Irrigation in Africa

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Irrigation in Africa has not developed to the same extent as in Asia. The special features of Africa for developing and managing irrigation projects, the present status and future potential of both rainfed and irrigated agriculture in 50 African countries, and the main problems facing Africa in the area of irrigation are analysed.

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For climatic, demographic and a variety of other reasons, irrigation development in Africa has thus far been primarily concentrated in the northern and north-eastern part of the continent, so much so that only six countries in this region account for 70% of all irrigated land in Africa.[1] Irrigated agriculture has a minor place in the economies of the sub-Saharan countries with the exception of Sudan, Madagascar and Nigeria. Of the 2.64 million ha of modern irrigation developed in sub-Saharan Africa, Sudan alone accounts for nearly two-thirds of the total at 1.7 million ha. Similarly, out of 2.38 million ha of small-scale or traditional irrigation practised in the region, Madagascar and Nigeria (800 000 ha each) account for slightly over two-thirds of the area.

As to be expected, irrigated area as a percentage of a country's area under temporary and permanent crops varies tremendously from one African nation to another. For example, nearly all the cropped land in Egypt is irrigated, but in countries like Angola, Central African Republic, Gabon, Togo and Zambia less than 0.3% of cropped land was under irrigation in 1982. Table 1 shows the seven African countries where more than 10% of the total cropped areas are irrigated.

Present and future irrigation

Two major problems encountered when analysing the extent of present irrigation (both modern and traditional) and future potential developments stem from lack of adequate and reliable data and the general weakness of the statistical reporting systems in most African countries which affects accessibility, availability and reliability of whatever data may have been collected.[2] Furthermore, lack of standardization, differing practices, varying coverages and definitions and use of different statistical methods make the problem even more complex. Thus, the figures used herein are the best that are available at present, but they should be considered and interpreted with some caution, especially when inter-country comparisons need to be made.

On the basis of climatic analyses, 29% of the land area of the continent is under desert-like conditions (annual rainfall less than 100 mm), 17% is arid (100-400 mm/year), 8% semi-arid (400-800 mm/year), 10% dry sub-humid (800–1200 mm/year), 20% moist sub-humid (1200–1500 mm/year), and the balance of 16% of land area is humid (annual rainfall over 1500 mm). Generally speaking, the dry sub-humid zone (growing period of 120–179 days per year) and moist sub-humid zone (growing period 180–269 days) have adequate moisture availability

[1]FAO, *Prospects and Trends of Irrigation in Africa*, Document ARC/84/6 for 13th FAO Regional Conference for Africa, Harare, Zimbabwe, 16–25 July 1984, FAO, Rome, April 1984, p 10.
[2]The World Bank, *Financing Adjustment with Growth in Sub-Saharan Africa, 1986–1990*, The World Bank, Washington, DC, USA, April 1986, p 120.

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for rainfed production of staple food crops like millet, sorghum and maize. This is summarized in Table 2.[3] Overall, considering the total African land area, approximately 25% can be considered suitable for rainfed production and another 10% is marginally suitable. The remaining 65% of the land is unsuitable.[4]

The availability of surface water varies tremendously in Africa. In the region of the Sahara and the Horn of Africa, there is no surface water since there is no runoff. In the Sudano–Sahelian region, extending from Senegal to Somalia, the average runoff is up to 10% of rainfall, and it increases to more than 20% in the wet tropical highlands of Ethiopia.[5]

In terms of irrigation development and management in Africa, there are several facts worth noting.

1) Africa generally has less available surface water per unit area and higher evaporation than most other regions of the world. Consequently, it also has less runoff into the sea per unit area when compared to other parts of the world.

2) With the exception of the Zaire River, most African rivers show considerable seasonal variation in flow.[6] The variations are more pronounced if natural regulators – lakes or swamps – are absent or if rivers drain from savannah or semi-arid areas where intense short-term precipitation may occur.

3) Natural sediment loads in the African rivers are generally lower than in other parts of the world, except when flowing through younger geological formations. Accordingly, for a major reservoir like Lake Kariba which has more than 60% of the volume as dead storage, the originally-designed reservoir life of 1000 years has recently been increased to 1600 years. In parts of Africa, however, human activities like overgrazing and deforestation are increasing silt loads of the rivers. Thus, Ibohamane and Moulela Reservoirs on the River Niger have lost nearly half of their storage capacities during the past 15 years.

4) The distribution of surface water resources in Africa is very skewed. For example, the Congo River Basin, which at 4000 000 km^2

[3]FAO, *Crisis of Sustainability: Africa's Land Resource Base*, Document AGD/801/1 for Expert Consultation on the In-Depth Study of Agricultural and Food Problems in Africa, Rome, Italy, 16–19 December 1985, FAO, Rome, November 1985, p 119.
[4]FAO, *State of Irrigation – Facts and Figures*, Document AGL:IA/86/Doc. I-A for Consultation on Irrigation in Africa, Lomé, Togo, 21–25 April 1986, FAO, Rome, March 1986, p 20.
[5]*Ibid.*
[6]FAO, *op cit*, Ref 1; FAO, *op cit*, Ref 4.

Table 1. The importance of irrigation in seven leading African countries, 1982.

	Irrigated area as % of area under temporary and permanent crops
Egypt	98.6
Madagascar	32.0
Swaziland	21.7
Sudan	14.1
Mauritius	13.1
Mauretania	12.0
Gambia	11.9

Table 2. Climatic characteristics and land use.

Climate zone	Length of growing period (days)	Approximate rainfall (mm/yr)	Moisture availability	Area (ha × 10^6)	% of total area	Main land use
Desert	0	<100	Deficit	822	29	Hunters, gatherers, nomadic pastoralists on opportunistic basis (camels and goats but no cattle).
Arid	1–74	100–400	Deficit	488	17	Extensive grazing of sheep, goats and camels, overgrazing causing desertification.
Semi-arid	75–119	400–600	Deficit	233	8	Nomadic pastoralists and cultivators meet in this zone; driest area where rainfed agriculture attempted, with millet and sorghum as main crops.
Sub-humid	120–179	600–<1200	Adequate	314	11	Arable crop production, main crops millet, sorghum, maize and groundnut; used by nomadic pastoralists in dry seasons and drought years. Fuelwood deficit or acute scarcity.
Moist sub-humid	180–270	1200–<1500	Adequate	584	20	Transition zone for agriculture – too wet for seasonal arable crops, too dry for tree and shrub crops; main crops cassava and maize. Severe tsetse infestations.
Humid	>270	>1500	Excess	409	15	Tree crops like oil palm, rubber, cacao; shifting cultivation with few livestock.

