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REPORT TO THE CONGRESS

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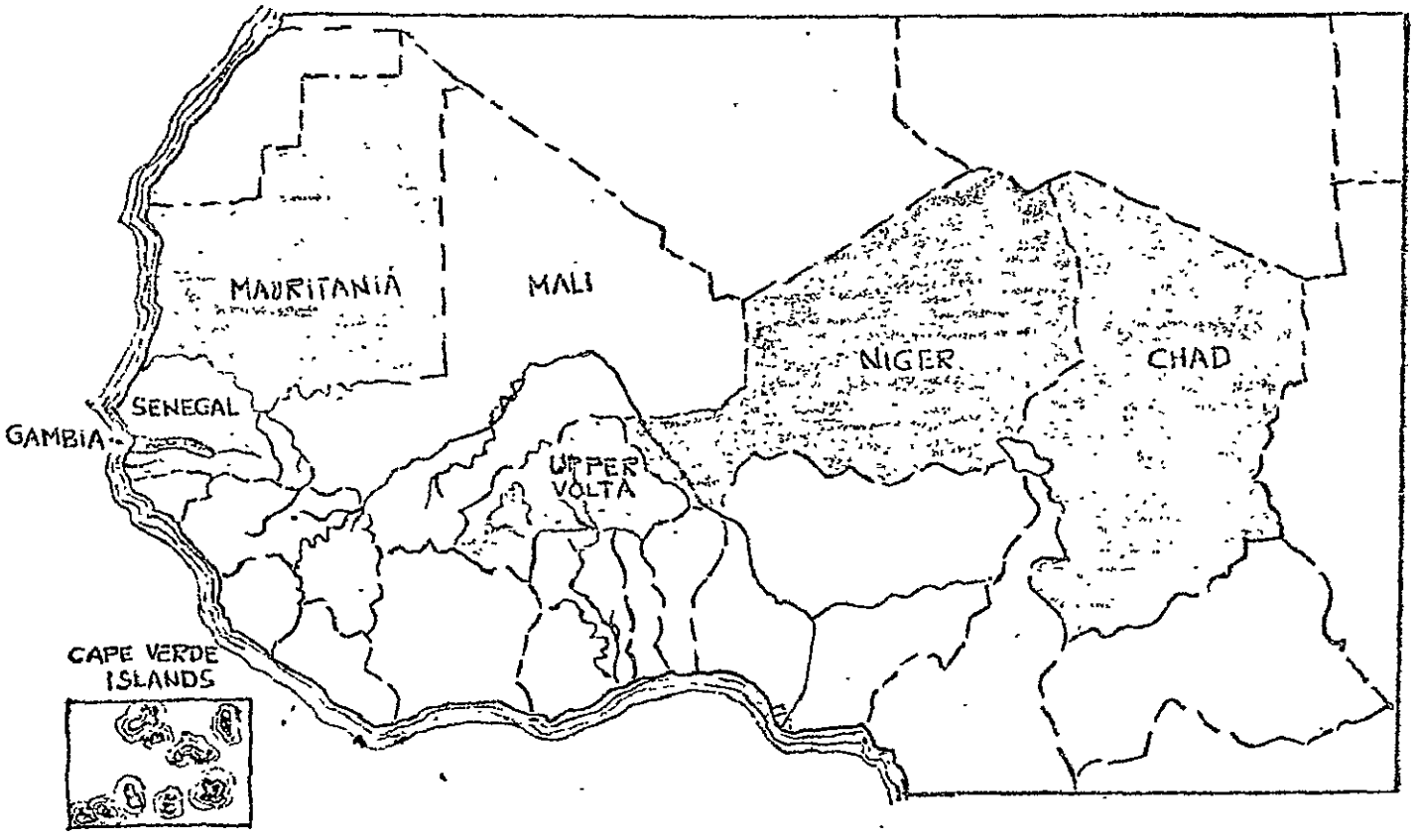

A Comprehensive Proposal for Designing a Long-Term Development Program for the Sahel

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SAHEL PLANNING TASK FORCE REPORT

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I. INTRODUCTION

A. Viewpoint.

Arid and semi-arid lands comprise one-third of the earth's land surface, but their capacity to support an equal percentage of the world's population is severely limited. In some cases, aridity has posed a formidable barrier to development although in some areas, tenacious millions have adapted to aridity -- to flourish with it when it flourishes, but to suffer its dire consequences. The people of the eight Sahelian nations of Chad, Mali, Mauritania, Niger, Senegal, Upper Volta, Gambia and Cape Verde Islands have faced this route. This report attempts to advance a strategy by which man through technology, training and management, can, as a process of adptation, transform a large marginally viable area into a land capable of sustaining an increasing population. This strategy implies that with today's know-how, a direction of development objectives, as well as the means toward attaining these objectives, can be projected into the remaining quarter of the twentieth century in order to stabilize the climatic effects which the Sahel poses to man as his numbers increase and demand more from his environment.

The prolonged drought of 1968-1973, the most severe in recent times, brought to the attention of the world that

there were close to 25 million people living on the brink of calamity. The drought also called to the attention of leaders of both the African Sahelian nations and the international donor community that if droughts were cyclical, rehabilitation and recovery efforts were merely "holding" operations until the next drought. Unless there was a significant response from the land and people, drought-related disasters would be chronic and economic growth and development would be nil.

In the wake of the most recent disaster, the Agency for International Development engaged a multidisciplinary group of experts assembled by the Massachusetts Institute of Technology (MIT) to initiate the development of a conceptual framework which could be used to appraise future long-range assistance strategies for the Sahelian region. The group drew several conclusions. First, it concluded that the recent drought was not indicative of an over-all climatic change and that the region must expect to cope with recurrent droughts of random frequency and varying intensities and at different locations. Second, the current loss of human lives and livestock and the region's increasing desertification resulted primarily from an overstressed, frail ecology; all the drought did was to accelerate the occurrence and intensity of these conditions. Even without the drought, given pressures from livestock and population at the time of the drought, the region would have

encountered the same problem within a decade or slightly longer. Third, and probably the most significant conclusion affecting the future of the Sahel, the MIT group found that "...with the known resources and under varying rainfall conditions, it is possible for the region to support the population projected for the year 2000 on a sustained basis."

Herein lies the basic optimistic note upon which the African Sahelian nations and the international donor community can hope for an era of positive economic development and improvement of the quality of life of the Sahelian peoples. But the technological solution requires will, planning, training, resources (both external and internal), and time, without guaranteed positive results. No perfect solution can be advanced. Development is evolutionary, but has to be planned by human beings for human beings. There will be risks, risks which may have dire consequences on the land and people. For this reason, projected goals must be negotiated, realistic, and most of all desired by those who must live with their consequences. Most of all, planners must be visionary, but humble.

B. <u>External Donors and African Regional Organizations Assisting the Sahelian Countries</u>.

This report reflects an initial, intensive undertaking by the Agency for International Development to present to the

Congress a proposal for developing a long-term comprehensive development program for the Sahelian States in West Africa. The countries of the Sahel have been visited, views of African government and regional organization officials have been sought, and meetings furthering coordination have been held with the international donor community.

Positions taken and recommendations made by A.I.D. in this report are believed to reflect the general views of the Sahelian States and the other donor organizations. Sectoral, economic and other reports prepared by international, bilateral and African regional organizations have been referred to extensively by A.I.D. in preparing this report and selective utilization of data has been employed.

Three major external organizations that are participating in assisting the Sahelian countries are the Fond European de Developpement (FED), United Nations (UNDP, UNSO, FAO, OSRO) and the International Bank for Reconstruction and Development (IBRD).

The Club des Amis du Sahel, which is designed to help coordinate external donor assistance, is in early stages of development. Major African regional organizations currently in existence and functioning are the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), the Niger River Commission (NRC), Lake Chad Basin Commission (LCBC), and Organization pour la Mise en Valeur du Fleuve Senegal, (OMVS).

Bilateral country donors include the United States, Canada, France, Germany, Netherlands, OPEC countries and Kuwait Fund for Economic Development. The USSR and the Peoples Republic of China are also donors.

Of current interest is the Club des Amis du Sahel. In October, 1974, the U.S. held preliminary discussions with the French Aid Organization (FAC) and members of the Organization for Economic Cooperation and Development (OECD) to advance the idea of institutionalizing sufficient flows of external resources to the Sahel in order to address fundamental long-term problems of the Sahel and bordering areas. As a result of these talks, AID and FAC requested the Chairman of the Development Assistance Committee (DAC), to convene an informal meeting of donors involved in the Sahel.

On January 30, 1975, the DAC called an informal meeting in Paris of OECD members, ~~Arab~~ OPEC States and the IBRD. A consensus emerged out of the meeting in favor of some form of coordinating body which would be concerned with the long-term development interests of the Sahel. The DAC Chairman was instructed to consult further with Sahel states to determine their interest in such a body. An outline with an initial conception of a Club des Amis du Sahel, a type of consortium or consultative group of donors and recipients,

was designed by the French and subsequently presented to the CILSS (a regional organization designed to coordinate the efforts and programs of the Sahel States) in March 1975. The CILSS reception of the idea of a Club was at first cautious, but generally favorable. Its concern was that it should be non-operational and not impinge on the respective roles of present governments and CILSS. Delegates returned to their governments to discuss the matter further.

Throughout 1975 discussions within the DAC continued. A fledgling staff comprised of an American and a French national, both seconded by their respective governments, were assigned to the DAC to work out the structure of the Club. Further negotiations with the African nations followed, and as the idea evolved there has been a net overall positive attitude toward the Club. The details and preliminary principles of the Club were discussed at the December, 1975 meeting of the CILSS in Nouakchott and it was decided that the first full meeting of the Club des Amis du Sahel would be held at the end of March, 1976 in Dakar, Senegal. The present concept of the Club is that it will be primarily a policy-making, coordinating body for the donors working together with CILSS and its members.

C. The Purpose of This Report

At a stage where the international donor community and the African Sahelian nations are trying to define the strategies and institutional set-up for planning and resource transfers, the Congress has asked the Agency for International Development how it would plan for a long-term comprehensive development program for the Sahel and other drought-stricken African nations.

