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AFRICAN IRRIGATION OVERVIEW

Interim Report

by

Jon R. Moris

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compilers

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Water Management Synthesis II Project
Department of Agricultural & Irrigation Engineering
Utah State University
Logan, Utah

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CHAPTER TWO

GENERAL CONCLUSIONS

(draft)

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CHAPTER TWO

GENERAL CONCLUSIONS

Institutional Aspects

1. African countries have a range of technologies for augmenting water control in farming, which thus qualify in the broad sense as types of "irrigation". However, the existing technologies are sharply divided between those within reach of individual smallholders--almost always pump-based systems with minimum physical works--and the two larger-scale extremes: either commercial estates (employing furrow or overhead irrigation, usually on sugar or coffee) or government sponsored schemes (generally flood-basin irrigation of rice or furrow irrigation of cotton). These three types have separate sources of finance, services, and management. Integrated, sector wide planning for irrigation is uncommon. In the whole continent, there are possibly only four countries with sufficient data and support to constitute sector-wide irrigation support: Kenya, Sudan, Senegal, and perhaps Zimbabwe. While all types of irrigation are considered in this report, it should be recognized that within given countries it is rare to find integrated planning for the whole irrigation sub-sector.[1] A particular problem in the ex-French countries is that frequently planning, design, and management functions for water development are located in different ministries.[2] To get an integrated approach to water management in such settings requires a substantial amount of inter-departmental cooperation.

2. The terms "irrigation policy" and "water management" tend to be associated in Africa with the larger, governmentally sponsored schemes. For example, in Kenya the National Irrigation Board deals only with its own schemes, which are all of this type. The focus on large-scale irrigation technologies neglects the privately-owned pump systems, whose number and needs are often not even estimated in the official documents.

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[1] We encountered only two sources which approximate what one would expect from a sector-wide review, for Niger (USAID 1984) and for Senegal (OMVS 1980).

[2] An unfortunate division of effort, given that in other respects the French sponsored Genie Rurale corps have a strong record in field engineering making them broadly equivalent to the US "irrigation engineer".

3. To the extent that there has been systematic planning for irrigation development, it is almost all linked to activities of the river basin agencies (RBAs) or to the Sahel zone's Club du Sahel. The largest of the river basin organizations are the multinational ones. The most advanced of these in terms of studies done and project underway is the OMVS (an interstate organization for the Senegal River linking Senegal, Mauritania, and Mali). Similar organizations exist for the Niger and Gambia Rivers, and in East Africa for the Kagera River (Rwanda, Tanzania and Uganda). Given that such organizations already exist, they appear to offer a logical point of attachment for future irrigation studies. It must be recognized, however, that RBAs are often denied operational responsibility despite their central role in sponsoring irrigation planning. (Since AID has a separate study underway on river basin development, the prospects for collaboration with RBAs are not examined in detail within this report.)

4. Country estimates of present and future irrigation potential are available mainly for the Sahel, in a series of useful Club du Sahel/CILSS reports. (The Club is a consortium of the OECD donor nations, whereas the interstate CILSS committee encompasses the recipient nations.) These joint reports outline the medium and long term planning considerations influencing irrigation development in the various Sahel nations. There have been in addition several international conferences dealing particularly with African irrigation, notably a workshop at the University of Cambridge (March 1983) and another at the University of Zimbabwe (September 1984). And, finally, the OECD and FAO have become more directly involved, the latter organization through its Land and Water Division, see Vinck (1983), Hekstra (1983) and Underhill (1984).

5. A serious constraint on overall irrigation planning is the lack of stable estimates of irrigation potential. This, in turn, reflects both differing definitions (full water control versus all types) and the nearly complete lack of data on certain types. Furthermore, while more complete hydrological data may expand estimates dramatically (as Toksoz 1984 suggests will generally occur), better knowledge of soils may instead deflate overoptimistic national estimates.

For AID's Africa Bureau, a priority concern should be to investigate how estimates of irrigation potential are prepared in the various countries where irrigation is being considered. Similarly, realistic data on actual returns comparing rain-fed and irrigation projects are needed before sensible choices can be made.

6. Few African countries know what their manpower situation is in regard to potential irrigation development. Roger Carter and his colleagues at Silsoe prepared a detailed estimate of manpower requirements for the development of Nigerian irrigation, including identification of technical cadres and the skills required of each, but to our knowledge this is the only such study on the continent. In some countries where irrigation is quite important, such as Somalia, the sections concerned at the ministry level have no systematic information available on the overall manpower situation for the sector as a whole. Most interventions which AID might consider will require such information, and in any case it is badly needed for internal planning within the country. A recent danger throughout northeastern Africa is the lure of the Gulf States employment market, where trained irrigation engineers can easily earn several times what their own countries can offer. With Arabic being the predominant language, anyone with these skills from the Sudan or Somalia can easily find jobs in the booming Gulf economy where virtually all agriculture is irrigated.

7. The most striking difference between sub-Saharan Africa and Asia or North Africa is the virtual absence of irrigation engineers as professionals. Most irrigation engineering in sub-Saharan Africa was provided until very recently by civil engineers (the principal exceptions being the French Genie Rurale corps, and the Gezira Board's water engineers). Once a project was designed and constructed, technical assistance for management of the production system came from agronomists--originally expatriate staff provided by the colonial government, or in recent years by international agencies such as FAO and the World Bank. Thus attention to the managerial integration of irrigation perimeters <u>as systems</u> has generally been lacking.

Irrigation Potential

8. African countries differ greatly in regards to their need for irrigation, and their potential water supplies which might be used for this purpose. Those countries usually earmarked as having major existing or potential for irrigation are the ones crossed by larger rivers, e.g. Senegal, Mali, Niger, Sudan, Ethiopia, Zaire, and Somalia. In these countries, the potential for irrigation depends on the interaction of several key factors:

- degree of seasonal fluctuation in water levels,
- existing commitments of the water budget,
- international control issues where a drainage is shared,
- participation within multinational river basin agencies,
- existence of soils suited to irrigation near the river.

9. Suitable conditions for large-scale irrigation thus tend to accompany Africa's major river basins, or else to be found on broad alluvial plains near the mouth of the larger rivers (e.g. the Shebelli and Juba in Somalia, the Lower Tana in Kenya, and the delta on the Senegal River). There are five major basins on the African continent usually recognized by geographers: the Djouf Basin (Niger River); the Chad Basin (the Logoni/Chari Rivers); the Sudd Basin (the Nile River); the Zaire Basin (the Congo River); and the Okavango Basin (the Zambezi River). However there are numerous smaller rivers which, if they tap higher rainfall zones in their headwaters, may also have substantial potential for irrigation development, e.g. the Senegal River and Gambia Rivers in the western Sahel and the Rufiji drainage in Tanzania. From a hydrologic perspective, it seems there is substantial untapped potential for irrigation development in places like Zambia, southeastern Zaire, or southcentral Tanzania. In these instances adequate existing rainfall or remoteness from markets makes the cost-effectiveness of irrigation dubious. On the other hand, in terms of Africa's long-run food supply situation it may be that further investigation of irrigation potential in these areas is warranted. On the whole, Africa has some 60 major rivers with potential for irrigation development (see Annex .. in volume two), mostly as yet untapped.

Conjunctive Groundwater Use

10. In theory, there are substantial areas of Africa where because the higher areas are situated around the periphery, the lay of the land would seem to favor groundwater accumulation within the interior. For example, Quaternary sedimentation in the Chad Basin is about 2,000 ft (470 m) deep and contains sandy zones which are now important acquifers (Pullan 1969:162). The other river basins also contain sites which are locally favorable for groundwater extraction, as do some of the coastal plains and deltas (though such water is often saline). However, even in the Sahel and Sudanic zones of West Africa there are large areas where rocks underlying the catchments are impermeable, the soils have low infiltration capacities, and evaporation losses are high. Such areas produce little groundwater recharge, despite topographically favorable conditions (Ledger 1969:90). Rodier (1963) points out that there is very little variation in geological conditions in Africa's vast tropical regions (excluding East Africa's highlands), which are underlain either by the old granite gneissic shelf of pre-Cambrian rocks or a cover of Ordovician sandstones. In the former, "there is no possibility of finding deep underground reserves" while in the latter there is "very little possibility" (Rodier 1963:184).

11. Along the continent's eastern side, the groundwater situation is complicated by the Rift Valley system of volcanic mountains and internal drainages. The mountains do sometimes provide acquifers, but water quality is often problemmatic both on the slopes and in the alkaline basins. Elsewhere one encounteres the same precambrian continental shield, which produces a characteristic topography of peneplain and inselberg hills. Boreholes (i.e., tubewells) drilled into this kind of weathered, metamorphic rock typically have limited yield and slow recharge--insufficient to support commercial irrigation.

12. There are numerous technical difficulties which accompany the use of limited recharge borehole supplies for small-scale irrigation: the high opportunity cost of water, dangers of drawing a well dry and consequent damage to the drill rods, shortages of diesel fuel, etc. To date, communication between well drillers and pump operators has been poor. Irrigation projects should draw upon the Scandinavians and Dutch, who have taken the lead in institutionalizing borehole pumping experience (Lium and Skofteland 1983, Falkenmark and Lundqvist 1984).

Soils Aspects

13. Soil conditions heavily influence site design and project location in those areas where water supplies permit irrigation development. Soils information is required for three distinct purposes within irrigation: i) in arriving at cost estimates for surface irrigation, since potential water losses determine whether or not canal lining is required; ii) in estimating land productivity under more intensive cropping; and, iii) in evaluating the long run constraints upon and impacts of irrigated production. The first aspect can be handled in a fairly routine fashion, providing the necessary test results are available. The second and third aspects are, however, much more difficult and constitute major areas of uncertainty at present.

14. If soils are sandy, water losses will be high and it becomes uneconomic to irrigate most crops by means of surface irrigation (here despite its higher unit costs sprinkler irrigation might become desirable). Clay soils retain moisture, often making canal lining unnecessary, but during rainy periods become waterlogged and thus are most suited to "wet foot" crops (like rice). Certain types of clay permit pre-irrigation, others do not. The peaty soils in highland marshlands (of Rwanda, Burundi, Uganda, and western Tanzania) are quite acidic, as are also West Africa's coastal mangrove swamps. Clay soils looking rather similar from lowland East Africa in the Rift Valley are instead quite alkaline because they occur in closed drainages where high evaporation concentrates the surface deposition of salts. Finally, away from the flat alluvial plains irrigation is often located in valley bottoms within a larger catenary sequence. Such sites are characterized by a high degree of variability in soil types as one ascends the catenary sequence.

15. The prominence of these features throughout the continent indicates that the success of irrigation on the alluvial plains of the Sudan (the Gezira and Rahad schemes), Niger (the Office du Niger), and in Kenya (Mwea Scheme) may not be widely replicable. Sites which have rich and uniform alluvial soils near a major river are unusually advantageous for irrigation--at least in comparison to the highly variable, nutrient depleted plateau soils seen elsewhere in Africa. Advance knowledge of

soils' characteristics and disposition is essential before one can arrive at realistic assessments of irrigation potential. Unfortunately, such information is usually missing at the initial stages of site review, so that by the time soils' survey results are available a commitment to undertake irrigation has often already been made.

16. A problem influencing USAID projects is which soils' classification system to employ within field surveys. Since AID has not been a major irrigation donor, neither the USDA nor the "unified" soil classification system (preferred by the Army Corps of Engineers and the US Bureau of Reclamation) are widely found. More common is the FAO system, or, in Francophone countries, the French-derived system. It is at present very difficult to cross-relate soils types between these four systems which are based on different soils features. While USAID typically requires that the USDA soils classification be used in its projects, local counterparts will usually have been trained in either the FAO or the French system. Any USAID funded surveys will therefore produce results which are noncomparable with earlier studies, and incompatible with work financed by the major European donors who have a larger commitment to irrigation in Africa. The overall impact of having four, overlapping and noncomparable typologies in use is to minimize the carryover between projects and to limit accumulation of soils' expertise.

17. On Africa's poorer soils, continuous and intenstive cultivation of the same piece of land is ordinarily not advisable. Experiments in West Africa have found that within five season of replanted maize, pronounced nutrient deficiencies (here of Mg) occur (IITA 1984:123)--probably caused by a high concentration of ferrous iron in seepage or groundwater. Soil structure deteriorates rapidly under continuous cultivation, and the abundance of iron can lead to formation of an irreversible "hardpan". Because of high rainfall intensities, even in semi-arid areas soil erosion may be high. Horticultural crops like tomatoes are susceptible to a build-up of root nematodes, usually overlooked by agricultural field staff. Some of the main irrigated crops (like cotton or rice) share their pests with indigenous food crops. When chemicals are applied, these soon enter the food chain because of the scattered

and intermixed nature of cultivation. All in all, these various considerations suggest that large, capital intensive irrigation works which force farmers into continued use of a small area are not advisable unless also accompanied by sophisticated crop husbandry and land management.

Environmental Aspects

18. In hot tropical climates, several of the most debilitating human diseases are water-linked. The linkage may be direct, through contamination and water conveyance (e.g. cholera); or it may be indirect, by providing a more favorable environment for parasite vectors (e.g. schistosomiasis, malaria, sleeping sickness, and river blindness). Some of these health hazards are so extreme that areas of otherwise fertile land have been abandoned, e.g. because of river blindness (in West Africa) or human sleeping sickness (in East Africa). Other water-linked diseases are spreading into new environments, e.g cholera and schistosomiasis within recent decades. The latter disease is so prevalent in African irrigation schemes that an increased incidence should be automatically entered into appraisal estimates as one of the costs associated with irrigation development. Belated efforts are now being made to modify the design of hydraulic structures taking into account the health risk factor. This remains a major area where further exchange of experience between countries and disciplines would be beneficial (Jewsbury 1984).

