# AN AFRICA STRATEGY FOR IIMI

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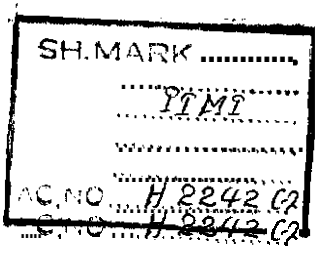



**JULY 1986**
**INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE**
**SRI LANKA**

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## Summary

This document was prepared for presentation initially to IIMI's Program Committee, which met in January 1986, and is the first step towards organizing a coherent program by which IIMI will relate to those African countries which practice irrigation.

Section 2 contains a rapid overview of the present state of irrigation in Africa. There is at present about 9 M ha of irrigated land in Africa. Much of this is concentrated in a very few countries: Egypt has 27% of the total, Sudan 19%, Madagascar 11%, Nigeria 9%, and Morocco 6 percent. The remaining 27% is dispersed among 37 countries; and a substantial number of these are highly relevant to IIMI's purposes, since their need for more food-production capacity is high, and their recent history of irrigation development has revealed management and planning difficulties. Section 2 also tries to identify certain distinctive elements of the African situation, which may lead to some research needs that differ from Asia's. Africa's generally low population density is emphasized, and its effects upon labor supply, market demand, and the frequently low utilization of rainfed agricultural potential. Also the prevalence in Africa of systems smaller in scale than those in Asia is noted, and with it the potential for self-managed systems.

In Section 3 is given a short selection of nine contemporary irrigation management problems. The list is neither exhaustive nor in any order of priority, but is chosen for relevance to several African countries, for relevance to IIMI's purposes and already established programs, and for inherent interest. This section is intended to impart a general idea of the challenges that will confront IIMI if it initiates an Africa program.

Section 4 proposes major features of such a program. It is based upon these premises (a) that resident scientist posts will be the principal mode of IIMI representation; (b) that IIMI should deploy its staff with the aim of establishing a relationship, either at residential or visiting level, with all countries which have irrigation; (c) that the main vehicle for identifying and analyzing local irrigation management problems will be collaborative research with local institutions.

The proposed program envisages that initially resident scientists will be deployed at 9 centers (Antananarivo, Wad Medani, Cairo, Rabat, St. Louis, Ouagadougou, Kano, Nairobi and Harare), and that all but the first three in this set will have multi-country assignments (Table 4) but with primary emphasis upon the host country.

In a further phase of consolidation of the program it is proposed that regional offices of IIMI would be established later, one for West Africa and one for East and Southern Africa. These will oversee and co-ordinate the work of the resident scientists.

It is envisaged that professional development and information exchange will fill a greater proportion of the resident scientists' time than in Asia. These items are discussed in sections *4.7* - *4.8.* The idea of a training center for all Africa is considered but deferred for re-examination as the program consolidates.

Program management, and liaison with Digana for co-ordination into IIMI's total program, are considered in Section *4.9*.

The launching of such a program requires a great deal of early administrative effort, and negotiations with many governments, both recipients and donors, as well as finding individuals with the talents required for resident scientist posts, so its timing is not predictable. In section *4.10* and Table 7 some effort is made to indicate the possible outline of a time schedule.

Initial proposals for appropriate research subjects at each of the nine centers are indicated in section *4.4, 4.6* and Table 5.

ACKNOWLEDGEMENTS

This document was written by Charles L. Abernethy (Consultant, United Kingdom) and Daniel Berthery (IIMI staff).

It draws substantially upon the findings of IIMI's exploratory missions to Africa and the collective African experience of the mission members who included, as well as the authors, Dr. Ralph W. Cummings (formerly Director-General ICRISAT), Geert Diemer (University of Wageningen, Netherlands), Dr. David Groenfeldt (IIMI staff), Robert Hlavek (CEMAGREF, France), Gilbert Manuellan (Ministry of Agriculture, France), Jean Verdier (CEMAGREF, France), Dr. Alfred S. Waldstein (Consultant, United States), Dr. Bret Wallach (Ford Foundation, Khartoum) and Dr. Thomas Wickham (Director General, IIMI).

These missions were greatly assisted by conversations with many members of national irrigation departments, universities and other institutions interested in irrigation, as well as by the Resident Representatives and local staffs of World Bank and Ford Foundation Offices, who were most valuable in arranging interviews and coordinating mission programs. The Ford Foundation also met most of the costs of one of these missions, for which IIMI records its gratitude.

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# 1 INTRODUCTION

## 1.1 IIMI's objectives and history

1.1.1 The International Irrigation Management Institute was formally established with headquarters at Digana, Sri Lanka, early in 1984. Its initial efforts have been devoted to establishing programs that relate to the irrigation systems of south and south-east Asia.

1.1.2 The central purpose of IIMI is to enhance national capability in managing irrigation systems. It aims to do this through three functions: research on common issues, training and professional development, and information exchange. Since research, even on generalized topics, has to be grounded in empirical field experiences and field data, IIMI seeks to deploy its professional staff mainly in the field, in the various countries where irrigation is significant. The headquarters in Sri Lanka will, it is planned, remain a relatively small core, for program direction and administrative support.

1.1.3 Within the total field of irrigation management, IIMI has identified three major themes upon which it aims to exert its principal research efforts. These are:

a. System management

b. Rehabilitation and design for management (that is design principles that facilitate good management)

c. Community-managed irrigation.

IIMI retains a further category for "other" research, to accommodate occasional interesting or significant topics that do not match these main themes.

1.1.4 IIMI tries to investigate aspects of these three themes, mainly through collaborative studies arranged with irrigation authorities (or other institutions such as universities) in the relevant countries.

1.1.5 Programs of study under resident IIMI scientists have been established in Indonesia, the Philippines, Sri Lanka and Nepal; and in December 1985 agreement was reached on the establishment of an IIMI branch in Pakistan.

## 1.2 Background to the preparation of an African strategy

1.2.1 As its south Asian operations begin to consolidate, IIMI wants to consider expansion of its range of knowledge and of services on a broader international basis, and its Board directed in June 1985 that a paper be compiled, suggesting a strategy for IIMI operations in Africa. The present document is the result.

1.2.2 In preparation for this, IIMI has sent three exploratory missions to different African countries during the latter part of 1985, in order to learn the views of people involved in African irrigation, as to what kind of programs they thought IIMI should offer, what management problems they faced, and what level of interest they felt in IIMI. These missions went to Senegal, Mali, Burkina Faso, Niger and Sudan in June 1985; to Morocco in May 1985; and to Madagascar, Zimbabwe, Zambia and Sudan in November-December 1985. The findings and recommendations of these preliminary missions have been given in separate reports; these findings are not recapitulated here, but they contribute the main sources of ideas for the present paper. In addition, individual members of the exploratory teams have contributed their extensive personal knowledge of other irrigation systems of the continent, *so* that this document draws upon direct experience or contacts with well over half of the African countries that practice irrigation, including all of the major ones, except South Africa.