The Congress added Section 494B to the 1975 International Development and Food Assistance Act instructing the President to begin such planning immediately, in consultation with the international donor community and with the participation of the African countries. Five million dollars has been authorized to be used to initiate this planning. The Congress requested the President to submit to the Foreign Relations and Appropriations Committees of the Senate and the International Relations and Appropriations Committees of the House of Representatives not later than April 30, 1976, a comprehensive proposal for developing a long-term comprehensive development program for the Sahel and other drought-stricken African nations. This report represents the fulfillment of this requirement.

While the report focusses on the eight Sahelian States, A.I.D. fully recognizes the serious impact felt by other African countries because of the regionwide dislocations from the drought and the pervasive impact on the economies. Other countries, how-

ever, have suffered from isolated drought conditions over the past few years and generally these droughts have not fundamentally altered their development plans. By concentrating on the Sahel, AID is better able to work within a defined area, suggest a strategy and identify measures to follow to help raise the economic level of this most seriously affected region. At the same time, it becomes clearer that there are similarities between the Sahelian States and other drought-affected African countries which can be addressed in a like manner and thus these other countries will benefit from projects identified in this report. Specific country adaptation will be required because of localized national problems, but replicability is possible.

D. Conclusions of the Report

Any attempt to design a development strategy for the Sahelian region must be couched in an extended time-framework. Neither the human capability nor physical infrastructure exists in any modern sense which would allow for near-term optimism for economic growth. Manpower trained in the most rudimentary of agricultural technologies is so thin as to be virtually non-existent. Roads are so few as to eliminate vast regions of the Sahel from anything but traditional commerce. And capital is so limited that developmental activities cannot be financed without substantial external donor assistance.

Recognizing this, the question is posed, "What do the people of the Sahel seek?" The answer is obvious for they desire the same thing people all over this earth seek -- a better life for themselves, ~~and~~ their children and future generations ~~to be~~. This is so simple a wish, yet in the Sahel, as in other underprivileged parts of the world, so difficult to attain. Translating this wish into development terms, these people seek economic growth, a growth which is compatible with and relevant to them and their life style. The challenge is out. These people seek improvement of their economic situation and the donors have the wherewithal, and, it is hoped, the will to help. The long term development goal, then, is by the end of this century to broaden and strengthen the capacity of the Sahelian countries to expand their production of goods and services while they minimize the risk of severe

deprivation due to drought and their dependence upon the rest of the world for a continuing transfer of material and human resources on concessional terms.

As part of this goal, each ~~member of the population~~ inhabitant of the region should be able to enjoy a standard of living which includes an adequate level of nutrition and health and an education preparing him to cope effectively with his changing environment. ~~In addition~~ to ~~building the human resource base, there should also be an increase in the availability of material resources to an extent which will permit the maintenance of a substantial level of nutrition and health and an education preparing him to cope effectively with his changing environment.~~ In addition to building the human resource base, there should also be an increase in the availability of material resources to an extent which will permit the maintenance of a substantial level of savings and investment and of essential government services. Finally, though there may still exist a need for foreign assistance in the year 2000, the countries should have resources sufficient to reduce significantly the concessional element of that aid and to plan toward a time when this dependency can be substantially eliminated.

The proposed development strategy to reach this goal is an integrated program which seeks primarily to maximize development of the agricultural sector while moving ahead simultaneously to improve other supporting sectors (education, health, infrastructure) in recognition of the fundamental interrelationships between them and

agriculture. Ninety percent of the people of the Sahel are engaged in agriculture, and roughly forty percent of the region's GNP comes from this sector. The impact of the rural area is pervasive in every facet of life and though much agricultural activity is today on a subsistence level, it clearly offers the best hope for development. It is firmly believed that whatever else is done in other sectors, priority must be given to supporting the development of the agricultural sector.

Within agriculture, the strategy proposed is to increase production of both food and cash crops through the intensification of dry land agriculture, employing greater utilization of relevant technology. At the same time, there should be a long-term commitment to studying the quantity and quality of ground and ~~river~~ surface water resources. Water is a vital, scarce commodity in the Sahelian area, and its optimum utilization (whether it be for irrigation, power or navigation) must first be determined before any major, irrevocable commitments are made.

Development of all other sectors, with perhaps the exception of minerals ~~everywhere~~ and of manufacturing and tourism, should evolve by complementing and contributing to agricultural development. This will not only most effectively achieve current national objectives but also lay the foundation for subsequent industrialization. With regard to mineral extraction, possibilities exist for

substantial economic resources, but to date too little is known about this sector to make it the major near-term vehicle for development.

GOAL, STRATEGY AND SECTORAL CONSTRAINTS AND ACTIONS

LONG-TERM GOAL	To broaden and strengthen the capacity of the Sahelian countries to expand their production of goods and services while they minimize the risk of severe deprivation due to drought and their dependence upon the rest of the world for a continuing transfer of material and human resources on concessional terms.
DEVELOPMENT STRATEGY	An integrated development program which seeks primarily to maximize development of the agricultural sector while moving ahead simultaneously to improve other supporting sectors (health, education, infrastructure) in recognition of the fundamental interrelationships between them and agriculture.

SECTOR	DEVELOPMENT CONTRAINTS	COURSES OF ACTION
Agriculture Grain	1. Physical Constraints: Dryland Agriculture a. Rainfall: Quantity and in regularity of distribution b. Low Soil Fertility c. Inefficient plant photosynthesis d. Pests and insects e. Low farm technology f. Post harvest crop losses g. Lack of crop diversity 2. Marketing Constraints: a. excessively large price differences between districts. b. lack of storage to hurdle drought c. lack of roads for inter-regional distribution d. lack of use of price as incentive to production.	1. Development of a Technical Package: a. better weather forecasting, optimal use of rain, exploitation of existing water resources adequate storage, irrigation. b. Use of phosphates, low-cost nitrogen, selected crops and varieties, potash, mixed farming. c. Research to improve photosynthesis. d. Pest control, seed protection (insects and birds) and fungal and bacterial diseases. e. Supply appropriate level technology to farms. f. Better resistant varieties and storage. g. Develop new cash crops, new varieties. h. Development of viable extension service for delivery. 2. Marketing Policies Consistent government price policy. a. ~~de-emphasize government interventions~~ b. encourage greater on-farm storage c. better feeder roads network

T. E. Matrix

	DEVELOPMENT CONSTRAINTS	COURSE OF ACTION
Agriculture		
Forestry and Land Management	1. Desertification: primarily localized due to overgrazing and removing vegetation--no real evidence of massive movement of desert 2. Deforestation: serious removal of trees for firewood, the major household source of energy, and ~~smoking~~ curing fish 3. Unmanaged land use: need for planning of land use in highly populated farm areas and in regions being opened for farming through the eradication of river diseases.	1. Forestry services must be reinforced 2. Training of cadres at all levels which means support of schools in Africa ~~and~~ West 3. Reforestation using proven varieties which can grow in various types of soils in the Sahel 4. Integrate forestry activities into productive agricultural and livestock activities through extension work done in these two major sub-sectors
Fisheries	1. Large insect and preservative damages of present yields. Losses in storage and marketing 2. Lack of adequate fisheries management: a neglected sector with much nutritional and revenue potential	1. Set up fishing cooperatives to disseminate technical information, create credit sources, and means of transporting fish to market. 2. Support fisheries training and management programs ~~in Chad and Mali~~.

GOAL, STRATEGY AND SECTORAL CONSTRAINTS AND ACTIONS

ECTOR	DEVELOPMENTAL CONSTRAINTS	COURSES OF ACTION
INFRASTRUCTURE A. Transportation	- Serious lack of adequate transportation infrastructure, equipment and management - Non-existence of objective, relevant criteria for economic evaluation of roads into undeveloped areas. - Inadequate maintenance capability and equipment facilities - Lack of management competence to operate railroads efficiently	- Study to develop new methods of evaluating economic feasibility - Feasibility studies to identify sites for road construction - Study to determine maintenance costs and equipment needs - Proceed with design and construction of those feasible roads identified by CILSS - Study railway systems with objective to improve operations, management and technical capabilities and determine equipment needs
B. Telecommunications	While the lack of a telecommunication is not now viewed as a major constraint to long-term development, several activities should be undertaken to support development of the agricultural sector.	- Telecommunication networks to receive and relay hydrologic data should be built - Study to determine extent of telecommunication network to serve needs of agriculture extension service and public health service
C. Power and Energy	- There is a need for regional cooperation and coordination of an energy program to plan for long-term power development - Growing shortage of wood for use as a fuel	- A power and energy survey to be implemented through each major river basin commission - A discussion on tree management ~~will be~~ is discussed in the Agricultural Sector under Reforestation
D. Water Resources	- Water is a vital natural resource in limited supply - Lack of data on the quality and quantity of overall water supply - There is little water management or control	- Undertake hydrometeorologic and hydrogeologic studies of river water and groundwater - Make detailed basin-wide mapping surveys - Develop systems analysis and water resource planning scheme - Carry out a basin-wide fishery study

SECTOR	DEVELOPMENTAL CONSTRAINTS	COURSES OF ACTION
	- No data on the relationship of groundwater to rivers and lakes - No data on possible impact from changes in water regime and introduction of irrigation - Severe shortage of skilled manpower to implement major basin development	- Improve staffing (both managerial and technical) of each river basin commission and carry out extensive training programs
II. Education and Human Resources Development	- Curricula of formal system remains oriented toward urban civil service - Access to education open to cities and disfavors rural areas and woman - Illiteracy is 90% or higher - Limited budgets restrict higher contributions by gov'ts to education - Manpower statistics are inadequate - Acute shortage of trained administrators	- Need reforms in primary and functional education - Expand non-formal education programs using for example, radios, extension programs, religious and private institutions - Need specialized and managerial manpower training programs
III. Minerals	- Limited and superficial data on mineral resources - Limited transportation facilities and lack of electric power restrain study and exploitation of resources	- Undertake preliminary mineral survey
IV. Health	- Parasitic infections, malnutrition, diseases and general poor health limit mental and physical development - Contaminated drinking water - Shortage of trained people, facilities and medicines	- Extensive training of physicans, nurses, paramedical and administrative personnel - Construct new and renovate basic medical facilities - Develop integrated rural health delivery system involving village workers, backstopped by mobile operational teams - Variety of research programs on regions' major diseases - Develop and delivery maternal and child health programs to rural areas

II. LONG-TERM DEVELOPMENT GOAL AND STRATEGY

The long-term development goal by the turn of the century is to broaden and strengthen the capacity of the Sahelian countries to expand their production of goods and services while they minimize the risk of severe deprivation due to drought and their dependence upon the rest of the world for concessional transfer of material and human resources. This goal can be articulated in three long-term objectives:

1. A standard of living which includes an adequate level of nutrition and health and an education preparing the individual to cope effectively with his changing environment.

