMVG, CBLT, BADOIE of FRIEND AOC, national databases, etc.), taking account of current and potential regional and national uses.

NHSs would receive support in the form of advisory missions to enable them to build databases which meet the project standards, especially with respect to data processing and controlling data quality. Quick quality control methods would thus be developed for use by NHSs and the PRC.

These advisory missions would be undertaken by PRC staff, and backed by one or several experts on short-term missions (total 4 months).

7.2.3.5 Training

Advanced equipment training sessions would be offered on DCP use and troubleshooting. Database training would focus specifically on data upgrading methods, field surveys, dataset control, and reprocessing archival data.

7.2.3.6 Interim progress reports and publications

The PRC would draw up 6-monthly progress reports and participating countries would prepare annual progress reports on activities and results. These reports would be presented to the RTC and the Steering Committee at the annual meetings. The PRC and participating countries would also publish a brochure for public release, which would present the project concept, objectives and initial results.

7.2.4 Project stabilization phase (18 months)

In this third phase, the AOC-HYCOS network would be operational and self-sufficient, following the scheduled shutdown of the ARGOS WHO-OCP network and the probable shutdown of the IFC-Hydroniger network.

Depending on available funding, the initial AOC-HYCOS DCP network would, if necessary, be supplemented and/or reorganized on the basis of experience acquired from the outset of the project and of new potential demand-driven orientations.

By this time, the NHSs should be relatively self-sufficient with respect to equipment management, databases and data dissemination. The PRC would then focus its activities on efficiently utilizing hydrological data acquired in this project. It would develop hydrological products and processing tools on a regional level to enable the different NHSs to produce tailored hydrological information. The PRC would thus develop exchanges with other national, regional and global databases.

The PRC, with the help of an expert on a short-term mission (3 months), and in agreement with data and information dissemination guidelines set down by the RTC, would provide the resources necessary for such dissemination, especially via Internet and the regional hydrological server.

The PRC would publish a CD-ROM containing the main project results and future challenges for the subregion. Experts would provide short-term support (total 9 months) for these development activities involving transfers to NHSs.

The PRC would set up training sessions on marketing and public relations for NHS head staff. In collaboration with the NHSs, it would organize national awareness workshops to promote hydrological information and regional cooperation. The PRC would benefit from the support of experts on short-term missions (total 2 months).

7.2.5 Monitoring and assessment

7.2.5.1 Project monitoring

The project would be monitored by the executing agency, which would submit annual progress reports to the RTC and the project Steering Committee. These reports would complement the 6-monthly reports prepared by the PRC and cover technical, administrative and budgetary aspects of the project, based on a number of key indicators, such as:

- the efficiency of the data collection and transmission system based on the quantity of raw data captured and stored in the national and PRC archives;
- the quality, accessibility and degree of updating the national and regional databases;
- the national, regional and global impact of hydrological products prepared by the PRC and the hydrological services of participating countries;
- the initiatives taken by decision-makers and users in making use of the hydrological information system developed within the framework of the project (AOC-HYCOS) as a tool for regional cooperation and collaboration for the assessment, monitoring and management of shared water resources.

7.2.5.2 Project assessment

The RTC and the Steering Committee would review the project once a year during their statutory annual meetings. In addition, an independent project assessment could be undertaken in the fifth year by an expert selected by the Steering Committee. This independent expert would visit the PRC and some participating countries and draw up a report according to guidelines set out by the Steering Committee. This assessment would cover:

- the design of the project;
- the implementation of the project;
- the results obtained as compared with those expected;
- the visibility of the project at national, regional and international levels.

The assessment, which would be presented to the Steering Committee, could also provide recommendations concerning the future of the project. The final report, including amendments recommended by the Steering Committee, would then be submitted to all participating countries for approval before being released to agencies through a distribution list approved by the Steering Committee.

Details of these activities and estimated costs are presented at the end of the logical framework in **Annex 9**.

8. Cost estimate and breakdown

The estimated overall cost of the project for a 5-year period is **around thirty-six million two hundred and seventy-one thousand French francs (36,271,000 FF).**

The expenses are classified in five general categories, as shown in **Tables 5 and 6.**

8.1 Equipment

PRC

- computer equipment;
- office equipment;
- support vehicle.

AOC-HYCOS network

- 125 DCPs and spare parts;
- equipment to renovate 35 stations and possibly a few existing ARGOS receiving stations;
- computer equipment for the NHSs for the use of DCPs, access to Internet and GTS, databases and formulation of hydrological products.

8.2 Technical assistance*

* *pooling all of the different expenses below into the technical assistance category does not mean that all of the corresponding amounts will have to be managed by the technical assistance. It is still too early to know exactly how this management could be shared between the technical assistance and the executing agency. However, it is essential that PRC expenses are directly managed by the PRC coordinator (assigned by the technical assistance) using an impress fund.*

- *Experts*
  - salary of the PRC coordinator;
  - salaries, per diem and traveling expenses for experts on short-term missions.

- *Local PRC staff*
  - database expert;
  - field expert;
  - computer assistant (part-time);
  - secretary.

- *PRC*
  - support missions to NHSs (network, database, hydrological products);
  - PRC running expenses, including contributions to cover overhead costs of the host institution;
  - organizing training courses, sessions and seminars;
  - publications.

- *NHS support*
  - project participation to cover AOC-HYCOS station installation, management and maintenance costs.

- *Training*
  - trainees' travelling and per-diem expenses;
  - trainers' travelling and per-diem expenses and salaries.

- *Meetings*
  - statutory annual meetings of the Steering Committee and the RTC;
  - meeting of the assessment committee to select the technical assistance and equipment.

8.3 Executing agency

Staff salaries and administrative expenses for:

- technical, administrative and budgetary supervision for the project;
- equipment procurement;
- interactions with EUMETSAT and NMSs;
- specific training on GTS.

8.4 Project assessment

- expert's salary, per diem and travelling expenses.

9. Project timetable

The 5-year timetable for implementing the project is given in Table 6.

Table 4
AOC-HYCOS - Budget breakdown per category

Category	Amount (thousands FF)	Subtotal/Category (thousands FF)	Amount (% total)
1. Equipment	13,346	**13,346**	36.8
2. Technical Assistance			
salaries and travel	5,022		13.8
local PRC staff	1,541		4.2
PRC operations	2,693 *		7.4
NHS support	6,413		17.7
Training	3,248		9.0
RTC & SC meetings	1,251		3.4
		20,168	
3. Executing agency	2,655	2,655	7.4
4. Assessment	101	101	0.3

* *including 815,000 FF (30.3%) for PRC operating expenses and contributions to cover the host institution's overhead costs.*

Table 5
AOC-HYCOS - Budget breakdown per year

Year	Amount (thousands FF)	Amount (% total)
1	5,170	14.3
2	9,954	27.4
3	8,671	23.9
4	9,084	25.0
5	3,391	9.4

10. Sustainability of the project

The sustainability of AOC-HYCOS is not solely based on its technological features which, as widely demonstrated, are efficient, cost-effective and well adapted to the subregional context. The success of the WHO Onchocerciasis Control Programme (OCP) fully illustrates this point.

The project will be sustainable because of its potential for restimulating hydrological activities. There will be, therefore, considerable emphasis on integrating these activities in socioeconomic development processes within the subregion and management of natural resources by:

- the selection of key stations which have a real national, regional and global interest for users, so that the AOC-HYCOS network will be able to meet the demand, even if this demand is still relatively unstructured;
- the use of modern technology for data collection and real-time and near real-time transmission, in order to improve the operation of the networks, the availability and quality of hydrological data;
- the improvement of data consistency and accessibility through the development of national and regional databases and a regional data and information exchange and dissemination system, thereby giving users ready access to data;
- the importance the project assigns to developing the capacities of NHSs, not only in technical areas, but also in identifying users, understanding their needs, appropriately formulating and disseminating the required information, thereby increasing decision-makers' awareness of their potential;
- implementing the project through a regional structure (PRC) hosted by an existing institution, using as much subregional expertise and experience as possible, which could provide a basis for setting up a future regional organization focusing on water resources;
- future integration of hydrological data from the regional database with other types of data (environmental, demographic, economic, land use, etc.), thus providing the region with a basic tool for natural resources planning and management.

Many worldwide[22] studies have highlighted the economic value of hydrological data. However, considering the current socioeconomic situation in the subregion, it would be hard to put a monetary figure on the potential value of hydrological information. It should not, therefore, be assumed that the regional hydrological information system planned within the scope scope of this project will be financially self-sufficient in the short- or medium-term, or that it can develop on a sound but

[22] WMO (1993) WMO - No. 733 Economic and Social Benefits of Metorological and Hydrological Services - Proceedings of the Technical Conference (Geneva)

solely market-oriented financial base.

Although it would be reasonable to assume that decision-makers and users will be ready to adopt this system by the end of the project, continuing support from the international community and sponsors will be necessary in some of the countries. This support could be tailored to the actual performances of the system and the extent of its adoption by participating countries.

11. Conclusion

The SSA hydrological assessment highlighted the fact that there is a marked absence of hydrological information systems and the few operational systems present are inefficient, especially in West and Central Africa. Moreover, there is still very little sustained regional cooperation for assessment, monitoring and management of transnational basins, even though most of the water resources in the subregion are derived from these basins.