1.2.3 The nine countries visited in this preparatory process were chosen *so* as to be adequately representative of the scales and methods of irrigation found in Africa and the climatic, human and economic environments within which it has to function. It was not thought practical, at this stage when IIMI is not yet certain what resources will be available to it for African operations, to visit more widely. As a result, this document contains some proposals for future operations in countries with which IIMI has not yet made formal contacts.

# 2 AFRICAN IRRIGATION: A SUMMARY

## 2.1 Distribution of irrigation

'.l Table 1 gives certain basic statistics about areas and populations in 48 African countries. The only African countries not included in that table are Seychelles (which is not always considered part of Africa), Djibouti (about which we do not have data, but it is very small) and South Africa (which is not expected to participate in IIMI's programs). Map l shows the country boundaries.

2.1.2 The countries of Table 1 are arranged in order of their total irrigated areas in 1982. Statistics of irrigated areas are always somewhat doubtful, and may mean different things. Here, we are using the data given in the FAO studies of Land, Population and Food, which (we understand) includes all land equipped for artificial application of water. Thus, Table l includes so-called "informal" irrigated land, as well as the larger "formal" systems built usually by the state or by companies. There are therefore some very substantial differences between the irrigated areas listed in Table 1 and those in other source-books (e.g. FAO Production Yearbook) where, in at least some countries, data seem to refer to formal systems only.

2.1.3 Table 1 helps us to make some basic sub-divisions among the rather large number of countries involved. There are 9.0 M ha of irrigated land in Africa. It is distributed very unevenly. Of the total, nearly 60% is accounted for by the "big three" countries, Egypt, Sudan and Madagascar. Each of these has an old-established tradition of irrigation, on to which modern systems have continued to be added in recent decades.

2.1.4 Nigeria comes next, with *840,000* ha. This statistic is perhaps among the most doubtful in the list. Nigeria's irrigation has grown fast in the past 20 years; but most of that growth has been in the "informal" or non-state sector, where units of development are small and hard to count or quantify. However, it does seem that Nigeria is rapidly joining the major group.

2.1.5 Then there are 16 countries which at present irrigate 50,000 to 500,000 ha. These countries are irrigators at a sufficiently substantial level to justify moderately strong irrigation departments in government, and a general awareness of at least some irrigation technologies among their farming population. These countries are Morocco, Algeria, Libya, Senegal, Guinea, Tunisia,

Mali, Zimbabwe, Tanzania, Ethiopia, Sierra Leone, Somalia, Mozambique, Ghana, Ivory Coasr, and Swaziland. There is a predominance of Mediterranean and West African countries. In regard to the figure of 500,000 ha for Morocco, we should again note that there is some doubt. The Moroccan system also is growing fast, and other data gives an area of irrigation as high as 730,000 ha for this country.

2.1.6 And then there is the largest set: 20 countries in which there is 10,000–50,000 ha of irrigated land. Typically such countries have only one or two state projects, sometimes also some commercially run estates for a special crop like sugar, and perhaps a little customary or village irrigation near rivers. The list of countries is quite long: they are numbers 21–40 of Table 1.

2.1.7 Last there are 8 countries (numbers 40–48) with negligible areas of irrigation in 1982. These are either very small countries, or lie in the high rainfall area of the central African rain forests.

## 2.2 Types and scales of irrigation

2.2.1 The methods of irrigation used in Africa are so diverse that rather little can usefully be accomplished by making generalized classifications. However, some limited generalizations may be of help, especially to readers more familiar with Asia or other continents.

2.2.2 The Nile system is the only one that bears any close resemblance to the major river irrigation systems of south Asia. It has major dams, and capacity for almost total regulation of downstream flows; it has a sequence of great barrages and some of the world's largest canal systems, distributing to land units in the order of 50,000 to 800,000 ha from a single outlet. It has therefore, major control and distribution problems at the very large scale where large irrigation bureaucracies must be a feature.

2.2.3 Elsewhere systems are generally much more modest. This has a variety of reasons: large rivers, and extensive alluvial plains, are by no means as common as in Sauth Asia; governments are often small and lack the organizational resources for such systems; but most of all the population density, and therefore the food needs, of Africa have not hitherto justified irrigation on the immense scales encountered in South and East Asia.

2.2.4 So village-scale systems of irrigation may be considered more "standard" in many parts of Africa. In Madagascar this accounts for 70% of all irrigation, and it is also present in Nigeria,

Senegal and many other countries in the middle rank of irrigators. Often these systems are traditional and get little or no help or stimulus from Governments. In spite of (or, some say, because of) this lack of government action, they have often flourished; most notably, it seems, in Nigeria. But firm facts on this sector are often in short supply, or inaccurate.

**2.2.5** Modern, medium or high-technology irrigation (meaning especially mechanized and micro-irrigation) has not yet made much impact in Africa. The Mediterranean countries, with an acute water shortage and also a high-price market in Europe for export crops, have invested in sprinklers and automatic control systems; Zimbabwe, with its very recent colonial history, and a substantial number of farmers of European origin with good resources of finance and technical knowledge, has its own irrigation equipment industry; but elsewhere flood irrigation in basins or furrows is normal.

## 2.3 Population

**2.3.1** A salient feature of Africa, which has important determining influences on its irrigation development, is its low population density. As with any other general statements about a continent, this not true everywhere: in the lower Nile valley and some other areas like western Kenya people are very closely packed. But all Africa has only two-thirds of India's population, although it is ten times as large. Overall, the numbers amount to 0.16 persons/ha (16 persons/km2). Only in the island states and the mountain-locked enclaves (Rwanda, Burundi) does it exceed 1 person/ha.

**2.3.2** For irrigation, this low population density has three significant consequences:

a. Labor is often scarce, and often labor, rather than land or water, is the limiting resource that most influences farmers' behavior and choices.

b. Markets for surplus agricultural production cannot be assumed to exist: distances to market are often great, and transport systems bad, so farmers are not necessarily market-oriented.

c. Not all potential rainfed agricultural land has yet been utilized.

**2.3.3** All these constraints are significant, but let us look particularly at the last one. It is a little difficult to quantify. The most serious attempt at this, on a continental basis, has been the FAO study of Land, Population and Food, in which each country (and in each continent, not Africa alone) was divided into many agro-ecological zones, whose food-producing potential was assessed on the basis of soil, terrain and climate parameters. On this basis

it appears (Table 2) that several of the favorably situated African countries are so far using, for rain-fed agriculture, only 5% or less of the potentially usable land. Over the whole continent, the proportion of potential land that is actually in use is only 17 percent.