2. ~~There should also be~~ An increase in the availability of material resources to an extent which will permit the maintenance of a substantial level of savings and investment and of essential government services.

3. Although there may still exist a need for foreign assistance, by year 2000 the countries should have resources sufficient to reduce significantly the concessional element of this aid and to plan toward a time when this dependency can be substantially eliminated.

These long-term objectives are consistent with those articulated by both the African Sahelian nations and the international donor community.

A. Long-Term Development Objectives

Long-term development objectives ~~at~~ of the Sahelian countries have been enunciated in various development plans and

were summarized at a Donor Conference sponsored by the Comite Inter-Etats pour la Lutte Contre la Secheresse dans le Sahel (CILSS) held in Bamako, March 1974:

1) The mitigation of consequences of future emergencies.
2) The attainment of self-sufficiency in food staples.
3) The acceleration of economic and social development with particular emphasis on the least developed countries.

The International donor community, as it has expressed itself in various published documents, seems to have largely accepted these objectives but has given priority attention to ensuring that Sahelian countries become self-sufficient in essential foods.

There appears to be some uncertainty, however, concerning just how self-sufficiency should be defined. A study done by SCET/SEDES for the French Ministry of Bilaterial Cooperation appears to define it as the maintenance of an improved standard of nutrition in all years, including those with drought as severe as was experienced in 1912-1915 or 1967-1973, without recourse to imports of essential foods. The United Nations Sahelian Office, on the other hand, in surveying various national plans, notes only that self-sufficiency in staple crops has become the major objective, without specifying under what conditions this is meant to apply.

In addition, they note that at least during the "medium term" recovery period, "....the economies of the Sudano-Sahelian countries will be greatly vulnerable to droughts. Even under the most optimistic assumptions, the recovery efforts cannot ensure that the countries concerned will be able to fully withstand the effects of possible future droughts without heavy external assistance." Finally, the FAO has stated that the problem of food shortage in the Sahel in time of severe drought should be solved with some form of institutionalized international insurance. This would seem to preclude local storage of the very large quantities of grain necessary to hedge completely against severe drought.

There is also a need to distinguish self-sufficiency in the region's dominant food crops, millet and sorgham, from that in foods like rice and wheat which form a smaller part of total consumption but which are growing in relative importance, especially in urban areas, because of taste preferences or their greater ease of preparation. Millet and sorghum account for a very small part of external trade in years of normal rainfall, whereas wheat and rice are imported in significant quantities, especially in Sengal and Mauritania, in nearly all years. It is clear that self-sufficiency in wheat and rice does not

exist for most countries but does for millet and sorghum in normal years.

Finally, there is the question as to whether self-sufficiency should be defined for the regional as a whole or for each individual country. Since it is listed as a priority objective in most of the national plans, we could conclude that countries see self-sufficiency as being defined at the national level. The donors, on the other hand, appear to think more in regional terms.

Part of the confusion over the meaning of self-sufficiency in essential foodstuffs is due to a lack of explicit analysis of how each definition might be achieved. With imported grains, there is no real problem. The governments can regulate taxes, subsidies, or restrictions on imports in any way they wish (with due regard to problems of smuggling) so as to maintain a given domestic price. This price, plus any direct subsidies or development programs, can be adjusted to encourage increased production, and thus substitution for imports, of these grains. If production techniques are relatively inefficient, this may be quite costly, but there is little doubt that it can be done. If necessary,

the governments can simply prohibit imports, thereby achieving self-sufficiency at a stroke (with exception again made for smuggling). This will cause the domestic price to rise sharply reducing demand and encouraging local production so that the gap previously filled by imports is eliminated.

The problem is much more difficult with millet and sorghum. Farmers usually plant something in excess of their requirements in years of normal rainfall so as to have a hedge against loss when the rains are poor. The grain is stored on the farm at harvest time and consumed throughout the year. If it is a good year, there will be surplus stocks which can be carried over to the following year. Alternatively, if the farmer believes his stocks are adequate, he will sell the surplus on the local market. In addition, he may be forced to ~~see~~ sell some grain at harvest time for needed cash. In either case, the excess grain sold tends to depress the local price, sometimes to very low levels. As a result, the farmer is disinclined to expand deliberately his production of millet and sorghum as a cash crop. If rainfall is good, he will receive a low price; if it is bad, he will need most of the grain he produces for his own consumption. Only if he has very large stocks, can he maintain his consumption standard and still have enough grain for sale to take advantage of high prices in poor years.

omit — Serves no useful purpose ? questionable

Most studies in this area have indicated that seasonal storage of grain is accomplished reasonably efficiently, by either farmers or traders, ~~although seasonal price differentials tend to exceed storage costs because of uncertainty concerning the total amount of stored grain and thus what the price is likely to be at the end of the season~~. Inter annual storage is clearly inadequate, as indicated by large differences in prices from year to year. ~~It is not clear why this is so~~. Fluctuations in yields are very large, and thus storage costs, particularly in the commercial sector, are quite high. But we do not know why farmers in some areas hold very large stocks, whereas storage in other areas is much smaller in relation to need. Only in isolated localities ~~exceptionally, however,~~ do we find stocks which would be adequate to sustain consumption at normal level during periods of as prolonged and severe drought~~, such~~ as ~~that which~~ occurred from 1969 to 1973.

Self-sufficiency in these food grains therefore already exists in good years. In poor years which may occur several times in a decade there will be some hunger and malnutrition~~, but people have adapted to this situation, and~~ We may be able to alleviate such situations ~~aid them by~~ reducing the ~~importance of any~~ bottlenecks which inhibit on-farm storage. Thus self-sufficiency can be maintained.

In catastrophic years, on the other hand, the existing system is clearly inadequate to preserve self-sufficiency. The two major alternatives to massive deprivation during these years are

1) to create public storage of food grain on a vast scale far beyond anything which exists in these countries today ~~and~~ or

2) to build up foreign exchange reserves or to make other arrangements with the international community to import necessary food in time of emergency. Only the food required until imports can be obtained will be stored locally in these countries. The former option preserves self-sufficiency in even the worst of years. The evidence indicates, however, that it would be extremely costly and probably impossible to implement effectively for many years.

Because of the confusion concerning its meaning, the ~~proximate~~ objective of self-sufficiency in essential foods might better be broken down into two separate objectives which are both broader in scope and consistent with the expressed desires of the countries concerned. The first of these objectives is to reduce economic as well as political dependence on the rest of the world. Although there may be disagreement over any particular manifestation of this objective, at a minimum it would involve a reduction of concessional transfers of human and material resources from the industrial countries. The second objective related to self-sufficiency in essential foods, but proposed separately at the March 1974 meeting in Bamako, is to minimize the risk of severe deprivation of the population and deterioration of the natural environment. In particular, the countries want to ensure that their populations have adequate food and water, even in the worst of years and that their wealth of natural

resources and animal herds is maintained intact. To these two objectives we might add the third, proposed in Bamako; i.e., to accelerate economic and social development with particular emphasis on the least developed countries. As an economic objective this can be restated as the desire to increase living standards, both in the present and in the future, on an equitable basis.

The reason for ~~specifying~~ examining multiple objectives is that they frequently may be in conflict with one another. Thus economic development requires making choices at the margin between present and future consumption as well as between growth and efficiency and equity of income distribution. For example, some profitable innovations may involve some increase in risk, while measures taken to minimize risk can often be costly in terms of growth and efficiency. Finally, the objectives of reduced dependency and minimization of risk would be in conflict if obtaining food from the rest of the world in time of emergency should prove to be a more reliable way of avoiding catastrophic loss than local production and storage.

B. The Current Economic Situation.

1. Present Living Standards and Recent Economic Growth. The countries of the Sahel are among the poorest in the world. As shown in Table 1, annual per capita GDP in 4 of these countries ranges

Table 1

Indicators of Current Living Standards

	Chad	Mali	Mauritania	Niger	Senegal	Upper Volta
GDP Per Capita, 1972 ($)	85	70	175	120	285	70
Labor Force in Agriculture (%)	91	91	85	91	76	89
Energy Consumption Per Capita 1966, (kg coal equivalent)	12	21	53	14	145	12

from $70 in Mali and Upper Volta to $120 in Niger. Mauritania, with $175 per capita is more favored only because of its rich iron ore deposits. Neglecting revenue from this source, its per capita GDP is only $125 per year. Furthermore, at current rates of exploitation these high-grade deposits will be exhausted by 1983, though it may be feasible to mine other low-grade deposits for a much longer period. Senegal, on the other hand, with a per capita GDP of $285, has a more broadly based economy in which both manufacturing and tourism contribute substantially to national income, although most of this is narrowly concentrated in the region of Dakar.

With the exception of Niger and Senegal, 89 percent or more of the work force is in agriculture with manufacturing contributing less than 6 percent of GDP. Even in Senegal agriculture accounts for 76 percent of total employment, and manufacturing only 14 percent of GDP. Thus most of the people of the Sahelian countries are heavily dependent upon rural production, and any effort to increase living standards for the majority of the population must involve development of this sector.

In addition, techniques of production used in these countries are very labor-intensive. Energy consumption per capita in 1966 was less than 21 kilograms of coal equivalent in all the countries except Mauritania and Senegal, compared with the LDC average of 427 kilograms. This implies a very low level of labor productivity and of the stock of capital.