19. Under tropical conditions, irrigation will usually be accompanied by vigorous weed growth--in water as well as on land. Rapid colonization of distribution channels can soon clog them, particularly if they are designed with a flat gradient. In fields, hardy tropical grasses may out-compete introduced rice, e.g. the "red rice" problem. Most damaging of all, the introduced water hyacinth (originally a native of Brazil) has spread in three decades from Zaire into Uganda, the Sudan, and even to Zimbabwe. In all these countries it has become a major pest,

choking waterways, removing oxygen from the water and thereby eliminating fish, and even clogging power turbines and water control structures. As with the incidence of health risks, the incidence of weed growth is a dynamic factor which changes over time and is difficult to accurately anticipate in the initial design. Recourse to herbicides is not always feasible because of the large areas which are infested, the comparatively low value of localized production, foreign exchange limitations on imported inputs, and unknown cummulative effects when introduced into complex food chains within relatively closed river systems. This aspect, too, needs experimentation and further study (Obeid 1975, University of Gezira 1979).

Engineering Aspects

20. Because of high temperatures, low cloud cover, and drying winds, potential evaporation (and also plant water loss to reduce heat stress by transpiration) tends to be high over most of the year. This explains why African landscapes which may receive what would be ample rainfall in temperate zones still appear semi-arid in vegetation and character. High evapotranspiration and limited groundwater recharge have the combined effect that rivers flow only during the wet season unless they tap large drainages (Ledger 1969). The top 2.0 - 2.5 m of water storage in any open reservoir will be lost to surface evaporation, greatly reducing the storage effectiveness of small or shallow reservoirs.

21. Intensive cultivation and grazing of African landscapes soon exposes large areas of bare soil, particularly where an "ironstone" cap has formed within the profile. As already noted, the rainfall typically occurs in thunderstorms of great intensity. The removal of soil through wind and water erosion takes place rapidly. Thus the fact that Africa's larger rivers--which, like the White Nile or Niger flow through buffering swampes--have low sediment loads does not mean the same is true of smaller rivers. These carry heavy sedimentation during their floods, sufficient to fill small reservoirs completely within 15-25 years. The

technologies introduced into Africa for water transport and control have generally been designed for other conditions where sedimentation is not as pronounced as it is here. High rates of sedimentation should be allowed for in the choice of canal gradients, in design of storage reservoirs, in estimating maintenance requirements, and in appraising economic benefits.

22. Water supply issues appear to have a preponderant influence on irrigation design in Africa, beyond what one might expect based on Asian or US experience. Again and again field difficulties can be traced to uncertainties or difficulties related to the supply situation: extremely flat gradients (on the major West African or Nile river systems), problems with intake structures, high evaporation losses from small dams, the shifting of riverbeds or the drying up of supposedly stable supplies, etc. Since supply is often seen even in the US as a matter for civil engineers, this may explain in part their larger role in African irrigation.

23. Canal lining is very expensive under typical African conditions, given the high foreign exchange content of imported cement and generally high transport costs. Africa's larger surface irrigation systems tend to be located where clay soils make canal lining unnecessary.

24. What to do about drainage emerges as a significant issue in many African irrigation systems. Proper drainage design influences incidence of diseases, weed growth, and rates of sedimentation. It is also complicated by the fact that adequate drainage must be provided even in very dry environments. While total annual rainfall may be low, the rainfall which arrives comes in the form of intense thundershowers which can quickly destroy unprotected water distribution systems. A further difficulty in West Africa is the extremely flat terrain along the major rivers (like the Niger), so that to protect the main system may require extensive (and hence costly) diking.

25. The danger arises because since drainage is not essential for the initial operation of a scheme during dry periods, designers may attempt to reduce construction costs by minimizing drainage works in the first phase. Often it will be stated that provision of drainage is the farmers' contri-

bution. To leave the drainage aspects for farmers to construct--given that this is a common good shared between them and that they do not possess mechanized equipment suitable for this purpose--is in effect to leave the total system unprotected.

26. The maintenance of physical works once constructed is seen as a major problem almost everywhere within Africa. In part, this appears to be a "public good" problem: unless all users do their part, individual inputs lose their effectiveness. For this very reason, the common expedient of expecting farmers' actions to provide maintenance is unrealistic in all but the most highly organized systems. However, the failure to provide maintenance may also reflect competing demands upon the farm labor force, as when its timing overlaps with the peak period of labor demand within rainfed cultivation. Also, to the extent that farmers have a part-time commitment to irrigation, or are alienated from the water delivery organization, maintenance is likely to suffer. Then there is the fact already commented upon above that poor design increases the need for maintenance, as does also vigorous weed growth and high rates of sedimentation in the tropical environment.

27. To engineers, one of the most annoying features of African irrigation is the necessity of anticipating multiple uses of the field area and of water conveyed through the system. African peasants are often short of fuel, forage, and staple foods. They will introduce banana plants, hedges, spice gardens, goats, and cattle. Whole villages will draw their domestic water out of the irrigation canals during the dry periods. Livestock will trample the field bunds, and contribute to erosion on the dikes... A priority areas for exchange of experience is to learn how such multiple uses can be anticipated most cheaply within standard designs. Since the reasons for these disapproved practices are firmly anchored within the local economy--often their <u>are</u> no alternatives within farmers' reach--at a minimum such uses could be planned for in advance.

28. In Africa, really "large-scale" irrigation of 10,000 ha or more in a command area is rare, being exclusively confined to alluvial plains near the largest rivers. If we take schemes of 5,000 ha or more in size, going from West to East to South, we find the Richard Toll plantations on the Senegal delta (..... ha); the Office du Niger in Mali (..... ha); Sudan's Gezira-Managil (..... ha) and Rahad Schemes (..... ha); Somalia's as yet undeveloped Lower Juba scheme (..... ha); Kenya's Bura Scheme on the Lower Tana (..... ha); the Hippo Valley Estate complex in Zimbabwe (..... ha); and ..... in Swaziland. More common are schemes in the intermediate, 1-5,000 ha range. The better known ones include Mopti in Mali, Bakolori in Northern Nigeria, Mwea in Kenya, ... in Sudan, Mbarali in Tanzania, ... in Malawi, etc. ..... Even with the inclusion of these smaller units, the number of clear "successes" is small. Most successful have probably been the commercially operated, "enclave" projects which mostly produce sugar--e.g. Richard Toll in Senegal and the Hippo Valley Estates in Zimbabwe. Fairly successful have been the Mwea Scheme in Kenya, and Tanzania's Mbarali scheme (both for flood rice production). Sudan's much larger Gezira Scheme--the largest in Africa--and Mali's Office du Niger get mixed reviews, with observers usually counting Gezira as moderately successful given the constraints on cotton prices but the Office du Niger as a failure. Rahad in Sudan and Bura in Kenya must also be regarded as very problematic. The point is simply that if one is interested in genuinely large-scale irrigation in Africa, there are only a few cases to examine and the record to date is quite mixed. Recommendations which are appropriate for these examples will likely differ in many respects from what one might perscribe for irrigation policies generally on the continent. Except in the instance of Somalia's as yet unfunded Lower Juba development, donors addressing assistance to Africa's largest irrigation schemes must deal with issues of rehabilitation and raising scheme productivity to minimally acceptable levels.

Agronomic Aspects

29. Despite a substantial number of irrigation projects, irrigation technology is employed on relatively few commercial crops--far less, for example, than would be the case in comparable US situations. By a large margin, the main irrigated crops in Africa are rice, sugar, and cotton--all three being crops which thrive on the heavy clay soils where most irrigation is practised. Next probably comes coffee, which under tropical conditions may require supplemental irrigation to maintain yields during dry spells, and wheat (grown for bread-making in the Sahel and in the Horn of Africa). Irrigation of annual field crops like beans, maize, and sorghum is relatively rare with the exception of maize in Somalia and sorghum within Sudan's Gezira rotation. At present, then, if the aim is to increase irrigation efficiency on Africa's larger schemes only a few crops must be dealt with, and these are ones for which there is a large technological backlog of comparative tropical experience. Exchanges of agronomic techniques and research results between countries is an obvious possibility, though the one international research center which has this mandate within Africa at present--WARDA located at Monrovia in Liberia--has a disappointing record to date.

30. Irrigated production is relatively insignificant as a proportion of total agricultural production in all but a handfull of African countries (see Table x.x). By far the greatest exception is the Sudan, where it is estimated that ..% of marketed product comes from the irrigated sector, followed by Madagascar (...%), Mauritius and Somaliland. Next in the relative importance of irrigated production come the Sahelian countries (Senegal, Mali, Niger, Mauritania, and Chad, in that order) and perhaps Zimbabwe and Swaziland, where the non-African large farming sector makes substantial use of supplemental irrigation. In a third tier of countries with significant individual schemes but where the overall contribution probably does not exceed 5% are Nigeria, Kenya, Tanzania, and Sierra Leone (?). In most other African countries, relatively little use is made of irrigation.

31. The kinds of irrigation development which are feasible in Africa differ greatly between types of technology and between areas. In the main, these types consist of: i) conventional flood-basin and furrow irrigation as used in larger schemes, ii) small, pump operated horticultural or oasis units, iii) water regulation in wetlands (swamps, bas fonds, fadama, etc.), iv) possible supplemental irrigation to field crops, and, v) overhead irrigation of commercial coffee or sugar estates. Types ii, iii, and iv are not well recognized, and so will be described briefly below.

32. The small-scale, pump-operated horticultural unit occurs throughout the drier areas of Africa, often without public sector assistance. In the Saharan borderlands it may be an oasis garden, which draws upon nearby sand dunes as the water collecting device. In the Sahel zone it may consist of reinforced shallow wells, sometimes using traditional lifting devices (e.g. the shaduf). In East and Southern Africa, it is likely to take the form of portable Honda pumps which farmers move from well to well or field to field as the need arises. Such units are by US standards very small, but they account for the larger proportion of privately owned irrigation in the whole of the continent. There are real dangers of overpumping, particularly when low recharge sources are tapped or when pumps proliferate around a fixed waterhole. Relatively little is known about how existing pumps are managed and maintained, or even what crops are being irrigated. PVOs would appear to have an advantage over large, bureaucratic agencies in assisting this sector, as would also private small businesses

33. Africa's "wetlands" (to use the inappropriate, temperate zone term) present a rather different situation, where the problem is more the <u>management</u> and not the absolute supply of water. To use seasonal swamps for arable farming requires a combination of drainage in the wet period and supplemental irrigation in the dry. So defined, there is a comparatively large area of Africa where impeded drainage, clayey soils are found. At high altitudes these become peaty and quite acidic (e.g. in Rwanda, Burundi, and western Uganda). At low altitudies to the contrary they tend to be alkaline.

34. At present, there is little exchange of information between countries on how such soils can be more effectively used. Researchers seem unaware that what the French term "mares" and "bas fonds" in the Sahel are basically the same as "fadama" soils in Northern Nigeria, "mbuga" soils in Tanzania, "dambos" in Zambia, and "vleis" in Zimbabwe. In all cases, the high clay content makes it difficult to work such soils without heavy equipment but at the same time the clay retains moisture and thus prolongs crop growth. Such soils are usually highly regarded by local cultivators, who mimic the "recessional" cultivation in farming down the slope as the season dries out. Various techniques for mounding, tie ridging, etc. have been developed to permit planting other than the usual wet-foot crops (e.g. cassava, yams, sweet potatoes instead of rice). Adequate water control could make a substantial difference in extending the utilisation period.

35. A special case in relation to swamp cultivation is found along West Africa's coastline, where marine incursion into former river valleys has created substantial areas of mangrove swamp. Here, in Sierra Leone, Liberia, and neighbouring countries, are found the "swamp rice" projects based on conversion of mangrove swamps to wetrice cultivation. The basic technique is to dike the swamps near the outlets to rivers in order to create a fresh water regime suitable for paddy rice cultivation. The issue to be faced is whether the substantial investments required are more cost-effective than would be assistance to West Africa's <u>much</u> larger area pf upland "dry rice" grown under rainfed conditions. There is also the question of coastal fisheries, since the mangrove swamps serve as a key marine habitat. The main source of technological experience is WARDA, headquartered in Monrovia (Liberia) but linked to sub-stations in Senegal (Richard Toll), Mali (Mopti for floating rice), and Sierra Leone.

36. Another topic where our existing knowledge base is seriously deficient is in regard to the potential pay-off from modest amounts of supplemental irrigation applied at critical points in the plants' growth cycle. Until fairly recently, it was not realized that short dry periods within the growing season were characteristic of much

of East and Southern Africa. The timing of these dry periods of 1-3 weeks' duration is unpredictable, but when they overlap either the germination or tasselling stages in maize production, they strongly depress yields (by as much as 50%). Indeed, maize is particularly susceptible in comparison to sorghum and millet and thus farmers' vulnerability is increasing as they shift over into maize production (a general trend over the whole zone). However, when rainfall statistics are aggregated into monthly totals the existence of these short dry periods is masked and rainfall would appear adequate. It was only with the innovation of aggregating data according to pentades (5 day intervals) and computer programs which could scan the immediately preceding and subsequent periods for rainfall that the prevalence of this type of drought was recognized (Janicki et al 1983). It now seems that within-season dry spells are a significant constraint on maize yields over much of the continent--a key finding, given the prominence of this crop as the continent's major staple food. If so, the question arises whether some type of supplemental irrigation might be devised specifically to address this problem.

37. Another important topic for agronomic research in Africa is to measure more precisely how planting dates and labor requirements interact, particularly when farmers are attempting to grow both irrigated and rain-fed crops. For virtually all crops, the usual research recommendation is to plant early for highest yields. What we do not know is where the trade-offs occur: how much of which crop is best if farmers grow several crops? Vigorous weed growth has already been noted as a particular problem in the tropics. For example, field interviews in Kenya found that weeding (generally done by women) was much easier when soils were still moist. It also seems that lowered weeding requirements are a principal reason why farmers prefer intercropping. While experiments measuring labor inputs are now finally being conducted on arable crops, there is as yet virtually no research looking at what happens when farmers are practicing both irrigated farming and rain-fed cropping. The situation becomes even less clear if we recognize the need to also include livestock enterprizes. And yet probably a majority of Africa's irrigation farmers outside strictly controlled schemes <u>do</u> practice rain-fed farming, and do keep livestock.