**2.3.4** So African governments wishing to increase their staple food production have (generally) a three-way choice: to increase the area under rain-fed production; to increase (by higher inputs or by market stimulus) the output of existing rainfed land; or to introduce irrigation.

**2.3.5** Moreover. these choices may (to some unequal extent) also be available to the individual farmer. He may (eg. in Zimbabwe) operate some kind of dual system in which he has irrigated and rain-fed land. He will apportion his efforts between these two according to his own estimate of the rewards they bring. He, or his family group, may, after irrigation settlement, retain access to rain-fed land, to which, he can return if he finds that he dislikes the different life of an irrigator.

**2.3.6** We emphasize these aspects of the rain-fed alternative to irrigation, beoause it seems crucial to understanding many happenings in African irrigation. There have been numerous reports in recent years of African irrigation systems failing: farmers deserting them, or showing insufficient motivation. If there were no alternative to irrigation as the means of feeding the family, it is hard to believe these things would occur.

**2.3.7** On the other hand, the availability in many countries of a rain-fed alternative means that, economically, irrigation must compete with this. Many modern schemes seem far too costly to meet this obvious criterion.

**2.3.8** Like many other human endeavors, irrigation is likely to meet with greatest success in conditions where it is most truly necessary. Table 3 is an attempt to identify "need", in the limited terms of food production and self-sufficiency. Here we compare the estimates derived from FAO's LPF studies (para. 2.3.3), of the population which could be supported under rain-fed agriculture alone, with the expected actual populations. Rain-fed agriculture can of course improve as inputs improve, and so in Table 3 we choose to look (rather arbitrarily) at conditions in the year 2000 under "low" or traditional agricultural inputs, and 25 years later under enhanced on "medium" inputs.

2.3.9 Of course such an index of "need" is rough and inexact, but it gives us certain indications of where the continent's food problems are likely to be most acute within the time-scales of planning processes. It seems reasonable to think that people and institutions in these countries will be particularly receptive to the kind of ideas in irrigation management, for which IIMI exists.

2.3.10 Looking at the upper half of Table 3, we see that major countries with large problems, either present or threatening, include especially Egypt, Kenya, Nigeria, Ethiopia, Algeria, Morocco; countries that must expect rather smaller deficiencies (but no less acute, since their size is generally smaller) include Rwanda, Niger, Uganda, Libya and Tunisia.

**2.3.11** But this exercise tells us something else about African irrigation. Two of the major practitioners, Sudan and Madagascar, do not, by these standards, "need" irrigation at all. In Sudan, the major irrigation schemes are not designed primarily for food, but for cotton and sugar, irrigated cereals having been included initially for the needs of the cotton cultivators. In Madagascar, on the other hand, although average population density is low, in the highlands it is comparatively large and food supply problems exist. In addition, the dietary tradition of rice was established long ago by immigrants from Indonesia, and for this crop irrigation is appropriate.

2.3.12 Over all these somewhat theoretical analyses loom two major facts: one is the high population growth rate, which means that, from now onwards, certain countries which did not formerly have severe food problems will, one by one, reach the final limits of their population-supporting capacity, and must change their technologies (including irrigation as one option); the second is that rainfed systems are vulnerable to the statistical variation of climate, and many countries in the Sahel and the South have recent harsh experience of this. *So* irrigation as a means towards food security has acquired new significance, particularly in Mali, Burkina Faso, Niger, and (perhaps to a lesser degree) in the SADCC states neighboring Zimbabwe.

## 2.4 The physical environment: geology, soils, and hydrology

2.4.1 If we exclude for the moment Madagascar and the smaller island states, the continent has four main highland zones that are the sources of its great river systems. These are:

| | |
|---|---|
| the Ethiopian highlands | Blue Nile, Atbara, Juba, Shebeli |
| the Atlas | numerous rather small rivers |
| the Guinea highlands | Niger, Volta, Gambia, Senegal, Casamance |
| the central plateau | Zambesi, Limpopo, Congo, White Nile, Tana, Ruvuma |

2.4.2 In addition, a significant water resource in Africa is its numerous rivers which end in inland lakes or inland deltas: the Shari, Okavango, Gash, Awash and many others.

2.4.3 The levels of development of African rivers vary enormously, over the entire possible spectrum from the Nile (which, unique among big rivers in the developing countries, is under total control of even its largest flows) to the Gambia or Okavango, which have experienced almost no development yet.

2.4.4 Except along the Nile, physical conditions have not favored extensive development on south Asian models. Africa's landscapes and geological structures are generally older, erosion and sedimentation rates therefore slower, than in South Asia, and so there are not immense alluvial plains of the Asian style, nor large fertile deltas. For these physical reasons, African irrigation systems are smaller and more fragmented. But the physical reason is only one part of this: population density and organizational difficulties are also important reasons why large scale development has not been normal in Africa, outside the Nile Valley.

2.4.5 Ground-water development has not yet assumed a very prominent role in African irrigation. Locally (e.g. Libya) it is certainly important, but on the continental scale the problems of fuel supplies have made it unattractive. Africa has only five significant oil producers (Algeria, Libya, Egypt, Gabon and Angola) and fourteen land-locked countries with severe transportation difficulties.

## 2.5 *Crops*

2.5.1 Whereas the primary purpose Of irrigation development in Asia is usually to grow a food crop-rice in the south-east, wheat in north India and Pakistan - a great deal of modern African irrigation has been established by governments with quite different (essentially macro-economic) objectives of growing export commodities, or of import substitution. Cotton, in Sudan and Mali, though in Mali it was unsuccessful and sugar, in a large number of countries, are the most obvious examples. Often these systems were established as profitable commercial enterprises; a common theme of the 1960's was their conversion to parastatal authorities whose performance has, on the whole, been disappointing.

2.5.2 Egypt is the only country with a highly diversified pattern of food, cash and fodder crops that could be likened to north India and Pakistan.

2.5.3 Under the pressures of population growth, these things are perceptibly changing, first of all in the deficit countries of Table 3. Nigeria, most notably, is experiencing a rapid increase in relatively small-scale irrigation for fqqd, especially in the north and center. More of this should be seen in future in the other deficit countries which have reasonably numerous surface water sources: Uganda, Kenya, Ethopia.

2.5.4 We should also note the significance of a modern phenomenon: the "peri-urban" agriculture that is springing up (often yielding high private profits) around cities in all parts of the developing world. Whereas national populations are growing at rates of 3 to 3.5%, urban populations grow at rates of 10 to 15% per year, and this creates markets, and rewards, of a quite different order, in a ring of perhaps 30 km. radius around each large city. Irrigation technology and crop choices may be quite different here (eg, emphasis on fruits and vegetables, and more likelihood of investment in wells and pumps).

