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WATER RESOURCES OF AFRICAN COUNTRIES: A REVIEW

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Foreword

In order to provide a rational basis for the discussion on increasing water scarcity and the potential for irrigation expansion in Africa, FAO undertook to compile existing information on the water resources of the African continent. Contrary to previous attempts, this survey is based essentially on country-based statistics and information contained in sector studies and master plans. Due account has been taken of the interaction of ground- and surface water and of the problem of trans-boundary flows.

It is believed that the statistical data presented reflect the most up to date information on water resources availability on the African continent. This booklet will soon be followed by a comprehensive publication of individual country profiles in the framework of the AQUASTAT database. It is hoped that the publication will be useful to both decision-makers and professionals in the water sector.

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The review described below was carried out in the framework of two initiatives by FAO in the field of water resources assessment. The first refers to the development of the information system on water use in agriculture and for rural development called AQUASTAT. Developed in 1993-94 and implemented first for Africa in 1995, this system aims at collecting country and sub-country information based on key indicators of rural water resources management with specific attention to irrigation and drainage. The programme has collected information at country level from all African countries, mostly through FAO offices in the countries and with the help of national and international resource persons. More than 400 major bibliographic references have been consulted, mainly consisting of sector studies (agriculture, water resources), master plans (water resources management, irrigation), as well as national and regional statistics and studies when available.

The second programme, which directly relates to the results of the present study, consists of collecting, reviewing and updating, in the light of new research and available technologies, the information on irrigation potential for Africa. This review is seen as one of the basic requirements for assessing this potential, which in turn should contribute to the information needed for the implementation of the Special Programme on Food Production for Food Security in Low-income, Food-deficient countries (SPFP). In terms of information needs, it has three main components: water resources, land suitability for irrigation, and irrigation water requirements. The present study refers to the first of the three components.

DATA COLLECTION AND ANALYSIS

Water resources

Very little information exists at present on water resources on a continental basis at country level. The only systematic country-based study was conducted in the 1970s, and led to the publication of a book entitled *"World Water Resources and their Future"* (L'vovich, 1974) which is still considered today a reference in that field. Based on a water balance approach and on a large amount of information on stream flow gathered around the world, L'vovich proposed a table of water resources by country, including water resources generated in the country, as well as flows from neighbouring countries. The book, written in Russian, was later translated into English and edited by the American Geophysical Union (1979).

At continental level, two other studies were carried out in the 1970s. Baumgartner and Reichel (1975) used a continental water balance approach with the purpose of assessing the water balance of the world. They proposed a continental estimate of African water resources where the distinction is made between the endorehic areas and the river basins discharging to the sea. At the same time, Korzun (1974) published an atlas of the world water balance, in the framework of the UNESCO International Hydrological Decade. The author proposed a water balance approach based on the estimation of the runoff coefficient. The maps which were developed, at scales varying between 1:10 00 000 and 1:50 000 000, show the continental distribution of rainfall, evaporation and runoff coefficient. Little attention is given in these approaches to the relationship between groundwater and surface runoff. In fact, water resources are considered to be equal to the volume of water flowing in the river system. In the 1980s, FAO carried out a study on water resources in Africa for the purpose of estimating irrigation potential for the continent (FAO, 1987). The study, based on a water balance

approach by river basin, was a first attempt to integrate surface water and groundwater resources with the support of a geographic information system.

More recently, the Russian Institute of Hydrology has been updating the information on water resources at continental level through a combination of data compilation and water balances which finds its origins in the works of Korzun. Shiklomanov (1990, 1993) is presently the most frequently quoted and the most up-to-date source of information on water resources at regional and continental level. An update of this information is to be published in 1995 in the framework of UNESCO's International Hydrology Programme.

At country level, the most recent systematic information about water resources can be found in the World Resources Report published biennially by WRI. In Table 22 of the reports, a figure is given for water resources for each country as well as incoming water. It is mainly a compilation of exiting information, including, for Africa, a large number of figures taken from L'vovitch (1974).

As indicated above, the present survey is principally based on information emanating from countries or regional organizations. Apart from sectorial reviews and water resources development master plans, the World Bank/UNDP hydrological assessment exercise, carried out in 1991/92, and country reports to the International Conference on Water and the Environment (Dublin, Ireland, 26-31 January 1992) were also important sources of information. The option to rely on country information to perform this survey is based on the assumption that no continental approach can be more accurate than studies carried out at country level. Only when no information was available at country level did the study refer to regional or global studies. Because it is still the only study which gives systematic information on water resources by country, L'vovich (1974) was used in such cases.

It was not surprising to observe that the most abundant literature on water resources was available in countries where water resources represent a major constraint to development, while in humid countries, most of the time, no major interest is given to the subject and information is rare. Egypt, South Africa, Morocco and the Sahelian countries, to give a few examples, abound in reports and statistics on water resources, while in Sierra Leone, Liberia, Cameroon or Zaire, this kind of information is scarce. In countries for which a lot of information was available, a critical analysis of the literature was necessary to select the most reliable information. The judgement was based on several criteria, including the source of information, the conceptual approach used to assess water resources, and the accuracy of the data. Cross-checking was carried out whenever possible, most notably with regard to information on trans-boundary river flows.

A final check was performed comparing the results by country with those obtained from the regional analysis by Korzun (1974), although no correction was made to the information collected at that stage unless evidence of misinterpretation of the data could be found. In the latter case, reaction by the official institutions in charge of water resources monitoring at country level was also requested and figures were revised in consequence. As a matter of comparison, the global estimate over Africa was then compared with the figures obtained from the global studies described above (Korzun, 1974; L'vovich, 1974, Baumgartner and Reichel, 1975).

Rainfall

Country estimates of average annual rainfall were also part of the information collected through the AQUASTAT survey. For 41 out of 53 countries, a quantitative estimate of this figure could be found. It was compared with the recently available digital map of rainfall over Africa (Hutchinson *et al.*, personal communication). Both sets of data showed

very good agreement except in arid countries where relatively large discrepancies could be found, probably due to the very low level of rainfall and extreme uncertainty over its spatial distribution. In an attempt to improve the homogeneity of rainfall information, it was decided to select the results from the digital map, except for the islands, for which no digital information was available. In total, it was possible to obtain a value for average precipitation for all but three countries: Comoros, São Tome and Principe and Seychelles. The rainfall information was used in this report for comparison with water resources estimates at country and regional level.

Concepts and conventions used in the review

Potential yield

Several approaches can be chosen when assessing water resources at country level. In most cases, a distinction is made between potential yield and water development potential. Potential yield is here defined as the global amount of water resources, be it surface water or groundwater, which is generated on a yearly basis, while water development potential considers other factors such as the dependability of the flow, the extractable groundwater, the amount of surface water available after removing the floods or consideration of minimum flow requirements for navigation, the environment and aquatic life. Obviously, this latter figure can never be larger than the potential yield and, in fact, it usually represents a small fraction of it. The major constraints to the use of this figure for assessing water resources at a continental level are that there exists no agreed principle to compute it and that it depends on a series of local factors which make comparative studies difficult to perform. Furthermore, water development potential can be modified with time and with the assumptions used for computation while potential yield has a physical meaning and could only be affected by changes in climatic conditions. In this review, the potential yield was used as the indicator to assess water resources by country.