Source: FAO, *Crisis of Sustainability: Africa's Land Resource Base*, see text, *op cit*, Ref 3.

covers nearly 16% of the area of the sub-Saharan Africa, has a mean annual discharge of 1325 km^3 which accounts for 55% of the mean annual discharge for that region. An additional seven rivers (Niger – mean annual discharge 179.8 km^3, Ogooue – 148.9 km^3, Zambezi – 103.4 km^3, Nile – 84 km^3, Sanga – 65.2 km^3, Chari-Lagone – 43.2 km^3 and Volta – 39.8 km^3) contribute a further 25%.

5) Flat terrains in the western part of the continent mean a limited availability of good dam sites. Many of the dams built in recent years have some of the highest ratios of area inundated to area irrigated in the world. Such topography also means long offtake canals may be necessary, unless pumping proves to be a more economic alternative to supply irrigation water.

6) With the exception of Sudan, irrigable soils are generally found in small areas dispersed over the entire region.

7) The occurrence of intense storms of short duration require high design capacities for not only spillways but also for surface drainage systems, thus increasing both costs and design and operating complexities.

8) Groundwater accounts for some 20% of the total water resources of Africa, but only about 10% of the land lies over high-yielding aquifers. The occurrence of groundwater is localized because of climatic and geologic conditions. Unlike Asia, fewer areas have extensive, shallow groundwater which are comparatively more economic as well as complex and quicker to develop.

9) The average annual water requirements of main food crops vary from 3000 m^3/ha for the countries of humid Central Africa to 16 000 m^3/ha in North Africa.

On the basis of information available at present, FAO has estimated the potentially irrigable areas in various African countries.[7] This is shown in Table 3. It should be noted, however, that these are estimates based on currently-available limited data which may not be reliable. Furthermore, countries often have somewhat imprecise definitions of what actually constitutes irrigation, and the extent of irrigated areas may vary from one year to another, especially for small-scale and traditional forms of irrigation which primarily depend directly on water available, and thus on climate. Overall, however, Table 3 can be used to obtain a general picture of African irrigation at present.

The rainfed land for each country in 1982 was equivalent to the arable land minus the estimated land area used for modern and traditional irrigation. Estimates of the areas of potential rainfed land are provisional and based on agroecological studies. Provisional estimates of irrigable lands assumed that 50% of the normal excess of precipitation over evaporation would be available for irrigation, and that irrigation efficiency is 50%. In other words, the effective water supply is one-quarter of the total excess.[8] Furthermore, only water derived from rain falling within each national boundary was considered.

On the basis of Table 3, it may be said that some 9010 000 ha of land was being irrigated in Africa in 1982.[9] This estimate includes all types of irrigation – large scale, small scale and various traditional forms of irrigation practised in different African countries. In contrast, total potential land that can be irrigated under the present social, economic and institutional conditions is of the order of some 44.75 million hectares. Thus it can be inferred that approximately 20% of potentially irrigable area was irrigated in 1982.

[7]FAO, *Need and Justification of Irrigation Development*, Document AGL:IA/8D/Doc. I-D for Consultation on Irrigation Development, Lomé, Togo, 21-25 April 1986, FAO, Rome, March 1986, p 26.
[8]*Ibid.*
[9]*Ibid.*

Table 3. Irrigated and rainfed areas for 50 African countries.

Country	Total area (ha × 10[6])	Population in mid-1983 (× 10[6])[a]	Rainfed area (ha × 10[6])[b] 1982	Rainfed area Potential	Irrigated area (ha × 10[6])[b] 1982	Irrigated area Potential
Algeria	238.2	20.6	6.53	7.51	0.35	0.13
Angola	124.7	8.2	2.94	77.31	0.01	7.94
Benin	11.3	3.8	1.34	6.35	0.02	0.09
Botswana	60.0	0.89	1.35	1.68	0.01	0.10
Burkina Faso	27.4	6.5	2.59	10.71	0.03	0.72
Burundi	2.8	4.5	1.09	0.99	0.01	0.05
Cameroon	47.5	9.6	5.89	31.54	0.02	0.37
Cape Verde	0.4	–	0.04	0.04	0.002	–
Central African Republic	62.3	2.5	1.88	35.83	–	1.95
Chad	128.4	4.8	3.10	17.04	0.05	1.42
Comoros	0.2	0.39	0.02	0.10	–	–
Congo	34.2	1.8	0.65	21.65	0.01	0.36
Egypt	100.1	45.2	–	1.04	2.47	–
Equatorial Guinea	2.8	0.39	0.13	1.85	–	0.10
Ethiopia	122.2	40.9	13.14	24.94	0.11	1.91
Gabon	26.2	1.11	0.28	12.88	–	0.44
Gambia	1.1	0.66	0.13	0.53	0.03	0.07
Ghana	23.9	12.8	1.04	10.96	0.06	012
Guinea	24.6	5.8	1.32	7.51	0.18	0.15
Guinea-Bissau	3.6	0.62	0.26	2.03	–	0.07
Ivory Coast	32.2	9.5	2.73	14.09	0.06	0.13
Kenya	58.3	18.9	1.85	6.72	0.05	0.61
Lesotho	3.0	1.5	0.23	0.34	–	0.02
Liberia	11.1	2.1	0.11	5.24	0.02	–
Libya	176.0	3.4	1.53	2.00	0.21	0.10
Madagascar	58.7	9.5	1.55	32.77	0.96	1.47
Malawi	11.8	6.6	2.29	4.12	0.02	0.29
Mali	124.0	7.2	1.91	16.79	0.15	1.49
Mauritania	103.1	1.6	0.18	1.40	0.02	0.04
Mauritius	0.2	1.03	0.09	0.10	0.01	–
Morocco	44.7	20.8	7.43	7.41	0.50	0.12
Mozambique	80.2	13.1	2.78	41.43	0.07	3.63
Namibia	82.3	1.11	0.65	0.51	0.01	0.05
Niger	126.7	6.1	3.63	11.76	0.02	0.10
Nigeria	92.4	93.6	27.06	47.90	0.84	3.73
Reunion	0.3	0.56	–	0.12	–	–
Rwanda	2.6	5.7	0.74	0.90	0.01	0.04
Sao Tome and Principe	1.0	0.09	–	0.06	–	–
Senegal	19.6	6.2	5.03	9.72	0.19	0.58
Sierra Leone	7.2	3.6	1.52	2.76	0.10	0.10
Somalia	63.8	5.1	1.02	1.74	0.08	0.09
Sudan	250.6	20.8	10.69	56.22	1.70	4.44
Swaziland	1.7	0.61	0.07	0.86	0.06	0.01
Tanzania	94.5	20.8	4.00	36.60	0.41	2.74
Togo	5.7	2.8	1.35	2.14	0.01	0.09
Tunisia	16.4	6.9	3.31	4.50	0.18	0.17
Uganda	23.6	13.9	4.17	10.75	0.01	0.48
Zaire	234.5	29.7	5.81	177.66	0.04	4.00
Zambia	75.3	6.3	5.13	51.08	0.02	3.93
Zimbabwe	39.1	7.9	2.55	15.91	0.15	0.41
Total	2851.6		143.18	836.09	9.01	44.75