The adverse financial situation in many countries is considerably aggravated by the fact that decision-makers have not understood that the hydrological cycle is crucial for socioeconomic development, environmental protection and biodiversity conservation.

The AOC-HYCOS project is aimed at avoiding definitive loss of the enormous potential and expertise in the subregion by promoting controlled reactivation of hydrological information systems and regional cooperation on water resources. Based on an integrated regional strategy, the project will involve installing specific proven tools, human resources development, tailored and targeted financial support, promotion and discussion with national, regional and international users - all conducted in an informative environment.

The ultimate goal is to encourage participating countries to take over AOC-HYCOS, and the system should develop gradually in response to the demand. Another objective is to enhance cooperation between the hydrological and meteorological services in participating countries, which is essential in areas such as water resources assessment and management, prevention of water-related hazards, climate monitoring and environmental protection.

The international community and external funding agencies should understand that the present project is a logical follow-up to the conclusions of the SSA hydrological assessment, based on a global approach to the problem. The objectives of this project, and of the whole WHYCOS Programme, are also in line with the recommendations set out in the global water resources assessment report mentioned earlier which was presented at the fifth session of the United Nations Commission on Sustainable Development (UNCSD) held from 5 to 25 April 1997.

Although the concept is global, it can obviously be implemented on the basis of successive geographical and/or institutional units, thereby taking into account local conditions and in particular the level of interest shown by national governments, initiatives taken by participating countries, and funding opportunities.

AOC-HYCOS

Draft Project Document

Annexes

Annex 1

Assessment of telemetry networks in West and Central Africa which were operational at the end of 1996

This annex provides an assessment of existing telemetry systems and their potential contribution to AOC-HYCOS objectives, together with ways they could be linked or integrated with the system.

1. List of operational hydrological networks

Hydroniger
WHO-OCP
OMVS
Hydraulique Guinée
Hydraulique Bénin
Chad Flood Warning
METEOSAT Congo
SONEL.

2. Serviceability of these networks

2.1. Hydroniger network

This is the oldest regionally-oriented data collection network in West Africa. It has been operating since 1984 and uses ARGOS transmission facilities. It supplies data for a hydrological forecasting system serving countries sharing the Niger River, which are grouped together in the Niger Basin Authority (NBA). It was implemented and managed from 1983 to 1991 within the scope of an international cooperation programme involving NBA member countries, UNDP, OPEC and WMO. It has been solely funded by NBA member countries since 1992.

Since the outset of this project, ARGOS satellite usage fees have been covered by the Centre National des Etudes Spatiales (CNES) in Toulouse (France).

The network is no longer able to operate normally due to a sharp drop in subsidies. Many stations are out of order and are no longer regularly monitored. Despite these problems, more than 45 stations were still running normally during the 1995 rainy season, but the number dwindled to 30 by December 1996, i.e. less than half the number of stations operating at the outset.

The Forecasting Centre is cleverly utilizing all resources at hand to keep the platforms operational, while building up the database with data obtained from stations which are still operational.

In the upper Niger River basin (Guinea), five Hydroniger DCPs are being managed and maintained within the scope of the WMO-OCP programme, as data from these stations is required for its hydrological telemetry network. In its present form it is quite likely that the Hydroniger network will continue degenerating.

The DCP equipment is not up to date and the network's satellite access might not be free for much longer. In the next 2 years, technical modifications in ARGOS data recovery mechanisms will substantially lower the frequency and quality of direct message retransmission.

Of the ten direct receiving stations (DRSs) which were initially installed, two are operating for IFC in Niamey (Niger) and two two others are still operational in Mali and Benin. The rest have either been shut down or are out of order.

2.2 WHO-OCP network

As part of its Onchocerciasis Control Programme (OCP), WHO utilize hydrological data in order to accurately quantify levels of pesticide which are to be sprayed onto the rivers and streams. For this entire area (eight countries), WHO has set up a network of telemetered limniographs capable of retransmitting, via ARGOS satellite, data which subsequently will be used for equipment maintenance. This information is captured, analysed and processed at two operational centres based at Odienné (Côte d'Ivoire) and Kara (Togo). Permanent WHO agents, under a coordinator based in Ouagadougou, are responsible for the overall organization and management of these hydrological operations.

Telemetry equipment is generally installed in already existing NHS stations. Some Hydroniger-type stations in Guinea are also used for this programme, with national teams contracted by WHO responsible for their routine upkeep and maintenance.

For its pesticide spraying the WHO-OCP programme manages and monitors more than 250 stations located in eight different West African countries: Guinea, Sierra Leone, Côte d'Ivoire, Ghana, Benin, Togo, Mali and Burkina Faso. Sixty-nine of these sites are currently equipped with ARGOS DCPs. These DCPs, which are more recent than those used in the Hydroniger network, are completely electronic and equipped with a cartridge data storage system. Data telemetered through DCPs in this network are managed by the West and Central Africa Regional Hydrological Observatory (OHRAOC), implemented by ORSTOM in Ouagadougou (Burkina Faso).

This Onchocerciasis Control Programme is ending and many telemetry stations in this hydrological network will be phased out gradually, with a total shutdown by 2002, as per the following timetable:

1997	Shutdown of a few stations in the Volta River basin;
1998	Shutdown of a few stations on Maraoué and Comoé Rivers in Côte d'Ivoire;
1999	Shutdown of all stations in Côte d'Ivoire;
2002	Shutdown of all stations in the network.

Distribution of WHO-OCP stations with telemetry capability in West Africa on 12 December 1996.

Country	No. of stations	Comments
Guinea	17 + 6	6 Hydroniger stations
Sierra Leone	6	
Côte d'Ivoire	23	Only 16 now operational
Ghana	4	
Togo	16	
Benin	3 + 5	5 Benin Hydrology stations
Total	**69 (80)**	**69 WMO-OCP plus 11 external stations**

Station maintenance and upkeep along with stream gauging, which is essential for plotting rating curves used to convert transmitted water levels into discharge, are carried out by national hydrological service (NHS) teams from the host countries. WHO has signed contracts with the national directorates of some of these countries specifically defining the type and level of service required and payment schedules. These contracts have rider clauses that are renegotiated annually.

In some countries work is carried out under these contracts using WHO equipment: vehicles, boats, gauging and camp equipment, etc. As NHS agents do not work full time on these WHO contracts they are able to continue their national hydrological service activities.

Agents working on these contracts are paid a set monthly allowance, with travelling expenses for a set maximum number of of days per month. The allowances and travelling expenses vary according to the agent's rank, responsibilities, and the country. As an example, the table below shows an income breakdown for national service agents in Guinea.

Table summarizing WHO allowances (US$) earned by agents in Guinea in 1996

Job Title	Monthly allowance	Daily travel rate	Maximum days	Total monthly in GF	Total monthly in US$*
Unit Head	29 000	21 500	10	244000	237
Engineer	25 000	21 500	10	240000	233
Assistant	22 500	11 500	10	137500	133
Driver	6 500	6 500	10	71500	69

* US$1 = 1030 Guinean francs (01/01/97)

2.3 OMVS network

In 1988, the Organization for the Development of the Senegal River (OMVS) began installing around ten ARGOS hydrological data collection platforms within the framework of research agreements. In order to be able to monitor discharge variations in real time in specific sections of the river the DCPs were installed at all main stations on the Senegal River and tributaries. The same equipment was used in the WHO-OCP programme, with the data captured in Dakar. The OMVS network ran for a few years, but has not been operational since 1993. Although some of the equipment is still on-site the ARGOS transmission facilities have been shut down. Most of the stations are also equipped with radios which means that hydrological information can be communicated daily to the forecasting and management services. Some stations in the upper Senegal River basin in Mali were recently connected to the automatic telephone system.

2.4 Guinea Hydrology network

As part of a feasibility study for the Garafiri dam, Electricité de France (EDF) procured five hydrological platforms for ARGOS transmission. They were installed in the main stations on the Konkouré River and tributaries. The satellite usage fees were covered by EDF, with installation and maintenance covered by an ORSTOM team in Mali in collaboration with the Guinea National Hydrology Directorate. Data were captured directly at the Hydroniger DRS in Conakry. This network was very efficient throughout the 2-year study. At the end of the contract, the equipment was handed over to the Hydrology Directorate. A few devices continued running on their own for 2 years and then stopped.

Four new ARGOS DCPs, along with maintenance and troubleshooting equipment, were obtained in 1992 as part of the "Water Resources Sector Programming Support" project, funded by the French Fond d'Aide et de Coopération. The old EDF platforms were then renovated and a new telemetry network became operational. This network was shut down at the end of the funding contract and the equipment is currently idle.

2.5 Benin Hydrology network

The Benin Hydrology network includes 33 stations, 22 of which are equipped for ARGOS transmission. Some of these stations are under the Hydroniger and WHO-OCP umbrella while the others are managed directly by the Benin Hydrological Service. In the last two years DCPs belonging to the Hydrological Service have been shut down because no funds are available to pay the satellite usage fees. Some of these stations have been taken over by the WHO-OCP programme and their ARGOS transmission capability has been restored.