Surface water and groundwater: the water balance approach

The most widely used approach to compute water resources at national level is to study surface water and groundwater resources separately. Although they are interlinked through the water balance, they have traditionally been computed separately. One of the major risks in assessing surface water and groundwater separately lies in the possible double counting of part of the resource: groundwater, part of the river base flow which originates from the aquifers.

This risk is related to the methods used to compute these two elements of the water balance. Surface water resources are usually computed by measuring or assessing total river flows occurring in a country on a yearly basis. In countries where part of the river flow is generated by the discharges from the upper aquifers (mostly in humid areas), this figure includes a part of the water resources which can be considered as groundwater and could in fact be developed through wells. In opposition, in arid areas, the river system usually acts as a preferential source for groundwater recharge and shows very limited base flow: river runoff typically occurs in flash floods of high intensity and short duration.

Computation of groundwater can be performed in two distinct ways which depend mostly on the climatic conditions of the area. In arid areas, the most classical way of computing groundwater is to estimate recharge from rainfall, while in humid areas, where aquifers are connected to the river system, it is usually associated with the base flow of the river system. The first method tends to over-estimate the groundwater resources, while the second usually gives a conservative measure of groundwater potential.

Although many countries fall into one of the two categories, most of them show important spatial variations of climates and may require different methods for estimating groundwater. At the country level, this results in a mixed situation where part of the groundwater constitutes the base flow of the rivers while another part is estimated from recharge.

When computing the water resources of a country, it is imperative to avoid double counting. In this survey, special attention was given to the computation methods so that a possible overlap could be detected and deducted from the accounting of water resources. Although it was not always possible to ascertain if there was double counting, in most cases the analysis of the available information made it possible to judge and avoid double counting.

Internal and global renewable water resources

A further step in computing water resources on a country basis is the distinction between internal and global water resources. In this paper, the term "internal renewable water resources" (IRWR) refers to the water resources resulting from the rain falling within the boundaries of the country. It is a combination of surface water and groundwater resources, in which double counting has been avoided in the way described above. Global renewable water resources (GRWR) are obtained by adding incoming water flows to the internal water resources. This flow consists most of the time of river runoff but, in arid countries, it can also consist of groundwater transfer between countries. However, groundwater transfers are rarely computed and require a good knowledge of the general behaviour of the aquifers.

The term "renewable" is used in opposition to fossil waters which have a negligible rate of recharge on the human scale and can thus be considered "non-renewable". Non-renewable resources are usually expressed either in terms of volumes or extractable flow, while

BOX 1: RULES USED FOR COMPUTING GLOBAL WATER RESOURCES

Trans-boundary rivers
The mean annual flow measured or estimated at the border is accounted for as external resources for the receiving country. It is not deducted from the resources of the donor country, except in the case of an agreed apportionment between countries. While internally-produced water resources are a quantity which should not vary with time, incoming flow may decrease with an increasing use by the upstream country.

A particular case is the situation where part of the runoff entering the country originates in the country itself, after having flowed into the upstream country. In such a case, and when the information is available, this flow is deducted from the incoming flow to avoid double counting.

Border rivers
As a general rule, 50% of the river flow can be assigned to each of the bordering countries. Several situations exist:

- The river exclusively borders the countries without entering into any of the riverine countries nor coming from them (this is the case of the Senegal between Senegal and Mauritania and the Zambezi between Zambia and Zimbabwe). In such a case, the incoming resources are estimated on the basis of the runoff of the river in the upstream part of the border section. When the runoff increases substantially from upstream to downstream, the downstream figure should be used, but after substraction of the part of the runoff generated by the country itself.
- If the source of the river is in one of the two countries, the rule applies only for the other country. For the originating country, 50% of the contribution from the other country could similarly be considered as external resources.
- If, on the contrary, the river enters one of the two countries after having divided the two countries, it is considered a trans-boundary river for the receiving country, in which case all the runoff at the entry point in the country is considered external resources. The 50% rule applies for the other country.

Shared lakes
- In the case where a lake has an outlet into a river (Lake Victoria into the Nile in Uganda, for instance), all the runoff at the entrance of the river is accounted for as external resources for the receiving country. For all the other countries, an equal share of this runoff can be considered as external resources, after having subtracted the country contribution to the lake. If this leads to a negative result, external resources are considered nil. If the river constitutes the border between two countries, the rule described above for bordering rivers applies.
- In the case of lakes without outlet, the global runoff entering the lake is estimated and shared equally between the riverine countries, after having deducted the part contributed from the country. If this leads to a negative result, external resources are considered nil for the country in question.

renewable resources are always a measure of flow, usually presented on a yearly basis.

In this review, both the internal and global water resources were computed, when the distinction was possible. The internal water resources figure is the only quantity which can be summed for regional or continental assessment, and it has been used for this purpose. When available, a measure of the fossil groundwater depletion, expressed as a potential rate of extraction of water from a non-renewable source, has been given, as well as figures for desalinated water, although in absolute terms this quantity is usually negligible.

Computing incoming water resources

The computation of global renewable water resources requires the assessment of water flowing from neighbouring countries. By definition, global water resources are not additive at the scale of international river basins. The definition implies that unused water, accounted for as a resource in upstream countries, is also considered a resource in downstream countries.

Rules have to be set for the computation of incoming water resources. In the case of groundwater, estimates are made on the basis of the characteristics of the aquifers and piezometric levels. In the case of surface water, several situations must be foreseen. The rules described in Box 1 are not absolute nor universal. They have been selected with the purpose of representing all the situations in the most realistic way possible. In summary, in the case of trans-boundary rivers, the mean annual flow at the border is considered as an external resource for the receiving country. In the case of bordering rivers or lakes, an arbitrary 50% rule is applied to distribute the water between the two countries. It should be stressed here that these rules have been set for the purpose of this exercise, and that they do not imply any consideration of judgement on possible or effective ways to share the resources. The difficulties encountered in setting these computation rules also show the arbitrary aspects of computation of global water resources for bordering water bodies, as compared to the indisputable measure of internal resources.

Period of reference

It was stated above that water resources are computed in terms of annual flow. This review concentrated only on long-term averages and did not consider inter-annual and seasonal variations. However, it should be stressed that the review is based on information available from a multitude of sources and that no consistency in the choice of the period of reference can be expected. As a general rule, when different scenarios were available, the longest possible period was selected for computing the average. It remains certain that the period of reference can vary significantly from country to country, leading to substantial inconsistencies. When possible, cross-checking information between countries was used to improve assessment in countries where information was limited.

An example can be found in the case of the Niger River, at the border between Niger and Nigeria. The study of the national water resources master plan of Nigeria was based mostly on assessment of water resources for a 10-year period in the 1980s. On the other hand, measure of the average flow for the Niger River at the border is available for the period 1952-1992. The Nigerian master plan finds a figure of 18 km^3/yr as inflow from Niger, while the long-term average estimates a runoff of 31 km^3/yr. In this case, the particularly dry period which was characteristic of the region in the 1980s translated into a value 30% inferior compared to the long-term average.