The growth performance of the Sahelian countries during the decade prior to the drought, as shown in Table 2, was very poor,

TABLE 2

Average Annual Rates of Growth

	Chad	Mali	Mauritania	Niger	Senegal	Upper Volta
Real GDP	2.0	3.0	7.0	2.0	1.6	2.5
Population	2.5	2.1	2.2	2.7	2.4	2.1
Per Capita Real GDP	-0.5	0.9	4.8	-0.7	-0.8	0.4

Except for Mauritania with its rapid development of iron ore exports, all the countries experienced little if any per capita growth of GDP. Even Mauritania's growth was largely confined to a small mining enclave and did not improve living standards for a broad element of the population. The reasons for this poor performance appear to be based primarily on the slow growth of crop production. Groundnut exports increased slowly in Niger and fell in Mali and and Senegal. Food production also appears to have remained stagnant. The only bright spots were the growth of cotton production in Chad, Mali, Senegal and Upper Volta and the general expansion of livestock production and sales throughout the region. The last is especially noteworthy because it occurred quite spontaneously as a result of rising demand in the coastal markets and without the benefit of government intervention, except for an extensive campaign against rinderpest.

Producer prices remained relatively stagnant as well, at least until 1970 when the price of livestock began to rise. Since consumer prices increased throughout the period, there was a decline in rural living standards in most areas. Wage earners in the cities appear to have fared somewhat better, though it is doubtful if average earnings kept pace with the increased cost of living.

2, Dependence: Besides being very poor, the Sahelian countries are highly dependent on the rest of the world for imports of essential consumer goods, skilled labor, and capital. As shown in Table 3, imports as a percentage of GDP vary considerably, but they import

all their petroleum products and even before the recent drought imported significant quantities of food. From 1965 to 1970 food

TABLE 3
Indications of Dependency

	Chad	Mali	Mauritania	Niger	Senegal	Upper Volta
Imports Relative to GDP(%)	35	22	67	17	30	24
Official Development Assistance Relative to Imports(%)	46	60	22	67	22	50

accounted for between 12 and 30 percent of total imports, and the percentage was increasing steadily. Because of the shortage of trained people, many skilled and managerial jobs must be filled by expatriates. More than half of the secondary school teachers, for example, are foreign. As far as capital is concerned, the great bulk of public development expenditures are made with foreign financing, especially in Chad, Mali, and Niger. As a measure of this, Official Development Assistance (which includes current budget support in addition to capital expenditures) as a percentage of total imports, varies between 46 and 67 percent for Chad, Mali, Niger, and Upper Volta. Most of this assistance is highly concessional in nature. Finally, except for Mali and Mauritania, where the state has a major role in industry, the non-agricultural private economy is both financed and managed by foreign interests, frequently with substantial incentives given by the governments.

Even with respect to economic policies, the Sahelian countries have little independence. Chad, Niger, Senegal, and Upper Volta belong to regional Central banks (for Chad this is the Banque des Etats de l'Afrique Centrale and for the others it is the Banque Centrale des Etats de l'Afrique de l'Ouest) which are members of the French franc area. In return for access to a common reserve pool (Compte d'Opérations) and guaranteed convertability of their common CFA franc, these countries have agreed to explicit restrictions on the monetary and fiscal policies which they may employ. Credit controls are used, for example, to maintain balance of payments equilibrium at the same time that free repatriation of remittances and investment income is generally permitted. The strict regulations governing credit, together with relatively low interest rates, favor foreign-owned operations at the expense of African entrepreneurs. Mali has its own central bank, but restrictions on independent monetary and fiscal policy are almost as severe as for the other countries. Only Mauritania, which left the franc zone, has the freedom to adjust its credit policies to promote local productive investment.

3. Risk of Fluctuations in Living Standards

Aside from low standards of living and lack of economic growth, as well as a high degree of dependence on the external world, these countries also suffer from large fluctuations in income. The major reason for this is the periodic drought which affects the region. This was most recently felt as a result of the sharp decline in rainfall in 1972 and 1973 following a relatively dry period from 1969 to 1971, but it is characteristic, to a lesser extent, of many other years as well. Aside from the direct loss of production and capital by farmers and

herdsmen, drought also results in decreased foreign exchange earnings from exports, increased demand for food imports, decreased tax revenues, increased demand for government expeditures for famine relief, decreased savings as people try to maintain their consumption standards, and a general shift away from more risky but perhaps higher yielding productive activities toward those which can be regarded as safer even if they are not as profitable in average years. All of these tend to inhibit growth and development.

Some indication of the magnitude of these effects during the recent drought can be seen from the percentage changes from 1972 to 1973 shown in Table 4. The loss of production of about 15 to 20 percent in

TABLE 4

Effects of Drought

	Chali	Mali	Mauritania	Niger	Senegal	Upper Volta
Change in Real Output 1972-73(%)						
GDP	-	-6	+1	-	-19	-9
Agriculture	-	-21	-13	-	-20	-16
Change in govt revenue 1972-73 (%)	-13	+9	+10	0	+9	+11
Change in Current Govt Expend.1972-73(%)	+2	+10	+33	+9	+8	+16
Change in Exports 1972-73 (%)	-6	+11	-	+1	-19	-
Change in Current Account Surplus as a % if Imports						
1972-73	+22	-5	+7	-	-11	+3
1973-74	-22	-35	-5	-	+14	-45

the agricultural sector was very severe for people who are already very poor. This average hides, moreover, important disparities between regions which resulted in some people losing virtually everything. The result was ~~extensive~~ human suffering and loss of life, the magnitude of which we can only guess at. There was also significant physiological damage done to some children because of malnutrition during this period, which will have its effect on productivity in future years. Finally, the decline in the size of livestock herds and the changes in their age and sex composition resulting from the drought will have effects on the production of meat and milk for a few ~~many~~ years.

There were important indirect economic effects as well. Although government revenue actually decreased only in Chad, the rate of increase for the other countries was generally less than it had been in previous years. In addition, inflation accelerated, and thus the real value of this revenue tended to decline. Expanded demand for current government expenditures is indicated by the fact that, except for Senegal, these expenditures grew more rapidly from 1972 to 1973 than did receipts. The rise in government salaries was greater than that of materials and supplies, moreover, indicating some decline in government effectiveness, a common phenomenon in time of fiscal pressure. Furthermore, the more rapid growth of expenditures over receipts tended to exacerbate the problem of budget deficits, especially in Chad and Mali. With respect to exports, the drought had a decidedly depressing effect, despite ~~especially considering~~ the fact that quantity declines were offset by commodity price increases on the world market. In addition, non-

agricultural exports, such as phosphate in Senegal and iron ore in Mauritania, helped offset the decrease in agricultural exports. With expanded demand for food imports, however, there was a sharp deterioration in most countries' balance of trade. Although the change in current account balance was positive for some countries and negative for others from 1972 to 1973, it was negative for all but Senegal from 1973 to 1974. Mali and Upper Volta especially were seriously hurt by the drought. The effects on current account were offset somewhat, however, by debt cancellation and relief and by external emergency assistance of various sorts.

One other source of instability also became apparent during the drought:concentration of exports on a few primary commodities. Senegal and Mauritania had the distinct advantage of having mineral products in addition to agricultural products and livestock as major exports. All the Sahelian countries, however, have at least 50 percent of their exports concentrated in no more than two commodities. As a result they are vulnerable to fluctuations in world market prices and weather conditions at home.

C. Constraints on the Achievements of the Objectives.

The Sahelian countries are highly constrained in pursuing their development objectives by a number of important factors. These include geography and other natural conditions, existing transportation and communications, infrastructure, levels of health and education, social structure and values, composition and growth of the population, opportunities to buy and

sell goods and services on external markets, the current state of knowledge, and policies of the national governments. Some of these constraints can be altered over time~~s~~, but others cannot. At any particular moment, however, each constraint can limit the pursuit of national objectives and thus determine which strategies are or are not appropriate.

Natural Conditions. The major natural constraint is the low qua~~lity~~ntity and high variability of rainfall, each of which becomes more severe as one moves from south to north. The short period during which agriculture is possible severely limits the crops which can be grown and places heavy demands upon labor in the growing season, while leaving workers underemployed during the rest of the year. In addition, soils are generally poor and fragile, lacking in many cases essential nutrients such as phosphates and nitrogen. Except in a few cases, mineral deposits are of poor quality. The region is fortunate in having three extensive river basins, but these are not easily exploitable with large-scale development projects. Finally, very low population densities imply that, except in a few areas, land is readily available, but its use is restricted by the prevalence of disease. In addition, the low density of population increases the cost of transportation and the provision of public services in rural areas.

Infrastructure. Partly for this reason, transportation and communications infrastructure, especially roads, is seriously deficient. This ~~is compounded by~~ results in the high cost of moving goods long distances to and from the coastal ports. River transport is possible in many areas only during certain times of the year because of the highly seasonal pattern of rainfall. Finally, the railroads which serve the region are poorly managed and inefficiently run.

Human Resources

Levels of health, nutrition, and education are generally poor. There is a high incidence of mortality and morbidity and a lack of energy resulting from disease, parasitic infection, and malnutrition, which lowers productivity. The educational system remains oriented toward the French-speaking urban civil services and away from the preparation of skilled manpower for development. Illiteracy rates of 90 percent or higher exist in most countries, and there is a critical shortage of high level administrative and technical personnel. Although relatively larger proportions of government budgets are currently going to education, the effort clearly is inadequate to support the pace of development desired.

Social Factors

The social structures and values which exist in these countries have evolved to allow traditional societies to cope with a highly uncertain environment. They allow for substantial flexibility and mutual support in the event of need, yet can inhibit individual initiative if taken independently. Of special importance is the pastoral tradition of subsistence milk production which can conflict with the use of herds for their output of meat. Also important is the symbiotic relationship which exists between pastoralists and farmers, allowing the former to trade labor, milk, and manure for cash, grain, and grazing rights. Finally, there is the important problem of overgrazing which results from the failure of traditional social authorities to control the use of the rangeland.

Population

Although its density is generally low, population is growing at rates varying from 2.1 to 2.7 percent per year, and this tends to inhibit development in several ways. First, it limits the capacity for domestic saving and investment by increasing the demand for consumption. Second, it creates a structure in which as much as 50 percent of the population is under 16 years of age, contributing to the demand for education, health, and other public welfare services at the expense of directly productive activities. Finally, it creates increasing pressure on the land in some areas, which requires either relatively rapid intensification of agriculture or out-migration.

Exterior Markets.