2.6 Future Chari-Logone Flood Warning network

The Water Resources and Meteorology Directorate of Chad (DREM) was granted funds by the French Fond d'aide et de Coopération (FAC) to purchase hydrological telemetry equipment for a future Chari-Logone River Flood Warning network at at N'Djamena. The equipment arrived in Chad in 1996 and the network is to be installed at the main hydrological stations before the 1997 rainy season.

This equipment includes:

4 PM46 (CEIS-TM) platforms equipped for METEOSAT transmission.

Each is equipped with sensors to measure the following:

water level
rainfall
air temperature
water temperature
ground temperature.

These four PM46 platforms are technically identical to those acquired in 1996 to equip hydrological stations for the MED-HYCOS programme. The stations in Chad therefore meet HYCOS standards and could provide the first link in a future AOC-HYCOS network.

Data will be captured at a METEOSAT Direct Receiving Station (MDRS) which was acquired for the flood warning programme. This station will be installed in 1997, together with the hydrological platforms.

2.7 Former METEOSAT Congo network

In 1990, a telemetry hydrological data transmission experiment was carried out in the Congo River basin as part of a contract signed between ORSTOM and the French Ministry of Research and Technology. The overall objective of this initiative was to set up a hydrological data retrieval, transmission and processing network tailored to large intertropical river basins. METEOSAT was the satellite data transmission mode specified in this contract.

Under the contract, a new hydrometeorological data retrieval platform was designed as well as a METEOSAT DRS. Eight platforms were built along with three MDRSs.

In 1990, two platforms were installed at stations in the Congo River basin and they ran well for 12 months without needing to be serviced. The complex political problems and poor safety conditions in the region jeopardized plans to install other equipment. Moreover, the experiment could not be continued with on-site equipment still operational due to the high satellite usage fees. A platform was installed at a station upstream on the Ubangi River. This gave the Waterway Service (Service des Voies Navigables) at Bangui access to real-time hydrological data thereby enhancing the accuracy of their forecasts with respect to water levels at certain critical sections of the river.

This experiment confirmed the suitability of the equipment design and the reliability of METEOSAT data transmission. It also highlighted the problem of station maintenance in politically unstable regions.

2.8 Former SONEL network in Cameroon

The national power company of Cameroon (SONEL) acquired 39 METEOSAT DCPs from CEIS-Espace. Nine of these platforms were installed at hydrological stations and conveyed water-level and rainfall data. Other platforms were equipped with rainfall, temperature and humidity gauges. All of these DCPs were operating at stations in the Sanaga River basin, with the aim of enhancing hydraulic impoundment and waterway management. It seems that this network was operational until 1995, and all data transmission was halted thereafter.

3. Review of currently operational telemetry stations

3.1 Status of telemetry stations on 12 December 1996

Country	Installed	Active in December 1996	Emitting on 12 December 1996
Benin	(12)	12	7
Burkina Faso	1	1	1
Cameroon	5	(4)	1
Côte d'Ivoire	24	23	16
Ghana	4	4	2
Guinea	33	30	21
Mali	(26)	20	12
Mauritania	1	1	1
Niger	9	9	7
Nigeria	18	(18)	3
Senegal	3	3	0
Sierra Leone	6	6	5
Togo	16	16	11
TOTAL	**158**	**147**	**87**

Bracketed values are estimates

"Installed" indicates that the DCP is in working order and can be operational
"Active" means that the DCP functions or is temporarily out of order and will be repaired and used "Emitting" means that the the DCP transmits messages which are received regularly

3.2 *Data transmission control by operators on 12 December 1996*

Operators	DCPs emitting
WHO-OCP	50
Hydroniger	30
OMVS	1
Hydraulique Guinée	2
Hydraulique Bénin	4
Total	**87**

4. Potenial involvement of these networks in the AOC-HYCOS project

4.1 General points

There are now 158 hydrological stations in West Africa which are equipped for routine data transmission. The data quality is generally good and the equipment should still be operational for a few more years. The AOC-HYCOS project, therefore, could quickly become operational by using this already functioning network.

4.2 WHO network

This network is run with equipment that is now about 10 years old but it has been efficiently maintained and hydrological data is collected at the stations. In areas where this programme will be kept operational, telemetered data from these stations could certainly be used to increase the number of stations monitored within the framework of an AOC-HYCOS programme. Conversely, ARGOS transmitters at these stations should probably not be swapped for METEOSAT transmitters. Although it is technically possible to do this only data on water and rainfall levels could be captured due to the poor capacity of these stations to capture data, and only part of the METEOSAT transmission potential would be realized. All on-site equipment will be donated to the NHSs at the end of the WHO-OCP programme, although these services probably will not be able to cover the ARGOS satellite usage fees. However, the water level gauges now installed at the WHO-OCP sites could be reused with HYCOS DCPs.

4.3 Hydroniger network

The equipment in this network is relatively out of date and increasingly difficult to maintain. HYCOS DCPs will have to be installed at already equipped sites which are to be included in the AOC-HYCOS network.

4.4 Other telemetry networks

Other ARGOS telemetry networks are generally not operational because the satellite usage fees cannot be paid and they will not be restarted. Some stations to be included in the AOC-HYCOS network at the outset may become operational if the ARGOS satellite usage fees are paid by the project during the appropriate period.

4.5 Non-telemetry stations

Data from several important stations are currently being transmitted to the Observatory via ORSTOM's RIO (Intelligent Computers Network) or by fax. Most of these stations have been proposed for inclusion in the AOC-HYCOS project. Before being equipped, these stations could be manually monitored, and the results presented on the World Wide Web, as happens now.

Annex 2

Current status of the West and Central Africa Regional Hydrological Observatory (OHRAOC)

1. Background

The concept of creating a regional hydrological observatory in West and Central Africa was put forward in the initial feasibility study on the WHYCOS-Africa project which was conducted in 1992 at the request of the World Bank. This observatory project was then secured in a large-scale ORSTOM research programme entitled *Spatiotemporal variability - Regionalization* (GP 222) and classified in FRIEND. The programme started in Ouagadougou in January 1995.

The first activities of the Observatory included installing a station equipped for direct reception of ARGOS data and real-time reception and storage of hydrological data from stations operating within the framework of the WHO Onchocerciasis Control Programme (WHO-OCP).

The results of the first test months of operation were conclusive and data collection was expanded to include a few stations in the Hydroniger network. In June 1995 Web pages (Internet) presenting hydrographs from a few telemetry stations were drawn up in collaboration with WMO and presented at the WMO Congress in Geneva. These pages were gradually enriched and access was granted to all interested NHSs. The Website was extended to include other stations without telemetry capability. Until late June 1996, NHSs and other regional operators contributed information on the basis of agreements confirmed during missions or by correspondence with NHS staff.

2. World Bank meeting of 2-3 July 1996

Activities of the Observatory and the Web pages were presented at the World Bank meeting, held in Ouagadougou in July 1996, marking the end of the Sub-Saharan African Hydrological Assessment Project (SSAHAP). There was unanimous consensus among participants that this experiment should be continued and reinforced through direct collaboration with hydrological stakeholders from AOC countries. They also stressed the importance of integrating the Observatory, with relevant adaptations, in the future AOC-HYCOS programme.

3. Current organization

Using standard transmission technology, 36 stations are now monitored on the basis of real-time data acquisition and nine via differed-time acquisition.

Using these data, the Web pages are routinely updated on an Internet server in Montpellier (France) and on a local ORSTOM server in Burkina Faso. These Web pages present hydrograms of discharges recorded at 29 hydrological stations from 12 different countries. The table below shows the distribution of the monitored stations. Five NHSs and two regional operators are also presented in these Web pages.

The Observatory is currently being run solely by ORSTOM. This organization will partially serve as a model for the future AOC-HYCOS programme, and AOC countries will benefit by having their situations presented to hydrologists worldwide via Internet. Once the AOC-HYCOS programme is implemented, the current activities of the Observatory could be taken over by the PRC.

Distribution of stations monitored by the Observatory on 24 December 1996

Country	Stations monitored	Stations on the Web	Data retrieval
Mali	8	6	6 Argos and 2 manual
Guinea	11	1	Argos
Sierra Leone	2	1	Argos
Senegal	0	0	
Côte d□Ivoire	2	2	Argos
Burkina Faso	2	2	Argos and manual
Niger	1	1	Argos
Ghana	3	1	Argos
Togo	1	0	Argos
Benin	7	7	Argos
Nigeria	2	2	Argos
Chad	3	3	Manual
Cameroon	0	0	
CAR	1	1	Manual
Congo	2	2	Manual
Zaire	0	0	
Liberia	0	0	
Gabon	0	0	
Total	**45**	**29**	

Data are only publicly disseminated after the NHSs, or operators managing the data, have given their consent. This is also the case for data received directly via ARGOS. During this experiment, working contacts were made with NHSs, including discussions on the problem of controlling telemetered data quality and on using new communication techniques (E-mail). In terms of Observatory organization, the results of this experiment clarified all of the information processing steps, systems were set up for direct data control, and critical steps were identified for the smooth operation of this structure. In 1997, a module is to be developed for automatic acquisition of satellite data which will subsequently be archived in the server database. In early 1997, the present Web pages will be transferred to the new WISE-HYDRO server. Potential Web page users will then have dynamic access to available data and new demand-driven regional hydrological products could be presented.