Evaporation from wetland and lakes

In most cases, internally generated water resources of a country can be computed by comparing incoming and outgoing flows and taking into account withdrawals occurring inside the country. In arid areas, however, this method would lead to under-estimates and even negative values for the internal water resources, which is not possible. This situation happens for instance in Sudan, or Botswana, where the amount of water leaving the country is inferior to the water flowing into the country. In those countries, "losses" by evaporation play a major role and a country-wide approach is not feasible. Generally, country studies dealing with such conditions work on the basis of river basins and aquifers. Groundwater is computed by the recharge approach and surface water potential is estimated at the points of the river where the runoff is maximum.

It is difficult to account for evaporation from large lakes in the water balance of a country. In at least three cases, a fair estimate of evaporation was computed. This is the case of the Aswan reservoir, with an estimated 10 billion m^3 lost yearly by evaporation, of the inner delta of the Niger river, in Mali, with an evaporation estimated at 33 km^3/yr (which is more than 50% of the internal resources of the country) and of Yaérés, in Cameroon, where evaporation from swamps amounts to 5 km^3/year. In Sudan, a global estimate of evaporation in wetland and the river system gave a figure of 108 km^3/yr, which represents 50% more than the internal renewable water resources and 40% of the global resources of the country. In the present review, no systematic approach could be taken vis-à-vis evaporation from lakes and other water bodies. In the cases of Mali and Egypt, the resources (external in the case of Egypt) were computed without removing evaporation losses. For Sudan, evaporation in wetland was subtracted from the total to obtain internal water resources. In humid areas, the partial balance between rain falling on the surface of the water bodies and evaporation makes this issue less critical and evaporation from large lakes is usually not taken into account in the computation of the water resources.

Results by country

Table 1 presents the results of the review in terms of water resources by country. Surface water and groundwater have been presented in a non-additive way, that is to say the base flow appears in both columns. The reason for this choice is that in most cases this is how the resources are presented in the country studies, and there is no objective reason to subtract the common part either from one or the other category[1]. In the groundwater column, a further index has been written to indicate if groundwater was computed through the recharge approach or through the base flow approach. To make the computation of internal renewable water resources possible, a third column was added where the part of surface water accounted for by the base flow, i.e., the common part between surface water and groundwater, was indicated. Internally produced water resources can then be computed by removing this quantity from the sum of surface and groundwater, thus avoiding double counting. Internal renewable water resources are also presented in Figure 1.

Global renewable water resources were computed on the basis of the rules described above. In an attempt to make the distinction between flow entering a country and border rivers, these two components have been presented in two separate columns. In order to complete the picture on water resources, non-conventional sources of water, including potential development of fossil resources and desalination, have been added to the table. For Africa, these two categories represent very limited volumes and are concentrated in the most arid area.

[1] Due to the different computation methods used and the large amount of uncertainty in the estimation of the two components, the figures on surface water and groundwater should be considered as indicative. Internal renewable water resources can be considered the most reliable figure.

Comparison with previous studies

Due to the global approach used in all but one of the previous studies mentioned above, comparison with the information collected in this study was possible only at continental level. Table 2 presents the results from the different studies for the African Continent.

Prior to analysing the figures, some important points have to be clarified. First, it should be stressed that, in this study, the figures proposed by L'vovitch (1974) were used for 10 countries out of 53, when no better information was found in country studies. Because all these countries are located in well endowed regions, they account for about 54% of the total water resources of the continent. The comparison with the figures by L'vovich is thus relatively biased.

Another important point concerns the method used by Baumgartner and Reichel (1975) to compute the figure of 3 400 km³/yr. This figure represents only the part of runoff which reaches the sea, excluding all losses in internal depression. The authors estimate that the area of these internal water systems represents about 41% of the area of Africa and that it receives approximately 14% of the rain falling on the continent (2.8 million km³/yr). This approach, based on a water balance where runoff is computed as the difference between rainfall and evaporation, was not primarily meant to assess water resources but runoff and, as such, should represent a lower limit for water resources, which is confirmed in Table 2.

The figure given by the World Resources Institute (1994) has been computed by the Institute of Geography of the former USSR, in a continuation of the works by L'vovitch, while the work by Shiklomanov (1993) is the continuation of those initiated by Korzun (1974). These indications may help in understanding the very close results obtained by these two groups of figures: about 4 200 km³/yr for the first group, and around 4 600 km³/yr for the second. Presently, a revision of the figures

TABLE 1
Water resources by country (all figures in km3/yr)