2.5.5 Rice does not have the great significance in Africa that it has in much of Asia. In Madagascar it is central and in several of the smaller west African systems such as Senegal and Sierra Leone, but generally it is minor, or absent. The prevalence of diversified cropping systems, often growing concurrent crops with quite different water needs, adds an extra parameter (compared to the rice mono-cultures) and complicates the study of problems like inequity.

## 2.6 Professional manpower

2.6.1 Trained manpower resources for the management of irrigation (and for functions like planning and design) are scarce in most African countries. Even the established countries do not have enough professionals. In Sudan there are very few irrigation engineers outside of the Gezira, Managil and Rahad Schemes, although what remains is close to 10% of all African irrigation. In Madagascar too, the range of operation of one trained professional is very large. The 21 countries at the threshold of irrigation development (para 2.1.6) have a general shortage of necessary manpower to get beyond that stage, **so** the early development often must be by expatriates and multi-national companies.

2.6.2 Facilities for training agriculturists or engineers specifically in irrigation management are rare. Egypt, Morocco and Sudan have such courses at Universities, **but** few others.

## 2.7 Organizations

2.7.1 Irrigation authorities in African countries take many forms, ranging from full Ministries of Irrigation (e.g. Egypt and Sudan) to a complete absence of any governmental irrigation bureaucracy (e.g. Zambia). There is no standard pattern. Integration of the agricultural and engineering aspects of irrigation seems on the whole to be better achieved in the countries that inherited French tradition of education and organization: in the anglophone countries irrigation development often has belonged to an engineering department such as public works or water development, divorced from agriculture, and this has sometimes created on undesirable dichotomy.

2.7.2 The largest state irrigation bureaucracies are usually found in the countries where substantial rivers and alluvial plains give opportunities for extensive development, including major river control structures. The Sudan Gezira system is often mentioned as the prototype of such organizations. In this model, the ministry of irrigation and the parastatal agricultural agency have enormous authority to direct farmers' activities: farmers' freedom of choice is very limited. This kind of organization can be interpreted as a case of the state seeking to ensure that it gets the results it requires from very large investments, and arranging an apparatus of tight control in pursuit of this aim.

*2.1.3* By contrast the countries whose irrigation development has been at small to medium scales may not need such powerful bureaucracies, and much more is usually left to the farmer. In such countries the present trend towards handing over control of systems to farmer organizations is usually quite active. In Madagascar for example the current aim seems to be towards treating the government's role as simply to provide an irrigation facility, and leave its subsequent management as much as possible to the farmers.

*2.7.4* Large-scale irrigation needs a focus of authority and discipline. Rules of various kinds (as to water distribution, rotations, maintenance work, planting dates) have to be observed by all participants. Shortages of professional manpower at present in many African countries make it difficult to establish effective authorities of the necessary strength. This is a further reason why the small-#tale seems to have the better chance of prospering in the immediate future.

# 3 CURRENT MANAGEMENT PROBLEMS

## 3.1 Self-management of irrigation systems

3.1.1 There is a quite widespread opinion, especially in countries with numerous scattered small systems, that matters would improve if the systems are handed over from government departments or parastatal bodies to some sort of farmers' organization to manage. This is not of course exclusive to Africa, but in Africa Madagascar is actively engaged in the process, and in Burkina Faso and Niger it is already implemented.

3.1.2 The choice of organizational structure, the extent of control to be retained by government, and the consequences upon system performance, are all unclear at present. The results of such moves have to be considered in terms of production, equity, and operating costs. Quite possibly, with some types of organization, we should see advantage in one of these directions offset by losses in others.

## 3.2 Labor constraints and farmer behavior

3.2.1 We noted earlier that low population densities in Africa mean, among other things, that labor may be a significant constraint. This is true in a number of countries, but could particularly well be studied in Sudan, where the standard holding size in the Gezira (17 ha) is particularly big, and where controversy about the best method of water supply (basically, night storage or continuous but reduced availability, but there are a number of conceivable variants) is very lively in the light of the imminent rehabilitation of Gezira.

3.2.2 The problem is to understand all the many factors that influence a farmer's allocation of time and effort among his various crops and agricultural tasks, of which water control is just one. Not only the farmer, but his seasonal hired labor, needs to be considered.

## 3.3 Stimulation of the very small scale

3.3.1 As yet, governments have found no successful formula for stimulating the success of very small scale (village or family) irrigation. In Nigeria this sector seems to experience success without much government attention, and many workers have praised the general performance of the informal sector. Could it be improved more rapidly by some suitable program of assistance? Madagascar, Burkina Faso and perhaps Senegal, offer opportunities for investigation of this, as of course does Nigeria itself.

*3.3.2* There seems to be a need also to define the sets of circumstances within which the very small scale will flourish. It cannot be spoken of as if it were a universal formula. For example, when usable tracks of fertile soils are not adjacent to the water source, government will usually have to intervene to build the water-transport system. Likewise, where water storage is necessary in order to extend crop seasons, or just for water security, government ordinarily has to provide this facility. In principle, the very small scale seems most relevant either where there is a high stream-density (e.g. Madagascar, the west Africa coastal belt) or where population density and food needs are still low enough to allow them to be satisfied from land close to the rivers and without storage.

## *3.4* Water-saving technologies

*3.4.1* We have seen already (Tables *1 - 3)* that the availability of land and surplus production potential is very variable across Africa, permitting few general statements. It is similar with water. There are, as yet, not a great many countries where water is really a scarce resource. But, of course, there are some such countries; they will, through the increase of population, become more; and in such countries special problems appear, needing their own special solutions. The most obvious such case is Egypt, where, after the construction of the Aswan High Dam in 1968, few strategies remain for increasing the gross amount of water available. The Jonglei Canal in southern Sudan will, if completed, increase Egypt's resource by some *10* percent; groundwater development may make a similar contribution. At current population growth rates, these measures together buy only an extra 6 or 7 years' time. Re-use of drainage water may likewise add an extra few years; but there seems little doubt that, within the range of planning time-scales, Egypt needs to find ways of adapting her water-use technologies *so* as to spread the available resource more widely, and to enhance the productivity of its water.

*3.4.2* Prominent among the possible technologies are sprinklers, micro-irrigation (drip or trickle), and precision (laser-controlled) land levelling. All these are common features in other systems where water is a limiting factor (e.g. the Murray Valley in Australia, and Arizona) but their use in developing-countries with small-holder systems has not yet had much success due to organizational difficulties, and also to'the need (in some cases) to switch to different crops in order to get benefit from these systems. In Africa at present, Morocco is the country with principal experience in this field.