Each NHS could also prepare their own Web pages using this server.

The Observatory currently operates with the active involvement of the following services and operators:

WHO-OCP (Onchocerciasis Control Programme)
Hydroniger
DNHE (National Hydrology and Energy Directorate, Mali)
DH (Hydrology Directorate, Benin)
DIRH (Hydrology Resources Inventory Directorate, Burkina Faso)
DREM (Water Resources and Meteorology Directorate, Chad)
DM (Meteorological Directorate, CAR)
CERGEC (Congo)
CRH (Hydrological Research Centre, Cameroon)

Based on recent discussions, collaborations with the following operators seem likely:

DRES (Côte d'Ivoire)
DNH (National Hydrology Directorate, Guinea)
VRA (Volta River Authority, Ghana)

Extracts from the Report of the African Conference, Addis Abbaba, Ethiopia
(20-25 March 1995)

II - 2 STRATEGY

The Problem

61. The SSA Hydrological Assessment has confirmed that there has been a serious decline in the networks of hydrological observing stations and in the quality of data being collected within SSA countries. The coverage of the network is not adequate to provide the required information. The decline in these services is such that generally the stage has been reached when it is no longer possible for them to provide adequate and accurate data and the information needed for water resources assessment and development projects, at the national and/or river basin levels, not to mention the essential inputs to regional and international programmes.

62. At the same time, all the conclusions of the various conferences, reports and projections have demonstrated that **water is becoming an increasingly scarce commodity in many countries in Africa** because of increased expectations for supply and the rising demand for water from a rapidly increasing population (up to 4% increase per annum in next 30 years), and because of increasing urbanisation and economic activity. But scarcity of water is obviously not the only problem. Excess of water (floods), erosion and sedimentation, deteriorating water quality and water pollution are also problems hampering the development of Africa. These problems cannot be solved without reliable data and information provided by the relevant national services.

63. Water resources management based on WRA, will have to be given its due role in enhancing efforts to combat desertification and mitigate the effects of droughts, thus help reach the goal of attaining food security over the next decade.

64. Lack of appropriate WRA strategies hampers efforts to control loss of productive land due to land degradation caused by erosion which also causes sedimentation problems particularly in the arid and semi-arid areas of Africa.

65. Understanding the causes of this situation should provide the basis for a framework strategy to realistically address the main problems documented in the SSAHA report.

The Causes

66. There is no doubt that the fundamental cause for the decline of the water resources assessment and management systems, at national, sub-regional and international river basin levels, is the slow-down or even reversal of socio-economic progress in a large number of the countries of the Region. But this is not the only reason. Besides the economic situation, there are several other historical and structural pre-existing causes. The adverse economic situation has revealed and emphasized the problems.

67. The decline of the water resources monitoring and assessment systems in the Region is commonly linked to the fact that policy and decision-makers, and indeed many of the donors, generally:

(i) **are unaware of the scarcity of water and how this will increase during the next few decades;**

(ii) **do not know how the deficiency in water will be met;**

(iii) **are unaware of the real economic value of water;**

(iv) **are not aware of the cost, in economic terms and human lives and suffering, of water related natural disasters;**

(v) **do not recognize the direct link between national economic growth, the health of the nation and the general environment, and the supply of good quality water.**

68. However, many African countries in recent years have acknowledged that they have water problems. Those who are leading the socio-economic sectors, are becoming more sensitized to them. The specific causes contributing to the above mentioned decline are as follow:

(a) In Africa, south of the Sahara, the water resources assessment and management systems were generally developed, at least in most of the Francophone countries and in many of the Anglophone and Portuguese speaking countries, before independence, with very little involvement of the post-independent governments. The funds used for the operation and the maintenance of these systems were generally provided from external sources.

(b) The national services have been increasingly confined to data collection, network maintenance and operation, while during the same period external consultant companies and experts were carrying out most of the work in the water sector on contract for donor agencies. Therefore, the national services gained little experience in development activities. In addition, some of the high level staff in these national services have more of an academic profile and are more interested in scientific research than in the application of results. As a consequence, these services are not seen by their own governments as really being involved in the development process, and the data acquisition duties that they perform are not seen as worthy of high priority funding.

(c) National services have generally failed to sell their activities. This is true not only for Africa, but also for other parts of the world. As an example, yearbooks often published by national services with several years' delay, are too often the only visible products of these services, and they are obviously of limited help to people seeking answers on available water resources and their impacts on the socio-economic development.

(d) In general the policy and decision makers, and indeed many of the donors are unaware of the economic value of data collection and of the dependence of water development on it. The link is not made between data and information on water, acquired by the national services through observation systems, and the development process. The non-specialist is unable to relate a set of mean daily discharges at a given hydrological station, or the length and the timeliness of this set of discharge data to the quality of water services.

(e) The funds for strengthening the operation and maintenance of the observation and information systems for water resources assessment and monitoring are meagre because the other sectors of socio-economic activities usually have priority. The policy and decision-makers in most African countries are not prepared to invest scarce financial resources in activities which do not appear to help in solving urgent, specific short-term problems. For the same reason, they do not place high priority on funding these activities in the shopping list for external support, which is becoming increasingly limited.

(f) There is an absence of policy and institutional set-up with appropriate delegation of authority and flexibility that would allow involvement and participation of local communities (stake-holder) in water resources assessment and further sustainable development, operation and management of the systems.

(g) Donors are also facing economic difficulties, although not of the same magnitude as those of the African countries. Generally, they have made great efforts to reduce the cost of their own national water resources information systems. Reduction of staff, institutional reorganization, together with a certain degree of privatization, improvement of productivity, optimization of networks, increased use of new technologies, better use of the existing information and an improved scientific base, are some of the aids used. This has been possible because the agencies concerned are not only producers of data, they themselves are users of data for water resources assessment and thus have a recognized role in technical decision-making and water management. Partly because of the difficulties of donors, the relatively poor results of their past investment in the "rehabilitation", "strengthening", "improvement" of African hydrological networks and services and, above all, the low priority generally given by the African governments to these activities, most donors have adopted a wait-and-see policy.

69. A combination of all these causes, has more or less prevented change. A vicious circle has developed, in which there is no market for the data because of the bad economic situation and a low level of governmental interest in what appears to be a non-profitable investment. Hence a meagre regular budget is allocated to these systems, a situation which leads to their rapid degradation, and a reduction of the quality and quantity of available data and information. Lack of information and hydrological products of value to policy and decision-makers reduces government investment in hydrological services even further, thus closing the circle. It is therefore paradoxical that at a time when demand for water in Africa is rising faster than ever before, knowledge of African water resources is deteriorating at a quickening pace. Water resources development schemes

cannot be designed optimally nor can they be managed in a cost-effective and sustainable manner due to the lack of sufficient high quality data on the available water resources and their space/time dynamic. This leads to enormous waste of scarce funds.

Purpose and aim of the strategy

70. The purpose of the new strategy is to provide a consistent and realistic proposal to address the problems the African countries have to face in order to soundly assess and manage their water resources, as a basis for:

- sustainable development and environmental protection;
- their participation, as independent countries, in the regional and international programmes.

71. The aim of this strategy is to break the vicious circle described above and as far as possible break the "dependency syndrome". This is possible only through a completely new approach, with the active and coordinated participation of all the actors: national policy and decision-makers; national services; users; the general public - in particular farmers, local communities, women and donors.

72. As conditions vary from country to country, the strategy has to be flexible and adaptable.

Main pillars of the strategy

1. ***There should be unequivocal evidence of a national initiative for a demand-driven activity.***
2. ***WRA should be planned and implemented within the capacity of the national economy.***
3. ***Political will to cooperate on the river, lake and groundwater basins at the sub-regional, regional and international levels should be enhanced and backed by concrete action.***
4. ***Direct linkages should be established with other water resources management strategies, such as the one currently being prepared for Sub-Saharan Africa by the World Bank.***
5. ***There should be willingness of the agencies in charge of the water resources information systems to improve their efficiency, productivity and to take initiatives and participate in the water resources development process.***
6. ***Donors and UN agencies involved in the water sector should coordinate their activities in the Region and align their support as much as possible, along the lines of this strategy.***
7. ***A world-wide campaign should be launched to promote this strategy, improve the awareness of the problems and highlight the water resources assessment programmes adopted by African countries.***

1 - Unequivocal evidence of a national initiative for a demand-driven activity

73. Existence and sustainability of national services should be built on **the actual demand** for information on water resources. The detailed analysis of the demand for information should therefore be a prerequisite to any action plan. This analysis should take into consideration the origin of the demand (national, sub-regional, regional, international), the sector of activity from which the demand comes (private, government, NGOs, scientific bodies, etc), the nature of the need for information (short, medium and long-term). The level of priority, the foreseeable evolution and the credit-worthiness of the demand should also be established.