	COUNTRY	Internal renewable water resources					Incoming water			Global ren. water res.			Other resources	
		Surface water	Groundwater		Overlap	Total	Surface water		Groundwater	Surface water	Groundwater	Total	Desalination	GW depletion
				C.		1+2-3	T	B		1+5+6	2+7	8+9-3		
		1	2		3	4	5	6	7	8	9	10	11	12
1	ALGERIA	13.2	1.7	a	1	13.9	0.4	0	0.03	13.6	1.73	14.33	0.03	5
2	ANGOLA	182	72	b	70	184	0	0	0	182	72	184	x	0
3	BENIN	10	1.8	a	1.5	10.3	0.5	15	0	25.5	1.8	25.8	0	0
4	BOTSWANA	1.7	1.7	a	0.5	2.9	11.5	0.3	0	13.5	1.7	14.7	0	0
5	BURKINA FASO	13	9.5	a	5	17.5	...	x	0	x+13	9.5	x+17.5	0	0
6	BURUNDI	3.5	2.1	b	2	3.6	x	0	0	x+3.5	2.1	x+3.6	0	0
7	CAMEROON	268	100	b	100	268	...	0	0	268	100	268	0	0
8	CAPE VERDE	0.18	0.12	a	0	0.3	0	0	0	0.18	0.12	0.3	x	0
9	CENTRAL AFRICAN REP.	141	56	b	56	141	0	x	0	x+141	56	x+141	0	0
10	CHAD	13.5	11.5	b	10	15	28	0	0	41.5	11.5	43	0	0
11	COMOROS	x	x		x	1.02	0	0	0	x	x	1.02	0	0
12	CONGO	222	198	b	198	222	...	610	0	832	198	832	...	0
13	COTE D'IVOIRE	74	37.7	a	35	76.7	1	x	0	x+75	37.7	x+77.7	0	0
14	DJIBOUTI	x	x		x	0.3	0	2	x	x+2	x	x+2.3	0	0
15	EGYPT	0.5	1.3	a	0	1.8	65.5	0	1.2	66	2.5	68.5	0.01	...
16	EQUATORIAL GUINEA	25	10	b	5	30	...	0	0	25	10	30	0	0
17	ERITREA	x	x		x	2.8	0	6	0	x	x	8.8	0	0
18	ETHIOPIA	x	x		x	110	0	0	0	x	x	110	0	0
19	GABON	162	62	b	60	164	0	0	0	162	62	164	0	0
20	GAMBIA	3	0.5	b	0.5	3	5	0	0	8	0.5	8	0	0
21	GHANA	29	26.3	a	25	30.3	22.9	0	0	51.9	26.3	53.2	0	0
22	GUINEA	226	38	b	38	226	0	0	0	226	38	226	0	0
23	GUINEA-BISSAU	12	14	b	10	16	11	0	0	23	14	27	0	0
24	KENYA	17.2	3	a	0	20.2	...	10	0	27.2	3	30.2	0	0
25	LESOTHO	4.73	0.5	b	0	5.23	0	0	0	4.73	0.5	5.23	0	0
26	LIBERIA	200	60	b	60	200	32	0	0	232	60	232	0	0
27	LIBYA	0.1	0.5	a	0	0.6	0	0	0	0.1	0.5	0.6	0.003	2 to 4
28	MADAGASCAR	332	55	b	50	337	0	0	0	332	55	337	0	0
29	MALAWI	16.14	1.4	b	0	17.54	1.14	0	0	17.28	1.4	18.68	0	0
30	MALI	50	20	a	10	60	40	0	0	90	20	100	0	0
31	MAURITANIA	0.1	0.3	a	0	0.4	0	11	0	11.1	0.3	11.4	x	0
32	MAURITIUS	2.03	0.68	a	0.5	2.21	0	0	0	2.03	0.68	2.21	0	0
33	MOROCCO	22.5	7.5	a	0	30	0	0	0	22.5	7.5	30	0.004	0
34	MOZAMBIQUE	97	17	b	17	97	106	5	0	208	17	208	0	0
35	NAMIBIA	4.1	2.1	b	0	6.2	11.3	28	0	43.4	2.1	45.5	0.003	0
36	NIGER	1	2.5	a	0	3.5	29	0	0	30	2.5	32.5	0	0
37	NIGERIA	214	87	b	80	221	59	x	0	x+273	87	x+280	0	0
38	RWANDA	5.2	3.6	b	2.5	6.3	0	x	0	x+5.2	3.6	x+6.3	0	0
39	SAO TOME AND PRINCIPE	x	x		x	2.18	0	0	0	x	x	2.18	0	0
40	SENEGAL	23.8	7.6	b	5	26.4	2	11	0	36.8	7.6	39.4	0	0
41	SEYCHELLES	x	x		x	x	0	0	0	x	x	x	0	0
42	SIERRA LEONE	150	50	b	40	160	0	0	0	150	50	160	0	0
43	SOMALIA	5.7	3.3	b	3	6	7.5	0	x	13.2	x+3.3	x+13.5	0	0
44	SOUTH AFRICA	40	4.8		0	44.8	5.2	0	0	45.2	4.8	50	x	0
45	SUDAN	28	7		0	35	119	0	0	147	7	154	0	0
46	SWAZILAND	x	x		x	2.64	1.87	0	0	x+1.87	x	x+4.51	0	0
47	TANZANIA	80	30	b	30	80	0	9	0	89	30	89	0	0
48	TOGO	10.8	5.7	a	5	11.5	0.5	0	0	11.3	5.7	12	0	0
49	TUNISIA	2.31	1.21	a	0	3.52	0.32	0	0.1	2.63	1.31	3.94	0.009	1
50	UGANDA	35	29	b	25	39	27	0	0	62	29	66	0	0
51	ZAIRE	934	421	b	420	935	84	x	0	+1018	421	+1019	0	0
52	ZAMBIA	33.1	47.1		0	80.2	35.8	x	0	x+68.9	47.1	x+116	0	0
53	ZIMBABWE	13.1	5	b	4	14.1	0	x+5.9	0	x+19	5	x+20	0	0
	TOTAL					3988								

C: Method of computing groundwater: a = recharge of the aquifers, b = baseflow of river system;
T: transboundary flow; B: bordering river; x: unknown; ...: negligible.

FIGURE 1
Internal renewable water resources by country (km^3/year)

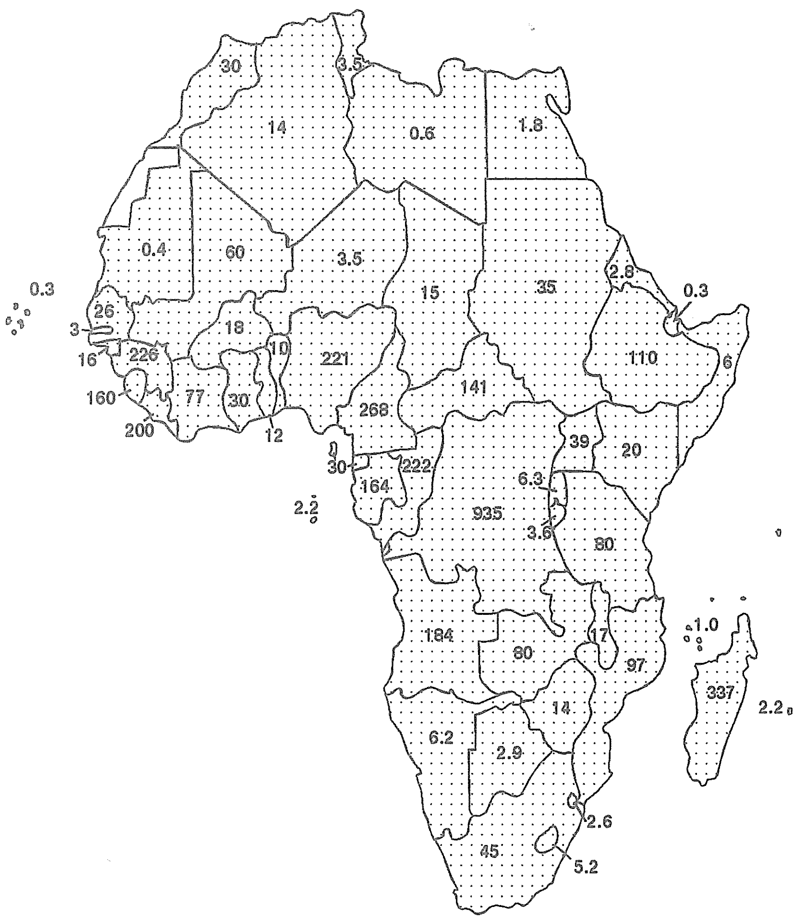


TABLE 2
Comparison with previous studies

Reference	Renewable water resources for the African Continent (km^3\year)
L'vovitch (1974)	4 225
Korzun (1974)	4 600
Baumgartner and Reichel (1975)	3 400
Shiklomanov (1993)	4 570
World Resources Institute (1994)	4 184
This study	3 988

by Shiklomanov, still at regional scale, is being carried out and preliminary results tend to show a global diminution at the continental level (Shiklomanov, 1994, personal communication).

This study shows a global figure lower than all previous studies except that by Baumgartner and Reichel. It is, logically, only slightly lower (4.7%) than the figure computed by the former USSR Institute of Geography, and significantly lower than the figures by Shiklomanov (1993) (12.7%). It is not the purpose of this comparison to explain differences in results. Computing methods and the assumptions they imply are so different that such an exercise would be pointless. Rather, the fact that the result of this study lies between the "conservative" figure of Baumgartner and Reichel, and the most "exhaustive" figures of L'vovitch and followers seems to assure, at least at continental level, the reliability of the information collected.

REGIONAL ANALYSIS

Due to the large number of countries and the diversity in computation methods, a study of the results by country would be of little interest.

Rather, a regional analysis, based on groupings of countries showing similar climatic characteristics, better illustrates the regional specificities and distribution of the resources. For the purpose of this study, Africa was divided into seven regions. Although such division is always arbitrary, it is believed that it corresponds to climatically homogenous zones. The regions, and the countries they include, are presented in Table 3. They are designated below as: Northern, Sudano-Sahelian, Gulf of Guinea, Central, Eastern, Indian Ocean Islands, and Southern. With the exception of the islands of the Indian Ocean, all groups are between 2 and 9 million km² in extent, the smallest being the Gulf of Guinea and the largest being the Sudano-Sahelian region.