Sources: [a]Data mostly from World Bank, *World Development Report 1985*, Oxford University Press, New York, USA, p 243.
[b]Data from FAO, see text, *op cit*, Ref 7.

The extent of irrigated area, as may be expected, varies significantly from one country to another. If the country with the maximum irrigation in Africa, Egypt, is considered, currently 2.47 million ha of land is under irrigation, and this constitutes nearly 28% of the total land under irrigation in Africa. At present, very limited potential exists in Egypt to expand irrigation into new areas economically. In contrast, the percentages of potentially irrigable lands that are under irrigation at present in many countries are quite low. The figures for a few select countries which have significant irrigation potential are as follows: Angola – 0.2%, Ethiopia – 6%, Mozambique – 2%, Nigeria – 23%, Tanzania – 5%, Zambia – 0.05% and Zimbabwe – 37%.

Need for irrigation

While much of Africa does not have adequate rainfall for crop production, significant areas can cultivate a wide range of crops, even though the average rainfall may not be adequate to grow the crops desired. For example, in a country like Kenya it is estimated that 750 mm or more of rainfall is necessary for crop production, but only less than 15% of the country receives this amount. Similarly some 19.8 million ha of Zimbabwe lies within a belt of low rainfall (450-800 mm) which is marginal or unsuitable for intensive crop production without irrigation, though it is suitable for semi-intensive livestock production and growing of drought-resistant crops.

Even in those areas where annual average rainfall may be adequate for agricultural development, the problem is further complicated by the wide variations in rainfall, both within the growing seasons and from one year to another. Thus, generally speaking, average annual rainfall may not be a good indicator of the production potential of the land, even assuming that soil quality is good and climate is hospitable. Thus, as far as farmers are concerned, unpredictability of rainfall and incidence of mid-season droughts are two of the most critical issues they have to face when adequate water control is not available.

The problem of unpredictability of rainfall is further compounded by the low water holding capacity of many of the soils of the various African countries. The high temperatures prevalent in the region also tend to deplete soil moisture quickly through evapotranspiration. Under this set of physical conditions, water stress is the most critical factor facing agricultural production.

In the absence of good water control, the vulnerability of agriculture to unreliable rainfall patterns and also to mid-season droughts, can be readily illustrated by considering the case of Zimbabwe. In 1980–81, when the rainfall distribution was good, Zimbabwe produced a record annual harvest of 2 million tons of maize. The following year with the onset of drought, maize production dwindled to 1.4 million tons, and it was reduced even further to only 600 000 by 1982–83.

Lack of irrigation intensifies the impact of drought both in terms of reduction of crop yields and area planted. In order to reduce perceived risks, farmers often change to types of crops that are seen to be less risky and comparatively more drought resistant, such as cotton, tobacco, sorghum, millets and soya beans. In view of these uncertainties, farmers are often further reluctant to invest in inputs like fertilizers, pesticides and improved seeds, since they are not confident of getting an adequate return on their investments. This creates a vicious circle which further reduces potential agricultural production.

The impacts of droughts, mid-season droughts and low rainfalls on agricultural production can be reduced significantly by the introduction of irrigation. Agricultural production can thus be stabilized at a relatively high level, which reduces the trauma associated with boom–bust production cycles.

Further extension of irrigation in Africa can contribute many benefits, among which are the following:

- The present staple food production (cereals, roots and tubers) has increased at the rate of 1.4% per year during the past ten years, predominantly from rainfed agriculture. Unfortunately, this rate is less than half the rate of population increase at 3% per year. By increasing cropping intensity, realizing high yields and stabilizing production, irrigation can substantially increase agricultural production from the present dryland farming.

- Food security in many countries and also in the presently marginal rainfed areas can be substantially enhanced due to higher agricultural production. This will improve the extent of food self-sufficiency of many nations.
- Farm incomes and employment opportunities in properly managed irrigated areas can be significantly higher when compared to the pre-irrigation periods. This in turn will contribute to the improvement of socioeconomic conditions, including nutrition of the people in the irrigated areas. Furthermore, if employment can be successfully created in rural areas, urban migration can be reduced.
- Agricultural production can preserve or earn additional foreign exchange through export of cash crops and by import substitution.
- Higher farm incomes, and the need for agricultural and irrigation machineries can contribute to the establishment of new forms of industry in the countries concerned.
- Large-scale irrigation requires the construction of dams, which can then be used to generate electricity. Since hydropower generation is a non-consumptive use of water, and irrigation is a consumptive use, the two are mutually compatible. This means that both irrigation and energy production can be successfully obtained from the same water development project.
- Irrigation projects can also be designed to provide domestic water supply for both rural and urban areas.
- Irrigation can be used as the engine for growth and to foster further integrated rural development.
- Irrigation schemes, especially small-scale ones, can be specifically designed and located so as to ensure that the benefits accrue primarily to the rural poor. Thus, important and complex issues like income distribution and equity can be reached through irrigation development.

Under these conditions and with the present food crisis in many African countries, there has been a natural tendency to look at both large- and small-scale irrigation as an important solution to increase the productivity of existing dryland farming. It is not surprising to find that many countries, international institutions and bilateral donors are looking at irrigation (especially large-scale irrigation) as an important means to increase agricultural production in Africa, when given the facts that: considerable potential exists to increase irrigated agricultural land by both surface water and groundwater irrigation; irrigation has played a minor role thus far in national economies; neither soil nor water are limiting factors to expand agricultural production; and many Asian countries, especially India and China, have increased food production significantly through the introduction of large-scale irrigation. However, if irrigation development is to be expanded in Africa, cropping intensity must receive adequate attention. Cropping intensity at present is about 130% in north and north-east Africa but is only about 110% in other areas. This means that the irrigation land use systems have to be further intensified in order to make them more efficient than they are at present.