2 - Planning and implementing water resources assessment within the capacity of the national economy

74. With the **information demand matrix** as a starting point, a second analysis should be undertaken to determine the most efficient and cost-effective means of responding to it in terms of:

- *institutional arrangements;*
- *financial and human investment;*
- *recurrent costs; and*
- *expected impacts and benefits.*

75. The next question to be asked is that of **affordability** in terms of actual national development. If the response to this question is positive, then the selected demand should be translated in terms of duties for the national services and the necessary means budgeted. However, there is a risk of limiting the activities of these services to urgent short-term specific problems, without sufficient attention being given to the medium and long-term problems. Overcoming these problems is essential to the development process.

3 - Enhancing and backing up by concrete action the political will to cooperate on the river/lake and groundwater basins at the sub-regional, regional and international levels

76. Over 50 major basins are shared between two or more African countries. Whilst there are some good example of international cooperation (such as in the Niger, Senegal, Gambia and Zambezi basins), there are many other examples where water resources development would be improved and costs reduced, by the timely exchange of real-time or recent, quality-controlled water resources information, through an optimized observation system, avoiding duplication and furthering cost-effectiveness. Actual involvement in river basin, sub-regional and international water assessment and management systems and programmes would also help participating countries to strengthen their national systems by facilitating access to other sources of financial support than the ones directly related to short-term development projects. As an example, part of the observation systems not directly related to short-term urgent, specific national needs but considered as essential both for the future development of the country and for international river basin, sub-regional and/or international programmes should be proposed for external funding.

4 - Establishment of direct linkage with the other water resources management (WRM) strategies, such as the one currently being prepared for Sub-Saharan Africa by the World Bank

77. The World Bank is preparing a *Water Resources Management Strategy*. This document "will outline appropriate actions in terms of policy and institutional reforms, investments, and regional programmes, needed by the countries to address important issues relating to water resources management,...". Among these appropriate actions is the need for appropriate information systems, in order to allow the countries to estimate the quantity and quality of water available, as well as the current and prospective water use and demand patterns. Although such a strategy should be tailored to meet specific national or basin characteristics and development priorities, ways of approaching common issues in water resources information systems would be recommended by the Bank. Therefore, it appears of upmost importance for the national and regional strategies for water resources assessment to be consistent with the World Bank WRM strategy.

5 - Willingness of the agencies in charge of the water resources information systems to improve their efficiency, productivity and to take initiatives and participate in the water resources development process

78. National services themselves must carry out an in-depth analysis of their situations and of their actual involvement in the development process of their country. Then they must recognize that data collection is not an objective in itself. They must improve their **contacts** with policy and decision-makers, the private sector, the general public and the international community, keeping in mind that their activities have to be **demand-driven** and that the satisfaction of user's needs is the first objective they have to achieve. Therefore, they must negotiate with the potential users of their products, on the basis of short-term and medium-term contracts covering objectives beyond the simple furnishing of data, with quality assurance and **feedback** mechanisms for the quality of the service provided.

6 - Donors and UN Agencies involved in water sector should coordinate their activities in the region and align their support as much as possible, along the lines of this framework strategy

79. Donors should be associated with the implementation of the new strategy and action plan for water resources in Africa. They should help African countries to develop realistic programmes for the establishment of sustainable water resources information systems, with clear and reasonable objectives, according to the needs expressed by the different categories of end-users at national, basin-wide, sub-regional and international levels, as well as the level and type of support these users are ready to provide. The national public and private enterprises should be responsible for the implementation of these programmes, on a contract basis, including periodic reviews for evaluation based on the obligation of

providing results. Donors have also to consider the benefits of providing their support for the development of regional cooperation projects, based on the free exchange of data and on the free dissemination of the information, especially in international basins. A project like the proposed Hydrological Cycle Observing System (**HYCOS-Africa)** is aimed at improving cooperation between national agencies in charge of water problems and creating a network of **reference stations** and an associated data base with long series of high quality data in the field of water and the environment. Therefore, this project is seen as one of the major tools to support national agencies and at the same time link with the Global Climate Observing System (GCOS), Global Terrestrial Observing System (GTOS), Global Environment Monitoring System (GEMS)/Water, etc to ensure the availability of the data necessary for global projects.

7 - A world-wide campaign to promote this framework strategy, improving the awareness of the problems and highlighting the new options adopted by African countries.

80. WMO and ECA should take the lead in the campaign to promote the framework strategy and the action plan. The other **activities of WMO** in the Region should be consistent with the recommendations of the Conference.

USE AND MAIN OBJECTIVES

reference station, controls the flow from the upper basin of River Oueme
reference station, downstream control of the Nanbeto Dam on the Mono River, regional interest
reference station, large hydro-agricultural developments, regional interest
control the flow of the Pendjari River when flowing out of Benin, regional interest
reference station for the upper Oueme river basin, site for hydroelectric power dams

mutipurpose dam site
hydro-agricultural development projects
hydroelectric power dams project
hydro-agricultural development schemes
lake entering a costal lagoon, fisheries, monitorig mangrove swamps and halieutic species

management of Sourou's hydro-agricultural structures
management of Sourou's hydro-agricultural structures
multipurpose dam project, regional interest
flow forecasting at the Bagre dam
regional interest, Comoe paddy project
Hydroniger station
regional interest
hydro-agricultural scheme, regional interest
regional interest
regional interest, Comoe paddy project
management of releases from the Sourou dam, regional interest

management of Sonel's hydroelectric power dams
management of Sonel's hydroelectric power dams
management of Sonel's hydroelectric power dams
water suppy for Mbalmayo and Yaoundé
navigation, water supply
hydro-agricultural and hydroelectric power development
hydroelectric power development
navigation
water resources management
hydro-agricultural development for SEMRY, regional interest for CBLT
water supply for Douala
water resources assessment by CRH
hydroelectric power project
management of Sonel's hydroelectric power dams
management of Sonel's hydroelectric power dams

navigation, water supply, hydroelectric power project
navigation
navigation, hydroelectric power project
navigation
agriculture, fisheries, navigation

hydropower project
irrigation (paddy), pisciculture
hydroelectric power opportunities
rural development project

environmental monotoring, game hunting area

road infrastructure, irrigation, flood forecasting project
flood forecasting project
flood forecasting project
flood forecasting project, irrigation
regional interest, SODELAC irrigation programme
control most of the flow from upper Chari River, irrigation project
large flood plain, irrigation by l'OMVS-D
irrigation schemes, low flow agriculture
important hydropower potential (Gauttiot's Falls)
irrigation, cattle farming
cattle, low flow agriculture
lake with manatees
irrigation
study of the Lake Chad

navigation, water supply, fisheries, recreation, hydroelectric power projects
navigation, water supply, fisheries, recreation
water supply, fisheries, hydroelectric power development
water supply, navigation, fisheries, recreation
water supply, fisheries, irrigation
scientific research, monitoring road infrastructure, international fisheries project
navigation, scientific research, water supply
navigation, road infrastructure, scientific research
road infrastructure, railway, scientific research

navigation, control of river flow from Kassai into Congo

public and private agencies, international organizations, basins development and exploitation, resources assessment and management

operation of Akossombo Dam
environment
environment
operation of Akossombo Dam
"

Reservoirs operation, hydroelectric power, fisheries, navigation, irrigation, flood forecasting

Segou Paddy Office, Compagnie Malienne de Navigation(COMANAV), flood forecasting, cattle farming
COMANAV, rural settlements, development plans, irrigation, navigation, dam management
irrigation, flood forecasting, navigation, reservoirs management
Paddy Office Mopti, flood forecasting
operation of OMVS structures, irrigation, forecast, reservoirs operation
operation of OMVS structures, irrigation, forecast, hydropower
Paddy Office Mopti, COMANAV, flood forecasting, cattle farming

SONADER
SONADER, OMUS, ONG and development stakeholders
NHS, water use
IRAT

hydroelectric power dam project, hydro-agricultural project, navigation
Niamey water supply, hydro-agricultural development
irrigation, control of flow entering Niger downstream the Jibia Dam in Nigeria
hydro-agricultural dam project, fisheries
dam project

rural development projects
water supply projects (recharge of the Agadez ground table)
hydroelectric power project
rural development projets
downstream control of reservoirs

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operation of Kainji hydroelectric power dam by NEPA

operation of Kainji hydroelectric power dam by NEPA
operation of Kainji hydroelectric power dam by NEPA
navigation, irrigation
navigation, water supply, hydroelectric power dam project
navigation, water supply
navigation, water supply, hydroelectric power dam project
navigation, water supply, hydroelectric power dam project
irrigation, water supply
irrigation, water supply

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international consultants, agencies, development firms, army
international consultants, agencies, development firms
development firms, water supply company, SGPRE
rural development, research consultants, army, SONEES, ONG, water supply company

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operation of the downstream hydropower dam of Nangbéto by CEB
irrigated sugar cane area, Nangbéto Dam operation
onchocerciasis control
irrigation, water supply, fisheries
water supply of Mango, flood protection, onchocerciasis control
flow into Lake Togo, irrigation, fisheries
contol of releases from Nangbéto Dam
onchocerciasis control
Nangbeto Dam operation, onchocerciasis control
Nangbeto Dam operation
Kara water supply, onchocerciasis control
2000 ha irrigation scheme

Annex 5

AOC-HYCOS standards for hydrological stations

One aim of the AOC-HYCOS project is to certify the quality and consistency of data from the most important stations in the AOC zone. Data quality is primarily dependent on the quality of the initial observations, which in turn depend on the field facilities and the data management and observation methods. Installation, control and recording criteria which stations in the AOC-HYCOS network are required to meet are as follows:

1. Compulsory observer

An observer should be posted at all stations regardless of what type of equipment is available. Observers at stations equipped with DCPs will control the quality of raw data, and adjustments can subsequently be made on the basis of the observers' control records. Observers will also be responsible for equipment safety. Theft of solar panels is currently the main cause of failures at telemetry stations in Africa. Observers should, therefore, be relatively well paid as a responsibility incentive. In addition they should be able to undertake further observations, e.g. monitoring rainfall levels, and even taking water samples.