Table 3 gives, for each country and for the seven regions, the value of internally produced water resources (including surface water and groundwater), and compares these figures with precipitation. The ratio of water resources over precipitation could be, in a first approximation, assimilated to a "runoff coefficient" and will be designated as such for convenience, but it should be clear that it also encompasses groundwater recharge, which becomes a crucial factor in arid and semi-arid countries.

Results from Table 3, as also summarized in Table 4, show that the runoff coefficient varies from 32% in the Gulf of Guinea, to 6% in the Sudano-Sahelian region. Notably, several studies seem to confirm that, in some parts of Sierra Leone and Liberia, runoff can represent up to 80% of precipitation. Although they represent the largest areas, the Northern and Sudano-Sahelian regions contribute the lowest amount to total water resources: respectively 1.2% and 4.3% of the total. The Southern region also shows a very low runoff coefficient.

Another interesting point is the distribution between surface water and groundwater and the part of the resources which is common to both (the "overlap"). In Figure 2, these three components of the resources have been displayed for each region in pie charts. It illustrates the difference

between arid and humid regions. In arid regions (Northern, Sudano-Sahelian and Southern), groundwater recharge is important and a large part of groundwater resources is not connected to the river system: base flow is limited and thus the "overlap" component is small. On the other hand, in humid countries, like the Gulf of Guinea and Central Africa, aquifers are connected to the river system and groundwater almost entirely constitutes the base flow of rivers. Overlap is thus almost equal to the groundwater resources itself.

Conclusion

Many studies were carried out in the late 1980s and in the 1990s on water resources in African countries, mostly in water scarce areas. The purpose of this study was a compilation and critical analysis of available information in order to draw a continental picture of the state of water resources. The study was part of a larger effort to improve the assessment of water resources and use and potential for irrigation in Africa. It is believed that such information can be of great use to all those concerned with the issues of water resources management in Africa. The bibliography and main sources of country information which were used in this compilation are also presented.

TABLE 3
Water resources compared to precipitation

COUNTRY	Area	Internal renewable water resources (IRWR) Surface water	Groundwater		Overlap	Total		Global renewable water res.	Precipitation	Ratio IRWR/Precipitation
	1000 km²	km3/yr	km3/yr	C.	km3/yr	km3/yr	mm/yr	km3/yr	km3/yr	%
ALGERIA	2381.74	13.2	1.7	a	1.0	13.9	5.84	14.3	162.9	8.5
EGYPT	1001.45	0.5	1.3	a	0.0	1.8	1.80	68.5	18.1	9.9
LIBYA	1759.54	0.1	0.5	a	0.0	0.6	0.34	0.6	46.1	1.3
MOROCCO	446.50	22.5	7.5	a	0.0	30.0	67.19	30.0	150.0	20.0
TUNISIA	163.61	2.3	1.2	a	0.0	3.5	21.51	3.9	33.9	10.4
SUB TOTAL NORTHERN	5752.84	38.6	12.2		1.0	49.8	8.66	117.4	411.0	12.1
BURKINA FASO	274.00	13.0	9.5	a	5.0	17.5	63.87	17.5	231.4	7.6
CAPE VERDE	4.03	0.2	0.1	a	0.0	0.3	74.44	0.3	0.9	33.3
CHAD	1284.00	13.5	11.5	b	10.0	15.0	11.68	43.0	446.5	3.4
DJIBOUTI	23.20	x	x		x	0.3	12.93	2.3	3.4	8.8
ERITREA	121.89	x	x		x	2.8	22.97	8.8	40.1	7.0
GAMBIA	11.30	3.0	0.5	b	0.5	3.0	265.49	8.0	10.9	27.5
MALI	1240.19	50.0	20.0	a	10.0	60.0	48.38	100.0	414.8	14.5
MAURITANIA	1025.52	0.1	0.3	a	0.0	0.4	0.39	11.4	101.9	0.4
NIGER	1267.00	1.0	2.5	a	0.0	3.5	2.76	32.5	227.7	1.5
SENEGAL	196.72	23.8	7.6	b	5.0	26.4	134.20	39.4	146.0	18.1
SOMALIA	637.66	5.7	3.3	b	3.0	6.0	9.41	13.5	161.3	3.7
SUDAN	2505.81	28.0	7.0		0.0	35.0	13.97	154.0	1092.6	3.2
SUB TOTAL SUDANO-SAHELIAN	8591.32	*138.3*	*62.3*		*33.5*	170.2	19.81	430.7	2877.5	5.9
BENIN	112.62	10.0	1.8	a	1.5	10.3	91.46	25.8	125.1	8.2
COTE D'IVOIRE	322.46	74.0	37.7	a	35.0	76.7	237.86	77.7	444.1	17.3
GHANA	238.54	29.0	26.3	a	25.0	30.3	127.02	53.2	301.7	10.0
GUINEA	245.86	226.0	38.0	b	38.0	226.0	919.22	226.0	451.2	50.1
GUINEA-BISSAU	36.12	12.0	14.0	b	10.0	16.0	442.97	27.0	61.6	26.0
LIBERIA	97.75	200.0	60.0	b	60.0	200.0	2046.04	232.0	231.9	86.2
NIGERIA	923.77	214.0	87.0	b	80.0	221.0	239.24	280.0	1087.3	20.3
SIERRA LEONE	71.74	150.0	50.0	b	40.0	160.0	2230.28	160.0	193.0	82.9
TOGO	56.79	10.8	5.7	a	5.0	11.5	202.50	12.0	68.9	16.7
SUB TOTAL GULF OF GUINEA	2105.65	925.8	320.5		294.5	951.8	452.02	1093.7	2964.8	32.1
ANGOLA	1246.70	182.0	72.0	b	70.0	184.0	147.59	184.0	1311.2	14.0
CAMEROON	475.44	268.0	100.0	b	100.0	268.0	563.69	268.0	758.0	35.4
CENTRAL AFRICAN REPUBLIC	622.98	141.0	56.0	b	56.0	141.0	226.33	141.0	859.7	16.4
CONGO	342.00	222.0	198.0	b	198.0	222.0	649.12	832.0	551.4	40.3
EQUATORIAL GUINEA	28.05	25.0	10.0	b	5.0	30.0	1069.52	30.0	58.3	51.5
GABON	267.67	162.0	62.0	b	60.0	164.0	612.69	164.0	482.7	34.0
SAO TOME AND PRINCIPE	0.96	x	x		x	2.2	2270.83	2.2	3.1	70.3
ZAIRE	2344.86	934.0	421.0	b	420.0	935.0	398.74	1019.0	3596.6	26.0
SUB TOTAL CENTRAL	5328.66	*1934.0*	*919.0*		*909.0*	1946.2	365.23	2640.2	7621.0	25.5
BURUNDI	27.83	3.5	2.1	b	2.0	3.6	129.36	3.6	31.7	11.4
ETHIOPIA	1100.01	x	x		x	110.0	100.00	110.0	818.8	13.4
KENYA	580.37	17.2	3.0	a	0.0	20.2	34.81	30.2	331.8	6.1
RWANDA	26.34	5.2	3.6	b	2.5	6.3	239.18	6.3	29.3	21.5
TANZANIA	945.09	80.0	30.0	b	30.0	80.0	84.65	89.0	885.5	9.0
UGANDA	235.88	35.0	29.0	b	25.0	39.0	165.34	66.0	267.3	14.6
SUB TOTAL EASTERN	2915.52	*140.9*	*67.7*		*59.5*	259.1	88.87	305.1	2364.4	11.0
COMOROS	1.86	x	x		x	1.0	548.39	1.0	1.7	60.0
MADAGASCAR	587.04	332.0	55.0	b	50.0	337.0	574.07	337.0	998.0	33.8
MAURITIUS	2.04	2.0	0.7	a	0.5	2.2	1083.33	2.2	4.4	50.2
SEYCHELLES	0.46	x	x		x	x	x	x	0.8	x
SUB TOTAL INDIAN OC. ISLANDS	591.4	*334.0*	*55.7*		*50.5*	340.2	575.30	340.2	1004.9	33.9
BOTSWANA	581.73	1.7	1.7	a	0.5	2.9	4.99	14.7	233.2	1.2
LESOTHO	30.35	4.7	0.5	b	0.0	5.2	172.32	5.2	23.1	22.6
MALAWI	118.48	16.1	1.4	b	0.0	17.5	148.04	18.7	120.1	14.6
MOZAMBIQUE	801.59	97.0	17.0	b	17.0	97.0	121.01	208.0	776.7	12.5
NAMIBIA	824.90	4.1	2.1	b	0.0	6.2	7.52	45.5	233.9	2.7
SOUTH AFRICA	1221.04	40.0	4.8		0.0	44.8	36.69	50.0	550.5	8.1
SWAZILAND	17.36	x	x		x	2.6	152.07	4.5	13.5	19.6
ZAMBIA	752.61	33.1	47.1		0.0	80.2	106.56	116.0	760.7	10.5
ZIMBABWE	390.76	13.1	5.0	b	4.0	14.1	36.08	20.0	254.9	5.5
SUB TOTAL SOUTHERN	4738.82	*209.9*	*79.6*		*21.5*	270.6	57.10	482.6	2966.6	9.1
TOTAL	30024.21					3987.9	132.82	5409.9	20210.2	19.7