Economics of irrigation development

For a variety of reasons, experience with the economics of irrigation development in Africa has generally not been positive. Costs of irrigation development have been higher than most other regions. Interregional comparisons by the Secretariat of the World Food Conference, held in Rome in 1974, indicated that the projects in Africa cost 64% more than in the Far East, 55% more than in Latin America, but 3% less than in the Near East (see Table 4). On the basis of recent experiences, it is likely that the costs in Africa may have risen somewhat faster than in the Far East and Latin America.

As to be expected, irrigation development costs vary tremendously from one part of Africa to another and are not readily comparable. One reason for the variation in costs is the extent of infrastructure development costs (transportation networks, bridges, power supply, settlements, agricultural machineries, etc) incorporated within the project. Thus, if a region is relatively well developed, the total cost of developing rural and urban infrastructure may not be very high since many of the requirements may already exist. On the other hand, in an underdeveloped region, incorporation of massive infrastructural development costs within irrigation projects is likely to produce a high cost of irrigation development per unit area. The extent of social services that are provided to the irrigators and their families will also influence irrigation costs.

Other important factors that may influence irrigation development costs are degree of water control necessary, remoteness of the site, types of structures that need to be constructed, source and availability of materials including construction machineries, government policies (inflated exchange rates, import duties and fuel costs) and availability of skilled and unskilled labour and technical services.

An idea of the variations of investment costs for different types of irrigation development in various parts of Africa can be best obtained by reviewing some recently completed projects. Table 5 shows such an intercomparison of irrigation development costs for 11 different projects from eight African countries constructed since the early 1970s.[10] It should be noted that the total cost figures are based on actual expenditures incurred during the various years of construction of the projects. In addition, inflation rates during the mid- and late 1970s were very high, and accordingly costs of those projects completed in the mid-1970s are quite low compared to present day development costs.

The range of irrigation projects listed in Table 5 is quite broad. It ranges from low cost rehabilitation schemes like the Drainage I scheme in Egypt where development costs were \$500/ha and \$364/family, to full water control at Morondava in Madagascar with costs of \$14 835/ha and \$11 928/family. High though the figure of \$14 835/ha may be, it is no longer uncommon to find irrigation development costs in Africa in the range of \$15 000–\$20 000/ha if all infrastructural development costs and technical and production support services costs are included. Thus, for the Bura Project in Kenya, the development cost has been around \$20 000/ha, 60% of which was non-productive infrastructure (\$12 000). Similarly for the Tshovane Project in Zimbabwe, the development cost was \$10 800/ha. However, when items like costs for settlement, agricultural buildings and machinery and road networks are omitted, the cost of irrigation development part only was \$750/ha. If official rates

[10]FAO, *Irrigation in Africa South of the Sahara*, Investment Centre Technical Paper 5, FAO, Rome, 1986, p 175; also FAO, *Economics of Irrigation Development*, Document AGL:IA/86/Doc. I-C for Consultation on Irrigation Development in Africa, Lomé, Togo, 21–25 April 1986, FAO, Rome, February 1986, p 21.

Table 4. Interregional comparison of irrigation development and rehabilitation costs, 1974.

Region	Costs of new irrigation development (\$/ha)	Costs of rehabilitation of existing projects (\$/ha)
Africa	2 400	500
Far East	1 466	418
Near East	2 467	560
Latin America	1 500	420

Table 5. Costs of selected irrigation projects in Africa.

Country/Project	Project type	Construction period	Development cost ($) Per hectare	Per family
Cameroon				
SEMRY I	Full control and dykes	1972–75	2 277	3 234
SEMRY II	Full control and dam	1978–85	9 778	9 128
Egypt				
Drainage I	Drainage	1970–80	500	764
Madagascar				
Lake Alaotra	Full control	1970–75	894	3 193
Morondava	Full control and dam	1973–81	14 835	11 928
Mali				
Mopti Rice	Partial control	1972–75	503	1 682
Morocco				
Doukkala I	Sprinklers, buried pipes	1976–80	5 374	5 443
Senegal				
River Polders	Full control	1973–78	4 172	7 485
Sudan				
Rahad	Full control, no dam	1975–82	3 138	2 826
Tunisia				
Medjerda	Rehabilitation	1975–82	909	10 100
Nebhaha	Rehabilitation	1975–82	858	2 145

of exchange are used, some projects in Ghana have cost as much as $40 000–$50 000/ha.

Even if it is assumed that the per hectare cost of irrigation development is $10 000, and the agricultural production system is reasonably efficient, a ton of irrigated rice will cost no less than $600 to produce. In contrast, the cost of importing high quality rice in coastal states of Africa was around $400–450 in 1980. If broken rice – the type generally imported by major rice-consuming countries like Gambia and Mauritania – is considered, the cost is lower by a further 40–50%. Furthermore, the cost of both rice and ocean freight rates have fallen

Table 6. Expected and actual performances of selected irrigation projects at project completion.

Item	SEMRY I	SEMRY II	Lake Alaotra	Morondava	Mopti	Rahad
Area Developed (ha)						
Expected	4 300	7 000	10 000	9 300	31 100	126 000
Actual	4 075	7 000	10 000	3 800	26 000	126 000
Cropping Intensity (%)						
Expected	134	158	150	160	–	85
Actual	173	180	100	90	–	83
Rice Yields (kg/ha)						
Expected	3 000	4 000/4 700[a]	3 350	4 000	1 860	–[b]
Actual	4 500	4 500/5 500	3 000	2 600	926	–
Incremental production of rice (tons)						
Expected	15 960	47 000	25 900	32 500	35 000	–
Actual	31 835	53 000	24 500	15 800	29 400	–
Costs ($ million)						
Expected	7.40	55.50	8.20	27.00	9.42	124.3
Actual	9.26	68.80	8.96	56.00	13.13	395.6
Implementation period (years)						
Expected	4.0	6.0	5.5	5.0	6.0	6.0
Actual	4.0	8.0	4.5	8.5	8.0	7.5

Notes: [a]Dry season/wet season.
[b]Expected yields – 2020 kg/ha for cotton and 2150 kg/ha for groundnut. Actual yields – 2278 kg/ha for cotton and 1780 kg/ha for sorghum.

significantly since 1980. The export prices of Thai white rice in April 1986 was $215/ton (in 1981–82 it was $390/ton), and broken rice $115/ton.[11] At these prices, it is not possible to grow rice in irrigated areas costing $10 000/ha to develop, which will have a competitive advantage over the current international export prices.