All the Sahelian countries have opportunities to buy and sell goods and services on external markets. They are fortunate in having relatively favorable market prospects for their major exports; groundnuts, cotton and livestock. Prices of grains, their major food import, are expected to fall in relation to those of their agricultural exports. The situation with regard to mineral exports of iron ore, copper uranium, and phosphates, seems to be ~~is also~~ promising over the long run. On the import side they face a major problem from the high price of petroleum products. The recent price rise of manufactured imports should slow, however, as inflation is brought under control in the industrial countries. Finally, most of these countries export labor on either a temporary or permanent basis to the coastal countries, where opportunities for employment exist. This has created political problems in the host countries which have become increasingly severe in recent years.

State of Knowledge.

The current state of knowledge varies markedly between sectors. It is probably greatest in cash crop agriculture, where research and development has been going on for many years. It is less extensive for food crops because this area was neglected in the past. Nevertheless, there exist known profitable technical improvements involving the integrated development of cash and food crops, both for dry farming and for small-scale irrigation. Such ~~a package~~ improvements also exist~~s~~ for ~~semi-~~more intensive livestock development in the Sudanian zone, but not for the Sahel.

Of equal importance, there is at present only the beginning of an institutional structure which can serve as a conduit for the exchange of information between farmer and experiment station. As with research and development, this structure is more fully developed for cash crops than for food crops and livestock.

There is less useable knowledge available at present for rational development of the river basins. The time needed to gather necessary hydrometeorologic~~al~~ data and to acquire information on ground water is about 10 years. There is more knowledge of geologic~~al~~ conditions, but much remains to be done here as well. In other high technology areas, such as alternative sources of energy, the dat~~e~~a are ~~more~~ scarcer.

Studies are available on the comparative social cost of various agricultural and industrial activities in two Sahelian countries, Mali and Senegal. These indicate that agriculture and livestock are generally ~~much~~ socially more efficient than industry and that within agriculture ~~that~~ production of export crops is more profitable than that of cereals. Including food crops in rotation with ground nuts and cotton,

~~however,~~ is very efficient, especially if combined with livestock in mixed farming. Industry employs much less labor than does agriculture, except in the informal small scale sector about which relatively little is known. Despite generally high costs, there are certain modern industrial activities, such as textiles and food processing, which appear quite profitable.

Government Policies.

Finally, there are a number of important constraints closely related to government policies. One of these is the limited capacity of the public sector to generate the tax revenue needed to finance even the recurrent operating expenditures required for the provision of essential government services. This is due in part to the weak tax base resulting from ~~the~~ a poor resource endowment and low level of economic development. It also results from the difficulty of collecting taxes in an area where administrative services in general are stretched thinly over vast areas of low population density and where national frontiers are long and difficult to patrol. Tax evasion and smuggling are therefore rampant.

A second policy constraint on agricultural development is related to government influence on the price received by farmers and herdsmen. For a variety of reasons, including the need for export tax revenue and political pressures to keep food prices low for urban consumers, the prices received by farmers are low in relation both to their levels on world markets and to prices of manufactured goods. One result is lower real income of rural producers, which discourages investment in agriculture and inhibits the expansion of production. Another is to encourage the consumption of imported foods, especially rice. At the same time, manufacturing activity is often protected from competing imports and granted direct incentives such as tax holidays and subsidized credit.

How does this reflect from low prices to farmers?

In the case of public enterprises, direct subsidies are often substantial. All this enables industrial activities to exist despite their frequent high social cost.

One of the effects of low levels of income in rural areas is to encourage migration to the cities and to other countries where wages are higher. This has several adverse consequences. First, migrants are apt to be those who are most skilled and innovative and who are in their most productive years, leaving behind people who are least able to undertake rural development. Second, there frequently are not the jobs available in the cities to productively employ these migrants, so they often move into the small-scale, informal sector, where productivity may be very low and where they increase the demand for public services. On the other hand, migrants who find useful employment and remit part of their earnings to their families may be an important source of income and capital. This is an area in which relatively little research has been done in these countries and thus the relative magnitude of these effects is not known. It does seem likely, though, that government policies concerning wage legislation and agricultural prices ~~, etc.,~~ are important variables.

Mention was made earlier of the rather unique monetary and fiscal system which exists in most of these countries because of their participation in the French franc zone. Some have argued that this has an adverse inhibiting effect on development because of the restraint it places on the use of independent monetary and fiscal policy to stimulate economic activity and credit expansion. It may also inhibit the creation of financial intermediaries, which could be important for generating domestic savings and their investment in productive activities. On the other hand, it has also been argued that the Sahelian econo[illegible]ies are too s[illegible]ll or n[illegible] and

inflexible to be able to undertake independent monetary and fiscal policies effectively and that they have, in fact, benefitted far more from French aid and technical assistance which might have been much more limited in the absence of these restrictions. There clearly is a need for further study to determine the effect of this constraint.

Finally, it appears that government policy with respect to transportation has been an important factor inhibiting development. Rates have been set unrealistically, often either at high levels to bring in profits to publically owned enterprises or at low levels to keep prices of agricultural products and imported goods low to urban consumers. Inefficiently managed public companies have often discouraged the creation of efficient private firms because of discriminatory practices, ~~such as their preferential access to spare parts~~. Roads have been allowed to deteriorate as ~~funds~~ resources which should be allotted for maintenance ~~have been~~ are diverted to new contruction.

D. Economic and Social Determination of a Strategy.

The choice of a strategy to attain the general long-term development goal and sub-objectives took into consideration the development constraints enumerated above. The following section is an analysis of alternative strategy options for overcoming these constraints, a discussion of the final strategy chosen, and a gross estimate of the cost of this strategy in the next 15-20 years. In addition to economic considerations, a section on the social rationale of the chosen strategy is also given.

4. Alternative Strategy Options

There are a number of alternative, but not mutually exclusive, strategy options which might be used in pursuit of the various economic objectives. In general, these options differ with respect to both their timing and the relative efficiency with which they attain each objective. They also differ in the extent to which they use scarce domestic resources and are affected by the various other internal constraints listed above. We have analyzed each option with respect to these criteria and restrictions, and from this analysis we have elaborated a long-term development strategy to be pursued. In designing this strategy, we have not caused it to be constrained by the availability of external capital to finance the foreign exchange costs of the program or by the terms upon which that financing should be made available. Rather we have estimated the total magnitude of the potential cost to the donors of achieving our long-term development goal.

The following were the major strategy options considered by AID:

a) Extensive development of small-scale irrigated and dryland agriculture, including mixed farming, by the introduction of existing technology packages together with the development of systems for supplying necessary production inputs and credit. This is the most effective strategy currently available for raising rural incomes for a large number of small farmers. Its effect on dependency rests on whether interventions are made which increase the production of export crops, such as cotton and groundnuts, or of crops like rice and sugar which compete with existing imports. Investment in export crops, while increasing on world market conditions, is also more effective in raising farmer incomes and contributing to foreign exchange earnings because of their greater social profitability. With respect to the other objective, reducing risk, this strategy is less effective. Limited water control for irrigated farming, for example is relatively profitable in years of adequate rainfall but is ineffective in periods of severe drought. Or fertilizers which raise yields in average years may actually increase farm losses in poor ones. There are, however, actions in this area which can be taken to reduce risk, such as the development of short-cycle cereals and more careful attention to soil preparation. The major constraint effecting this strategy is probably lack of trained administrators

and technicians who will be needed if existing rural development institutions are going to be developed and extended to all farmers in the Sahelian countries. There is therefore an urgent need to increase the capacity to train people in this area. Inadequate transportation, health, and effective education are also important constraints, but these can be eased by expanding agricultural development programs to include other necessary components in an integrated way. Pricing policies in these countries should also be altered to provide adequate farmer incentives.

b.) Develop semi-intensive livestock production, including water development, pasture improvement, range management, and improved animal husbandry and health practices. In the Soudanian zone, a technical package exists and is currently being applied; a similar package remains to be developed in the Sahelian zone. Where it is possible, this type of intervention appears to have a high economic rate of return and to increase incomes of large numbers of herdsmen. Since exports of livestock are an important source of foreign exchange, this option increases dependency on external markets, but to the extent that favorable economic conditions in these markets persist, the capacity to service external debt is increased and dependency reduced. As the size of the livestock herd is expanded, there is some increased risk of loss in time of severe drought, but this can be mitigated by appropriate conservation measures such as protection against overgrazing. In addition, as the wealth base of the herdsmen increases, each is better able to protect himself against the effects of such loss. Extension of this type of program will run into

How is this option possible before steps have been taken to regenerate megafauna in the already over-grazed areas of the Sahel?

many of the same constraints as agricultural development, such as lack of trained manpower and existing infrastructure. The solutions are similar, including training programs and integrated rural development schemes. In addition, there are important problems posed by the large cultural gap which separates herdsmen from the intervening government agencies and by the difficulty of finding ways in which pastoral people can contribute financially and politically to these programs.

c) Development of intensive irrigated agriculture made possible by large-scale river basin development. Because of the greater degree of water control which it provides, this option is relatively effective in reducing risks. It does not, however, provide complete security, since water will be inadequate if drought lasts several years in succession. In addition, rates of return on this type of investment, given current economic conditions in the Sahelian countries, are generally estimated to be quite low. These can be expected to improve in the future, however, as the demand for power, transportation, and agricultural production increases. This option also poses important questions concerning its effects on the distribution of income and wealth, because of the geographical concentration of investment which is implied, and on the social changes required by a radical transformation in agricultural techniques. The major constraint limiting large-scale river basin development, however, is the lack of suitable data upon which to make rational

investment decisions. Even if a program is started immediately to acquire these data, the necessary sequence and timing of activities is such that at least 10 to 15 years would be required before extensive construction could begin. There is also a need to develop and to test crop varieties and methods which will be suitable for this type of irrigated agriculture.

d) Expand the production of fish by investing in new catch preservation techniques, by gathering data for fishery management, and by establishing fish ponds. This appears to be a very profitable sector in which to intervene. The major constraint is a critical shortage of trained personnel.