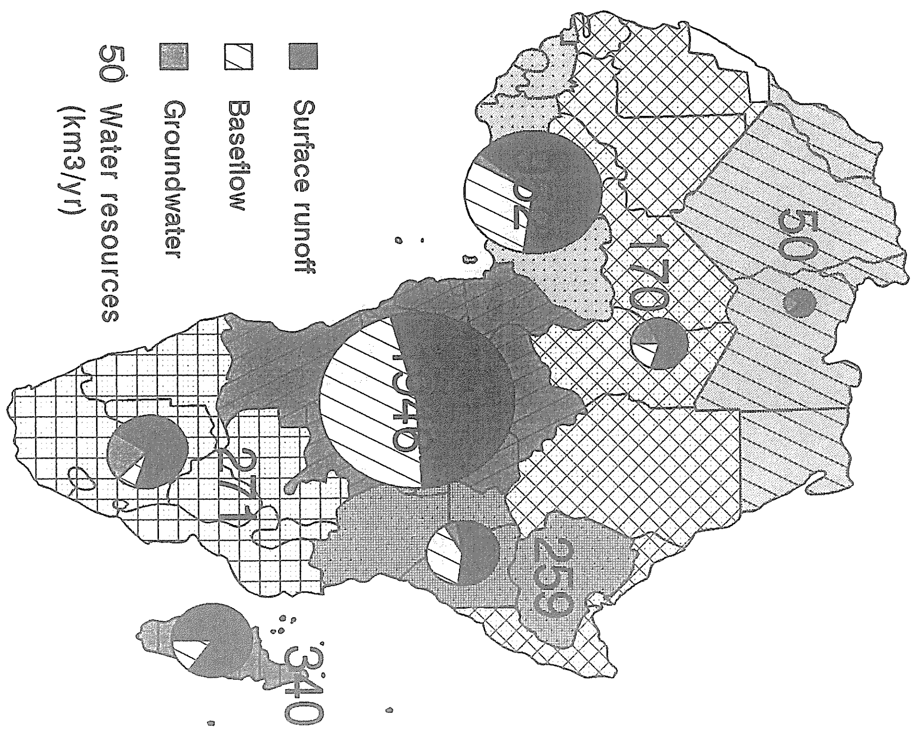
C: Method of computing groundwater: a = recharge of the aquifer, b = baseflow of river system; x: unknown.
Figures in italic indicate incomplete information for the region

TABLE 4
Regional distribution of water resources in Africa

Region	Population 1994	Area	Rainfall	Internal renewable water resources				Internal renewable water res. per caput (m^3)
	(1000)	(1000 km^2)	(km^3/yr)	(km^3/yr)	(mm/yr)	% of total	% of rainfall	
Northern	123 697	5 753	411	50	8.7	1.2	12.1	404
Sudano-Sahelian	83 350	8 591	2 878	170	19.8	4.3	5.9	2 040
Gulf of Guinea	172 804	2 106	2 965	952	452.0	23.9	32.1	5 509
Central	71 473	5 329	7 621	1946	365.2	48.8	25.5	27 227
Eastern	142 531	2 916	2 364	259	88.8	6.5	11.0	1 817
Indian Ocean Islands	15 048	591	1 005	340	575.3	8.5	33.8	22 594
Southern	92 205	4 739	2 967	271	57.1	6.8	9.1	2 939
Total	701 108	30 024	20 210	3 988	132.8	100.0	19.7	5 688

Northern: Algeria, Egypt, Libya, Morocco, Tunisia
Sudano-Sahelian: Burkina Faso, Cape Verde, Chad, Djibouti, Eritrea, Gambia,Mali, Mauritania, Niger, Senegal, Somalia, Sudan
Gulf of Guinea: Benin, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria, Sierra Leone, Togo
Central: Angola, Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Sao Tome and Principe, Zaire
Eastern: Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda
Indian Ocean Islands: Comoros, Madagascar, Mauritius, Seychelles
Southern: Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe

FIGURE 2
Regional distribution of water resources



BIBLIOGRAPHY

Baumgarter, A. and Reichel, E. 1975. *The World Water Balance*. Elsevier, Amsterdam and New York. 179 p + 31 maps.

CIEH [Comité inter-Etats d'études hydrauliques]. 1976. *Cartes de planification des ressources en eau souterraine des états membres du CIEH de l'Afrique Soudano-sahélienne*. Notice explicative. Ouagadougou.

FAO. 1984. *Agricultural Research in The Gambia River Basin*. Report of a review mission. 43 p.

FAO. 1987. *Irrigation and Water Resources Potential for Africa*. Report FAO/AGL/MISC/11/87. Rome. 127 p. plus maps.

Gleick, P. (ed.). 1993. *Water in Crisis: A Guide to the World's Freshwater Resources*. Oxford University Press, New York. 473 p.

Korzun, V.I. *et al.* (eds.), 1974. *Atlas of World Water Balance*. USSR National Committee for the International Hydrological Decade. English translation: UNESCO, Paris. 1977. 35 p + 65 maps.