Expressed in a different fashion, if it is assumed that the market price of rice is $222/ton, milled rice yield is 68% and economic rate of return (ERR) is 12%, 10.1 tons/ha of rice yield is necessary for any scheme to be economic. At a lower ERR of 7%, the yield required is still a high 8.4 tons/ha. These yields are not generally achievable at present. Furthermore, these calculations only consider investment costs; operations and maintenance costs of the irrigation system are neglected.

An important implication of the high costs of irrigation development is their overall economic justification. For staple food crops like maize and paddy, investment costs higher than $4500/ha generally mean that economic returns from agricultural production are not adequate to justify the costs incurred. If the investment costs are higher than $6000/ha, none of the cereal crops are likely to generate profit at the best levels of production efficiency found in Africa. High investment costs can only be economically justified with high value cropping patterns consistent with high levels of agricultural production. While in a few instances like the Mwea Scheme in Kenya (5692 ha of irrigated land which was developed in 1954 using Mau Mau detainee labour), the rice yields have been more than 5 tons/ha, the actual yields have not been as high as expected – in fact in many cases they have stagnated or even fallen during the past decade. The expected and actual rice yields for some selected projects are shown in Table 6.[12]

For irrigation projects with high development costs, it is necessary to either obtain very high levels of efficiency which have not been achieved thus far, add to the cropping pattern higher value crops, or to provide subsidies. Because of this situation, there is already some pressure to change the cropping pattern in many projects by replacing ordinary crops with cash crops. Low cost recovery is a major problem in irrigation projects in Africa. Even for the relatively successful Mwea Scheme, the National Irrigation Board (NIB), which administers it, made a loss of K£ 262 391 in 1979–80 and K£ 429 063 in 1980–81. NIB's income from the water rates, cultivation charges and other sources covered only about half of its expenditure for the scheme during those years.[13]

The Evaluation Service of Fond d'Aide et Cooperation indicate a dismal picture for various irrigation projects in West Africa:

> The Mopti II Rice Project, which aimed to improve water control for traditional rice irrigation in Mali, raised the government contribution to the cost of producing a ton of paddy by 20% and the foreign exchange cost by 25%. Value added fell by 4% and farmer gross returns by 13% compared with the without-project situation. Furthermore, the project completely failed in its main objective, which was to generate a marketable surplus of rice to supply government institutions.
>
> In Senegal in 1983 it was calculated that the government was spending the equivalent of about US $12.1 million to produce 54 000 t rice ($ 225/t). Plans to increase output to 150 000 t in 1990 would lower the unit cost $ 195/t, but raise the total cost to $29 million. Meanwhile in 1983, for each kg of paddy purchased from tenants at $0.16, the government was paying a subsidy equivalent to $0.06 for production on village schemes or $0.10 for major schemes.
>
> In 1983 SODESUCRE in Ivory Coast was producing irrigated sugar at

[11]FAO, *Food Outlook*, No 4, May 1986, FAO, Rome, p 34.
[12]FAO, *Irrigation in Africa South of the Sahara*, *op cit*, Ref 10.
[13]Republic of Kenya, *Report of the Inter-Ministerial Committee Appointed by the Permanent Secretary of the Ministry of Agriculture to Study National Irrigation Board Service Charges and Related Issues*, Ministry of Agriculture, Nairobi, Kenya, July 1983, pp 69–107.

$1.07/kg. Despite a period of much lower world sugar prices, the local market could support a price up to $0.34/kg. However, even this would only allow SODESUCRE to meet its operating costs and offered the company no prospect of ever repaying the loans.[14]

Faced with this type of situation, the government responses have been to waive cost recovery, subsidize part of operating and maintenance expenses of irrigation systems, and/or subsidize producer inputs and services. Pressure to continue these policies are likely to increase in the future if the debts incurred for irrigation infrastructural developments are expected to be serviced from project incomes.

One noteworthy exception to the above state of affairs has been Zimbabwe. The Zimbabwean government has generally undertaken to build and operate the storage facilities and infrastructures necessary: downstream developments like construction of irrigation networks and land development works have been left to the private sector. This combined effort of irrigation development between public institutions and the private sector has worked quite well, certainly significantly better than in most African countries where the records of the government-sponsored authorities to develop and manage irrigation works have been generally disappointing.

For irrigation in commercial settler farms and commercial farm units in Zimbabwe (together they account for 90 500 ha of irrigated land or 69.6% of total irrigation in the country), beneficiaries have to reimburse the government all capital costs as well as operating and maintenance costs over a 40-year period, at a fixed interest rate which was prevalent when the project was completed. Accordingly, the country has a wide range of water charges that vary from Z$ 2.5/1000 m^3 for old projects to over Z$ 25/1000m^3 for new schemes because of inflation and higher interest rates, which have risen from 3.5% in 1947 to 9.5% in 1981.

Small-scale irrigation development

Much has been written recently on small-scale irrigation development in Africa. There is no doubt that considerable potential exists for small-scale developments where easily obtainable water – rainfall, runoff, natural storage in dry season – can be used. Under appropriate site conditions, small-scale irrigation has some special attractions. They do not require major investments in physical infrastructures, and foreign exchange requirements – if any – are low. Such schemes can be developed at relatively low costs and thus can be cost-effective for a wide variety of crops including basic staples. Farm level investments are also lower when compared to large-scale irrigation projects. Since small-scale projects are less complex and simpler to construct, less time is required for planning and construction and hence they contribute to the national food production effort quite quickly.

For small-scale irrigation projects, the cost per hectare of development is likely to be less than similar costs for large-scale development. Rigorous cost analyses for small-scale irrigation projects in Africa are few and far between. Generally the beneficiaries provide some labour and/or resources for the construction of the projects and they also play a more important role in their operation and maintenance. This means that the government costs are reduced, and the costs that are currently quoted are only the financial costs to the government – the contributions of beneficiaries are generally not accounted for.