Social Aspects

38. Because the creation of a water delivery system precedes the organization of farmers on larger irrigation schemes, and because of a mutual lack of understanding of each other's disciplines, neither water management specialists nor social scientists have a very clear idea how the technical and social systems interface within African irrigation. The points where coordination is necessary between the water delivery system and farmers' social organization include:

- allocation of land and water rights
- any activities where farmers participate in the planning, construction, and management of facilities
- farmers' labor input into the irrigated cropping system
- farmers' labor input into system maintenance
- timing of joint activities, farmer to farmer, and farmer to agency
- systems for conflict resolution linked to water management
- farmers' existing skills and attitudes related to water management
- backward and forward linkages ("upstream/downstream") generated by irrigation on the larger economic and social system.
- constraints on irrigation generated by the farmers' other enterprise and social commitments.
- increased health costs associated with irrigation

39. Two observations stand out clearly from our preliminary review. First, irrigation technologies differ greatly in what is expected from farmers and in the demands they impose on existing economic and social system. Second, with a few exceptions--largely consisting of recent Ph.D. studies not yet published--systematic descriptions of the key areas of interface between social and technical systems are missing. Instead, one encounters fragmentary and incidental references scattered through hundreds of sources oriented towards answering other theoretical issues. The bits and pieces of relevant information are really little more than clues to indicate that a given case is potentially significant, but hardly complete enough in their own right to warrant an annotated bibliographic entry. This was the basic problem encountered in Tiffen's review of the land tenure literature vis-a-vis irrigation, but it is also a characteristic of the literature on the other sociological aspects.

40. The popularity of small-scale pump irrigation systems, and their spontaneous spread throughout much of the Sahel zone, is probably a direct consequence of the minimal demands such systems make upon farm households. A farmer buying a pump retains almost complete control over how and when it is used, becoming subject only to fuel availability and access to mechanical services. At the other extreme, a tenant who takes up an irrigation plot within one of Africa's larger schemes must accept many restrictions: on residence, inheritance, use of water, crops grown, planting of trees, and even easement rights for transport and livestock (in the more strictly controlled schemes like Mwea in Kenya). The technologies in present use cluster at these two extremes, perhaps reflecting the fact that the middle-scale, partly mechanized farm entrepreneur whose operations might have bridged between the two types is almost entirely absent within Africa--except, of course, in the former "settler" mixed farms of East and Southern Africa.

41. We should also note at the outset that field engineers in Africa often feel most of the constraints limiting the application of standard technologies are of a sociological, administrative, or political nature. Sociologists might in turn argue that because of the separation in time between the design phase and actual production, engineers can if they so desire blame "social factors" for all low performance even when basic design errors have existed from the beginning. Given the prominence in Africa of what everyone admits are "social problems" influencing irrigation, it is noteworthy that little systematic effort has been directed towards actual study of the difficulties being experienced. Field engineers seem to believe that better communication--which is seen as the sociologist's function--would improve farmers' understanding of the system. Once grasped, this knowledge would cause the social "obstacles" to crumble and scheme efficiency could then rise.

42. Anthropologists (who along with economists are the main social scientist familiar with African data) feel instead that the points of stress one encounters in the field are quite predictable, and should have been ameliorated long before now by adjustments in the design phase. Perhaps the resistance of civil engineers stems from an intuitive realisation that

their standard solutions have such high social costs when implemented in a typical African setting that explicit recognition of social factors would necessitate a rethinking of engineering practice and hence of the typical scheme design.

43. To a considerable extent, the objectionable features of large-scale irrigation in Africa are not intrinsic to irrigation as such, but grow out of linkage of this technology with organized settlement schemes (particularly in East and Southern Africa). Scheme managers claim that to recover irrigation costs they must either control the marketing of the major crop (usually rice or cotton), or farmers' residence within the scheme--and usually both aspects. Left to their own devices, subsistence farmers will be unable to pay for irrigation water. Of course, in accepting the need for bureaucratic controls as a cost-recovery device, African countries find that irrigation development becomes still more expensive because of the many further infrastructural and overhead costs associated with bureaucratic management of a large settlement scheme. In marked contrast, within small-scale pump schemes farmers pay for their own petrol and parts--in effect, a water user's charge--and thereby avoid all the complications entailed in dealing with a large irrigation agency.

44. Another belief among engineers working in Africa is that African peasants have only a few decades' experience with irrigated farming and so lack many of the essential skills such farming depends upon. The real situation is more complex. First, Africans have been in contact with irrigation-based civilizations (notably Egypt) for several thousand years, and small-scale devices like the shaduf have been present in the Sahel zone for a very long time. Second, there were traditional systems based on furrow irrigation in parts of East Africa (notably among the Marakwet, Taita, Kilimanjaro, Pare, Usambara, and Sonjo peoples). We also know that one of the region's major archaeological sites at Engaruka in Northern Tanzania incorporated an elaborate network of irrigation canals. And, third, wherever the Arabic influence was spread--from Senegal to Zanzibar--one found hand-irrigated horticultural gardens.

45. What is perhaps more significant is the type of irrigation practised. Furrow-based systems incorporating a long main canal were confined to mountainous areas with reliable rainfall and rocks for lining the canal. The only systems remotely comparable to those of the Philippines and Indonesia—upon which much of the writing about community participation is based—were found in Madagascar, whose population did originate (in part) from Southeast Asia. In such systems, the combination of flood basin irrigation for wet rice farming and extensive hillside terracing makes it imperative that farmers cooperate quickly when a water conveyance structure is breached. (Loss of one terrace high on the slope endangers all of those below.) In tropical Africa, by way of contrast, there are few fast-flowing rivers; terracing for paddy rice production was not found; water supplies dry out rapidly; and a breach in the water conveyance system does not threaten the whole community. Farmers had not developed the technology for land levelling, and because of porous soils over much of the area little attempt was made to construct major canal systems. What farmers did develop all across Africa was what we might describe as "garden box" irrigation: small square basins into which water was conveyed by hand or by a short inlet channel. We are told by irrigation engineers who have observed such systems that the efficiency of water use was relatively high, and the major areas for potential improvement revolve around employing modern materials to line the channels and larger-volume pumps in place of traditional lifting devices.

46. Thus the observation that African peasant farmers lack certain crucial skills required in modern irrigation is valid, but perhaps not for the reasons commonly adduced. By and large, African peasant farmers do not share indigenous traditions for cooperation which derive from the water management system itself.[1] Schemes which depend on the joint action of farmers in allocating water and in maintaining physical works should anticipate the need for much training and supervision. Similarly, Africans lack technologies suitable for land levelling. Any design which calls for farmers to do their own field levelling after the conveyance system is in place is, therefore, problematic.

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47. Several features of indigenous African socio-economic organization complicate farmers' likely reaction to irrigation opportunities. First, there is the constraint imposed by the tiny size, mixed cropping, and non-contiguous pattern of many farmers' fields. Second, over much of Africa the woman and her children constituted the basic, food producing unit. Addition of an irrigated plot as a speculative investment by a husband does not necessarily guarantee the family labor needed, nor does it automatically benefit other members of the household. Third, the small-scale, labor intensive nature of traditional irrigation caused it to be viewed by farmers as a subsidary concern undertaken as a hedge against famine but not as a person's primary farm investment. And, fourth, within the drier lands where irrigation is most needed it competes with livestock enterprizes for farmers' land and capital. Depending on how it is planned, irrigation can either be for the benefit of or to the detriment of livestock producers (who may be the irrigators themselves).

48. Women's involvement in irrigation appears to grow more problemmatic as schemes mature. On Mwea, in Kenya, there have been riots by women, and youths growing up within the scheme have difficulty obtaining wives from adjacent off-scheme communities because of the difficulties Mwea's households face. The things of most importance to women--clean water supplies, fuelwood, access to gardenplots, smallstock, and freedom to market crops where they wish--are often eliminated from scheme plans at the design phase. Yet almost everywhere in Africa one sees illegal banana plants growing on the irrigation bunds, and cattle grazing the ratoon growth in the fields. Certainly much more could be done to insure that the advantages of water management <u>acrue to the entire household</u>.

49. The whole issue to farmers' participation in irrigation planning, implementation, and maintenance has begun to receive more attention in recent years (Underhill 1984).

Economic Aspects

50. In Africa, there is a low ceiling on the sustainability of irrigation investments imposed by farmers' dependence on hand labor and their limited entry into commercial production. Where acreages are so small and farmers only employ hand tools, there is little scope for realizing profits sufficient to pay for irrigation. This farm-level energy constraint limits the basic productivity of farming irrespective of crop (with certain high value horticultural crops like spices or bananas being perhaps the main exception). Profitable irrigation is at present confined either to small-scale pump irrigation on higher value crops within reach of consumer markets, or large-scale "plantation" irrigation of the major export crops.

51. The deteriorating economic situation in sub-Saharan Africa has had a direct, immediate, and strongly adverse impact on irrigation. First, there is a cost-price squeeze affecting particularly sugar and cotton (and thereby threatening the entire irrigation sector in the Sudan). Second, borehole supplies ("tubewells" in Asian parlance) cannot survive without imported parts and fuel. In attempting to evade the parts constraint, countries have become increasingly dependent on a large number of donors. This in turn has had the effect of diversifying equipment sources but increasing local vulnerability because few of them are well represented by in-country suppliers. Third, shortages of fuel accentuate the riskiness of irrigated farming (as observed in Somalia in mid-1984) so that farmers may revert to what are essentially risk-minimizing, "rainfed" techniques even when farming within the irrigated perimeters.

52. Small-scale irrigation projects do not appear to show markedly lower unit costs than do large ones. The lack of a close association between scale of technology and unit costs suggests that the relationship is complex, and there are probably several intervening factors. Very expensive schemes can be found at all points across the spectrum, ranging from tiny installations serving a few families to quite large perimeters of several thousand hectares. Donors should not therefore assume that small-scale projects in Africa are inherently lower cost per unit of water delivered than large ones.

53. Irrigation usually involves an intensification of farming, by increasing output per hectare. However, intensification at the same time increases the "upstream", systemic demands made upon the larger environment. More inputs must be available, more soil nutrients are removed, the land is more intensively used, more energy is required, etc. These added tensions are multiplied, however, when double cycle cropping is attempted. Double or even triple-cropping maximizes the competition with farmers' other, non-irrigated enterprizes--a serious problem in Africa. The plant growth cycle may overlap cloudy periods when ripening is depressed. The build up of pests and root nematodes accelerates. Soils do not receive time to dry out, and the extended moisture regime encourages diseases. Inputs must be continuously available, and management must be able to schedule several overlapping support activities, e.g. transport of the harvested crop while preparing land for the new crop. What this all means is that farmers may gain, say, 25% in net income even though costs and managerial effort have increased almost 100%.[1] If we weigh in the larger constraints--the poor quality of storage, unavailability of inputs, weak managerial capacity in field agencies, unreliable transport, etc.--it can be seen that premature intensification can easily overwhelm the system's institutional capacity. Furthermore, within the African environment there are strong ecological arguments in favor of allowing land to rest and minimizing the withdrawal of nutrients. Considering both of these aspects, it might be wiser to subsidize investment costs directly rather than aiming for a multiple cropping regime simply to make the appraisal estimates seem more favorable.

54. The above problems also apply to intensification of rain-fed farming. This is the principal reason why one cannot simply contrast the returns from investment in rain-fed farming to returns from irrigation to decide if assistance to irrigation is a sensible strategy for USAID. Farming in Africa occurs across of continuum of gradually increasing intensity, and both the constraints and the returns change as the system comes under greater tension. Sometimes population pressure leaves no choice but to move towards greater intensity: the question then is whether or not water is the critical limiting factor.

[1] These are rough estimates of the actual difference in returns realized when Kenya's Mwea Scheme added second cycle cropping in 19.. (see Kenya's NIB Annual Report for

Humpal's background paper on agronomy suggests that, in actual fact, soil fertility is a more limiting factor on intensification than is water availability and management (p. xx). However, to gain the benefit of fertilizer application, farmers may also require a reliable moisture regime so that some irrigation is still necessary. The issue is not simple, and cannot be adequately resolved by a mere contrast between returns to irrigation vs. rain-fed farming investment.

55. This does not mean we should overlook the high unit costs of most irrigation investment as it has occurred to date within Africa. The high per hectare costs of most schemes are the primary reason that loan-financed projects usually aim for a double or even triple cycle of irrigated production--an expedient we have already warned against. They also underlie the omission of drainage works and field levelling from project designs--another counterproductive option. Thus in reality present cost estimates probably understate the true costs on Africa's formal schemes. When farmers use irrigation on only one crop and if additional health, land levelling, and drainage costs must be entered, total costs soon outweigh the potential benefits--particularly if in real world production the scheme management cannot maintain reliable water delivery. This is why one must question the addition of unrelated infrastructural costs to a system which is already very expensive: a road network, scheme offices, perhaps a rice processing mill, houses for tenants, etc. And yet to attract and hold a labor force the typical irrigation project must at least equal the level of basic amenities (household water, access, fuel availability, and rain-fed cultivation plots) which will be found in neighbouring communities. It is obvious, then, that cost considerations pose very difficult trade-offs within the design process.

56. Because irrigation is so expensive and concentrated, its provision under public funds does raise questions of basic equity. Four equity-related issues are of particular concern in African irrigation development. First, as Tiffen's background paper stresses, the land taken for scheme development may have been intensively used so that those evicted before construction may number as many as those ultimately given plots.

Second, on bigger schemes with cotton or rice farmers require a large labor input. If women and children provide such assistance, they deserve a more direct share of profits than present institutional patterns provide (which explains the chronic labor shortage on these schemes.) Third, secondary benefits such as access to schooling for children or increased employment are significant where large-scale irrigation has been developed. Any weighing of benefits which excludes such considerations should be challenged, since the benefits in question are highly valued in African countries. And, fourth, in poor countries the decision to invest entails a high opportunity cost for other sections of the country which must be denied foreign exchange and comparable levels of investment. Thus large-scale irrigation inevitably introduces issues of inter-regional equity. In short, these four aspects have sufficient weight to indicate that economic (as contrasted to financial) analysis should always precede major irrigation investments.