2. Staff gauges in running order

The staff gauges are a key element in the system; all gauges have to be accurately levelled so that the settings match and do not drift with time. There can be considerable differences in levels read from the gauge and those recorded by the sensor, especially during flooding. The sensor measures the hydrostatic pressure just above the intake, which is generally located around the low-water gauge. During flooding, water levels are measured on gauges installed along the river banks, which are sometimes remote from the main axis of the low-water gauge. For some rivers, there can be differences of more than 10 cm between the gauge readings and the sensor recordings, even when there is no doubt as to the quality of the sensor. In such cases, the gauge reading should be selected since the conversions of the water levels into discharge are based on this reading.

At these stations, all gauges should be accurately calibrated, readable and attached to solid benchmarks. Moreover, the gauge settings should match those used when the initial flood gauging was done.

3. Benchmarks

Several solidly anchored benchmarks are required at each station so that control measurements can be obtained periodically. These include:

- benchmark for gauge calibration;
- benchmarks for positioning the axis for gauging sections;
- benchmarks for positioning flood gauging sections;
- benchmark for control sections (sometimes downstream).

All of these benchmarks are interconnected and their positions are plotted on a station survey map.

4. Routine cross-sections

At each station, some survey work will be undertaken at the beginning of the project. A gauging section should be drawn up at this stage. If cross-sections were done previously and the exact locations they were obtained from are known, then new ones should be measured at the same locations.

All cross-sections should refer to a benchmark and be expressed according to a fixed-point survey system.

5. Flood gauging site

It is important to keep the flood gauging site cleared and clean. Whenever possible, there should be a well maintained vehicle access to the site.

6. Float gauging

For some stations with poor access or when flood gauging is difficult, it would be advisable to set up a float gauging base with benchmarks anchored on both river banks.

7. Raingauge

Each station should be equipped with a raingauge which is read by the observer. This gauge will be managed according to guidelines set by the national meteorological services. For security reasons the raingauge should be kept close to the observer's quarters for security reasons. Rainfall data is to be collected at the same frequency as the water level data.

8. Logbook container

Each station will be equipped with a letterbox-type container attached to a wall in the observer's quarters. This container is secured with a combination lock and contains logbooks with recently recorded water level and rainfall data. This will allow field survey teams to check the measurements when the observer is absent.

9. Water sampling

At some stations the observers should be able to collect water samples at set frequencies.

10. Standard logbook

A standard logbook for recording water levels is compulsory. It should be designed such that three readings a day can be noted, along with the exact times when they are obtained, with three separate sheets per month. A special space will be provided on the logbook for the hydrological number of the station.

11. Site maintenance

The observer should keep all access routes to the facilities clean, especially around the site where the DCP and associated sensors are installed.

12. Station folder

Each station should have a folder in which all documents concerning previous and current operational information is archived. This folder will contain the latest topographical maps and complete DCP installation instructions.

A field survey sheet should be drawn up for each station. Teams visiting the station will have this field sheet to hand. It will contain all essential information for understanding the hydrological operations at the station, together with details of the equipment. It will also include the rating curve which is being verified.

Annex 6

Proposed role for the AOC-HYCOS Pilot Regional Centre (PRC)

The main role of the Pilot Regional Centre in the AOC-HYCOS project is to implement, coordinate and manage the project through monitoring, training and assistance activities. The PRC will provide a forum for the activities of this cooperative network linking all participating countries.

The main proposed tasks for the PRC are:

Assist NHSs with installing, operating and maintaining DCPs;

Manage the reception of raw data transmitted by DCPs, along with their archiving;

Disseminate raw data received from DCPs to all participating countries as quickly as possible, using all available means of communication;

Monitor all DCPs daily and notify the concerned NHSs of any problems if they have not taken the appropriate measures within the agreed time limit;

Participate in the development and implementation of a regional electronic data exchange and dissemination system;

Participate in the development and implementation of a regional database;

Participate in the development and improvement of national databases;

Organize regional and global data and information exchange and dissemination in collaboration with participating countries;

Develop hydrological products in collaboration with participating countries. Disseminate these product through all available media, particularly through the regional hydrological server;

Develop, manage and implement a training programme which promotes the main project objectives and involves training courses, workshops, national and regional conferences, and individual training sessions at the PRC;

In collaboration with the Regional Technical Committee propose initiatives to facilitate and develop regional technical and scientific cooperation in the field of water resources assessment and management.

The PRC will undertake the above tasks with the support of the technical assistance.

Annex 7

Requirements of the Pilot Regional Centre (PRC)

The PRC will be hosted by an institution in the subregion

1. Staff

1 coordinator
1 database assistant
1 field assistant
1 computer assistant (part-time)
1 secretary

The coordinator will be appointed by the technical assistance, whereas the other staff will be recruited locally by the technical assistance, or supplied by the host institution, or by another regional institution.

2. Facilities

3 offices
1 computer room
1 secretary's office
1 storeroom
Permanent access to a workshop
Temporary access to rooms especially set up with computers and training equipment

3. Equipment*

Office equipment
Computer equipment, including:

METEOSAT Direct Receiving Station (MDRS)	Calculator for the MDRS
HYDROM database calculator	ORACLE Solaris server calculator
Server-specific streamer	Network equipment (charts and cables)
Network repeater	Regular working calculators
Calculator for the PRC Coordinator	Laptop computer equipped for transmission
Laptop computer for field-use	Inverters
Modems	Network streamer
Digitizing table	Standard and special software packages
Purchase ORACLE	Laser printer
DCP memory board reader	Colour printer
Colour scanner	Fax
CD-ROM engraver	External hard drive

1 support vehicle

* Depending on the location of the PRC, some of this equipment could be supplied by the host organization, particularly the MDRS.

Annex 8

List of hydrological stations with telemetry capability in West Africa

Stations proposed for the AOC-HYCOS project by NHSs are shaded

Num.	Station	River	Country	Funded by	Status
9783	BANON	ADJIRO	BENIN	WHO	In service
9545	KANDI BANI	ALIBORI	BENIN	NH	Shut down
10195	VOSSA	BEFFA	BENIN	WHO	Out of order
9771	ATHIEME	MONO	BENIN	DH	Out of order
9526	MALANVILLE	NIGER	BENIN	NH	Out of order
9586	KABOUA	OKPARA	BENIN	WHO	In service
9777	BETEROU	OUEME	BENIN	WHO	In service
9770	BONOU	OUEME	BENIN	NH	Out of order
9774	PONT DE SAVE	OUEME	BENIN	WHO	In service
9772	PORGA	PENDJARI	BENIN	DH	Out of order
9773	COTE 238	TEROU	BENIN	WHO	In service
10196	ATCHERIGBE	ZOU	BENIN	WHO	In service
9591	KORIZIENA	GOROUOL	BURK.FASO	NH	In service
9518	BUFFLE NOIR	BENUE	CAMEROON	NH	Out of order
9515	GAROUA	BENUE	CAMEROON	NH	Out of order
9511	RIAO	BENUE	CAMEROON	NH	Shut down
9517	DJELEPO	FARO	CAMEROON	NH	Out of service
9516	COSSI	MAYO-KEBI	CAMEROON	NH	Shut down
10165	NIAMOTOU	BOA	COTE IV	WHO	Shut down
10162	BIANKOUMA	BAFING	COTE IV.	WHO	In service
10158	NGOLODOUGOU	BAGBE	COTE IV.	WHO	In service
9512	KOUTO	BAGOE	COTE IV.	NH	In service
10144	TIASSALE	BANDAMA	COTE IV.	WHO	In service
10135	BAFECAO	BANDAMA	COTE IV.	WHO	In service
10143	TAABO	BANDAMA CANAL	COTE IV.	WHO	Shut down
9513	SAMATIGUILA	BAOULE	COTE IV.	NH	Out of order
10132	VIALADOUGOU	BOA	COTE IV.	WHO	In service
10138	ANIASSUE	COMOE	COTE IV.	WHO	In service
10149	AKAKOMOEKRO	COMOE	COTE IV.	WHO	In service
10169	BADALA BAGBE	FEREDOU - GOUBA	COTE IV.	WHO	In service
10159	GBELEBAN	GBANHALA	COTE IV.	WHO	Out of order
10190	DEBETE	KANKELEBA	COTE IV.	WHO	Out of order
10147	BOUAFLE	MARAOUE	COTE IV.	WHO	In service
10145	KONGASSO	MARAOUE	COTE IV.	WHO	In service
10140	ZUENOULA	MARAOUE	COTE IV.	WHO	In service
10141	DIMBOKRO	N'ZI	COTE IV.	WHO	In service
10137	DIMBOKRO KAN	N'ZI	COTE IV.	WHO	In service
10136	NZI'NOUA	N'ZI	COTE IV.	WHO	In service
10130	SEMIEN	SASSANDRA	COTE IV.	WHO	In service
10161	DABALA (BOROTOU)	SASSANDRA	COTE IV.	WHO	In service
10181	ASSUBENDE	PRU	GHANA	WHO	In service