[14]Fond d'Aide et Cooperation, quoted in FAO, *Irrigation in Africa South of the Sahara*, *op cit*, Ref 10, pp 34–35.

Even taking into account the above facts, government costs for small-scale irrigation projects are generally much less than for large-scale developments, although they naturally vary depending on the complexity of schemes, terrain conditions, etc. The use of runoff water, bottomland development or lifting of water from shallow wells by hand or animal power for irrigation purposes cost under $1250/ha. If it is necessary to construct river diversion structures with gravity flows, development costs per ha range from $2500 to $3750. Current FAO estimates of irrigation cost in Francophone West Africa for low-pressure sprinkler systems suitable for small farmers is of the order of $3200/ha, but high-pressure systems for large estates are likely to cost $4400/ha or more.

Development costs of small-scale irrigation in Zimbabwe have not been cheap due to their remoteness, long haulage distances for construction networks and the density of field networks. Recent costings by the Ministry of Agriculture for 80 ha schemes for the National Small-Scale Irrigation Fund have ranged from Z$ 3000 to Z$ 5500 per hectare. However, costs for some individual projects have been estimated at as much as Z$ 12 000/ha.[15] For groundwater irrigation with boreholes and pumping, costs of small-scale village schemes (tens of ha) in Francophone West Africa have been estimated at $12 000–$15 000/ha. When the additional high costs of pump operation and maintenance are added, unit costs of development of these types of schemes appear to be substantially higher than for most large-scale surface irrigation costs.

Although small-scale irrigation schemes have many advantages, they also tend to suffer from certain disadvantages like diseconomies of scale, poor efficiency and quality control and lack of appropriate governmental interest and supervision due to their decentralized nature and small size.

Constraints to irrigation development in Africa

There are many constraints to irrigation development in Africa. The main ones will be discussed below.

Cost

As discussed earlier, costs of irrigation development in Africa have been quite high in recent years when compared to other major irrigating countries. When compared to India, unit costs in Africa are much higher because of: lack of infrastructure, local manufacturers, local sales and servicing agents; shortage of trained manpower of all types; severe climate; overvalued exchange rates; high import taxes and also other taxes like the 15% wage tax as in Mali; lack of control on foreign consulting and contracting parties; lack of standardization of designs and equipments; and absence of effective institutions. Table 7 shows the intercomparison of some basic unit costs between India and selected African countries.[16]

Technical complexities

Irrigation developments face some technical difficulties in Africa. Low flows in many rivers could be only a few cubic metres a second, but flood flows could be 10 000–15 000 times greater. Total annual flow in a wet year could be ten times that of a dry year and occurrence of intense

[15] Asit K. Biswas, *Irrigation in Zimbabwe*, Report to the Joint ECA/FAO Division on Agriculture, Addis Ababa, Ethiopia, February 1986, p 28.
[16] FAO, *Economics of Irrigation Development*, *op cit*, Ref 10.

Table 7. Comparison of unit costs for irrigation development between India and selected African countries.

Item	Cost ($/unit) India	Burkina Faso	Cameroon	Malawi	Mauritania	Niger
Cement (ton)	80	120	105	115	200	140
Diesel (litre)	0.32	0.55	0.36	0.60	0.45	0.45
Steel (ton)	560	760	850	1000	2300	760
Unskilled labour (per day)	1.35	2.20	8.00	0.43	2.50	2.20
Civil engineer, 5–10 years' experience (per year)	2 700	10 000	12 500	4 600	10 000	10 000

storms of short durations mean larger spillway capacities and drainage facilities. These issues make design and management problems more complex than in temperate regions where river flows and rainfall patterns tend to be more uniform.[17] Continual extraction of base flows could create salinity intrusion problems as has been noted in the Senegal and the Gambia rivers.

Lack of hydrological and soil data in many areas has made irrigation development technically a more difficult process. A typical example is the Limpopo Project in Mozambique whose planned potential has never been reached due to poor soil conditions in part of the project area which were undetected in the planning stage. Under these circumstances, foreign consultants – who are generally not very familiar with the project areas and often concerned with their own reputation – have opted for a more conservative design than necessary, which has in turn increased project costs.

Poor operation and maintenance

Proper operation and maintenance (O & M) of irrigation and drainage works has been a continual problem in nearly all countries of Africa. Consequently, priority is being given to rehabilitation of existing projects at present. On the basis of present experiences, it appears that annual O & M costs vary from 0.5–2.0% of the construction costs depending on type of irrigation systems and their locations.

Poor O & M stems from many factors, not the least of which are inappropriate budget allocation and its unglamorous image among engineers – since O & M assignments are seldom considered desirable, they are often staffed by inexperienced or poorly-qualified staff. Low cost recovery and failure to earmark revenues earned from the schemes for O & M further aggravates the situation. An example from Kenya will illustrate this point.

Of the six schemes operated by the National Irrigation Board of Kenya (NIB), incomes from five schemes were totally insufficient to pay for their O & M costs for 1982–83, the latest year for which all figures are available (see Table 8). However, NIB's income from the most successful Mwea Scheme now exceeds expenditure after some financial restructuring. This has partly been made possible by NIB's reduction of expenditure on repairs and maintenance to below the level necessary for long-term operational efficiency. All the surplus of the Mwea Scheme is being diverted to support NIB's other loss-making schemes. As a result, in 1983, only 39 of the Mwea's 60 tractors, one of three cars and 39 of 72 motorcycles were serviceable. Thus, the 1983 Report of the Inter-Ministerial Committee appointed to review NIB found that 'canal maintenance has been reduced significantly and weed growth and silting

[17]Asit K. Biswas, *Climate and Development*, Tycooly, Oxford, UK, 1984.

Table 8. Income as percentage of expenditure for six schemes of NIB, Kenya (1982–83).

Scheme	Income (% of expenditure)
Mwea	179
Ahero	41
West Kano	32
Bunyala	71
Perkerra	13
Hola	19

is beginning to inhibit the flow of water'. Furthermore, 'production will certainly fall in the near future if the present policies are continued'.[18]

Deferral of O & M activities to future years is not an economic proposition since it not only reduces the efficiency of irrigation systems but it also raises the final cost of rehabilitation to significantly higher value than the cumulative annual O & M costs had these been properly carried out. Experience from Mali indicates that after ten years of neglect, the rehabilitation cost is roughly equivalent to ten times the combined appropriate annual O & M costs.