e) Invest extensively in mining and other high technology activites such as solar energy. Where high quality mineral deposits exist in reasonably accessible areas, they can be an important source of income, government revenue, and foreign exchange. Mining employs relatively few people, however, and its effects on income distribution are generally adverse. One important advantage of mining activity is that it is not affected directly by drought and thus can be an important source of stability, providing needed foreign exchange to import food in the event of emergency. The major problem with this option in the Sahelian countries, however, is that with the exception of a few areas having deposits of iron ore, copper, phosphates, and uranium, most known mineral deposits

cannot be profitably exploited at present because of low concentration, lack of electric power, and long distance to evacuation points. Knowledge of the geology of the region is inadequate, however, and further exploration is required. As far as solar energy and other high technology activities in this area are concerned, information is very scanty but that which exists does not seem promising for the near future.

f) A major effort to industralize, and thus to diversify the economy, by undertaking large public investments or by offering substantial incentives to private investment. Massive industrialization at this time would not be as socially profitable as investment in agriculture and would tend, moreover, to concentrate income in the hands of a few. In addition, dependency would probably be increased rather than reduced, as the countries' imports were shifted away from consumer goods toward intermediate products and capital equipment. Finally, the major risk at present is inadequate food, and industrialization would do little to decrease this. Rather than being a constraing, government policy in this area usually acts to artifically stimulate high cost industrialization. Those industrial activities which are socially profitable, however, should be encouraged.

g) Large-scale investment in extensive health and education program in rural areas. It has frequently been argued that the direct provision of welfare services, especially to the rural population, is necessary in order to effectively increase the standard of living of those with the lowest levels of income, who frequently are unable to participate

~~participate~~ effectively in agricultural development programs. While this might be partially true, it ignores the problems created by improving the health and education of people without at the same time increasing their opportunity to be productively employed. In addition, these programs place enormous requirements on government resources without contributing directly to ~~those~~ them. While this ~~the strategy~~ option would probably reduce risk of death because healthier people are better able to withstand the effects of starvation, it does not deal directly with the problem of inadequate food, and famine would, in fact, actually make the program more costly and less effective to the extent that it increased people's susceptibility to disease. Nevertheless, it is agreed that lack of progress in this area could inhibit rural development, so there is a need to include some aspects of health improvement and education in the integrated rural programs.

omit. Doesn't make sense

h) Expand and improve the road network in order to stimulate agricultural and commercial activity. This would be important in increasing incomes for large numbers of farmers. It might increase dependency on imported fuels, but this would be more that offset by greater exports. Risk would be substantially decreased, because improved transportation facili~~ties~~ties emergency distribution of food. The major constraints are the capacity of the governments to maintain the ~~r~~road network and the absence of appropriate criteria for evaluating the developmental impact of roads.

i) Encourage migration of people out of areas of limited potential and into regions where the environment is more suitable for agricultural development. The option of encouraging migration has mixed effects on income and its distribution. While productivity of the migrants doubtless increases, the people left behind are deprived of the services of those workers in their most productive years. The flow of remittances into the areas of emigration may, on the other hand, be an important offsetting source of income, though the usefulness of those remittances in time of drought is questionable unless there is an adequate flow of food into the region to prevent their prices from rising sharply. It is with respect to the objective of reducing dependence, however, that this option is least acceptable, since where migration takes place across national frontiers, there may be important political problems. Given this constraint, which is becoming increasingly severe in West Africa, large scale regional migration does not appear to be a viable option, especially in relation to the rapid growth of population which is occurring. On the other hand, movement of people into higher rainfall, but underpopulated, areas in some of the countries could alleviate the pressure of growing population elsewhere. The major constraint here is the existence of disease, such as onchocerciasis and trypanosamiasis, in the higher rainfall areas.

j) Achieve self-sufficency in the production of essential foods under all weather conditions by a combination of increasing the capacity for cereal production and increasing grain reserves stored for emergency use. This strategy option is designed to reduce both dependence upon foreign food aid and the risk of severe deprivation due to drought. It is likely, however, to be expensive in terms of the cost of collection and distribution, bulking and unbulking, storage, and interest charges if stocks are centralized at the regional or national level. Given the general shortage of qualified personnel, there is also the question as to whether a task of this huge magnitude is a desirable use of these very scarce domestic resources. Unless such a storage program can successfully cope with the problem of fluctuating supplies, moreover, there is the likelihood that it may actually make the situation worse rather than better. This would occur, for example, if stocks which are counted on in an emergency were found to be spoiled or if farmers were offered a price by the grain marketing authority which caused them to reduce rather than augment their on-farm stocks of cereals. Furthermore, the record of public intervention in domestic food grain markets of most LDCs has been dismal. Most grain storage is done on the farm, however, and there appear to be opportunities for offering incentives and improvements which would increase the size of these stocks, though probably not to the levels necessary for truly catastrophic loss.

K) Store food reserves at levels sufficient to sustain the population until imported food can arrive and be distributed and hold foreign exchange reserves or make arrangements with the international community to ensure that adequate food can be imported in the event of emergency. This is probably the least costly way of mitigating the effects of severe drought, though it implies that transportation networks from the ports to the interior must be strengthened. At first glance it appears to increase dependency and to be less effective than storage in minimizing risk. But this assumes that the world market is a less reliable source of supply than domestically produced and stored grain in a drought-prone region with a low capacity for effective administration. Furthermore, to the extent that food is purchased out of foreign exchange reserves or is obtained as part of an international insurance program rather than received in the form of foreign aid, dependency is reduced. The major constraint is probably in the transportation sector, and here there is a need to introduce emergency relief as a criteria in evaluating projects. The acquisition of foreign exchange reserves is also a problem, but it can be alleviated by concentrating on profitable production for export rather than on relatively unprofitable import-substitution actitivies.

2. The Development Strategy

The optimum strategy should consist of not one but several of these options joined together to form a consistent and cohesive structure which allows for the uncertainty implicit in all long-range planning and for the essential sequence and timing of activities required for rational investment. With this in mind, the development strategy we propose is to concentrate on development of the agricultural sector within the context of an integrated rural development approach. That is, action in other sectors such as transportation, health and education should basically complement development of the agricultural sector. The strategy also provides for appropriate phasing in of higher levels of technology, including large scale river basin development, by beginning the necessary ground work of data gathering. There is a need to move quickly to apply known technology and to expand research and development in agricylture and livestock, to build the infrastructure required for these actions, and to provoe for an intensive program to train people in the necessary specialties who are capable of conceiving, elaborating, and implementing the projects, policies and programs growing out of this approach. Substantial resources are also required to gather the hydrometerological and hydrogeological data which are essential for application of higher levels of technology as soon as this is appropiate.

The emphasis on the agricultural sector should involve the increase of both cash and food crops, and in many cases livestock. We estimate that through the application of known technology there

will be a modest increase in production per farm spread over large numbers of people, which, when viewed ~~from~~ for the region as a whole, will result in a substantial overall expansion of production. The development of small and medium sized farms is, in fact, the most efficient way known today to increase the productive capacities of these countries and to expand their resources available for future investment and the provision of essential government services. In addition, these programs will serve as a vehicle for developing the institutions required to link the farmer with the research and development being conducted in this area, which will contribute to future sustained improvements.

The West African meat market currently offers substantial immediate profits to producers in the livestock sector as a result of recent strong upward pressure on meat prices. The sector lacks, however, a suitable technical and institutional package for introduction into the Sahelian zone to increase production and preserve the fragile environment. Thus the strategy in this area is to experiment with numerous pilot projects to develop an effective package for later diffusion throughout the zone. In the higher rainfall Sudanian zone, on the other hand, a suitable package already exists and is currently being introduced in several countries. Assuming this effort succeeds, it should be duplicated elsewhere in the zone. In addition, research and development in the livestock sector should be further expanded to enable these countries to take advantage of their apparently strong regional comparative advantage in this activity. Finally there is an

important need in this sector, because of its extensive nature, to establish effective institutional ways for strengthening the relationship between herdsmen and the intervening government agencies and of allowing the former to participate in the conception, financing, and implementation of these programs.

There appear to be substantial benefits which can be gained from relatively modest investments in the fishing industry. These include treatment to avoid insect damage, gathering information for fishing management, establishment of fish ponds, and urgent training of personnel. Interventions should be made in fishing, as in agriculture and livestock, which are consistent with the integrated rural development concept.

With respect to mining and large scale river basin development, our strategy calls for priority emphasis on gathering essential data which will permit rational planning and investment in these sectors as soon as this information is available to permit analysis. With the exception of a few deposits of iron ore, copper, phosphates and uranium, which either are currently being mined or could be mined in the near future, most known mineral deposits cannot be profitably exploited at present because of low concentration of the deposits, lack of electric power, and long distance to evacuation points. More geological exploration is required, however, and part of the strategy is to undertake further studies.

As for river basin development through large-scale multi-purpose projects, adequate data are almost entirely missing. An urgent program of basic data gathering and pilot projects for various types of irrigation, managed fisheries, hydropower development and other related activities is required before extensive construction of sophisticated projects ~~can~~ should be begun. Perhaps 10-15 years of study and pilot project experience is needed prior to undertaking the major construction of projects that irrevocably commit the utilization of scarce resources of river and ground water. Furthermore, major capital investments in this area do not appear to be economically profitable at present. Even if foreign exchange costs were all financed from exterior sources, a heavy concentration of effort during the next one or two decades on intensive large-scale irrigation instead of more broadly based integrated rural development, livestock, and fishery projects would be a very inefficient utilization of scarce domestic resources. While greater total yields might result, the costs would be high, and it would have adverse effects on the distribution of income and, to be successful, would require a major alteration in the lives of the people affected. Within 10 to 15 years, however, the necessary data for rational investment in this area can be gathered, and socio-economic conditions, including the profitability of large-scale irrigation, may well have changed. Therefore, our strategy calls for taking all measures necessary to gather information and to plan for multi-purpose river basin development, so that when

the data and pilot project experience are available, the projects for which vast resources must be committed can make the best use of the invaluable water available in the rivers and underground.

In the interim period, while basic data are being obtained in order that the utilization of surface and ground water in the river basins can be planned rationally, that water can be employed for irrigation in small-scale activities to increase agricultural production. Clearly, the largest single impact on the lives of the subsistence farmer that additional water can provide is by insuring that the rainy-season crop will have the best possible yield. Supplemental water provided from the major rivers and lakes, from wells, and from catchments in bas fonds, marigots and on-farm man-made ponds can make this possible on hundreds-of-thousands of hectares before it is known how and where to build upstream storage that can furnish water for large-scale, year-around irrigation.