L'vovitch, M.I. 1974. *World Water Resources and their Future*. Russian ed. Mysl, Moscow. Translation into English by R.L. Nace, American Geophysical Union. 1979, 415 p.

L'vovitch, M.I. 1977. World water Resources. Present and future. *Ambio* VI(1). *Water: A Special Issue*. pp. 13-21. Stockholm.

Margat, J. 1991. Ressources en eau des pays Africains, utilisation et problèmes. In: *Proc. of VIIe Congrès mondial des ressources en eau*. Rabat, 13-18 mai 1991. Vol. 1. IWRA/AIRE/AIREH, Rabat. pp. SS4-27 to 47.

Margat, J. 1994. *Les ressources en eau des pays de l'O.S.S. - Evaluation, utilisation et gestion*. Observatoire du Sahara et du Sahel, Paris.

Shiklomanov, I.A. 1990. Global water resources. *Nature and Resources* 26(3): 34-39.

Shiklomanov, I.A. 1993. World fresh water resources. In: *Water in Crisis: A Guide to the World's Freshwater Resources*. P. Gleick (ed.). Oxford University Press, New York. pp. 13-24.

UNESCO. 1972. *Etude des ressources en eau du Sahara Septentrional*. Rapport final + 7 annexes techniques. Paris.

United Nations. 1987. Groundwater in Northern and Western Africa. *UN-DTCD Natural Resources/Water Series no. 18*. New York.

United Nations. 1988. Groundwater in Eastern, Central and Southern Africa. *UN-DTCD Natural Resources/Water Series no. 19*. New York.

World Resources Institute. 1992. *World Resources 1992-93: A Guide to the Global Environment*. Oxford University Press, New York. 385 p.

World Resources Institute. 1994. *World Resources 1994-95: A Guide to the Global Environment*. Oxford University Press, New York. 400 p.

SOURCES OF COUNTRY INFORMATION

ALGERIA

Pérennes, J.J. 1993. *L'eau et les hommes au Maghreb: Contribution à une politique de l'eau en Méditerranée*. Karthala, Paris. 646 p.

ANGOLA

FAO. 1980. Angola. *Mission de formulation pour le secteur agricole*. Rapport préparé par PNUD/FAO projet ANG/79/016. 2 volumes. FAO, Rome.

FAO. 1992. République populaire d'Angola. *Mission d'identification générale de projets dans le secteur agricole*. FAO Centre d'investissement. Programme de coopération FAO/Banque mondiale/Banque africaine de développement. Rapport N° 3/92 CP/ADB-ANG 11. FAO, Rome.

MINADER. 1993. *Plano director de irrigação em Angola*.

BENIN

BCEOM/SOGREAH/ORSTOM. 1993. *Evaluation hydrologique de l'Afrique subsaharienne*. Rapport de pays: Bénin.

ORSTOM & Direction de l'Hydraulique du Bénin. 1993. *Ressources en eaux superficielles de la République du Bénin*.

Piaton, H. 1986. *Plan National d'Irrigation en République Populaire du Bénin*. Rapport de la mission d'identification.

BOTSWANA

FAO. 1991. *Botswana: Irrigation Subsector Review. Prospects and Constraints*. Report prepared by C. Chapman for Project TCP/BOT/0051: Assistance in Irrigation Development. FAO, Rome.

FAO. 1994. *Project Findings and Recommendations*. Terminal Report of UNDP/FAO Project BOT/86/010: Water Conservation Facilities and Irrigation Development. FAO, Rome.

Gieske, A. & Gould, J. (eds.). 1994. *Proceedings of the Integrated Water Resources Management Workshop 1994*. Kanye, Gaborone. 17-18 March 1994. Published by the Dept. of Environmental Science and Geology, Univ. of Botswana, Gaborone, with SIDA funding.

Ministry of Mineral Resources and Water Affairs, Department of Water Affairs. 1992. *Botswana National Water Plan Study*. Prepared by SMEC/KPB/SGAB.

SADCC [Southern African Development Coordination Conference]/AIDAB [Australian International Development Assistance Bureau]. 1992. *Regional Irrigation Development Strategy, Country Report: Botswana*. Harare.

BURKINA FASO

Ministère de l'eau et Ministère de la coopération des Pays-Bas. 1989. *Etude du bilan d'eau au Burkina Faso*. Rapport intermédiare de la deuxième phase 1987-1990. Tome II: Inventaire des ressources en eau. Ouagadougou.

Ministère de l'eau et Ministère de la coopération des Pays-Bas. 1991. *Etude du bilan d'eau au Burkina Faso. Etude du schéma directeur d'approvisionnement en eau potable du Burkina Faso (1990-2005)*. Version définitive. Tome I: Rapport national. Ouagadougou.

CAPE VERDE

PNUD/CNAG [Conselho nacional de aguas]. 1993. *Schéma directeur pour la mise en valeur des ressources en eau (1993-2005)*. Rapport préparé de projet CVI/81/001, Assistance à la J.R.H.

CONGO

MottMacDonald Intl./BCEOM/SOGREAH/ORSTOM. 1992. *Evaluation hydrologique de l'Afrique subsaharienne. Rapport de pays: Congo.* Rapport préparé pour la Banque mondiale, PNUD, Banque africaine de développement et Ministère français de la coopération.

COTE D'IVOIRE

Mott MacDonald International. 1991. *Evaluation hydrologique de l'Afrique Sub-Saharienne. Pays de l'Afrique de l'Ouest. Rapport de pays: Côte d'Ivoire.*

DJIBOUTI

Müller, W. 1982. *Inventaire et mise en valeur des ressources en eau de la République de Djibouti*. Rapport préparé pour projet N° 78.2233.1. Coopération Hydrogéologique Allemande. Bundesanstalt für Geowissenschaften und Rohstoffe. Hanover, Germany.

EGYPT

Arab Center for the Study of Arid Zones and Dry Lands. 1988. *Water Resources Assessment in the Arab Region.* ACSAD, Damascus.

Attia F.A.R. 1993. Environmentally sound management of Egypt groundwater resources. In: *[Proceedings of the] Seminar on Techniques of Groundwater Management in the Arab Region*. 20-23 December 1993.

Rofail, N. & Zahran, M.S. 1994. Available water resources in the Arab world and expected future demand. Paper prepared for the ACSAD preparatory expert meeting for the Arab Ministerial Conference on Sustainable Agriculture and Rural Development, Arab League Center, Cairo, 25-29 September 1994.

ERITREA

FAO. 1994. *Eritrea, Agricultural sector review and project identification*. 3 volumes. Report prepared by FAO/IC under Technical Cooperation Programme project TCP/ERI/2353. FAO, Rome.

ETHIOPIA

Aytenffisu M. 1981. *Groundwater in Ethiopia*. DTCD/ECA Groundwater in Africa (unpublished).

GAMBIA

FAO. 1982. *The Gambia: Water Resources Development in the Framework of the National Food Plan*. Report prepared by P. Pallas P. and S. N'Guiamba for FAO Technical Cooperation Programme project TCP/GAM/0104. FAO, Rome.

FAO. 1984. *Agricultural Research in The Gambia River Basin*. Report of a review mission. FAO, Rome.