Poor planning and management

Poor planning and management is inexorably linked with many of the constraints discussed in this section such as inadequate O & M or lack of trained manpower. Poor planning and management is primarily responsible for the Club du Sahel and CLISS conclusion that 'the area under modern irrigation in the Sahel has doubled during the period 1960 to 1979, but generally speaking, during the past few years, the development of new areas has barely surpassed the surface [area] of older ones which had to be abandoned'.[19]

Lack of technical expertise

Availability of all types of technical expertise in planning, implementing and operating irrigated agricultural systems is a major constraint for development and management of irrigated agriculture. While traditional irrigation based on simple technology has long been practised in suitable locations and in sub-Saharan Africa, the introduction of large-scale formal irrigation for commercial crop production – requiring extensive physical and social infrastructures, efficient management and marketing, experienced farmers, and the use of modern technology and regular supplies of inputs – is of comparatively recent origin. These two types of irrigation have relatively very few issues in common.

On a long-term basis, training is probably the most important requirement for successful development and management of large-scale irrigation in Africa. The lack of trained and experienced irrigation engineers has tended to increase the cost of irrigation projects. Once irrigation is introduced, lack of trained water management personnel and the absence of farmers experienced in irrigated agriculture reduces the benefits expected from the schemes. In addition, lack of technicians and similar other personnel of lesser levels of expertise, who are essential for irrigated agriculture, is creating another serious bottleneck.

Expatriate staff have been a mixed blessing to African countries. On the positive side they have contributed considerably to the planning, construction and operation of irrigated agriculture as in the SEMRY projects in Cameroon. Projects in the Gambia and the Burkina Faso, largely developed and operated by expatriate Chinese personnel, have produced 10 tons of paddy per hectare per year. In most cases, however, training of African personnel who were supposed to have taken over from their expatriate counterparts has not been satisfactory. In many instances such training and manpower development has not taken place at all: in the 1250 hectare Kou Project in Burkina Faso, where there were 60 expatriates at one time, not even a single African staff received any training in five years. Consequently, when the expatriate staff leave, project performances start to decline rapidly. Furthermore, the cost of expatriate staff is high: they accounted for 20% of the total costs of the

[18]Republic of Kenya, *op cit*, Ref 13.
[19]Club du Sahel and Permanent Interstate Committee for Drought Control in the Sahel (CLISS), *The Development of Irrigated Agriculture in the Sahel*, Club du Sahel, Ouagadougou, 1980, p 33.

SEMRY (Société pour le Développement des Plantations de Canne à Sucre, l'Industrialisation et la Commercialisation du Sucre) projects over the five year construction period.[20]

Another problem is the lack of trained extension workers required to ensure that benefits from irrigation projects accrue. A recent review of extension workers used in the Sahelian irrigation concluded that 'their theoretical training is sometimes barely credible to the farmers whom they are supposed to guide'.[21]

Inadequate research

There have been substantial funds available for agricultural research in Africa during the past two decades. Expenditure on agricultural research as a percentage of agricultural GDP in Africa is now substantially higher than Asia and most of Latin America as shown in Table 9.[22] The number of agricultural research scientists more than doubled during the decade 1970–80.[23]

In spite of this expenditure, 'agricultural research after political independence has been of limited scope, poorly organized, badly managed and lowly funded'[24] and 'most observers agree that the technology shelf (in agriculture) in sub-Saharan Africa is nearly bare'.[25] Reasons for such a poor state of research are many. Among the problems are the following:

- donors who pay for most of the agricultural research generally shape research policies, priorities and institutions with minimal national involvement;
- poor bilateral and multilateral donor coordination contributes to duplication of efforts, confusion due to conflicting advice, changing priorities and differing requirements;
- high cost and underuse of researchers (average cost $50 000/ scientist/year in sub-Saharan Africa compared to half this cost in Asia);
- isolation of researchers;
- lack of incentives, equipments, library and computing facilities, on-time fund availability and supporting personnel to conduct research effectively; and
- weak institutional research bases which have very little high level political or bureaucratic support.

[20]FAO, *Irrigation in Africa South of the Sahara*, *op cit*, Ref 10.
[21]Club du Sahel and CLISS, *op cit*, Ref 19.
[22]R.A. Evenson, 'The IARCs: evidence of impact on national research and extension of productivity', prepared for the Consultative Group for International Agricultural Research, Draft, 1985.
[23]The World Bank, *op cit*, Ref 2.
[24]FAO, *Crisis in Sustainability: Raising Productivity*, Document AGD/801/2 for Expert Consultations on the In-Depth Study of Agricultural and Food Problems in Africa, Rome, Italy, 16–19 December 1985, FAO, Rome, Italy, November 1985, p 68.
[25]The World Bank, *op cit*, Ref 2.

Table 9. Comparison of agricultural research efforts, 1980.

Region	Expenditure on agricultural research: As % of agricultural GDP	Expenditure on agricultural research: Per scientist man-year ($10³)	Agricultural scientist (man-year/$10 million agricultural GDP)
Africa			
West	1.19	83	1.42
East	0.81	46	1.76
Southern	1.23	50	2.47
Asia			
South	0.43	34	1.29
Southeast	0.52	25	2.07
Latin America			
Temperate South America	0.70	53	1.32
Tropical South America	0.78	56	1.77
Central America and Caribbean	0.63	62	1.20

Source: R.A. Evenson, see text, *op cit*, Ref 22.

Any attempt to make irrigated agriculture an overall success in Africa must include more effective research that considers the continent's tremendous heterogeneity in climate, soils, availability of other natural resources, levels of development, types of institutions and social and cultural norms.

International rivers, lakes and aquifers

Another constraint to irrigation development in Africa is the general lack of treaties or agreements for effective utilization of water bodies shared by two or more countries. Of the nine international water bodies shared by six or more countries, five are in Africa. The Niger runs through ten countries; Nile and Zaire, nine countries; Zambezi, eight countries; and Lake Chad is shared by six countries.[26] Nearly 60% of the surface area of Africa can be accounted for by shared river and lake basins. At least 80% of the total surface area of 20 African countries lies within international basins. These countries are Benin, Burkina Faso, Burundi, Central African Republic, Congo, Equatorial Guinea, Ethiopia, Gabon, Gambia, Guinea, Lesotho, Malawi, Nigeria, Rwanda, Sudan, Swaziland, Uganda, Zaire, Zambia and Zimbabwe.[27]

Few river and lake basins in Africa are contained entirely within one country. Intergovernmental commissions or planning agencies have been formulated for coordinated and integrated development of several basins – Gambia, Kagera, Lake Chad, Niger, Nile and Senegal – but progress in most cases has been rather slow. United Nations Environment Programme is now assisting Zambezi Basin countries to develop an action plan for development.