Except for Senegal, which already has a sizeable manufacturing sector, industrialization is not included as a major part of the strategy over the next 25 years. This is because most modern industrial activities cannot compete profitably with agriculture in the Sahelian countries. They also employ relatively few workers and therefore unfavorably influence employment and the distribution of income. During the next two decades the foundation for industrialization will, however, be laid in two important ways. First, there are some industries, such as textiles and food processing, which are currently profitable and might even contribute to exports. These

will play a vital role in developing management capabilities and a skilled and disciplined labor force to serve as the core upon which to base future industrialization. Second, the expansion of income in the agricultural sector will enlarge the size of the domestic market for manufacturers. This demand will at first be met by imports but will subsequently allow for the profitable exploitation of scale economies as domestic production is substituted for these imports.

Finally, the strategy calls for the development of transportation, education and health as an adjunct to agricultural development and at a pace determined by the expansion of productive resources generated by agriculture which can be drawn on to sustain these activities. Investment in roads, schools and health facilities are of little value unless public expenditures are adequate for their maintenance and operation. In addition, there is an overwhelming need to improve the effectiveness of these programs. We envision that most investment in these areas should take place within integrated rural development programs. These will provide both the administrative framework and the resources necessary to achieve success. A major exception to this would be work to eradicate onchocerciasis and trypanosomiasis in higher rainfall areas where it is an impediment to agricultural resettlement. In addition there is a need to evaluate more carefully the benefits to be gained from investment in transportation, education and health, since it is clear that they ~~both~~ all contribute to production

and are valued for non-productive reasons as well. Conventional cost-benefit analysis should be modified to allow for criteria other than economic profitability in evaluating these projects.

This strategy will offer increased protection against the effects of moderate fluctuations in rainfall and will even improve the ability of people in these countries to avoid severe deprivation due to prolonged drought. This will occur because of improved techniques and seed varieties introduced both into dry land and irrigated agriculture and because of the expansion ~~of land and irrigated agriculture and because of the expansion~~ of land under small-scale irrigation. It will also occur if incentives and improvements are offered to increase on-farm storage. We believe that there is at present, however, no known way to make the region completely self-sufficient in essential foods in time of severe and sustained drought such as that recently experienced. Even major river basin development is no protection against drought of this magnitude since the reservoirs simply dry up. Consequently, as part of the strategy, we recommend that reserves be stored in the country at levels sufficient to sustain the population until imported food can arrive and be distributed, that foreign exchange reserves be accumulated or other arrangements be worked out with donors for the purpose of importing goods from the rest of the world in the event of need, and that studies be initiated to examine the costs and benefits of holding and distributing emergency reserves of foreign exchangec, cereals, water and animal feed in alternative ways.

3. SOCIAL JUSTIFICATION OF THE STRATEGY

A strategy to emphasize development of dryland and small-scale irrigated agriculture, livestock, and fisheries would essentially mean building up of the rural sectors which comprise more than 90 percent of the total population. Such a stragegy using labor-intensive technology with active participation of the rural population would:

- lead to increased agricultural, livestock and fish production both for domestic consumption and for export;
- increase income and expand the options available to the rural population to make meaningful decisions about the quality and direction of their own lives. The prime beneficiaries, in other words, will be the rural poor, the small farmers and herdsmen who comprise the overwhelming majorities of Sahelian populations;
- not subject the environment to unknown risk and in some areas actually reverse the existing movement toward environmental degradation;
- be based on voluntary rather than coerced participation.

This would contribute in a maximum way to personal well-being and social, as well as economic, development.

The nature of land in the Sahelian countries is such that it has eco-ethnically segmented the population into herding and farming peoples. The strategy proposed by A.I.D. will emphasize "development from below" which is based on the existing strengths and capacities of the population. It encourages complementarity rather than competition through a natural specialization and efficient exchange of goods and services. To see the full importance of this we should examine further the complex societies.

a. The Sahelian Farmers

Sudano-Sahelian farming societies are complex and varied. Certain broad generalizations, however , can be made, as long as it is understood that they are generalizations and do not describe any particular society.

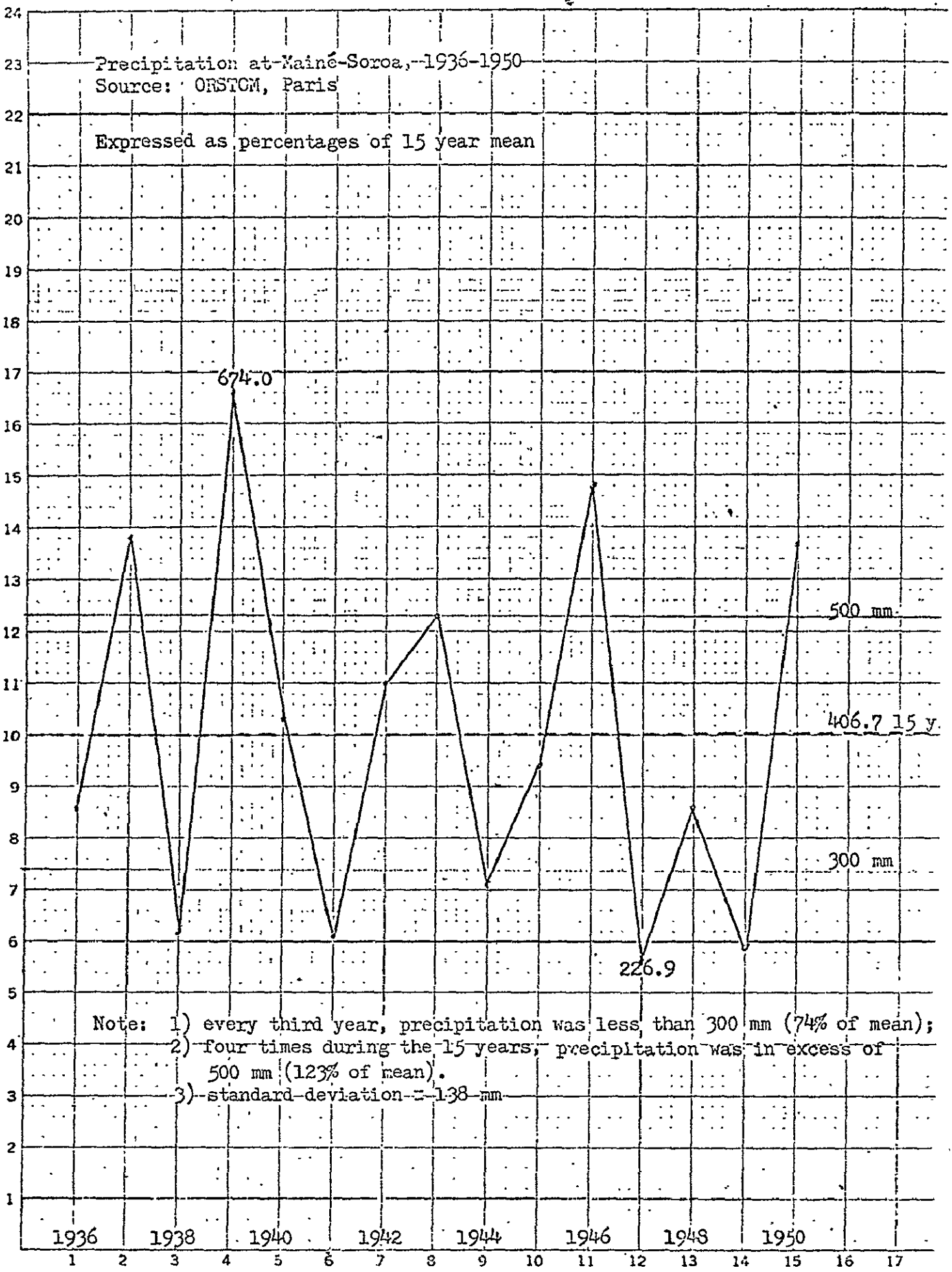
Most of these farmers cultivate using simple tools (the hoe, the digging stick), relying primarily on labor from their own households, supplemented at peak times by exchanges from friends and relatives, or from formally structured groups (such as age grades among the Malian Bambara). Wage labor, particularly for cereals cultivation, animal traction, pesticides, or commercial fertilizers are little used, because the costs, in money and/or in labor requirements, outweigh the perceived benefits. Peasants are not hidebound traditionalists, nor do they irrationally reject yield-increasing inputs. On the contrary, they clearly calculate the risks involved and reject those actions which increase the risk of not having sufficient

food. Interventions which are relatively without risk, such as adding fungicide to seed before planting, have been eagerly and widely adopted.

The farmer's task is to allocate his resources (labor, land, tools) to assure himself and his household of having sufficient food for home consumption and sufficient cash to pay taxes and to provide items which cannot be locally produced. In the more arid parts of the region, harvests are unlikely to be adequate in one out of three years, requiring that sufficient surplus be produced in the other years to carry over. The zone is remarkable for the vast array of straw, mud, and clay farm and household granaries in which the surplus production of a good year is stored.1/

Where rainfall is sufficient, and where marketing facilties exist, farmers have allocated some of their land and labor to the production of a cash crop, such as groundnuts or cotton. Frequently governments have encouraged this production by the development of an extension and marketing service (such as Operation Arachide in Mali or U.N.C.C. in Niger, both for groundnut production), through which the farmers are organized in producers' cooperatives (without, however,

1/ Consider, for example, the non-drought years of the late 1930s and 40s in the Sahelian village of Maine-Soroa, Niger. As can be seen on the following graph, there is a regular oscillation around the mean annual precipitation of 400 mm), and every third year total precipitation fell below 300 mm, the minimum which provides for an adequate harvest under local technology. However, from time to time precipitation exceeds 500 mm, and the harvests are plentiful, providing the cushion for the deficit years.


Precipitation at Mainé-Soroa, 1936-1950
Source: ORSTOM, Paris
Expressed as percentages of 15 year mean
674.0
500 mm
406.7 15 y.
300 mm
226.9
Note: 1) every third year, precipitation was less than 300 mm (74% of mean);
2) four times during the 15 years, precipitation was in excess of 500 mm (123% of mean).
3) standard deviation = 138 mm
1936
1938
1940
1942
1944
1946
1948
1950
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

being permitted to have a voice in the price received for the crop), and through which the farmers may receive selected seeds or commercial fertilizers at subsidized prices or credit to buy a pair of oxen and a plow.