Num.	Station	River	Country	Funded by	Status
10176	BUI DAM SITE	VOLTA	GHANA	WHO	In service
10192	ASUKAWKAW		GHANA	WHO	In service
10163	KOUNDEBOUM	BALE	GUINEA	WHO	In service
10168	SASSAMBAYA	BALE	GUINEA	WHO	Out of order
10139	GUEASSO	BOGHO	GUINEA	WHO	In service
2454	DIANI BAC	DIANI	GUINEA	?	In service
10154	BARANAMA	DION	GUINEA	WHO	In service
10152	DIAMARADOU	DION	GUINEA	WHO	In service
10146	MORRISSINANDOUGOU	GOUAN	GUINEA	WHO	In service
10189	KABA	KAKRIMA	GUINEA	?	Out of order
2453	COGON	KOGON	GUINEA	?	In service
10129	NIANSO	KOKOULO	GUINEA	?	In service
10204	BADERA	KOLENTE	GUINEA	WHO	In service
10188	GARAFIRI	KONKOURE	GUINEA	?	In service
10186	KALETA	KONKOURE	GUINEA	?	Out of order
10198	KODIANA	KOURAI	GUINEA	WHO	Out of order
10164	PONT KOUYA	KOUYA	GUINEA	WHO	In service
10178	BANIE	LABERO	GUINEA	WHO	Out of order
10155	DIALOUA	MAFOU	GUINEA	WHO	In service
10167	SEREKOROBA	MAFOU	GUINEA	WHO	Shut down
9594	KANKAN	MILO	GUINEA	WHO	Shut down
9503	KEROUANE	MILO	GUINEA	WHO	In service
9508	BARO	NIANDAN	GUINEA	NH	Shut down
10185	SASSAMBAYA	NIANDAN	GUINEA	WHO	In service
10157	YARAKOURA ex 10166	NIANDAN	GUINEA	WHO	In service
9544	FARANAH	NIGER	GUINEA	WHO	In service
9548	KOUROUSSA	NIGER	GUINEA	WHO	In service
9578	MANDIANA	SANKARANI	GUINEA	NH	Out of order
10150	SANANKORO	SANKARANI	GUINEA	WHO	Out of order
9502	TINKISSO	TINKISSO	GUINEA	WHO	In service
10160	FIFA	TINKISSO	GUINEA	WHO	In service
2452	GAOUAL	TOMINE	GUINEA	?	In service
8786	BAFFING MAKANA	BAFFING	MALI	OMVS	Shut down
8788	DIBIA	BAFING	MALI	OMVS	Shut down
9532	PANKOUROU	BAGOE	MALI	NH	Out of order
8780	OUALIA	BAKOY	MALI	OMVS	Shut down
9533	DOUNA	BANI	MALI	NH	In service
9529	BENENY KEGNY	BANI	MALI	NH	Out of order
9540	KOUORO	BANIFING	MALI	NH	Shut down
9528	BOUGOUNI	BAOULE	MALI	NH	Out of order
9542	DIOLA	BAOULE	MALI	NH	Out of order
8781	GOURBASSI	FALEME	MALI	OMVS	Shut down
9534	AKKA	ISSA BER	MALI	NH	Out of order
9523	NIAFUNKE	ISSA BER	MALI	NH	In service
9519	DIRE	NIGER	MALI	NH	In service
9527	KIRANGO AVAL	NIGER	MALI	NH	Out of order
9531	KOULIKORO	NIGER	MALI	NH	In service
9541	ANSONGO	NIGER	MALI	NH	In service
9530	BANANKORO	NIGER	MALI	NH	Shut down

Num.	Station	River	Country	Funded by	Status
9525	KEMACINA	NIGER	MALI	NH	In service
9522	KENIEROBA	NIGER	MALI	NH	In service
9539	KORYOUME TOMBOUCTOU	NIGER	MALI	NH	In service
9543	NANTAKA	NIGER	MALI	NH	In service
9593	TOSSAYE	NIGER	MALI	NH	Out of order
9520	SELINGUE AVAL =9535	SANKARANI	MALI	NH	In service
9535	SELINGUE BARRAGE	SANKARANI	MALI	NH	Out of order
8785	KAYES	SENEGAL	MALI	OMVS	Shut down
9536	GOUNDAM	TASSAKAN	MALI	NH	Out of order
9500	MANDIANA BAC	TINKISSO	MALI	NH	In service
8789	KAEDI	SENEGAL	MAURITANIA	OMVS	Shut down
9505	KAKASSI	DARGOL	NIGER	NH	In service
9501	DIONGORE	GOROUBI	NIGER	NH	Shut down
9504	ALCONGUI	GOROUOL	NIGER	NH	Shut down
9590	BAROU	MEKROU	NIGER	NH	Out of order
9507	KANDADJI	NIGER	NIGER	NH	In service
9506	NIAMEY	NIGER	NIGER	NH	In service
9509	W-PARC	NIGER	NIGER	NH	Out of order
9537	GARBEKOUROU	SIRBA	NIGER	NH	Out of order
9510	CAMPEMENT DU W	TAPOA	NIGER	NH	Out of order
9558	MAKURDI	BENUE	NIGERIA	NH	Shut down
9560	IBI	BENUE	NIGERIA	NH	In service
9551	LAU	BENUE	NIGERIA	NH	Out of order
9562	TAPORE	DONSA	NIGERIA	NH	Out of order
9556	KENDE	HYDRONIGER	NIGERIA	NH	In service
9554	WUYA	KADUNA	NIGERIA	NH	Out of order
9557	KATSINA ALA	KATSINA ALA	NIGERIA	NH	Out of order
9553	BARO	NIGER	NIGERIA	NH	In service
9596	LOKOJA	NIGER	NIGERIA	NH	Out of order
9563	ONITSHA	NIGER	NIGERIA	NH	In service
9546	YIDERE BODE	NIGER	NIGERIA	NH	In service
9559	KAINDJIDAM AVAL	NIGER	NIGERIA	NH	Out of order
9561	KAINJI DAM AMT	NIGER	NIGERIA	NH	Out of order
9550	GASSOL	TARABA	NIGERIA	NH	In service
9555	JEBBA		NIGERIA	NH	Out of order
9592	UMAÏSHA		NIGERIA	NH	Out of order
9552	LOKOJA		NIGERIA	NH	Out of order
9524	WUROBOKI		NIGERIA	NH	Out of order
8782	NGOUI	DOUE	SENEGAL	OMVS	Shut down
8784	BAKEL	SENEGAL	SENEGAL	OMVS	Shut down
8783	DAGANA	SENEGAL	SENEGAL	OMVS	Shut down
10003	KABA FERRY	KABA	SIERRA LEONE	WHO	Out of order
10006	OUTAMBA PARK	KABA	SIERRA LEONE	WHO	Out of order
10004	MUSAYA	MONGO	SIERRA LEONE	WHO	Shut down
10002	ARFANYA	SELI	SIERRA LEONE	WHO	In service
10134	MARAMPA	SELI	SIERRA LEONE	WHO	Out of order
10173	ANIE PONT CH. FER	ANIE	TOGO	WHO	In service
10191	BLITTA	ANIE	TOGO	WHO	In service
9580	POUDA	BINAH	TOGO	WHO	In service

Num.	Station	River	Country	Funded by	Status
9583	KPESSIDE	KARA	TOGO	WHO	In service
10170	BONGOLOU	MO	TOGO	WHO	In service
10182	DOTEKOPE	MONO	TOGO	WHO	In service
10183	TETETOU	MONO	TOGO	WHO	In service
10171	LANDA MONO)	SIO	TOGO	WHO	Out of order
10187	KESSIBO (Dodji)	WAWA	TOGO	WHO	In service
10131	GLEI		TOGO	WHO	Shut down
10179	GOUBI		TOGO	WHO	Out of order
10172	KPELOU		TOGO	WHO	Out of order
10202	KISSIDOUGOU	NIANDAN		WHO	Out of order
10199	ATCHANGBADE			WHO	Out of order
10175	Banc test Odienné			WHO	
10151	DIMORI			WHO	Out of order
9549	JEBBA				In service
10156	KPASSA			WHO	Out of order
10201	OUEME PONT				
10203	SORMOREA			WHO	In service
10148	TITIRA			WHO	In service

Annex 10

List of people interviewed in the 16 AOC countries visited

BENIN

André TOUPE	Director
Pierre ADISSO	Chief of the Hydrology Service
Flavien LANHOUSSI	Hydrological Engineer
Daniel CHABI GONNI	Hydrological Engineer
Antoine GOHOUNGOSSOU	Head Hydrological Technician
Félix HOUNTON	Director, Permanent Representative of Benin with WMO
Epiphane AHLONSOU	Chief of the Climatological Division
Albert TONOUHEWA	Chief of the Hydroagricultural Service
Amidou Roufaï TAMAMA	Water Resources Director