*3.4.3* Perhaps it should be emphasized that the management need is not for research into the available technologies: there is plenty of that

in the richer countries where those technologies are established. The problem is to identify ways of using these well-established technologies in the context of small-holder communities where (for instance) substantial numbers of farmers will have to join together in some sort of association to meet the capital and operational costs of such equipment; and at present, because the price of canal water is usually low or zero, they may think they get no financial benefit from doing such investment.

*3.4.4* Further, it may be noted that in the surface irrigation technology that is normal today, farmers have only vague knowledge of their water applications, and therefore derive no practical benefit from the very large amount of knowledge that now exists on crop water requirements. Most **of** the water-saving technologies make it much easier to measure water use, and *so* to learn about regulating applications.

## 3.5 Equity

3.5.1 The question of equity in water distribution affects the same countries as the previous point; for inequity (although it certainly exists in all systems) is much more serious in water-deficient systems. When water is abundant, inequity implies waste, because usually the lowest recipient still manages to get enough: the problem then is that some use far more than they need, but in general one need not worry greatly about this. But in water-deficient systems the power-structure within the user community takes over, and (broadly speaking) the most influential will secure to themselves adequate shares, thus passing an intensified deficiency to those further down the hierarchy of power.

3.5.2 Irrigation bureaucracies have the role of trying to counterbalance this process and to reimpose equity in the distribution network. Sometimes (e.g. Sudan Gezira) they seem to manage this rather well; in other places (e.g. Upper Egypt) severe inequity and so-called "tail-end" problems remain acute, and probably get worse with **the** passage of time. Quite often these inequities are rooted in design and control-facility defects. Equally often, they may reflect the irrigation bureaucracy's **own** integration into the power structure.

3.5.3 In Egypt, the problem is further compounded by physical difficulties like weed growth and siltation, which change system operating characteristics.

3.5.4 Equity has been very little measured, and not enough is known about its magnitude, trends of change, nor the institutional circumstances conducive to improving it. Egypt offers favorable conditions for such investigation, as also does Morocco, where physical control methods are different.

## 3.6 The planning dimension, and the early phases of introducing irrigation

3.6.1 We noted above (para 2.1.6) the large set of countries, 21 in all, which have 10,000 to 50,000 ha of irrigation. All of these are in sub-Saharan Africa. We can call these the countries still on the threshold of irrigation: not yet, usually, having many irrigation specialist personnel nor a strong irrigation authority. This is the biggest set, and it is true to say that this is the most common situation of African countries at present. Of course their food and population situations vary widely: some, like Zaire, do not have great need of moving beyond this phase, but others, such as Kenya and Uganda, Mauretania and Niger are, as we saw in Table 3 (para 2.3.8-10), prominent among those that must expect growing difficulty in feeding their population.

3.6.2 It seems, from the large number of countries that get into this "threshold" group but do not move on out of it, that there are special problems associated with this phase. It has been characterized by quite a number of recent failures and disappointments. Countries in this phase lack experience and institutions of irrigation, and seems prone to make planning misjudgments because of this.

3.6.3 The questions when, and by what route, to embark upon irrigation: what scales of project to foster, how to help the farmer community over the transition in life-style, how to integrate irrigation with rainfed farming and pastoralism, what institutions to develop (among farmers and within the government apparatus) - all these issues are of high significance to the "threshold" countries. University training in the developed countries, or even in the established irrigation societies like India or Egypt, rarely tells their staff anything useful about how to confront this set of problems.

## 3.7 Settlements

**3.7.1** A further large range of management problems, mainly (but not only) affecting the countries that are embarking newly on irrigation, is contained under the general heading of "settlement". New systems need farmers, and the modes of selecting these and allocating land and water rights among them may have much effect upon subsequent success or failure. Failure to take heed of traditional views of water rights has often been criticized; although it is also argued sometimes that the introduction of (for example) storage facilities may, by introducing a new flexibility into flow patterns, remove part of the basis of the traditional arrangements.

**3.7.2** In general, the role of settlement policy in determining project success is not well established (as a general principle, rather than in occasional cases ) and opportunities to study this occur at present in Zimbabwe, where new resettlement schemes are proceeding; and also in some west African systems, such as the White Volta Schemes in Burkina Faso.

**3.7.3** This topic does not fit readily any of IIMI's three established themes of study (para 1.1.3) *so* if it is be adopted it would have to be as part of category (d), other research, and it requires some firmer justification than the earlier issues. We think that this is one of the issues that is more prominent in Africa than in IIMI's first areas of activity. Of course it exists in south Asia (especially in Sri Lanka), but on balance there are far more existing, settled systems in Asia, and conversely less planning of new ones in virgin areas. Further, Africa's low population densities mean that we will very rarely find that the existing local population is sufficient for a new irrigation development (as may often be the case in India, for example): in Africa, importation of selected people into the project area is a normal requirement, and a normal early phase of managing that project.

**3.7.4** So our justification for proposing the inclusion of this issue is that the farmers are key personnel in the running of an irrigation system, and that their mode of selection and the arrangements made for them (housing, village locations and size, physical and social structures) impact strongly upon the system's subsequent performance.

## 3.8 Conjunctive operation of irrigated and rainfed agriculture

**3.8.1** We have observed that much of Africa, and nearly all of sub-Saharan Africa, has rainfed alternatives to irrigation as a mode of production. This does not only mean rainfed an able farming: animal production is also a common mode. There are places where two, or even all three, of these modes co-exist. In such cases irrigated plots will ordinarily be very small.

**3.8.2** There is scope for studying these combinations. What are their economics? Do food security objectives alone justify their irrigation components? How do farmers distribute their available effort between the different modes of production? For this subject Zimbabwe again offers opportunities of study; so do Senegal, Burkina Faso and Niger.

**3.8.3** This, like the preceding item, does not fit easily into IIMI's existing program themes. Once again, it exists in south Asia (notably in north central Sri Lanka), but overall has less importance there. The justification is much the same as for the previous point: it is a rather common issue in sub-Saharan Africa, and if the issue is neglected there are likely to be irrigation management difficulties.

## 3.9 Financing of operating costs

**3.9.1** The search for more satisfactory methods of financing operating costs proceeds in most countries at present. It is commonly perceived that arrangements under which the farmer pays either none of these, or else some arbitrary amount that is unrelated to the true costs, put a heavy burden upon the State budget. The move towards self-management has much to do with this: there is an expectation that, if users'committees can be established and can be made strong enough to accept the burden of operating costs, they may be more efficient managers in the sense of keeping control of these costs. On the other hand, it is also possible that, if the irrigation bureaucracy does not directly control maintenance work, this work will not be done, and rehabilitation will be increasingly frequent. Farmers generally may assume that the State will meet rehabilitation costs.