57. Existing economic analyses have often made strong assumptions about the systems being appraised. Possibly the single largest source of error has arisen when the costs of farm labor have been heavily discounted. The standard argument is that farmers enjoy free family labor, and have few renumerative options for their own effort. Even without irrigation, this is seldom the case within present African farming systems where seasonal labor bottlenecks tend to be very pronounced. If we add in the preference farmers show for long distance trading and for labor input into high priority livestock enterprizes, it is virtually certain that the work devoted to irrigation will be perceived as having a high opportunity cost. These facts are well known in the literature. It seems farm labor costs have usually been eliminated from benefit-cost calculations because this was the only way appraisers could make benefits look sufficiently attractive to justify the high investment costs. The artificiality of such appraisal estimates will increase over time, since labor costs are likely to rise substantially once the area as a whole begins to develop economically.

58. The fundamental motivation for investing in irrigation in many African countries appears to have been the desire to stabilize food supplies internally. Increased food and forage self-sufficiency is sometimes portrayed by outsiders as an "irrational", "political" objective which fails to

recognize international comparative advantage. To the contrary, we see many reasons why most African nations have a strong incentive to increase their food security by every feasible means. One has only to contrast the relative situation of the Sudan--where Gezira is feeding not only its own population but also numerous refugees from the East and West--with that of Ethiopia in late 1984 to appreciate why this should be so. We suggest the error lies not so much in the desire for food security, but rather in the assumption that irrigated production is always the priority means for achieving this objective.

59. Locational and pricing issues frequently emerge as key considerations affecting the success or failure of particular irrigation projects. In regard to project location, difficulties in assuring water supply may leave planners with few options. Transport costs in Africa tend to be high, especially in remote areas lacking feeder roads and mechanical services. If irrigation is to be developed at such sites, it must be accompanied by major infrastructural investments and high production and marketing costs will be built-in from the very beginning. It must also be noted that in Africa such costs have a high foreign exchange content. For some highly mechanized crops (such as wheat), the foreign exchange costs necessitated by internal production may exceed what would be required to import the crop. Similarly, the components within irrigated production--preliminary surveys, imported pumps, fuel, and external management--have both a high foreign exchange content and are expensive and difficult to supply in remote places. These are potent considerations for a donor like USAID to weigh.

60. The pricing issue arises wherever a government attempts to subsidize consumers by controlling grain prices--as, in fact, the majority of African states do. Most African countries have in place price control mechanisms of one kind or another. Often these are linked to marketing boards which handle cereal crops as well as food imports. We should note that at a theoretical level concessionary food imports have much the same impact on irrigated producers as do arbitrary price controls: in either event, the producer receives less than might otherwise be the case. When the production process is very expensive, the resulting ceiling on profits will constrain spread of the technology. The "failure" of a scheme in this situation may simply reflect unrealistic pricing policies.

Managerial Aspects

61. The principal agencies holding the hydrological and environmental data needed for irrigation development usually do not have executive responsibility for carrying out field programs. It is, in fact, quite common to find responsibility for assisting irrigated agriculture to be located in different agencies and ministries: construction to be under a Ministry of Works, planning in a River Basin Authority, water management under the Ministry of Water Development and Power, agronomy under Agriculture, and perhaps human aspects under a Settlement Commission. Even in countries which have an agency specifically in charge of irrigation development--like Kenya's National Irrigation Board--there will be numerous other units located elsewhere in the governmental structure which carry out similar functions. Since an equivalent degree of fragmentation is found between specialties and between the approaches of various donors, the accumulation and transfer of irrigation management experience has been extremely limited.

62. In particular, African countries have often relied upon outside assistance when undertaking irrigation projects. Each donor nation tends to inject its own field unit systems into schemes it finances: the Dutch building polder-type units, the Chinese making flood-basins for paddy rice, and the World Bank perhaps financing dikes for floating rice (e.g. in Mali). Some schemes have alternated between donors, e.g. the Mbarali Scheme in Tanzania begun by FAO and completed by the Chinese. With Chinese designed and assisted schemes--we should note that both Chinas have been quite active assisting irrigated rice development in Africa--African field staff may have little concept of the Chinese planning and managerial systems (a diffuculty Dutch volunteers working with the Malawi Government's projects mentioned). Such confusions become exacerbated on larger, multi-donor projects where one country may supply the extension component, a second the construction financing, and an international agency the agronomy component. (FAO's financial year ends in December, the World Bank's in June, and USAID's in September.) Multiple reporting and accounting systems greatly increase the effort required of scheme management.

63. There is a general perception among external technicians working within Africa, irrespective of discipline, that management has been weak on many African schemes. A partial explanation is provided by a review of African management studies which found that while general management principles explain internal agency functioning quite well, it was in their relationships to the environment that agency experience differs most (Kiggundu et al 1983). Since implementation of irrigation schemes will necessarily involve managing linkages which tie into the larger natural, economic, and administrative environment at many points, it could be predicted that these relationships will be problematic. Under present economic constraints, it has become more and more difficult to implement any project which has a large element of physical works and construction in it.

64. It is instructive that those who have been most intimately involved in irrigation planning tend to segregate managerial tasks into quite distinct stages: planning, construction, water management, agronomy, economics, human settlement, impacts, and the policy environment. By parcelling out managerial tasks in this fashion, the demands which must be faced at any one point in time are minimized. Given the great complexity of decision-making in African irrigation schemes, this is probably a necessary expedient. Nevertheless, it also breaks the connections between components in the system, and thereby renders integrated management much more difficult.

65. At present, Africa's larger schemes growing cotton or sugar face a severe cost-price squeeze. Managers are unsure how to best respond, with the temptation being to squeeze tenants' profits rather than to cut back on overhead costs. The Sudan has turned to mechanization of production as its answer, hoping thereby to boost productivity sufficiently that irrigation charges can remain what they were. In practice, because of numerous other constraints linked to mechanization, this option seems to have introduced more problems than it solved. It certainly greatly increases the tension on local managerial capacity.

66. Most schemes approach the issue of irrigation extension from an internal standpoint, emphasizing a "top down", water delivery scheduling approach. There is hardly any systematic literature on this topic.

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DRAFT

AFRICAN IRRIGATION OVERVIEW

IMPLICATIONS FOR DONORS

(Chapter VII)

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AFRICAN IRRIGATION OVERVIEW

IMPLICATIONS FOR DONORS

(Chapter VII)

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EXECUTIVE SUMMARY

Implications for Donors (Chap. VII)

1. Virtually all expert observers recommend against expanding finance for irrigation by the mere addition of new projects. We concur that top priority must go to institutionalization and rehabilitation.

2. An initial analytic step which WMS II could provide is to clarify which kinds of activities contribute most directly towards deepening institutional capacity in the irrigation sector. Terms like "planning" and "extension" are often used loosely, without recognizing either AID nor recipients know how these terms actually apply within irrigation.

3. AID should recognize that it will usually be a small donor in relation to irrigation. This suggests that to get maximum benefit from a wide spectrum of field activities AID should adopt a collaborative approach where many of the primary costs are borne by other donors.

4. U.S. expertise available to work on African irrigation is very thin, in part because of AID's small commitment in this area, but also because of language barriers (French, Arabic, Portuguese) and the predominance of the former colonial powers (France, England) in giving assistance. To change this situation will require a vigorous and planned effort, possibly by means of "tag-along" or rotating post-doctoral fellowship arrangements.

5. It should be recognized that the U.S. government is supporting African irrigation through World Bank/IDA funding to field projects. To date, the Bank has rarely used U.S. expertise for evaluating its irrigation projects. However, the weak performance of these projects indicates there is much scope for improvement. A joint AID/Bank effort aimed at strengthening institutional support for irrigation ought to be considered. (Ronald Ng is reviewing the Bank's extension and monitoring activities, and could serve as the liaison for such an effort.)

6. AID already had under way several "farming systems' research" (FSR) projects in countries where irrigation is important, e.g., Sudan, Niger, and Tanzania (among others). Because these are already operational, an irrigation "add-on" component could be rapidly implemented. There is a strong case to insist that FSR projects pay more attention to irrigation.

7. Many African countries have established river basin authorities (RBAs) of one type of another. We have noted the RBAs are usually

the only base for existing irrigation planning in a given country. AID should explore a "package" of modest support measures aimed at buttressing the institutional effectiveness of such agencies. Possible components might include:

- Training at the M.S. level (initially in the U.S. but with theses done in the home environment), followed by in-country workshops;

- Africa or region-wide seminars to direct RBA attention to new concepts, procedures and resources (e.g., farmer participation, remote sensing); and

- Devising simplified planning and monitoring procedures adapted to African conditions (rapid reconnaissance, etc.).

8. A major gap is the almost total absence of information on irrigation manpower on the African continent. A systematic approach to training for irrigation requires information on staff training needs, which is simply not available. (Remedying this gap might be a suitable area for WMS II project involvement.)

9. Another unexpected gap is in regard to irrigation economics, a key policy concern given the high costs of irrigation investment and the many complications arising from incorrect estimation of labor costs. Each REDSO office should have at least one irrigation economist, perhaps a rotating fellowship position, to rapidly expand the number of those familiar with African irrigation economics.

10. AID's regionally-based REDSO offices would seem to afford a useful base for assignment of interns who would rapidly acquire a broad comparative experience. Such staff should have already completed a field assignment (M.S. or Ph.D. in a African rural setting). The REDSO framework allows maximum flexibility in arranging staff assignments, and spreads the load of support over several countries. We recommend a focused program to deepen the irrigation expertise located at the REDSO level.

11. Priority attention should be directed towards the choice of crops to be irrigated, and the question of competition for labor between irrigated and rainfed staple crops. It seems obvious that high-value market gardening depends upon low transport costs and a concentration of demand. It also seems that forage utilization is an important objective where farmers are involved with livestock. These are all agricultural economic considerations which must be more adequately integrated into future irrigation planning.

12. Scheme management as presently found in Africa depends heavily on various internal routines -- precedents, rules of thumb, and administrative procedures. While rarely documented outside the

agency concerned, these have an enormous influence on farmers' productivity and commitment. Both in regard to improving participation and women's involvement, the adequacy of such institutional arrangements is critical. We suggest that dialogue and comparative research on these procedural, "O&M" aspects would be a suitable area for any special studies AID might fund.

13. Many observers have stressed that irrigation maintenance constitutes the weak link undermining the long run viability of African irrigation schemes. Rates of depreciation for equipment remain extremely high, while already constructed physical works rapidly deteriorate. Further investment in new projects or, for that matter, in the mere physical reconstruction of old ones, cannot be justified until a better understanding is reached on the causes of poor maintenance. This topic cries out for multidisciplinary analysis, and should receive high priority in future research.

14. One likely reason for poor maintenance is a failure of incentives in regard to women's participation in irrigated farming. The significant role of African women in many irrigation systems is not as yet matched by their control of resources or access to profits. In large part this is a consequence of the comparatively weak unification of household production (as contrasted with Asia or Latin America). AID should explore procedural innovations which would increase women's leverage within the emerging systems for irrigated production. Some assistance might also be given to a small unit in FAO looking at women in African agriculture, perhaps by means of funding for a linked associate's position.

15. How to increase farmers' own involvement in African irrigation systems remains an unresolved need. It is clear that as presently being implemented, irrigation on Africa's larger schemes excludes farmers from almost all aspects of managerial control. As long as this tendency persists, irrigators will see themselves as tenants and will continue to resist making private constributions to facilitate scheme irrigation. A comparison between introduced systems and spontaneous or traditional ones might pinpoint how to generate greater farmer commitment. (We note also that this topic is receiving priority attention from various European donors, and has been the focus of efforts by Harry Underhill in FAO over the past few years.)

16. Detailed analysis of the skills farmers possess and need is not available for the various systems of African irrigation. A comparative documentation of "extension" as it actually occurs is essential before donors impose their own ideas (e.g., the World Bank's "T and V" system). Another gap is in regard to how to use irrigation as a drought relief measure. In Kenya, Ethiopia, or the Sudan the incoming "farmers" may be destitute pastoralists with little experience of irrigated farming.

17. Greater involvement of the private sector remains an official U.S. government objective. In Africa, it is complicated by the presence of outside minorities and the pronounced duality of the agricultural sector. Some possibilities for donor support include:

- A systematic effort to retrieve the substantial experience of private consultancy firms, which have been very active in the design of African irrigation schemes. Here there is a large literature found mainly in England and Holland not available within U.S. academic collections.

- Encouragement of exchanges of expertise within African countries between the large-scale commercial sector and the public or PVO agencies helping small-scale irrigation.

- Establishing better technical "backstopping" for NGO and PVO irrigation projects.

- Possible credit assistance to the small-scale "market garden" farmers oriented around purchase and maintenance of pumps. However, great caution must be exercised since such projects are quite risky.

18. The evident lack of feedback from operational systems into project design arises because of a deep split between civil engineers doing construction and external agronomists (often FAO-provided) assisting crop production. In most African countries, irrigation engineering as a discipline does not yet exist. Donors should encourage any measures which facilitate the emergence of irrigation engineering as a unified field, combining aspects of design, construction and management.

19. AID/Washington needs to recognize that because of its few irrigation-related projects in East and Southern Africa, the usual "participant training" device for deepening in-country technical skills cannot be relied upon. If African countries are to send staff for training in the USA, they must do so under some other mechanism. We see this as an opportunity to shape an emerging professional discipline, but warn that as presently given, much U.S. training is likely to be inappropriate to African conditions.

20. In regard to technology choice, this report has identified numerous problems. At a minimum, donors can avoid compounding managerial difficulties by introducing unsupportable "orphaned" equipment. They can also buttress in-country repair and servicing capacity, an objective AID has several times adopted (Senegal, Mali) but which appears exceedingly difficult to accomplish. Perhaps an exchange of experiences between countries and donors would help? More fundamentally, there are obvious gaps where present technologies are inadequate:

- An absence of low energy pumping systems, which would be within reach of smallholders' financial capability;

- Development of systems combining full irrigation for one crop cycle and supplemental irrigation for the rainfed crop;

- A frequent failure to anticipate multiple uses (livestock, households, etc.) of irrigation water;

- A need for an exchange of ideas about animal traction equipment suited to lighter weight African cattle;

- Exchange of experience concerning working in heavy clay soils; and

- Development of a means for applying supplemental irrigation to rainfed cereal crops during within-season droughts.