BURKINA-FASO

Kandaogo SAVADOGO	Director of the Water Resources Inventory
Jean Pierre MIHIN	Chief of the Hydrology Service
Pierre ZOUNGRANA	Hydrologist
Innocent OUEDRAOGO	Head of the "DGH Support" Project
Ambroise OUEDRAOGO	Director of the Hydroagricultural Service
Alassane DIALLO	Director
Frédéric OUATTARA	Chief of the Computer Service
Mamadou Lamine KOUATE	Director General
Florent OUEDRAOGO	Head of the Ziga Project
Patrice GUISSON	Technical Director
Clément ZONGO	Technical Director
Ouiraogo BOUDA	Chief of the SPHT p.i.
Sibiri COMPAORE	DEMH
Jean de Dieu YAMEOGO	SPHT
Idé BANA	Natural Resources Management Consultant
Vim KERE	Hydrologist (WHO-OCP)
Michel GAUTIER	Hydrologist (ORSTOM)

CAMEROON

Daniel TIAGUEU	Director of Water Resources and Urban Water Purification
Jean Oscar EDUMA	Deputy Director of the Rural Hydrological Resources Service
Jean Marie BEYINDA	Director of Energy Resources
Tash Z. TONGABIANG	Sub-Director of Electrical Resources
Protait NOMO	Chief of the Control and Development Service
E. EKOKO-ETOUMANN	Director
Justin MBAH	Climatology Service
Jean DOUNLA	Rural Engineer
Georges E. ECODECK	Director
Vincent N'GAKO	Chief of the Research Service
Jean-Pierre BOUM	Chief of the Hydrological Research Centre
Daniel SIGHOMNOU	Researcher
Luc SIGHA-NKANDJOU	Researcher
Aurélien AGBANONCI	Deputy Resident Representative
Timothy BESINGI	Sustainable Development Consultant and Head of Public Affairs
Madame EYIDI	Programme Coordinator

CENTRAL AFRICAN REPUBLIC

Simon YANOU-GONIA	Secretary General
Clément FEIZOURE	Director
Jean-Pierre DACKOU	Chief of the Hydrology Service
Joël TETEYA	Chief of the Agrometeorological Service
Athanase YENDELE	Hydrologist
Etienne N'DORYAN	Hydrologist
Etienne M'PECO	Director General
DOUTAMBAYE	Rural Engineer
Hubert LECLERC	Director General
Gérard CHALANDON	Deputy Coordinator
Louis JOUNY	Hydrographer
Remy LOUNGOUPOU	Chief of the Studies, Organization, Planning, Equipment and Marketing Studies Service
François ENGUEHARD	Economic Development Consultant, Deputy Chief of Mission
Gilbert POUMANGUE	Assistant to the Resident Representative
Léon DIBERET	Economist
Maxime-Faustin MBRINGA TAKAMA	Sustainable Development Consultant

CHAD

Djogromel ALAINAYE	Chief of the Hydrology Service
Mouhyddine Mahamat SALEH	Hydrologist
Etienne KISSISSOU	Hydrologist
Ngaradédji GUIRBAYE	Hydrologist
Tellro Waï NADJI	Hydrologist
Tapsala ABBA	Hydrologist
Aina Appolos WALBADET	Hydrologist
Gaounan DOUBABE	Chief of the Rural Roads Division
Oumar Matar BREME	Technical Assistant for the UNDP/INT/006/93 Project Sustainable Development Network Programme
Abdel-Madjid Z. MAGGAR	Technical Director
Abdallah ADAM	Chief of the Technical Unit
Amhed SEDICK	Hydrologist
Mahamat Saleh ADAM SALEH	Programme Coordinator
M. Nicolas FORNAGE	Rural Development Consultant

CONGO

Bienvenu MAZIEZOULA	Hydrologist
Jean Sulpice NGOUMBI-NZOUZI	Hydrobiochemist
Noël MOUKOLO	Hydrogeologist
Jean Auguste TCHIKAYA	Hydrologist
N'KELE	Director General of Water Resources
YOULASSANI	Chief of the Control and Legislation Service
Robert ALAIN	Coorinator
Fidèle NGOUALA	Director General
M. François OYOU	Direcftor of Meteorology, Permanent Representative of Congo with WMO
Pierrette BAYIDIBILA	Chief of the Pollution Division
Benjamin BITSOUMANI	Chief of the Agricultural Meteorology Division
Daniel EVOUYA	Chief of the Synoptic, Aeronautical and Maritime Service
Laurentine NZITOUKOULOU -BIDIE	Head of CLICOM
Dr. André SABOUKOULOU	Programme Administrator

COTE D'IVOIRE

Mme Kone SARAMATOU	Water Resources Directorate
Djouka ANZENI	Water Resources Directorate

GABON

Daniel ONDO NDONG	Director, Permanent Representative of Gabon with WMO
Michel ASSOGHO	Meteorological Engineer
Antoine ANGO-OSSA	Water Resources Director
Bernard VOUBOU	Head of the Environment Programme
Mme Jeanne Colette MABERT	Programme Assistant
Didier MEBALEY	Economist

GHANA

ABOADJE	Acting AESC Director
J. WELLENS-MENSAH	Chief of the Hydrology Service
P. MOTTE	National Meteorology
PR AMUSU	Water Resources Research Institute
Opoku ANKOMAH	Water Resources Research Institute

GUINEA

Kankalabe DIALLO	National Hydrological Resources Director
Aliou DIALLO	DNH
Sao SANGARE	DNH

MALI

Koliba KONARE	Resident Representative
Mamadou SIDIBE	DNHE Director
Navon CISSE	DNHE
Mamadou DIARRA	ENI
Abdoulaye TRAORE	ENI
Amadou Z. TRAORE	ENI
Aboubacar MAIGA	Livestock Directorate
Jean D. DIASSANA	Livestock Directorate
Nancoman KEITA	Rural Engineering Director
Paul COULIBALY	Rural Engineering
Mamery DIAKITE	Rural Engineering
J-Pierre BRICQUET	ORSTOM

MAURITANIA

Bachir LAKDAFF	Permanent Representative
SARR	Chief of the Hydrology Service
Representative	UNDP
Chief	Cooperation Mission

NIGER

Issa SOUMANA	Water Resources Director
Abdou OUSMANE	Chief of the Hydrology Service
Garba RADJI	Chief of the National Hydrological Forecasting Centre
Abdourhamane DAOUDA	Hydrology Engineer
Abdou HASSANE	Director of the NER/94/002 "Plan Eau et Développement" Project
Seyni MOUSSA	Director of Rural Engineering
Idrissa ALSO	Director
Mamadou DAOUDA	Chief of the Agriclimatology Service
Maïkassoua GUERO	Development Director
Diawatou TALATA	Chief of the Development and Monitoring Service
J. S. OLIVEIRA	Director General
Rui SILVA	Hydrologist
Jean-Pierre TRIBOULET	Hydrologist
Sitapha TRAORE	Executive Secretary
Oumar OULD ALY	Coordinator
Mamadou SOUMAH	Maintenance Expert
Gustave TCHOUE	Data Processing Expert
Saley GARBA	Computer Technologist
Ahmed TRAORE	Head of the Climatology Unit
Isaac RUSANGIZA	Head of the Training Division
Michel FOUSSARD	Consultant for the Health and Institutional Cooperation Sector

NIGERIA

J.A. HANIDU	Director of Water Supply and Quality Control Department
J.O. BASSEY	Director of Hydrology and Hydrogeology Department
J.O. ADESUYI	Deputy Director of Hydrology and Hydrogeology Department
John Ayoade SHAMONDA	Chief Hydrologist
Olufemi O. ODUMOSU	Chief Hydrologist
Abdoul DIALLO	Senior Officer Industry
Dr J. Owelibo SUBAH	Senior Officer Agriculture
Amadou MANGANA	Division Ressources Naturelles

SENEGAL

Mme Astou F. FALL	Chief of the Water Resources Service
Bachir DIOP	Permanent Representative
Seni COLI	
Ouattara BAKARY	OMVS
Représentant	OMVG

TOGO

Derman ASSOUMA	Director General
Kodjo ATIVON	Deputy Director General
Kossi HODIN	Chief of the Hydrology Division
Awadi Abi EGBARE	Director General, Permanent Representative of Togo with WMO
Koffi AFIDEGNON	Chief of the Synoptic Division
E. Sébabé ATI-ATCHA	Chief of the Agrometeorological Division
Téna LOKMENDA	Chief of the Climatology Division
Abalo ALOU	Climatology Division
Fidèle Mawouko K. AFANOU	Assistant Climatologist
Cocou Crespin DAGBA	Chief of the Research and Control Services
Koami R. M. AZIABLE	Chief of the Civil Engineering Division
Kossigan K. DUHO	Senior Programme Coordinator
Ganda Seyni HASSANE	Chief of the Rural Development and Environment Division (DDRE)
Joseph ATTIN	Macroeconomist
Chaîbou TALABE	Head of the Swiss Fund Utilization Project

Table 6

AOC-HYCOS. Project timetable