**3.9.2** Suitable formulae for the sharing, between the users and the State, of the operating costs still need to be found, and IIMI has already begun studies of this question in its Asian programs. Initially, this question can be studied in all parts of Africa: the existing formulae can be compared. At present, changes are envisaged in a number of countries, and when such changes occur there are special opportunities for learning their consequences.

**3.9.3** This issue is intimately bound up with the question of markets and prices, which is unfortunately too enough ignored as a major influence upon irrigation performance. When irrigated agriculture is profitable, it is likely to be easier to secure payment of operating costs from the users. In several African countries in recent years, market and price liberalization policies have had dramatic effects upon crop production: sometimes much greater effects than could be expected from any other management action. Sudan and Madagascar report this effect, and Nigeria's market driven "informal" irrigation, like the widespread "peri-urban" irrigation are examples of apparently successful development in rather strong contrast to many public-sector developments. In particular, these irrigators make no demand on the State for operating subsidies: so there are lessons to be learned by studying them.

**3.9.4** This is an issue that is relevant in most countries, but Nigeria and Madagascar may offer especially good opportunities for study.

# 4 AN IIMI PROGRAM

## 4.1 Functions

4.1.1 IIMI's programs, established already in Asia, contain three functional areas: research, training and professional development, and information exchange. In the Asian programs, research is dominant over the other two, to the extent of 60 - 70% of all efforts.

4.1.2 All of these three components should again be present in an Africa program. The balance among them, however, should be different. Moreover, it will not be the same in all parts of Africa, nor at all stages of IIMI's program development.

4.1.3 Research is still likely to be at the forefront in programs with the major irrigators: Egypt, Sudan, Madagascar and probably Morocco. These are countries where (except Madagascar) local training facilities in irrigation up to graduate and even doctoral level exist, and the need for IIMI to provide alternatives is not evident. They are countries where the strength and diversity of the professional irrigation service should ensure useful possibilities for collaborative research, and for the translation of research results into practical actions.

4.1.4 In the smaller countries it is otherwise. Needs are different. Collaborative research cannot be proposed where there are few possibilities of finding counterpart staff. But in these countries there will be strong demand for information exchange and professional development services. We do not mean to say that there would be no research in these countries, but that it would not take the major role.

4.1.5 For these "threshold" countries (as we have named them above, para *3.6.1)* there is an additional facility which, we propose, IIMI should prepare to offer: an advisory service, especially focussed upon planning issues. We think that a source of neutral, and free, advice, based on observation and experience of related situations elsewhere, would be much welcomed. It may take IIMI two or three years to develop the nucleus of such a service, but we propose it be incorporated now into IIMI's planning.

## 4.2 Staff deployment

4.2.1 Tables 1 and 3 which show where existing irrigation is most widespread, and where future food deficits are most likely to stimulate new irrigation developments, help us to form ideas about an appropriate geographical distribution of staff. First, let us set down some general considerations.

4.2.2 IIMI is concerned with irrigation management. It is interested in other stages and phases of irrigation activity, if they affect management. For instance, IIMI must become interested in planning and design of irrigation, because bad planning and bad design may produce serious, even insoluble, management problems. But IIMI is not an aid donor sponsoring the development and expansion of irrigation. To study irrigation management, there should be already some useful amount of existing irrigation. Therefore IIMI will be attracted towards placing resident staff in countries which already have much irrigation: those at the top of the list in Table 1.

4.2.3 But that is certainly not the only criterion. From IIMI's point of view, its interest in rehabilitation and in community-managed systems draws it also towards countries with smaller systems, and those whose management problems, although smaller in scale, are nevertheless acute.

4.2.4 This list is long, and there is no possibility that IIMI will have staff in them all. However, we may set, as a desirable objective, that IIMI should try to ensure that its staff deployment enables it to have a regular relationship, at least at a visiting level, with as many as possible of the 41 countries where irrigation is practiced.

4.2.5 This aim can only be achieved by some sort of regional or multi-country assignments of staff. We suggest that the most useful way to organize such a pattern of representation will be by choosing certain key or focal points, in countries where we believe receptivity of IIMI aims and inputs will be high. In these we propose the creation of IIMI's centers of operations. The characteristics of such centers are discussed in section 4.3. In the first place the professional resources available at such a center will essentially be the single resident scientist, with occasional temporary attachments as described in section 4.3.

4.2.6 Staff at such a center of operations will have assignments to devote say 60 - 70% of their time to work in the base country, and the remainder to liaise with a certain set of adjacent countries.

4.2.7 This pattern of representation is attractive, because it is capable of growth in a variety of ways, and does not therefore make future adjustments difficult. If available resources were to expand, IIMI will have the option either of strengthening its numbers in a

particular center where, for example, an active resident scientist has stimulated interesting lines of study; or of deciding to open a new office and sub-dividing a region that seems to be too big for one resident scientist.

4.2.8 When we try to choose those key countries from which such staff will operate, we may be guided (in part) by Table 3. This indicates which countries face the most serious food-production problems. It is reasonable to expect that interest in IIMI's objectives will be greatest in the countries high on this list, and this view has been confirmed in the findings of the exploratory missions. Thus the first 18 countries of Table 3, all of which face food deficits even if they improve the technical levels of their rainfed agriculture, are all possible staff locations.

4.2.9 We now can state three criteria for choice of staff locations:

a. extent of existing irrigation

b. expected food-production deficit

c. regional situation, including transport links to an adjacent set of countries.

4.2.10 To this we may also add a criterion which is vague but must be kept in mind: the political and institutional stability of a country. As an international body IIMI would not wish to exclude from its program any nation on the grounds that it is undergoing political turmoil, but there are a few countries where the continued disruptive effect of such events may have weakened the relevant institutions to the point where any management problems in irrigation stem principally from this cause, and any conclusions there about management issues would be very suspect.

4.2.11 A further consideration is the existence of competent irrigation institutions to which the resident scientist can relate. But this again is not a clear standard or pre-requisite. If, for example, the management conditions in a particular country are very inefficient, some people may say that is precisely the kind of place that needs IIMI. But IIMI is a young institute, and at least in its own formative years, its main function must be the study of management, and the formation of a solid information base from which increasingly good information and advice can be disseminated in coming years. It must beware of tackling the most intractable situations first, and in choosing its staff locations It should look for a certain minimum standard in the national irrigation institutions.

*4.2.12* We should also state a selection criterion that we have not used, which is that of official languages. The problems of the existence of francophone, anglophone and other zones in Africa cannot be evaded in regard to training and information matters, and we deal with these below. But we do not think IIMI should subscribe to segregation of countries on this ex-colonial basis. In west Africa especially, resident scientists will have to be bilingual, since there are adjacent pairs of countries in each language group (e.g. Nigeria and Chad, Senegal and Sierra Leone) which may, on other stronger considerations, have to fall within the domain of one resident scientist.