21. Irrigated production in Africa encounters severe difficulties related to soil exhaustion, nematode and pest buildup, and a proliferation of terrestrial and aquatic weeds. Because these are delayed impacts, their significance in depressing crop yields has probably been underestimated. We have no clear solutions, but note past U.S. assistance to the National Academy of Science for exchanges of technical information on such topics.

22. Another area of comparative U.S. advantage concerns support for agricultural applications of remote sensing (LANDSAT, etc.). Contrary to some U.S. opinion, a continuation of these activities drawing particularly upon U.S. weather monitoring capability is vital. (For example, such data was the best firm evidence that Africa's current drought was not primarily man-caused.) Cross-linkage of regional precipitation patterns to river-basin planning is a strategic necessity for the USA and any other donors concerned about African food availabilities. A missing element has been to focus on the "early warning" aspects, so that countries with installed irrigation capacity will have enough time to shift priority towards food grain production in the rainfall deficit years.

23. In general, environmental complications (especially those related to health) constitute a significant constraint upon African irrigation. Individual countries may lack the technology and interest to engage in long-run environmental monitoring. As in the past, donor pressure has been the main reason for inclusion of this focus in project designs. The presence of UNEP in Nairobi, which has often sponsored useful work on energy and environmental aspects of African agriculture, offers a possible base for expanded attention to this aspect of African irrigation. There is also need to exchange information on public health costs associated with different types of irrigation technology.

24. This report would not have been feasible without access to the irrigation "network papers" provided by London's Overseas Development Institute (ODI). ODI is already in touch with many of Africa's irrigation practitioners, but the task has grown to unmanageable proportions beyond ODI's present resources. Since a substantial proportion of the passive membership in ODI's irrigation network are Americans, modest assistance from AID might be welcomed.

25. Finally, it is a regrettable fact that politica. priorities often determine donor interests. For African irrigation, an irony we have pointed out is that several poor socialist countries have major irrigation potential and may control their neighbor's potential as well. This is certainly the case for Ethiopia and Guinea, and to a lesser extent, also for Angola and Tanzania. It is not in the national interests of western donors to let short run political considerations dictate where assistance will be given in African irrigation, neither now nor in the future. It would be in Africa's interest to insure that each western embassy is provided with a map on which the continent's major river drainages have been drawn to reinforce this elementary point.

CHAPTER VII
IMPLICATIONS

Issues

The literature already contains three useful listings of the main issues donors should weigh when appraising irrigation development. Two come from AID-financed studies (Berry et al., 19__; Steinberg, 1983: 35-65) and one from the OECD (Carruthers, 1983:68-75). Drawing most heavily on Carruthers, we suggest 15 points on which policy decisions are required in African irrigation:

1. Where and when to subsidize?
2. New projects or rehabilitation?
3. Drainage or more irrigation?
4. Large- or small-scale irrigation?
5. Direct investment or price support?
6. Public or private development?
7. Hydro-power versus irrigation?
8. Hardware or management?
9. Conjunctive use of groundwater?
10. River basin authorities versus individual schemes?
11. Scope for alternate energy sources?
12. Swamp-rice versus rainfed rice?
13. Rightholders versus cultivators?
14. Full Control versus supplemental irrigation?
15. Technology transfer or technology development?

Familiarity with the general arguments advanced by Steinberg and Carruthers is here assumed. We have emphasized instead the special features which may alter standard prescriptions when one is dealing with African irrigation. It will also become apparent that there are not too many continent-wide prescriptions. On most issues, each country has peculiarities which will require extra attention in choosing an appropriate strategy.

1. Where and When to Subsidize?

The first issue to consider in regard to irrigation investment is, according to Steinberg, "Who pays?" (1983:43). By now, the relevance of criteria for cost allocation should be obvious. We have seen that African irrigation tends to become inordinately expensive, that smallholders cannot afford major capital improvements, that the typical peasant farm is "energy starved," and that African governments cannot assume increased recurrent cost burdens. Furthermore, well-intentioned plans for double cycle cropping -- introduced primarily to boost farmers' cash flow as a means of enhancing benefits and repayment capacity -- are not technically advisable under typical African conditions.

Thus, deciding "who pays" is a core issue which must precede consideration of all others on our list. It is fairly clear that under typical African circumstances irrigation simply cannot pay its own way until the accompanying farming system has reached a fairly advanced stage of commercialization, e.g., supplemental irrigation for Kenyan coffee farms or valley-bottom irrigation on Zimbabwe's large farms. The implication for donors is, therefore, that some element of subsidy is inevitable if a country intends to proceed in developing irrigation. The operational question is then not whether to subsidize, but where, when and with what consequences? If so, a financial appraisal is not enough: a country must also look at the economic costs and returns, both at the enterprise level and for the sector as a whole.[1] Questions to weigh include whether to finance initial construction on a grant basis, leaving the host country to concentrate on financing recurrent costs?[2] Can the nation afford to exempt its irrigation schemes from duty on imported inputs? Should an irrigated cereal crop enjoy a

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[1] An excellent study which does distinguish between financial and economic considerations, private versus social profitability, and marketing as well as production costs is the five nation Stanford comparison of rice in West Africa (Pearson et al., 1981).

[2] Grant-financed initial construction may, in fact, leave countries in a worsened situation because of their acute recurrent cost constraints. Here see Finney (1984) and the whole literature on this topic.

protected local market? What about concessionary food imports? Would rainfed agriculture give higher or more reliable returns from a similar level of subsidy? What aspects can be left for on-farm financing, given that irrigation as presently encountered tends to be highly risky?

2. New Projects or Rehabilitation?

Obviously, in those countries like Niger or Tanzania where the rate at which already developed irrigable land is going out of production exceeds the development of new irrigation, rehabilitaion should take first priority. In recent years, this has indeed been the emphasis among most donors. However, experience with attempted rehabilitation shows the issue is not so clearcut:

- Engineering considerations tend to predominate during rehabilitation, when in fact the greatest need may be for "O&M" modifications.
- The need for rehabilitation is usually linked to a lack of adequate maintenance procedures. Unless these can be instituted within the local system, physical reconstruction will effect only a temporary improvement.
- Where the main system has been allowed to badly deteriorate, the costs of reconstruction can be just as high as for the building of new schemes.
- The pyramiding of new loans on top of old ones creates a crushing financial burden beyond the support capacity of many schemes.
- If the root cause for failure to do maintenance is a tight recurrent cost constraint influencing the whole system, this situation needs to be diagnosed and dealt with at a policy level first.

Thus, while the balance of effort in Africa probably should be directed towards improvement of existing irrigation, it does not necessarily follow that physical reconstruction of these schemes under external loan financing is what is needed. A carefully done, case-by-case comparative analysis of "O&M" deficiencies which makes rehabilitation necessary within existing schemes would appear to be precondition before effective remedial measures can be instituted.

3. Drainage or More Irrigation?

This report has argued that rainfall intensities are such in tropical Africa that drainage must be provided alongside any water supply improvements if these are fairly substantial in size. Farmers' lack of equipment and resource constraints make it unlikely they can add drainage works by local effort. A particular technical problem is how to achieve adequate drainage on the very flat alluvial plains in parts of the Sahel, e.g., along the Niger River or near Lake Chad. Elsewhere for the most part existing schemes can utilize the topography for drainage (provided that care is taken in the initial design). Health hazards and the removal of weeds from drainlines constitute a serious, often overlooked problem. For these reasons we should avoid replicating in Africa the arbitrary division between drainage and irrigation engineering which is found in the USA.

4. Large- or Small-Scale Projects?

If in Africa small-scale projects are not necessarily cheaper to build, they are nevertheless easier to withdraw from; managerial assistance by an NGO rather than the government is more feasible; they represent a smaller financial commitment; field layouts can be more adapted to farmers' needs; and there is at least a theoretical possibility farmers will be more involved and consequently more committed. We recommend, therefore, a bias towards assisting small-scale projects and technologies, traditional as well as modern. This recommendation is heavily qualified by reservations outlined in earlier chapters, and also touched upon by Carruthers (1983:70-71). It ignores the fact that schemes requiring large reservoirs or major canals are bound to be large-scale in nature. It also conflicts with a pervasive opinion within AID/Washington that small projects are just as demanding of supervision and management as are large ones. While this may be true, the consultants drawn upon in this study were nearly unanimous that in Africa smaller, flexible projects on average outperform the larger ones. One final point: these arguments do not rule out experimentation within large systems to decentralize scheme functions and increase farmer participation, e.g., as the Dutch have attempted in the Office du Niger.

5. Direct Investment or Price Support?

Carruthers warns that for irrigation to succeed, agriculture must be profitable (1983:71): "There is clearly no point trying to enforce water charges or other taxes if farmers do not have a reasonable income." He outlines a downward spiral where governments try to maintain low food prices while allocating an over-valued exchange rate and imposing inefficient bureaucratic controls on agricultural production. When production stagnates, the availability of cheap food aid on concessionary terms removes the pressure to allow a raise in farmgate prices. The dangers of this situation are by now well recognized (World Bank, 1981; Bates, 1981), particularly within USAID. (However, if we accept this argument at the farm level we must also recognize its validity at the country level, where adverse terms of trade vis-a-vis the industrial nations have a great deal to do with the current difficulties of irrigated cotton production in the Sudan or sugar production in Malawi.)

The central economic issue remains how to introduce irrigation technologies in systems where because of very small farm sizes and low productivity farmers cannot individually afford expensive capital improvements. While better prices might raise the ceiling on affordable investment slightly, the gap between smallholders' existing technology and what outsiders might recommend continues to be very wide. This explains why so many countries have introduced intermediary institutions whose service charges in turn depress farm prices.

6. Public or Private Development?

Carruthers is probably correct in insisting that irrigation development is one sphere of economic activity where both public and private initiatives are required (1983:72-73). This message will not satisfy either side in the continuing debate over "privatization," incentives and bureaucratic reform. The situation is further complicated in Africa because here "private" does not describe a unimodal cluster of firms. Instead, as a rule the "private sector" in African countries is sharply bi-modal, being split between traditional small-scale farming (and trading) and large-scale, export-oriented

"plantation" agriculture, as often as not owned by outsiders. A third group are the missionaries and other NGOs, but helping smallholders rather than the plantation crop sector.

While large-scale operators may cooperate with public agencies in sharing experience (something we recommend), their scale of operations is so much larger that on vital managerial aspects they have little that is suited to the smallholder. As noted above, this disparity explains why many African governments of all ideological complexions have been forced to establish intermediary service organizations to assist irrigated smallholder farming. Furthermore, most activities needed for developing irrigation -- testing of materials, design of new systems, modeling of aquifers, integrated planning of groundwater and surface supplies, controlling of saline intrusions -- are not activities the private sector will underwrite (Carruthers, 1983:72). Nor are the individual African regimes eager to see non-national firms play a larger role by being given privileged access to credit or preferential donor assistance. Thus, AID/Washington's policy mandate to give greater assistance to the private sector runs directly counter to local political realities in many ex-colonial African nations. To the extent that "aiding the private sector" will mean giving assistance to outsiders (e.g., Lebanese in West Africa or Asians in East Africa) or even to tribal elites, it often cannot become a stated policy. A possible resolution would be to encourage activities which bring both sectors together and to deepen institutional resources (training, research and extension) available to the whole irrigation subsector.

In regard to small-scale operators, AID has much greater flexibility for rendering support, but comparatively less to offer because such systems are so different from our own. There appears to be a genuine "technological gap" at the micro-irrigation end of the spectrum, where farmers are irrigating market gardens from very limited supplies. As a donor, AID could also underwrite credit for small-scale operators -- though this should be linked to training because of high risks and frequent failures. AID could do much more to insure technical backstopping for various NGO, PVO and Peace Corps projects active in small-scale irrigation. An assessment of "technology backstopping"

needs for small-scale NGO projects might be a suitable topic for an all-Africa workshop.[3]

7. Hydro-Power versus Irrigation?

Hydro-power generation and irrigation needs can come into competition in several ways. If irrigation is developed upstream from power generation, the loss of water can necessitate a significant reduction in hydro-power generation -- as, for example, Tanzania's irrigation schemes in Mbeya Region above the Mtera and Kidatu dams on the Ruaha River. Where power generation lies on the upstream side, the need to maintain flow even in the rainy season will reduce water storage available for dry season irrigation. But much the most important interrelationship concerns the cessation of annual flooding on rivers where this may have been significant to farmers, e.g., the Aswan High Dam on the Nile (Waterbury, 1979). In West Africa, on the Senegal and Niger Rivers, farmers practiced "decrue" (or "recession") farming, planting their crops on river terraces as the floodwaters receded. While not "irrigation" in the strict sense, this tradition made maximum use of scarce moisture and existing clay soils in an otherwise barren environment. It is sufficiently important that the new upstream dam on the Bafing River (a major source of the Senegal's fow) has been designed to provide an artificial "flood" through controlled water releases. For similar reasons, some have proposed that Tanzania's Steigler's Gorge Dam (not yet financed) should also allow for controlled downstream flooding in the Rufiji Delta (_____). In either case, the artificial "flood" will lack the sediments which are mainly deposited in the reservoir's upper end.

One might question spending time on this issue when throughout this report large projects have been downplayed. However, three added facts are relevant. First, the tradeoffs between hydro-power, dry season irrigation and "decrue" (or equivalent, downstream pump) farming are a significant issue in three countries high on USAID's priority list

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[3] AID policy on the public versus private issue is discussed at some length in Steinberg (1983:57-60).

(Egypt, Sudan and Senegal) and also in systems which derive their water from neighboring countries, e.g., Somalia and Mozambique. Second, Africa has a tremendous, though underdeveloped hydro-power potential. At some time in the future the continent will surely overcome its structural disabilities within the international exchange system. It would be very helpful to have worked out in detail the interrelationships between power generation and agriculture before further large schemes are launched. Third and perhaps most appropos to this report, it is discouraging to see high voltage transmission lines passing right over irrigable lands in countries where water pumping still depends on diesel engines. Hydro-power in Africa has largely been used for industrial development, not irrigation. Since the continent does have such large reserves of untapped hydro-power potential, the present energy constraints within irrigation ought to be viewed as an inheritance from the past and not a constraint upon future development.