PNUD. 1994. *Bilan diagnostic des ressources en eau du Sénégal.*

Projet MH/PNUD/DADSG - SEN/87/006 *Planification des ressources en eau.*

GHANA

Water Resources Research Institute/FAO. 1993. *Survey on water use for agricultural and rural development*. Technical Document (unpublished).

GUINEA BISSAU

Mott MacDonald Intl./BCEOM/SOGREAH/ORSTOM. 1992. *Evaluation hydrologique de l'Afrique sub-Saharienne. Pays de l'Afrique de l'Ouest. Rapport de pays: Guinée Bissau*. PNUD.

PNUD. 1991. *Schéma directeur pour le secteur eau et assainissement*. Rapport de projet GBS/87/002. 2 Vol.

KENYA

Ministry of Water Development. 1992. *The Study on the National Water Master Plan*. Prepared with the assistance of Japan International Cooperation Agency (JICA).

LESOTHO

Lesotho Highlands Development Authority. 1990. *Lesotho Highlands Water Project, Environmental Action Plan.*

Ministry of Natural Resources. 1994. *Hydrogeological map of Lesotho*. Scale 1:300 000.

LIBYA

Salem, O.M. 1992. The Great Manmade River project. *Water Resources Development* 8(4).

Pallas, P. 1980. Water resources of the Socialist People's Libyan Arab Jamahiriya. In: *The Geology of Libya*. Proceedings of the Second Symposium on the Geology of Libya. London: Academic Press.

MALAWI

Chirwa A. B. 1994. *Integrated Water Resources Management Plan for the Zambezi River Basin*. Country Position Paper presented at the Workshop held at Livingstone, Zambia, 2-6 May 1994.

UNDP. 1986. *National Water Resources Master Plan*. Projects MLW 79/015 & MLW/84/003. Department of Water, Ministry of Works and Supplies.

MALI

PNUD/UN-DTCD. 1990. *Schéma directeur de la mise en valeur des ressources en eau du Mali*. Rapport de projet PNUD/UNDTCD MLI/84/005.

PNUD/UN-DTCD. 1991. *Schéma directeur de la mise en valeur des ressources en eau au Mali - Volets hydraulique agricole et cultures irriguées par Cheick Bougadary Bathily*. Rapport de projet MLI/89/003.

MAURITANIA

PNUD. 1990. *Schéma directeur pour la mise en valeur des ressources en eau.* Rapport de projet PNUD/DTCD/MAU/87/008.

MOROCCO

AIGR [Amicale des ingénieurs du génie rural]. 1991. *Annuaire 1990 du Génie Rural*.

BRGM/SOGREAH/SCET/CINAM, 1991. *Etude du schéma directeur national d'approvisionnement en eau potable des populations rurales*. Mission d'évaluation globale de la situation actuelle d'AEP du milieu rural, PNUD.

Conseil supérieur de l'eau. 1993. *Aménagements hydro-agricoles. Situation actuelle et perspectives*. 7[e] session, Rabat.

MOZAMBIQUE

Ferro, B.P. & Bouman, D. 1987. *Hydrogeological map of Mozambique.* Ministry of Construction and Water/UNICEF.

UNESCO/UNDP. 1984. *Present situation of water resources management in Mozambique.* UNDP/UNESCO Project MOZ/81/001. National Water Directorate, Maputo.

NAMIBIA

Ministry of Agriculture, Water and Rural Development, Department of Water Affairs. 1991. *Perspective on Water Affairs.*

Ministry of Agriculture, Water and Rural Development, Department of Water Affairs. 1993. *A Digest of the Water Supply and Sanitation Sector Policy of the Government of Namibia.*

Ministry of Agriculture, Water and Rural Development, Department of Water Affairs. 1993. *Central Area Water Master Plan. Phase I.* GTZ.

NIGER

FAO. 1993. *Schéma directeur de mise en valeur et de gestion des ressources en eau.* Rapport de projet NER/92/007.

SOGREAH/BRGM. 1981. *Etude du plan de développement de l'utilisation des ressources en eau du Niger.*

NIGERIA

JICA [Japan International Cooperation Agency]. 1993. *The study on the national water resources master plan.* Federal Ministry of Agriculture, Water Resources and Rural Development.

Mott MacDonald International. 1992. *Sub-saharan Africa Hydrological Assessment.* Country Report: Nigeria (with BCEOM and SOGREAH).

SAO TOME AND PRINCIPE

World Bank. 1993. *Democratic Republic of São Tome and Principe. Country economic memorandum and key elements of an environmental strategy.* Report 10383 - STP. World Bank, Washington DC.

SENEGAL

Ministère de l'Economie, des Finances et du Plan. 1990. *Plan directeur de développement de la Rive Gauche du Sénégal.*

PNUD. 1994. *Bilan diagnostic des ressources en eau du Sénégal.*

SOMALIA

FAO. 1989. *A Brief Description of Major Drainage Basins Affecting Somalia.* Prepared by D. Kammer. National Water Centre, Mogadishu. Project Field Document No. 14. SOM/85/008.

SOUTH AFRICA

Department of Water Affairs. 1986. *Management of the water resources of the Republic of South Africa.*

FAO. 1992. *South Africa, Agricultural sector mission.* Working Papers. Document No. 123/92/CP-RSA 1 SR/WPs.

Water Research Commission. 1991. *Researching and applying measures to conserve natural irrigation resources.*

SWAZILAND

FAO. 1994. *Present land use map of Swaziland, scale 1:250 000.* Field document of UNDP/FAO project SWA/89/001.

FAO. 1994. *Water resources and irrigation.* Project SWA/89/001.

Water and Sewerage Board. 1992. *Annual report 1990-91.*

World Bank. 1987. *Swaziland agricultural sector update.*

World Bank/UNDP. 1990. *Sub Saharan Africa Hydrological assessment.* Country Report: Swaziland.

TANZANIA

FAO. 1993. *National Action Programme for the United Republic of Tanzania.* FAO/IAP-WASAD. FAO, Rome.

TOGO

GERSAR/IGIP/SOTED. 1985. *Schéma directeur d'aménagement des eaux du Togo.*

Laboratoire Central d'Hydraulique de France. 1982. *Atlas des besoins et des ressources en eau. Stratégie d'aménagement des ressources en eaux du Togo.*

TUNISIA

Agrar, Coyne et Bellier, GKW, Ministère de l'agriculture. 1992. *Economie d'eau 2000.*

Direction générale du génie rural, Ministère de l'agriculture. 1994. *La gestion de l'eau en Tunisie.*

Direction générale des ressources en eau, Ministère de l'agriculture. 1991. *Commission de réflexion sur le développement des ressources en eau de surface.*

Hamza, M. & Khanfir, R. 1992. *Evolution du potentiel et de l'exploitation des ressources en eau souterraines.*

UGANDA

UNEP. 1988. *Strategic Resources Planning in Uganda, Volume IV: Water Resources.*

ZAMBIA

JICA [Japan International Cooperation Agency]. 1992. *Master Plan Study on Hydrology Observation Systems of Major River Basins in Zambia.* Final Report.

JICA. 1994. *The Study on the National Water Resources Master Plan in the Republic of Zambia.* Progress Report No. 2 prepared by Yachiyo Engineering Co. Ltd.

ZIMBABWE

FAO. 1993. *National Action Programme: Zimbabwe.* FAO/IAP-WASAD.