## *4.3* Characteristics of an IIMI center of operations

*4.3.1* Before proceeding to the difficult question of choosing an initial set of centers of operation for IIMI in Africa, let us first consider what features we expect to see in such a center, and how it may operate.

4.3.2 We have already seen (in paras *4.2.2 - 4.2.5)* the reasons why there should be two basic types of centers: those that deal with one country where there is plenty of existing irrigation, and those which, while they are based in one country and will relate predominantly to that country, nevertheless have an assignment to relate at a lower level of frequency to a number of adjacent countries.

4.3.3 The first set seems easier to organize, **so** let us consider them first. The key person in such a center is clearly the resident scientist. He may come from any one of the several disciplines involved in irrigation. Since, in the foreseeable future, it seems unlikely that IIMI will find the means to give him a permanent colleague from any complementary discipline, it follows that in choosing these resident scientists IIMI will seek people with a broad intellectual range, who are not narrow specialists in single disciplines. We recognize the difficulty of finding these people, but consider it an important requirement.

*4.3.4* But the resident scientist will not be alone. His work will be supplemented in several ways. Sometimes he will have **a** visitor attached to his office, under the IIMI fellowship program (see para *4.5.1* a), for perhaps a year or two. These will generally be youngish professionals from other countries, and desirably from other disciplines, and their presence will provide the occasional opportunity for opening **a** fresh line of research.

4.3.5 In these countries, the irrigation bureaucracy is large and there are several institutions with which the resident scientist can work. Research will be his preener as his colleagues with single-country centers.

4.3.10 In relation to the other countries of his region, the resident scientist operates at a different level of intensity. He will be able to spend only 5 - 10% of his time in each; and even less in some larger groupings.

4.3.11 We envisage that his task initially is simply to get to know the irrigation institutions and their principal people; and to involve them when he can in IIMI's activities. He should know whom to invite to workshops, and whom to propose for other professional development activities. He will be a channel for passing on information to them about IIMI's research findings elsewhere, and occasionally advising them as to how these findings can improve their own performance.

4.3.12 Perhaps most important, he should always be looking out for fruitful research opportunities in these adjacent countries. Although he may not find it possible to devote his **own** time to these, he should be able sometimes to use the fellowship system in order to place an IIMI person for a limited time in an adjacent country to research a given situation. This may well prove to be one of the best ways of broadening IIMI's geographical range of knowledge into countries whose irrigation activities are not sufficient to warrant a permanent presence.

## 4.4 Centers of operation

4.4.1 After considering all the criteria in section 4.2, and the specification of a center's typical activities in section 4.3, we propose that IIMI should plan its African operations around nine centers. These centers, and the adjacent sets of countries with which each center would be associated, are listed in Table 4 and outlined on Map 2. In the following paragraphs we indicate our reasoning for each of the nine, and give some indication of their expected working environment, especially the institutions to which they may mainly relate. Table 5 indicates which research questions we believe they should address initially; but it is to be expected that in practice the considered views of the collaborating bodies, and the personal skills of the resident scientists, will introduce modifications to this.

*4.4.2* The first three centers in the list, Antananarivo, Wad Medani and Cairo are rather obvious choices. These are in the three countries (Madagascar, Sudan and Egypt) with the most extensive irrigated areas, accounting altogether for 57% of all African irrigation. We envisage each of these as a single-country assignment. We should note that we have considered the possibility of a single center for the Nile Valley (Egypt and Sudan) but do not recommend it. Together the two countries have about *4.2* M ha of irrigation in a great number of major and medium-sized systems, presenting many management problems. We think that these important questions will be addressed much more effectively from two separate centers.

*4.4.3* In Antananarivo, the main counterpart organizations with whom IIMI should seek to collaborate will be the Ministry of Agricultural Production and Agrarian Reform (MPARA) and the National Center for Applied Agricultural Research on Rural Development (FOFIFA). Madagascar's large proportion of small systems, and its current movement towards self-management of its medium systems, offer interesting opportunities for study. In general the country's agriculture is passing through a period of changes in organization and financing, *so* management problems are numerous.

*4.4.4* In Sudan the likely collaborating bodies will be the Hydraulics Research Station of the Ministry of Irrigation, the University of the Gezira, and the Sudan Gezira Board. All of these are at Wad Medani, so that city, rather than Khartoum, should be IIMI's base. The consensus of views expressed to IIMI by Sudanese officials is that they would like IIMI initially to interest itself in the Gezira-Managil Project area. Though it is big, it is less than half of all Sudan's irrigation, so it should be expected that IIMI's interests would radiate in later years to Sudan's many other forms of irrigation. The likely early subjects of study in the Gezira would include the question of appropriate patterns of water delivery (e.g. rotations, night flows) that best suit the farmer's labor situation.

4.4.5 In Egypt irrigation research is performed principally by a number of institutes that are colledtively grouped under the supervision of the Water Research Center of the Ministry of Irrigation, and this would be the principal body with which IIMI should initially collaborate. In Egypt the problems of large systems have to be studied, and in the special context of highly-diversified cropping, and of incipient water deficiency. Some highlights of such problems have been mentioned earlier in sections *3.4* and *3.5*.

*4.4.6* Continuing through the list in Table *4,* we come to Morocco. As Table shows, it has the fifth largest area of irrigation on the continent (and we have observed, para *2.1.5,* that the figure may be greater), **so** there is evidently a case to regard it also as a single-country center for IIMI. However Table *1* also shows us that the three other Mediterranean countries are also all in the top ten in extent of irrigation, while Table *3* puts them all also in the top ten in regard to insufficiency of rain-fed capacity. Moreover, the four countries have a number of similarities in language, culture, topography and hydrology that make them a rather natural regional grouping from IIMI's viewpoint. If IIMI's center in Morocco were given a role limited only to that country, it would seem desirable also to propose a center for the three others; but we regard that as an inappropriate solution at this stage of IIMI's development, and prefer to envisage that a base in Rabat would be related to the three adjacent countries along the lines proposed in paragraphs *4.3.9* - *4.3.12.*

*4.4.7* The principal partners for IIMI in Morocco should be the Hassan II Agro-Veterinary Institute at Rabat, and some of the nine Regional Offices for Agricultural Development. Prominent subjects of study would include the interaction of design and management, and the financing of irrigation costs. A number of other possibilities were identified in the report of IIMI's exploratory mission of May **1985.**

*4.4.8* The group of countries around the western coast spans two very different climatic regimes, from the arid and semi-arid conditions of Mauretania and northern Senegal, where the Senegal River constitutes the major agricultural focus, to the seasonally very wet climates of the states between Gambia and Liberia, where irrigated rice, usually in seasonal swamps, is significant. Senegal, combining parts of both zones, and having the greatest amount of irrigation at present, seems the natural place in which to locate a center.