8. Hardware or Management?

Many think this is the overriding question to be addressed in African irrigation. It is difficult to answer, because the usual means donors employ to gain influence over project management is through financing increments to "hardware." Without building new schemes, would donors be allowed to assist on "O&M" issues? In Africa, the answer might well be "yes" for the simple reason that Ministries of Agriculture find themselves hard pressed to plan and supervise irrigation development.

In the section on irrigation management, seven types of "software" were identified as potentially contributing to the effectiveness of irrigation in Africa. Not all are operational at the moment -- which partly explains glaring gaps and weaknesses in many of Africa's present schemes. Let us recapitulate what the seven types of management include. First, there is the general planning and supervision at the sector (Ministry of Agriculture or Irrigation Board) or river basin level. Second, there is often a temporary but strategic managerial phase responsible for scheme construction -- particularly if surface irrigation of more than say, about 50 ha, is contemplated. Third, one

often finds in Africa a scheme or agency management in charge of a given perimeter or system: sometimes a formally organized settlement scheme (as in Kenya's NIB settlements or Zimbabwe's lower Sabi schemes), other times maybe just a small PVO unit. Fourth, there is always a need for hydraulic ("main systems") management of the pumping or intake facility and the linked distribution mechanisms. Fifth -- though this is often the missing element in Africa to date -- there may be a user organization involved in water allocation, dispute resolution and maintenance. Sixth, we must also recognize on-farm water management, which will involve the control of land, soil, crops, water and people. And seventh, over time there may emerge need to manage the socioeconomic and environmental impacts of irrigation. Of these seven levels where "software" is definitely required, few authorities on irrigation recognize more than three or four. Because of the particular problems encountered in Africa, here irrigation advisors need to become cognizant with all seven.

A principal message of this report has been that these levels are rarely considered jointly. Each managerial unit concentrates on its phase in the project cycle in the hope that ultimately crops will be grown and farmers benefit. Indeed, one cannot even tell from the literature on most schemes what managerial practices are in general use. One suspects that as currently implemented, irrigation "management" concentrates on physical construction -- always a particularly demanding task in Africa -- with "scheme" management coming in once a perimeter is "handed over." Enough is known about field difficulties (disease outbreaks, fuel shortages, power outages, sidelined pumps, poor seed, bird damage, crop spoilage, and missing or high cost transport) to suggest that there is very little margin for error.

We need to recognize that field operations under typical African conditions encourages an opportunistic, day-by-day management style which differs greatly from the procedurally complex routines outsiders often recommend. In stating Africa's need for better "software," we are not implying that the "high technology" routines coming into vogue among U.S. irrigation engineers represent a good, or even workable, solution.

Instead, the argument is that the managerial sphere must be where attention is concentrated in an effort to earn how and why existing systems "go wrong." Only then can one select among "software" options and design more effective forms of training.

9. Conjunctive Use of Groundwater?

Where water supply from flowing rivers is so difficult, the question naturally arises whether instead irrigation should not draw upon "tubewells" (or "boreholes," as they are called in Africa). At a policy level, the answer obviously must be "yes" -- but strongly qualified by recognition that pumping has a particularly bad record in Africa and that there may be large areas where the low yield from wells cannot support anything beyond a very small patch of irrigation. What donors could assist with is in promoting the exchange of experience between those working on household and community supplies, often based on pumping, and the irrigation sector in the same country. European donors such as SIDA and the Dutch have put heavy investments into development of community supplies in Africa, and have accumulated valuable experience.

10. River Basin Authorities versus Individual Schemes?

We have noted that many African countries have created river basin authorities responsible for planning resource development in their respective areas. The degree of executive involvement varies, ranging from those like Senegal's SAED, carrying direct operational responsibilities for small-scale projects, to those with purely planning functions like Tanzania's RUBADA (for the Rifiji Basin) or Kenya's TARDA (for the Tana and Athi River Basins). The prior existence of such agencies gives an additional option to donors interested in assisting African irrigation. In many countries, donors have three basic probabilities: (a) assistance to individual field projects; (b) support to the irrigation section in the Ministry of Agriculture; or (c) support to one or more river basin authorities (RBAs). The policy issue then becomes to determine under which circumstances irrigation agencies, ministry units, river basin authorities, or individual projects merit

which kinds of assistance? No general answer applicable to all of Africa is possible. The priority placed on irrigation differs from country to country, as do the levels of performance shown by outwardly similar organizations. One can, however, identify the advantages and disadvantages of assisting the RBA-type units.

The principal advantage is the fact already noted that RBAs are often the only administrative units which already possess a rudimentary irrigation planning capability. If an aim of assistance is to deepen in-country technical capabilities, then the RBAs constitute a feasible starting point. Most are parastatals, and as such, have a better chance to attract and retain specialized staff. Irrigation planning is usually already within their formal scope of operations, so that complicated negotiations and new legislation are unnecessary.

Their orientation towards planning can also become an obstacle, if it becomes an end in itself or if inappropriate methodologies are adopted. Vincent (1984:28) warns that American concepts of river basin planning can be quite detrimental in an African context. And, one might add, very expensive: development agencies can soon develop an enormous appetite for an interminable series of "preliminary investigations."

In view of the latter danger -- which African experience indicates is quite real -- we suggest that AID might concentrate on developing more appropriate and cost-effective training and research methods for RBAs. Among these might be:

- Training at a Master's level in irrigation-related fields;
- Regional or Africa-wide seminars to direct attention to new concepts, procedures and resources (e.g., farmer participation, remote sensing applications); and
- Derivation of simplified planning and monitoring techniques which would be more cost-effective under African conditions.

11. Scope for Alternate Energy Sources?

If African peasant farmers depend mainly on human or animal power, and if irrigation agencies have such difficulty obtaining fuel, why cannot other forms of renewable energy be employed? Each of the alternative source -- methane, windpower, solar power, photovoltaics,

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and even new domesticates like water buffalo -- has its adherents. The record so far, however, suggests once again that caution be exercised. Any alternate energy source which itself requires complicated technology is likely to malfunction in the harsh African environment. Similarly, any "appropriate" technology which is vulnerable to neglect or misuse is also likely to fail.

In the longer run, it may be feasible to power small-scale equipment from photovoltaics (provided the vandalism problem can be overcome), just as the inclusion of lucinae stands within a surface irrigation system could provide the raw material for biogas generation. A more risky and still longer-run option would be to copy Brazil in using sugar byproducts (ethanol or alcohol) derived from irrigated production for powering scheme equipment. All three options are techically feasible today, but represent fairly high risk possibilities in the more remote parts of Africa for primarily managerial and environmental reasons. What is clear is that energy costs continue to rise, while farm operations remain energy-starved for want of a cheap and readily accessible fuel. Thus, further experimentation is warranted, and meanwhile the calculation of energy budgets (both in the ecological and in the financial sense) ought to accompany any in-depth analysis of proposed irrigation developments.

12. Swamp-Rice versus Rainfed Rice?

Africa has its own traditional varieties of "upland" rice, which appear to have been domesticated within West Africa itself (Harlan, 1985). In recent decades, flood-basin types from Asia have been replacing upland rice in the coastal, West African countries even though proportionately rainfed rice production is still far more significant. Nevertheless, by draining valley bottom lands ("swamps," though many dry out seasonally) and switching to wet rice varieties, per hectare yields can be greatly increased. Most state-sponsored have been of the "swamp rice" or valley improvement kind. Since, as we have seen, seasonally waterlogged lands are widely found throughout tropical Africa, the issue arises whether or not valley improvement schemes are as cost-effective as equivalent investment in "rainfed" upland production. At the country

level, several USAID analyses have addressed this question -- usually in the form of a crude contrast between "irrigated" versus "rainfed" development -- with the usual result being to recommend concentration on rainfed production.

In reality, it is not quite so simple. The valley-bottom "vertisols" represent some of the best agricultural land available provided they are intelligently used with suitable technologies. The division between "irrigation" and rainfed" cultivation is here also arbitrary, since what usually occurs is not full irrigation, but rather a combination of drainage, impoundment (for "wet" rice), and some supplemental water to extend the soil moisture regime. Within individual countries of West Africa one finds a diversity of rice production systems extending along a continuum of gradually increasing investment intensity. While some "polder" type swamp schemes can be extremely expensive, others based on slight modification of farmers' existing technology are not. The Stanford comparison of rice production in five West African nations gave different results for each country and for individual systems (Pearson et al., 1981). We therefore recommend an updating of the Stanford analysis employing present prices and incorporating additional crops (wheat, sorghum and cotton), while focusing more agricultural engineering attention on the technological issues inherent in valley-bottom improvement.

13. Rightholders versus Cultivators?

Tenure problems arise as an issue because in Africa those controlling plot rights -- whether they are bureaucratically appointed managers or male kinsmen in charge of a compound -- often cannot provide the labor irrigated production requires. Since this is also true for much of Asia's irrigation, observers may have been slow to recognize its ramifications in the African context. The "problem" exists because in either of the two contexts -- scheme or compound -- those recognized adminisratively and socially as rightholders are under minimal pressure to acknowledge cultivators' claims over irrigated land and its production. For example, when irrigation schemes insist upon retaining rights of eviction over tenants, they create a psychological climate

wherein the individual farmers will be unwilling to invest in long-term improvement, or sometimes even in canal maintenance. Similarly, if household bonds are weak and a woman anticipates being dispossessed (of either her home or her share of crop returns), she is unlikely to provide the substantial labor input which irrigated rice or cotton requires. If the household head is away on labor migration -- as African males often are -- the woman left behind may have no authority to incur capital investment or even to receive production credit. The looseness of household ties in traditionally polygamous Africa constitutes a major difference from many parts of Asia (and Madagascar) where a fairly tight integration of household activities underlies the success of irrigated production. The "success" stories like Taiwan are often countries where the tradition of unpaid family labor has been strong. In Africa, to the contrary, those expected to do much of the field work do not receive support from the larger social system to insure a fair distribution of profits. Thus, agricultural economic analysis, which assumes that households operate as a family firm with shared resources and profits, can yield quite misleading results if uncritically applied in an African context. There is ample evidence that those doing field work are not utilizing irrigation to the full extent which is technically feasible. While one can guess at their reasons, such guesses constitute an insufficient base for policy formulation.

We recommend, then, that targeted research under various social and technical systems must be undertaken. Furthermore, donors who finance irrigation projects are in a position to insist that procedural changes are made which give greater security to cultivators. It is a strange situation indeed that in rural systems where women had quite strong traditional rights to irrigated food crops, under "modern" bureaucratic schemes they lose these safeguards. Some fairly simple procedural improvements are usually feasible. One could insist, for example, that daughters as well as sons could inherit plotrights; that whoever is in day-to-day charge of the crop can be issued credit; and that houseplots can be owned by families outright (thus safeguarding the value of house improvements). Some countries have already implemented such changes;

exchanges of operational experience might facilitate the diffusion of better procedures aimed at increasing household security and intra-household equity.

14. Full Control versus Supplemental Irrigation?

It will be noted that the question usually posed, whether to stress irrigated versus rainfed agricultural development, has not received as much emphasis in this report. Here we suggest an intermediate position makes the most sense. We note that commercial farmers in East and Southern Africa have usually found it necessary to develop supplemental irrigation in order to achieve reliable crop yields. If so, the same need probably exists within smallholder farming. Regularization of rainfed crop returns by stabilizing planting dates and eliminating the within season dry spells might represent a more desirable (and water conserving) objective than "full" irrigation with its heavy water demands. The main problem is, of course, the high cost of present technologies for achieving this objective. Generally, the large-scale farmers in Africa employ movable piping and overhead sprinklers, requiring heavy initial investment. Some suggest that drip irrigation represents an ideal compromise where water is scarce, but here, too, practical difficulties -- termites and impure water -- are encountered. Perhaps the answer is to incorporate water harvesting during the rainy season; or else to add a rainfed, supplemented crop grown alongside the area used for "full" dry season irrigation. We do not yet have answers, but the need to pay more attention to partial irrigation seems obvious (repeating a point made vis-a-vis "swamp" systems).

15. Technology Transfer or Technology Development?

The final issue is one which underlies many aspects of this review: the selection, adaptation and support of irrigation technologies. Questions which come under this rubric have surfaced again and again in this review. For example, it is clear that some irrigation techniques must be accompanied by certain technological capabilities (e.g., freedom to import parts or access to streamflow data) before they can be used effectively. But which ones depend upon which "upstream" support

capabilities? Again, when should African governments accept "orphaned" equipment imported at donor insistence? (This has been a frequent issue in irrigation because rapid repair is usually essential.) Which aspects of US, Egyptian or Asian irrigation experience can be transposed directly into African practice? Are there "miracle" technologies (like drip irrigation) which might dramatically improve output within African irrigation? Can systemic weaknesses at the local level be offset technologically by increased investment? Why are even simple technologies like pump-set operation so problemmatic in rural Africa? Can given technological packages such as Dutch polder techniques be disaggregated and employed selectively? When and where should donors sponsor technologies which are new to Africa, such as overhead sprinkler irrigation or satellite-based "early warning" systems?

Whatever one might conclude theoretically, such questions are at present answered largely by default. Particular donors almost invariably stress the kinds of technology already in use at "home" or developed in their former colonies (e.g., the "Gezira" system). It is clear that for the large-scale commercial producers who enjoy exemption from currency restrictions, the standard "off-the-shelf" solutions from advanced nations can usually be made to work under highly standardized, plantation crop situations. However, as soon as one must deal with typical smallholder situations in the more remote communities, technologies tend to become quite problemmatic unless carefully adapted to circumvent local constraints. The adaptation and support elements are often overlooked in programs aimed at direct technology transfer. Since irrigation is essentially a repetitive activity, involving a network of support institutions, we recommend that donors put greater stress on deepening local technological capabilities.

Gaps

The scope of work for this overview specified that it should identify priority areas needing further attention -- the "gaps" within present research or within the existing distribution of institutional effort. What are, then, the most significant missing elements whose lack contributes to the present low efficiency of Africa's irrigation?