The problems associated with the management of international rivers in Africa are likely to become more complex and intense than ever before. For example, as Sudan requires more water for irrigation, it can come mainly from the Nile. However, this would be detrimental for Egypt which already uses all the water it can get. Similarly, construction of dams in Ethiopia may be essential to develop further land for irrigation in Somalia. With strained relations between Ethiopia and Somalia this may not be a feasible solution. Similarly, countries depending on hydroelectric power from the Kariba and the Volta dams have to agree among themselves to release adequate quantities of water to satisfy irrigation schedules. Thus far there is a considerable reluctance, especially at the Kariba, to release water according to irrigation demands at the cost of changing hydropower generation patterns.

Environmental and health issues

The environmental implications of irrigation development in Africa have been quite significant. Construction of reservoirs and canal systems for irrigation without adequate drainage has tended to increase the water table in Egypt and Sudan. These developments together with the tendency of farmers to over-irrigate are contributing to an increase in waterlogging and soil salinity. In Sudan, the combination of soil salinization and financial and institutional problems appears to have reduced the area being irrigated.[28] Soil salinization not only reduces agricultural yields but are also expensive to ameliorate.

The introduction of perennial irrigation has substantially increased incidence of diseases like schistosomiasis in Egypt, Ghana, Kenya, Nigeria, Sudan, Tanzania, Zambia and Zimbabwe.[29] Malaria is another

[26] Asit K. Biswas, 'Management of shared natural resources: problems and prospects', *Journal of the Indian Water Resources Society*, Vol 3, No 1, January 1983, pp 7–18.
[27] *Ibid.*
[28] FAO, *Irrigation in Africa South of the Sahara, op cit*, Ref 10.
[29] Asit K. Biswas, 'Environment and sustainable water development', Key-Note Address to IVth World Congress, International Water Resources Association, Buenos Aires, 1982, Published in *Water for Human Consumption: Man and His Environment*, Tycooly, Dublin 1982, pp 375–392.

serious disease that is causing increasingly more concern. A study of two villages in the Kano Plains of Kenya, one a newly established village within the 800-hectare Ahero rice irrigation scheme and another older village nearby in a non-irrigated area with traditional mixed agriculture, showed remarkable differences in terms of differing mosquito species. In the new village, 65% of mosquito bites were from the *Anopheles Gambiae* complex (principal vectors of malaria in tropical Africa), 28% were of *Mansonia* species (vectors of lymphatic filariasis and Rift Valley fever) and 5% were of *Culex quinquefasciatus* variety (another vector of lymphatic filariasis). In contrast, 99% of the mosquitoes in the older village belonged to *Mansonia* species and less than 1% were *Anopheles Gambiae*. Thus, irrigation can change the transmission patterns of mosquito-borne diseases. This is an especially important consideration for tropical Africa, where most of the global total of more than one million deaths due to malaria now occur.

Another major social problem that has been created by large-scale irrigation developments is the displacement of local inhabitants. Major displacements have occurred due to construction of the Aswan Dam (120 000 people), Kainji (42 000–50 000), Kariba (50 000–57 000), Kossou (75 000), and Volta (80 000–84 000). Inadequate planning, insufficient budgets, incomplete execution of plans, inordinate delays, corruption and little appreciation of sociocultural problems of the displaced persons contributed to the unsatisfactory resettlement processes in all the above mentioned projects.[30]

Monitoring and evaluation of irrigation projects

For all practical purposes, regular monitoring and evaluation of irrigation projects is unknown in Africa. For example, very little information is available on ex-post evaluation of African irrigation projects, especially after five to ten years of operation. Virtually all of the ex-post evaluations were carried out immediately after completion of the projects. At this early stage:

- projects were continuing to benefit from the intensive support and supervision extended by both national governments and external agencies;
- governments are under pressure, both internal and external, to show that the projects are performing well;
- governments' interest in the new projects is still high;
- management inefficiencies have not yet had an impact on the overall performance levels of the projects;
- cumulative impacts of inadequate operation and maintenance budgets have not reduced the early efficiencies of the projects;
- agricultural production support services have not declined commensurately with the declining government interest; and
- major changes in crop prices have not changed the cropping patterns for which the schemes were designed (changes in cropping pattern could significantly change overall water requirements).

In view of the above factors and the general lack of monitoring and evaluation of irrigation projects by both internal and external organizations after few years of operation, the expected benefits from large irrigation projects often do not occur. In the few instances they do occur, the time frame over which the benefits accrue becomes very different. Thus, a World Bank evaluation of the Lake Alaotra Project in

[30]Asit K. Biswas, 'Health, environment and water development: an understanding of the interrelationships', *The Environmental Professional*, Vol 7, 1985, pp 128–134.

Madagascar four years after completion indicated that the incremental annual production had declined considerably without any of the expected crop diversification or double cropping. Accordingly, it is clear that unless countries adopt monitoring and evaluation on an ongoing basis, as an integral part of the management process of the large irrigation schemes, many of the projected benefits will not occur.[31]

Concluding remarks

While a first glance at irrigation development shows it to be a tempting alternative to resolve Africa's present food crisis by providing better water control, in reality the issues are not so simple. Undoubtedly irrigation can significantly increase agricultural production, but many other conditions need to be satisfied before this can happen at reasonable investment costs. It would require the simultaneous availability and support from smoothly-functioning infrastructure in the areas of: agriculture (research, training and extension), economics (ready availability of inputs, credit, agro-industry, and marketing and transportation network) and social services (education and health). If irrigation projects are properly managed and if the above conditions are satisfied, irrigation can live up to its promised potential. It should also be noted that it will not be an easy task to satisfy these conditions, especially in Africa where experiences with irrigation management have been of comparatively recent origin. Thus, irrigation is unlikely to prove to be a panacea for Africa, but if approached carefully and cautiously it can undoubtedly make an important and lasting contribution to the resolution of Africa's food crisis.

[31]Asit K. Biswas, 'Monitoring and evaluation of irrigation projects', *Bulletin, International Commission on Irrigation and Drainage,* Vol 34, No 1, July 1985, pp 12–18.