*4.4.9* Alternatively, it may be considered possible to associate these countries with the Sahel group that is discussed next, and develop one single center for them all. However, since this area has a large number of comparatively small states, this would mean that the resident scientist would have to get to know a large number of different national facilities and institutions in order to work effectively, and we find it hard to apply the kind of organizational models we have conceived in section *4.3.* We think that the western set, especially Senegal, is important enough to justify a local IIMI center; and the same can be said of the Sahel group.

*4.4.10* Within Senegal we propose that IIMI be located at St.Louis rather than Dakar. The most important and interesting development, currently and in the coming decade, is the harnessing of the Senegal River by dam construction, which will change the modes of irrigation in the lower river and delta. The implementing organization SAED (Society for Management and Exploitation of the Lands of the Senegal Delta and the Senegal and Faleme Valleys) seems to be the most appropriate body with whom IIMI should collaborate, and its headquarters are at St. Louis which is in the delta. Also at St.Louis is the training institute CNAPTI (National Center for Application and Development of Irrigation Techniques). Other relevant bodies with whom IIMI would interact will be the Senegal Institute for Agricultural Research (ISRA), and the Organization for Development of the Senegal River (OMVS: a joint Mali-Mauretania-Senegal body), both of which are at Dakar, and the West Africa Rice Development Association, whose headquarters are at Monrovia but which also operates in Senegal.

*4.4.11* Early subjects for research for IIMI's St.Louis center will probably focus on the many human and institutional issues arising as a consequence of the change in control of the Senegal river, and the implied change from informal to formal irrigation arrangements. These include resettlement, the planning and financing of institutional arrangements, farmer behavior and reaction to the transition.

*4.4.12* Next we consider the Sahel group of countries, those immediately south of the Sahara. As Map 2 shows, we propose treating as a related group, for IIMI's purposes, seven countries of which three (Mali, Burkina Faso and Niger) are in the Sahel proper, and include much desert, plus the four coastal states to the south of these (Ivory Coast, Ghana, Togo and Benin) which have a strong graduation of climate from the wet coastal belt to semi-arid conditions in the north.

*4.4.13* It seems more difficult here than in some of the other groupings to select the most suitable base for IIMI. The area has three major river systems (Senegal, Volta and Niger), but in most of the countries there is a lot of informal or village irrigation, much of it using the many small rivers that drain from the plateau region of Burkina Faso. Mali has most irrigation among these countries, but its major authority, the Office du Niger, has been one of the least successful irrigation bureaucracies in Africa, and does not seem to offer the minimum conditions mentioned in para. *4.2.11.*

*4.4.14* The coastal countries offer other difficulties, although on the grounds of communications Abidjan or Lome might have attractions. But in all these countries the irrigation is in the north, quite far from the coastal capitals. Also the wet coastal belt offers good food-production resources, ***so*** the motivation towards irrigation studies in these countries is likely to be less powerful than in the drier Sahel countries.

*4.4.15* The special difficulties of the Sahel countries through the past **15** years are well known, and we think that IIMI should if possible be represented there. This seems to imply a choice between Ouagadougou and Niamey, and, of these two, we think that Ouagadougou should be preferred for three reasons: its irrigation development will be based on small to medium systems which seem to promise the best opportunities for success in this environment; the city is already the base of a number of international bodies (notably the Permanent International Committee to combat the Sahel Drought, CILSS, and the International Committee for Hydraulic Studies, CIEH); and it also contains one of the most prominent francophone teaching establishments with irrigation interests, the International School for Rural Development Engineers, EIER.

*4.4.16* Organizations with which IIMI would expect to collaborate are, within the Burkina Faso government, the National Office for Dams and Irrigation Management (ONBAH) and the Volta Valleys Development Authority (AVV); and on the international level, CIEH and EIER (above). Research topics would probably include the ways of promoting self-managed and small-scale systems, as well as resettlement, and the use of conjunctive irrigated and rain-fed farming systems.

*4.4.17* Nigeria is (like Morocco) a country with a great deal of irrigation. But unlike Morocco, relatively little of it is in the public systems. Formal irrigation in Nigeria is rather recent, and has not ***so*** far achieved a distinguished record. The management reasons, both for the lack of success in the state sector, and the flourishing of the informal sector, seem to offer interesting topics for study.

*4.4.18* We suggest that, although the extent of Nigeria's irrigation seems to justify a base for that country alone, IIMI should nevertheless include with it Chad and Cameroon, which would be hard to associate with any of the other proposed centers.

*4.4.19* IIMI has not yet been able to include a visit to Nigeria within its exploratory program, *so* we do not at this stage wish to propose the specific institutions with which its center should collaborate. Nigeria has quite a large number of possible institutions, because of its federal structure and its large river basin authorities. It may be that, because of the apparent importance of informal irrigation in Nigeria, a university may be a more appropriate collaborator than an irrigation bureaucracy here. Ahmadu Bello University at Zaira is one possibility.

*4.4.20* Since irrigation is predominantly in the semi-arid north, Kano (or possibly Kaduna) would be suitable as a location for the IIMI center.

*4.4.21* We may omit a large area south-east of Nigeria from IIMI's interests because these countries (Zaire, Gabon, Congo and Central Africa) have high rainfalls and little need of irrigation.

*4.4.22* In eastern and Southern Africa irrigation is rather new, but has been given added impetus by recent droughts. Nevertheless there is a lack of obvious locations for IIMI, because nowhere is there much existing irrigation, We propose that in the south IIMI base a center at Harare, for two reasons: Zimbabwe has the largest amount of irrigation in the region, and the SADCC (South Africa Development Coordination Conference) regional grouping, although its secretariat is in Botswana, has assigned to Zimbabwe the leading role in its food security program, within which irrigation management is a component. Further, Zimbabwe is likely to have a significant number of new resettlement projects with irrigation, because of land transfers following decolonization.

*4.4.23* We envisage that the IIMI center will collaborate, at the national level, with Agritex, the technology and extension wing of the Ministry of Lands, Agriculture and Rural Development, and the University of Zimbabwe; and at the international level, with SADCC.

*4.4.24* Subjects of study will probably include the planning and financing of small-scale systems, as well as resettlement and conjunctive irrigated/rain-fed farming.

*4.4.25* In East Africa there is less present irrigation than in any of the other regions, and so we have given special thought to the question whether IIMI should be represented there. We reach the conclusion that it should. This area, including Kenya, Ethiopia, Somalia, Uganda and (probably) Rwanda and Burundi, faces a diverse collection of difficult problems. Their problems differ, but the unifying factor is that they all face serious food deficits, either now or imminently. Table 3 confirms this: all these six countries appear in the top 18 deficit countries of that table.

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