1. Irrigation Engineering

At several points in this report it has been pointed out that irrigation engineering in the American sense is largely absent from Africa, except perhaps in the Sudan and Egypt. When tasks requiring irrigation expertise arise, decisions tend to be made either by civil engineers (at the design and construction phases) or by agronomists (in scheme operation and water management). Few of the civil servants who staff Africa's river basin authorities and ministry-linked irrigation units are actually professional irrigation engineers. Most come to their assignments from other professions, and see themselves more as employees of the agency than as irrigation managers per se. As a consequence, the handful of qualified irrigation engineers in each country will be preoccupied in dealing with donors and reviewing new projects. While the manpower gap is being gradually closed by recruitment of newly trained professionals, "irrigation engineering" does not exist as an integrated field combining elements of design, construction and water management within a single discipline.

On the one hand, this situation leaves room to shape the emerging discipline in ways more suited to Africa's needs -- as, for example, in combining aspects of drainage and irrigation right from the start.[4] On the other hand, it also explains the technical void encountered in most countries on matters related to water management. Without enough trained professonal staff, African irrigation agencies rely heavily on outside consultants and on accidents of bureaucratic precedent to determine their managerial systems.

2. Manpower and Sector Planning

Few African countries have in hand systematic plans for the strengthening of manpower support for irrigation development. Most have never analyzed staff needs in the irrigation subsector, nor do they have

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[4] In-country programs for training irrigation engineers constitute an obvious area where fairly modest donor commitment might have major long-run impacts. If we look at numbers being trained, Egypt is at present by far the largest source for African professional manpower in relation to engineering and irrigation (FAO, 1984).

accurate or even up-to-date statistics describing the sector. Sometimes, as in Kenya, individual units have good documentation, but the overall effort is badly fragmented. More typically, as in Somalia, the necessary information for irrigation planning is simply not available and no realistic program for staff preparation exists. Of course, staffing weaknesses go hand-in-hand with an absence of sector planning. As a consequence, in most countries technical design and even field supervision depend on donor-financed, expatriate staff who leave when their contracts terminate. We have pointed out that this situation greatly reduces the possibility of organizational learning taking place within local agencies officially responsible for irrigation. Even after two decades of external assistance, many African countries have surprisingly little institutional capacity for planning and managing their irrigation subsectors.

3. Project Documentation

For African irrigation, the "literature" such as it is consists mostly of project documentation: preliminary reviews, appraisal reports, design specification documents, donors' performance audits, a sprinkling of trip reports, terminal reports and project evaluations. For most larger projects, several consultancy firms will have been involved. Their reports are user-commissioned. Sometimes individual authors rework their data for academic publication, but much more commonly the reports can only be found in the firm's headquarters or stacked against the back wall of some minor official's office in the recipient agency. Officials receiving this documentation have no incentive to integrate the information into a larger picture; and, indeed, the site and project-specific format makes synthesis difficult. If a report is utilized at all, it will generally be to provide some snippet of factual information which can be incorporated in a subsequent report on the same area or project. In many African countries, the only general collections of such technical materials occur in donor's offices, particularly within USAID and the World Bank.

This background accounts for the thinness of US documentation on African irrigation. The two principal exceptions are US theses based on

African field research and the World Bank's home office collections (to which access is usually restricted). For the bulk of materials on African irrigation, one must travel to company offices in England and on the continent or to library collections in Germany, Holland, London, Paris and Rome where the larger volume of donor-financed activity has originated. In particular, we suggest that there is a need for an inside review of documentation held in the United Kingdom, since British consulting firms have been especially active in Africa.

4. Vertisol Management

Vertisols -- what a lay person calls "black cotton clay soils" -- are found throughout the tropics, wherever soil formation occurs under circumstances of impeded drainage. Such soils constitute an important resource because of their moisture retaining capacity and their differential fertility, not only in Africa but also in India and Brazil (where they are also significant). In the review of technical aspects, it was pointed out that while these soils are difficult to work with light equipment, they are nonetheless the site for most flood basin irrigation of rice in Africa. Depending on the situation, they may be either acidic (highland swamps and coastal mangrove swamps) or alkaline (saline "pans" in closed drainages). The main point is that they react to moisture very differently from the sandy loams prized by plough farmers. With vertisols, canal lining may be unnecessary -- a significant advantage in Africa -- but water control structures must be specially constructed. Also, their high moisture retention may permit preirrigation and the growing of a subsequent, "ratoon" crop. For all these reasons, while vertisols constitute a key resource, they require distinctive engineering and agronomic management. Individual African countries are rarely in a position to tap the continent-wide experience with such soils. We suggest that donor support for exchange of managerial experience, coupled with further research to identify the most cost-effective crop and equipment combinations, would be something AID should consider. Any such exchanges of experience should also draw in irrigation engineers from Egypt, India and Brazil.

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5. Weed Control

An unexpected finding has been that control of weeds -- terrestrial as well as aquatic -- is a major difficulty within African irrigation. Terrestrial weeds are, of course, usually treated as a farm-level problem, whereas aquatic weeds are seen as a threat to the water management system as a whole. Nonetheless, both types pose a high level of threat to irrigated production. Without repeating the technical arguments about "red rice" and other common weeds, we note simply that the partial completion of scheme works which often occurs provides ideal circumstances for rapid weed growth, just as do tropical canal systems for aquatic weeds. More attention to this aspect is imperative, since there are good reasons for suspecting that under typical conditions for smallholder production the degree of weed challenge may be far greater than is commonly acknowledged.

6. Maintenance

If, as earlier WMS II studies suggest, physical rehabilitation is in effect the provision of "deferred maintenance," then it seems plain that maintenance has been the weak link in many African irrigation schemes. The resulting deterioration is evidenced by inoperable equipment, by weed-choked canals, and by the erosion and failure of physical works. To the outsider, it seems poignant that such expensive irrigation works should be allowed to deteriorate so rapidly in such poor countries. Tractors and pumps which could have served for ten years may have an average working life of two to three years. Some schemes now require rehabilitation before their original loan financing is half repaid. Observations of this nature explain the nearly unanimous agreement that poor maintenance constitutes the single most important unresolved problem in African irrigation. Of course, it is linked to many other issues: recurrent cost constraints, the impact of currency and import restrictions, farmers' alienation or insecurity, improper design, seasonal bottlenecks in labor supply, etc. We reiterate, therefore, a plea made in last year's review of Sahelian irrigation: that this topic should receive top priority within any field research that donors might finance (Moris, Thom and Norman, 1984).

7. Irrigation Extension

As a rule, either irrigation "extension" is derivative from scheme requirements and confined to the project/scheme environment (as in Gezira, the Office du Niger, or Kenya's National Irrigation Board's schemes) or it is totally absent, leaving a void between the water supply section and the usual, rainfed farming orientation of the general extension service (as in Somalia). To irrigate successfully in Africa, farmers require a number of specialized skills: knowledge of how to level their fields, the signs of moisture stress in plants, when to stop watering, control of salinization, interactions between watering and fertilizer use, how to avoid waterlogging and unnecessary erosion, synchronizing irrigation activities with rainfed farming, how and when to do maintenance, the rotation system (if practiced), signs of nematode buildup, and how to recognize and control weed growth. This incomplete listing is sufficient to indicate that there is a fairly large element of skill and local experience needed.

Farmers who have grown up within an irrigated farming system (such as in Gezira or Madagascar) probably acquire most of the necessary skills informally. Elsewhere on the continent, to the contrary, adult farmers who in other respects know a great deal about plant husbandry may nonetheless lack these special skills. Where initial extension and training has been weak, farmers become entirely dependent on scheme management for advice, and they are likely to perform certain key operations (like field leveling) so poorly that yields are greatly depressed. This situation in turn reinforces stereotypes held by managers and staff about farmers' low motivation and interest, setting in motion the issuance of unexplained directview?? which further depress farmers' performance. The need for advance instruction is particularly great when irrigators are former pastoralists, whose traditional way of life differs at almost every point from what is required in irrigated farming.

Hardly anything is known about the actual content of "irrigation extension" as it occurs in Africa. There is an urgent need for comparative data of this nature, since the World Bank is wily-nily imposing its India derived "training and visit" system on most

African countries which accept its financial assistance in the irrigation sector.

8. Intra-Household Economics

Identification of household economics as a "gap" may strike African specialists as strange, since there is a huge literature on the continent's systems of production and exchange. There are even a number of detailed sources on the role of women in African peasant farming. The "gap" is not, therefore, a lack of basic sources, but refers instead to failure to integrate and apply this knowledge within analyses of irrigated farming. In part, there is a gap if we are interested in detailed economic analysis of the irrigated subcomponents within larger arable farming systems. However, there also appears to have been deliberate blindness towards likely production costs, since to have accepted realistic estimates would have wiped out the apparent benefits which were being claimed for irrigation projects. Incorporation of more realistic figures on likely yields, labor costs, time scheduling, etc. would have made it clear that most African irrigation projects have been problematic right from the start.

To understand future irrigation performance, donors must become willing to incorporate actual field data reflecting typical conditions into project appraisals and evaluation. In systems where households are only loosely integrated, allowance must be made for the possibility that returns within the household unit may be insufficient to guarantee the necessary commitment by women and other farm laborers. Analyses must also take into account the opportunity cost of farm labor during the peak bottlenecks so characteristic of African hoe cultivation. Planners must recognize women's strong commitment to achieving food security, and their limited access to credit which forces them to give priority to low input, rainfed cultivation even under conditions of high risk. In short, there are a bundle of agricultural economic issues which require knowledge of patterns of internal household organization within African farming systems. While many of these relate specifically to the woman's sphere, there are also other aspects of a more general nature requiring similar data. Estimation of farm investment potential, labor costs,

livestock economics, locational economics and intra-household distribution requires a type of applied household economics which is not yet available for most settings where irrigation might be considered.

9. US-Based Irrigation Expertise

The thinness of US documentation on African irrigation is matched by equivalent weakness in regard to irrigation expertise. There are only a handful of practitioners in the USA with professional interests in the various aspects of African irrigation. It was anticipated that there might be few US irrigation engineers interested in Africa, but in fact, irrigation economists are just as scarce. Yet, paradoxically, one finds numbers of younger scholars eager to work on applied aspects of irrigation development -- individuals with the necessary field acquaintance and language skills, but usually lacking technical training in irrigation or sufficient support to maintain an active involvement.

Given the lack of senior specialists, it is apparent that AID's future programs will depend upon expanding the numbers of younger professionals in irrigation-related fields. We strongly endorse the concept of "tag-along" assignments, whereby younger workers are funded to accompany the few senior experts on applied assignments in Africa. Another option might be to initiate an exchange program, wherein US graduate students lacking field experience might "fill in" at the host-country level for nationals who come to the USA under long-term training arrangements. Still another need is for establishment of two or three US centers where there is adequate documentation and staff background to provide relevant short and longer term training oriented towards African water management.

The difficulties we have encountered in assembling this report from (mainly) US sources will also apply when efforts are made to train African nationals within the USA. It is clear that US institutions have not paid much attention to African irrigation, and have relatively little to offer when it comes to an integrated, relevant perspective. To give adequate managerial training always requires having at hand a wealth of materials related to the problem: case studies, exercises, description of field constraints, etc. At present this context relevant

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to African circumstances is missing within US technical training, which instead perpetuates a bias towards further specialization and "high technology" solutions.

AID Strategy

The message our review holds for AID/Washington may at first glance seem contradictory. African countries will be forced to rely more on irrigation in the future, and -- in view of the low levels of present performance -- have an urgent need to learn how to use irrigation technologies more cost-effectively. Nevertheless, because in most African countries USAID has become a minor donor, we cannot recommend any dramatic increases in AID's direct financial support to underwrite new irrigation projects. Existing African irrigation projects are simply too expensive to warrant receiving scarce investment funds from a small donor. This conclusion is strongly supported by the background papers prepared independently by Vincent, Humpal and Sparling (DATE). It also echoes the World Bank's "Berg Report" (1981:78), and Carruthers' OECD review (1983:15), both of which recommend an initial concentration of attention on improving output from present schemes rather than upon starting new ones.

Instead, the consensus among nearly all expert observers is that first priority within the irrigation subsector should be to strengthen its institutional capacities. As a general strategy, this has the advantage of providing a base for future project funding while also assisting countries to get higher returns from already committed projects. In a few instances where a country is heavily dependent on its irrigation sector (as in Sudan and Somalia), the U.S. Government may find it politically desirable to intervene at the production level, but even in these cases we recommend AID moves cautiously. At present, the USAID system in Africa, both at regional levels and within country missions, simply does not have enough qualified irrigation engineers to plan and supervise an expanded portfolio of irrigation projects. An immediate area for attention should be to expand US technical capabilities for dealing with irrigation and water management issues in African contexts. Thus, improvements in "institutionalization" are

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needed in the USA itself as well as in recipient nations.

By "institutionalization," what is meant? Basically, "institutional measures are those which increase the capacity of national, regional and local systems to use irrigation more intelligently. More effective irrigation planning, based on actual field information and realistic premises, is one obvious requisite. Ways must be found to stimulate feedback from the farm and scheme levels. Decision-making procedures themselves need revision, so that once problems are identified they receive prompt and effective remedial attention. An organized capability to provide specialized assistance when individual schemes need help must be created. And, of course, projects must be institutionalized at the local level so that scheme users -- the farmers themselves -- understand what is required and participate to insure the success of their own irrigation.

In reviewing how AID might best render such assistance, we have kept two limitations in mind. First, over the past two decades USAID in Africa has paid little systematic attention to support for irrigation. Very little of value can be found in AID's Washington-based documentation service on African irrigation. When US firms have been active implementing irrigation-related activities (mostly in the Sahel), they have as likely as not employed French Canadians or European engineering staff on those aspects requiring detailed African experience. For East and Southern Africa, USAID has neither the engineers nor the documents required for an upgraded program of institutional support. We must therefore be realistic in assessing which are the areas of comparative US advantage, recognizing that on some desirable topics the US has little to offer. Second, except in a few countries, it is quite unlikely USAID will ever serve as the major donor assisting irrigation. Among other donors, the Dutch, Germans and Japanese are already far ahead and will likely remain so. This situation makes it desirable that AID coordinates its input to take into account what other donors are already doing within the continent. It also suggests we cannot rely upon "spin-off" benefits (participant training, etc.) from USAID's present projects to meet the main need for institutional strengthening. If this becomes AID's goal for the

irrigation subsector, it must be addressed directly.

Taking the above limitations into account, we propose . . . options as suitable areas for immediate AID support:

1. Cooperation with other donors:
2. Incorporation of Irrigation into FSR Projects
3. Scheme and Systemic Malfunctioning
4. RBAs and Irrigation Planning
5. Remote Sensing Applications
6. Women-in-Irrigation-Development
7. Deepening of US Capacity

1. Cooperation with Other Donors

In the short run, AID needs to incorporate the experience of other donors which have been active in assisting African irrigation. In saying this, we do not imply that these countries necessarily have better water management expertise than does the USA. The point is simply that documentation on irrigation consists largely of project reports of one kind or another: appraisal estimates, site surveys, trip reports, managerial audits and terminal evaluations. Such materials are usually commissioned, and rarely find their way into academic collections outside the country where they occur. In Africa, the main donors have been the World Bank, FAO, France and England; supplemented in recent years by the various development banks and funds and newer donors such as the Dutch and Germans. To consolidate Africa's present experience with irrigation, one must start with the agencies and donors who have been doing actual irrigation projects -- and that means going outside the USA (with the World Bank's Washington headquarters being the one notable exception). Our inability in this study to tap these other sources -- except for those in France, which were visited -- was a serious limitation, which probably reduces the general applicability and validity of our conclusions.

Beyond talking to those who have implemented irrigation in Africa, AID should reach a policy decision to participate vigorously in various low level, multilateral activities which are already under way. For

instance, FAO and the Dutch have strongly supported small-scale irrigation in Africa (Underhill, 1984), and FAO is taking the lead also in analyzing women's participation (Dey, 1984). Both kinds of activity merit additional support, and would constitute excellent starting points for a collaborative effort. AID should strengthen its representation at the various regional conferences on irrigation, which have become more important as the number of donors and potential recipient nations have increased. Assistance might also be given to ODI's irrigation network, which has reached a size where to remain effective it must have additional resources. None of these initiatives seem very glamorous, but they have the advantage of bringing US technical personnel into contact with those involved on a day-to-day basis in the planning and field implementation of African irrigation projects. Another source closer to home is the World Bank, which despite its policy pronouncements, remains closely tied to a number of large investments in African irrigation. While liaison between the Bank and AID in Washington has been smooth, for irrigation expertise the Bank has generally drawn on non-US sources. One way or another, AID and its associated contractors must develop direct access to an experiential base on African irrigation before other forms of institutional support become feasible.

2. Incorporation of Irrigation into FSR Projects

Currently AID has under way several farming systems research (FSR) projects in Africa (in Sudan, Tanzania, Malawi, Ruada, Burundi and Botswana, among others). The rationale for these projects has been the need to identify existing constraints and to describe the needs of various farming systems. Similarly, ILCA has sponsored several in-depth investigations of the role of livestock enterprises within the larger farming systems (with regional centers in Kenya and Mali as well as in Ethiopia itself). Then, under AID funding CIMMYT has its East and Southern Africa program, based in Nairobi, but conducting farm-level diagnostic surveys and seminars throughout the region.

Irrigated production exists as a significant option in many of the countries where FSR research is being done. The failure of researchers

to give it explicit consideration probably stems from the fact already noted that irrigated enterprises are often only a subcomponent within larger, non-irrigated systems. Also, early FSR research was preoccupied with rainfed, arable farming to the extent even of ignoring livestock enterprises which were also often present. We suggest that there is no defensible reason for arbitrarily excluding irrigation and livestock aspects from FSR, even in systems where these various enterprises are not tightly integrated.

Adding an irrigation component would thus complement existing FSR activities. From AID's standpoint, since these are already funded projects, some finance might already exist which could be tapped; or, alternatively, a minimal startup period would be needed if it were decided to broaden their objectives by additional funding for attention to irrigation and water management aspects. Several specific changes might be instituted along with such modifications: (a) incorporation of more attention to farm decision-making and intra-household aspects; (b) careful attention to competition between rainfed and irrigated enterprises; (c) analysis of the institutional risk which farmers incur when attempting irrigation; (d) analysis of on-farm labor costs and returns, between enterprises and throughout the season; and (e) estimation of returns from different potential innovations. The value of such information for understanding why irrigation has not been popular is obvious.

3. Scheme and Systemic Malfunctioning

A broad review such as this one, based mainly on a literature search, can only provide rough estimates of systemic performance. Numerous examples were given in earlier chapters to support the conclusion that Africa's irrigation performance is generally far below its design potential. Suggestions were also given why irrigation has been so problemmatic, but here the findings are of necessity more tentative. Only a handful of field visits were permitted; field practitioners were, with a few exceptions, not interviewed; and the engineering component is very poorly covered in the available US literature. It would seen essential, then for AID to further refine the

broad conclusions advanced within this report.

Three possibilities for doing so suggest themselves. First, better coverage of individual scheme experience would seem imperative. There are whole countries not covered in this report (e.g., Angola and Mozambique, as well as most of central Africa), just as there are many interesting schemes where the documentation is not available within the USA. Second, it might be fruitful to look at irrigation systems region by region -- a task fairly well in hand for the Sahel, but barely begun for Africa's other regions. There are pronouced regional differences which are bound to have direct policy implications; and, in any event, AID's own approach to project monitoring makes use of regional REDSO units. Third, it would be productive to look at particular technologies or situations (lakeside pumping; flood rice cultivation; swamp improvement, etc.) comparatively. (Since these constitute a very large agenda for potential action, we stress the need once again to avoid duplicating what other donors may have already begun.)

However obtained, more precise knowledge of the causes of scheme and systemic malfunctioning must be in hand before investments of the usual "institutional building" variety are launched. Public agencies have such an insatiable appetite for conferences, courses, training modules, publications, and the like that we cannot recommend the customary "shotgun" approach to deepening institutional capacity. First, let it become clear what the real reasons for poor performance have been, and then begin packaging remedial interventions.

Of course, gaining such information on schemes which are not USAID-funded will be difficult. Descriptions of main system management and present irrigation procedures are almost entirely missing, and must be created from scratch. In the process, it ought to be possible to learn why maintenance is so poor, necessary skills which farmers lack, and reasons for excluding them from meaningful participation. Informaton will also be required on the bureaucratic aspects of agency operation, and on the performance of necessary support institutions in the external environment.

4. RBAs and Irrigation Planning

As already noted in this chapter, AID could focus assistance for improving irrigation planning within the existing river basin authorities. Here the danger to avoid is to merely duplicate the present pre-investment planning which is already under way for the larger, multinational RBAs like the OMVS. Such projects simply substitute outside planners for local ones; they can become very expensive; and the large number of RBAs opens the door for a never-ending stream of requests. Instead, we recommend AID focus on improving existing methodologies and in-country capacities to do integrated water management planning. Topical attention (conveyed by means of short courses, regional workshops, etc.) might address needs such as development of rapid reconnaissance methods, better integration of soils information, exchanges of experience with regard to vertisols, identification of labor constraints and comparisons between technologies. RBAs might also benefit from manpower analysis and provision of externally assisted training to fill certain priority needs. They are strategically located to monitor environmental impacts, and might welcome assistance to facilitate this important function. In some countries where agricultural engineering has been established within higher level agricultural training, USAID might encourage linkages between training and river basin institutions. Another priority area would be to assist RBAs in evaluating and (where appropriate) organizing technology support to the irrigation subsector. Finally, RBAs should devise their own rating system for measuring scheme and project performance -- a development which might serve as a potent stimulus towards better performance.

In all instances, the goal should be to demonstrate an integrated, multidisciplinary approach in practice. Perhaps AID/Washington could select one or two river basins to serve as pilot areas for the application of more flexible, field oriented approaches -- maybe the Gambia and Juba basins? We assume further details about how such a program should be implemented will be forthcoming from AID's parallel review of four African river basins.

5. Remote Sensing Applications

Until recently, the USA has enjoyed a technological advantage in providing high quality LANDSAT imagery for African natural resource planning. Assuming that the non-military US remote sensing capability remains in the public sector, it offers substantial promise for estimation of rainfall coverage, and hence of irrigation demand. Weather satellite imagery has been drawn upon to provide relatively quick overall estimates of moisture and vegetative growth conditions. No other source can provide equivalent information for such large areas of the continent. We suggest such data should be integrated into a continent-wide "early warning" system, whose forecasts of impending drought would be shared with the countries concerned. In several key countries (from the perspective of US interests) this information, if provided promptly, could trigger a shift towards increased cereal food production in the irrigation sector, e.g., as happened in the Sudan this past year. There are undoubtedly other applications which also merit further refinement, carried out by collaborative teams of US scientisits and host country nationals. One suspects, for example, that spatial and trend analysis of the degree of environmental degradation taking place on the continent will continue to command policy-makers' attention. There is no reason why measurement of broad environmental trends cannot be combined with specific attention to hydrologic aspects. It would be a pity if at just the point where we are learning how to make these technologies genuinely useful, further financial assistance is withdrawn.

The above arguments constitute strong reasons why the US should maintain its present comparative advantage in applying remote sensing to the estimation and planning of natural resources. Of course, should Washington's proposals to "privatize" these publicly funded services be implemented, most LDCs will turn to other non-American sources which are already under development. If, for strategic reasons, the US government must fund such uses of remote sensing anyway, we consider it far preferable that this work is conducted in public where the countries being analyzed can participate and learn from the experience.

6. Women-in-Irrigation-Development

It seems that ultimately many issues in African irrigation revolve around gender-linked differences in farmers' commitment and access to resources. We note that the role of women in African farming is already an academic area where US researchers have a comparative advantage. One thinks immediately of Simmons, Fortmann, Staudt, Peters, Atherton, Jones and Spring (among others). Without recapitulating the points noted earlier in this chapter, we recommend that AID funds a modest "add-on" program targeted specifically at learning how African women participate in and benefit from irrigation. A topical focus on irrigation would give greater practical thrust to AID's present WID commitment, and might constitute justification for added support. The individual studies required would be mostly small-scale, to insure that intra-household aspects receive scrutiny. Perhaps the FAO office working on this topic or the two African REDSO units could provide an organizational base, to which researchers might be attached under a rotating, post-doctoral fellowship.

7. NGOs and the Private Sector

Another option for AID support would be to concentrate on helping the NGOs and PVOs active in African small-scale irrigation. For example, Kenya's small, PVO-assisted schemes reviewed by Kortenhorst have experienced many technical problems. Weber's background paper (1984) for this study cites numerous further examples from other parts of Africa. These suggest that small schemes can be just as problemmatic as large ones if designs are faulty or technologies inappropriate. Given that PVO staff are usually motivated and willing to experiment, helping them resolve technological and organizational problems might give AID access to a wide spectrum of African field experiences at comparatively low cost. There are individuals who have accumulated an in-depth understanding of particular aspects of irrigation development, but one usually finds they focus on only one or two elements of the larger process, and they are not free to advise beyond their own limited circle of projects. An outside organization (such as WMS II) could assist in pooling this valuable experience and making it more widely available.

In regards to private sector irrigation within African countries, there is an equivalent need to stimulate sharing of technological experience between large-scale, commercial operators and PVOs or public agencies working with smallholder farmers.

8. Deepening of US Capacity

The eagerness of US institutions for federal funds sometimes disguises the true situation vis-a-vis availability of manpower and resources to undertake requested technical tasks. This seems to be the case in regard to African development. While there are many American specialists with African experience, most are social scientists without in-depth understanding of the technical side of irrigation. Others lack the French or Arabic or Portuguese needed to undertake field assignments. And still others will find the deteriorating security and supply situation daunting. For all three reasons, we identified the thinness of US capacity as a major constraint limiting AID's scope of action in the short-run.

Remedial interventions should address both staffing and institutional resources. On the staffing side, we have suggested more use of "tag-alone" assignments to bring in young professionals who will acquire broadened field experience. This is particularly necessary in regard to the technical specialties (agronomy, irrigation engineering, hydrology, soil science, etc.) but it also applies to irrigation economics and settlement organization. (French and Arabic capability are also crucially important in certain countries, but many potential candidates already have the necessary languages from their initial field assignments.)

In regard to institutional resources, we propose greater use by Americans of London's ODI irrigation network rather than attempting to duplicate this listing of field practitioners. Access to field reports and theses on Africa needs to be improved at the major US institutions which AID intends to involve. Many of the needed resources do exist within the US, but are scattered within institutions which do not have an irrigation emphasis.

Bridging the Gap

This study has aimed to fill a gap in the literature by providing a continent-wide overview of African irrigation experience to date. Our contributors discovered the task sometimes exceeded the means within their reach. Not only is there a major gap between academic sources -- which generally can be located within the USA -- and the many user-commissioned project reports filed away overseas, there is also a chasm separating engineers who design and construct Africa's schemes from the agronomists and administrators who try to make them work. The first gap was expected, but the second one was not. We close this study, then, by identifying several areas where at present effective inter-communication often breaks down:

- Between civil engineers and agronomists (design versus operation);
- Between scheme managers and farmers;
- Between technology suppliers and technology users;
- Between plot-holders and field workers; and
- Between scheme members and surrounding communities.

The WMS II project originated because of concern that field programs would benefit from an integrated perspective, utilizing water management as a unifying device to highlight interconnections between sectors (and hence, between analytic disciplines). The "synthesis" element expressed AID's belief that field projects should not keep repeating each other's mistakes. This review makes it abundantly clear that both concerns are especially relevant within African irrigation. Present organizational structures virtually guarantee a fragmented approach to irrigation, leaving each set of actors in a position to blame others for the obvious faults which abound on every side. And, as a consequence, learning from past experience does not occur. We hope the views expressed in this report will constitute a first step towards a comprehensive understanding which will enable all of those involved to assume collective responsibility and, eventually, to devise more effective solutions.