Governments have complained that where coercive sanctions to get the farmers to participate in the commercial sector are not employed, the farmers often do not meet expected quotas. Yet the governments have often not provided information, such as the price at which the crop will be purchased, prior to planting, which would enable the farmers to make a more informed judgement. In other cases prices have simply been too low or the government has lacked the funds or equipment to buy the crop. Farmers may well know how to expand production without major technological interventions, but with inadequate incentives, they have not always found it in their interests to do so.

Since most farmers neither irrigate nor add chemical fertilizers to the soil, soil fertility is maintained by a combination of the following practices: intercropping, manuring, broad spacing, shallow cultivation, and fallowing.

Intercropping is the practice of planting both several varieties of the same crop and different species in a single field. Each variety has its particular advantage; e.g., some do better in low rainfall; some are pest, disease, or fungus resistant. Prudence dictates, therefore, that the farmer hedge his bets with some of each, sacrificing the possibility of a spectacular harvest for the likelihood

of a reasonable one. Mixing several species also has the advantage of moderating the nutrient demand that comes from a homogeneous stand, and where the mixture includes a legume like cow peas, it actually enhances the nitrogen content of the soil.

While farmers do not use chemical fertilizers they do recognize the nutrient value of manure, and have a range of techniques to get manure on their lands. Some farmers own stock of their own which they pen at nights for a year or so. That land is then farmed, the animals being moved to a new pen some distance away, and a new field is thereby in process of enrichment. On the extremely arid Bandiagara Plateau in Mali manure is carefully collected, and small plots, often no more than a meter square, are built up out of a mixture of manure and soil, and then watered by hand. This is very laborious, but yields of 4 to 6 tons per hectare of such a high-value crop as onions have been reported. The most typical means by which land is manured, however, is for the farmer to turn his post-harvest land into pasture, where pastoral herdsmen bring their animals. In eastern Niger farmers use a number of techniques to get the herdsmen to come to their fields, especially directly after the harvest when the stubble is rich and the manure will in consequence have a good nutrient quality. Farmers may purchase animals which they consign to the herders, establishing a claim which the herder meets by bringing the animals to the owner's fields after the harvest. Farmers have even dug wells on their lands to entice the herders by facilitating the watering of

stock, and they may present them with gifts of sugar, tea, and the like. It is important not to underestimate the contribution made to fertility of agricultural production by relationships which are established between sedentary farmers and transhumant pastoralists.

Farmers recognize the nitrogen fixing contribution of certain trees, notably the acacia albida, or "gao." Millet planted in proximity to that tree grows richer and taller than millet planted at a distance. And since the gao has leaves in the dry season, it does not interfere with the passage of sunlight to the maturing plants. Its dry season leaves provide fodder for animals, who browse under its branches and further enrich the soil. Experiments are currently underway to explore the possibility of widespread plantation of the gao, for they are also excellent sources of honey.

Plants are spaced more broadly apart than seems necessary in the average year. Yet the farmer does not plan for the average year, but for the deficit year. His plants are widely separated in order that there be sufficient ground water for them to ripen during the one year in three or four when rains fall to below 70% of normal.

The hoe and the digging stick similarly are not simply traditional devices to fall away in competition with the plow. There is some evidence that these tools may have genuine adaptive value in that they protect the soil.

Because he tills by hand, and because his most important activity is weeding, the farmer is limited in the amount of land he can farm largely by the amount of labor he is able to mobilize. Thus reason dictates that he increase the size of his household, and the

evidence is that the more children a man has the more affluent he is likely to be. Some of the motivation to have a large family is non-economic, of course, but it also makes perfectly good economic sense, especially in view of the risks inherent in high rates of infant and child mortality. Exchange groups also satisfy some of the need, but everyone requires the group at the same time.

Manuring, intercropping, shallow tilling, and labor notwithstanding, after two to four years the land must be allowed to go into a relatively long fallow period, to restore its nutrient content. Shifting cultivation is a perfectly sound way of managing soil fertility so long as the ratio of available land to population remains favorable. Thus far it is relatively favorable in the Sahel, although very much less than has been supposed.

In addition to the movement of fields there is also the movement of agricultural peeples. Young men from Mali, Upper Volta, and Niger regularly migrate to the wage labor areas of the coast in search of employment, and a significant portion of the farm revenue is derived from remittances by these Sahelian migrants. The bulk of the movement is in the dry season, following the harvest. Most workers return for the planting the following May or June, but increasingly, as they find high-paying jobs, some stay longer and longer.

Arid zone farmers also raise small ruminants, sheep and goats, which can be herded from the village, and need not be consigned, as do cattle, to specialists who keep them away from the village during the planting season. Small ruminants have unfortunately been neglected

in much of the thinking about livestock in the Sahel -- largely because goats have an undeservedly bad press. They are important in a number of areas, however, for the startup costs are much lower than for cattle, they consume less water, and, in the case of goats, they can browse on scrub that would not support larger stock. They can be consumed by a small group in a single sitting, and therefore can provide needed high-quality protein from time to time without risk of spoilage. And being small, they are relatively liquid, convertible into cash.

Thus, what appears to be a simple operation is, on analysis, a complex one, and requires skillful management of land, animals, and personnel to provide for a livelihood. The major conclusions to be drawn are:

- these operations are integrated; they form a system. Interventions must consider the whole interconnected network if they are to be successfully introduced and adopted.
- interventions should have due regard for increase of risk.
- the greatest resource for development in the agricultural sector is the Sahelian farmer, experienced, skillful, and knowledgeable. It is imperative that he be made an active participant in the design, assessment, and management of developmental interventions.

b. Herdsman

The strength and durability of the Sahelian herdsman's adaptation to the arid Sahelian environment is found in his multiple resource

exploitation. Instead of concentrating his efforts and investments on a single economic activity, the Sahelian pastoralist distributes his activities across a wide range of ecological niches. He thus hedges his bets, assuring himself and his family a reasonable level of living in all but the most rainfall-deficient years, a level which supports an exceptionally large number of persons in an environment which seems to have no alternative uses. This is a fact of tremendous import. The northern ranges of the Sahelian zone support somewhere between 10 and 20 percent of the total 25 million population of the CILSS states through a combination of subsistence dairying and meat production. No one has ever seriously proposed an alternative to animal husbandry for this terrain, and any substantial shift from dairying to a more beef-oriented activity would result in some decline in the number of individuals which can be supported. Since the pastoral population is probably close to its limit today, as the overall CILSS states population rises to more than 40 million by the end of the century, the fraction characterized by pastoralists will decline. Nonetheless, their contribution to the overall economy by making productive use of an otherwise economically sterile landscape, may be of increasing significance as the world demand for meat rises more rapidly than supply.

The components of multiple resource exploitation are reasonably well understood.

Most herding societies maintain a broad range of livestock. In addition to cattle, they keep varying numbers of sheep, goats, and often camels. Each of these animals makes a different consumptive demand on the environment, and when their relative numbers are in balance, the environment is not subjected to extraordinary demands on one of its resources. Some animals graze and some browse. Goats are effective climbers of low trees, and camels, of course, can find food at considerable heights. The animals have different demands on water, and different capacities to cover distance on the ground. Some of them are resistant to diseases to which others readily succomb. The social organizations of herding societies tend to be quite flexible, and this flexibility enables them to respond to the varying demands of their livestock. That is to say, herders can organize themselves in ways which best maintain the herds, combining and recombining in order that the animals may profit maximally. Of course the goal of this action is not the well-being of the animals *per se*, but the well-being of the herders who live with them in relationships of ~~mutual~~ symbiosis.

While the ultimate fate of any animal is the cooking pot, and herdsmen themselves enjoy eating meat, the fundamental socio-economic activity of Sahelian herdsmen is *subsistence dairying*. In order that the largest number of persons may subsist on the herd, the primary claim on the heifer's milk is made not by the calf but by the people. This means that some of the production from the herd is consumed directly by the pastoralists while other output, primarily in the form of meat, is sold to others. The strategy of subsistence dairying

implies a demographic herd structure that is quite different from that of the beef herd. The only way to increase substantially herd offtake, which currently requires retention of some 90 percent of its members annually, is to reduce calf mortality and/or to increase the rate of calving. These actions must be comined with providing sufficient incentive for the herder to convert animals to other values.

Herdsmen have developed elaborate codes to regulate their relationships with farmers. The principal exchange, already mentioned, is the post-harvest conversion of cultivated fields into pasture, in which animals graze on the cropped farms, eating stubble and providing manure. Additionally, there are sales of hides, butter and cheese, milk (both fresh and curdled), meat, and purchases of millet, sorghum and the like. Especially during the dry season, when herdsmen and farmers are in close and continuous contact (since animals do not have to be kept away from the cultivated fields), herdsmen provide labor for the farmers in exchange for cash and food. Finally, while many farmers own livestock, these are generally consigned to herdsmen for pasturing, with the herdsmen receiving either cash or a portion of the increase of the herd.

Many pastoralists also farm, making use of their flexible social organization to mobilize labor for agriculture as well as for pastoralism.

To prevent the accumulation of animals among a few rich persons, herdsmen have developed various redistributive mechanisms. Animals

are reallocated through loans, marriage gifts, tribute, etc. Some herding peoples have traditional relationships of political dominance over some agricultural peoples, such as the relationships between Tuareg and Buzu in Niger. While the exchanges are hardly symmetrical, the Buzu received protection and access to animals, and gave their Tuareg captors labor and agricultural produce.

The most striking adaptive mechanism is, of course, movement, especially the regular seasonal movements from northern pastures in the rainy season to cropped fields in the dry season. Associated with free movement is necessarily the notion of free access to pasture. This results in over-grazing, and local pasture improvement is seen as an invitation to others to bring in their animals. There is some dispute, however, over what should be done to avoid this.

Like the Sudano-Sahelian farmer, then the pastoral herdsman also manages a complex operation, involving people, animals, land (both pasture and crop land), water, markets, etc. He has chosen to do so by an ecological adaptation which we label "subsistance dairying," in which the goal of the enterprise is not maximization of income or profit, but supporting on the produce of the herd the largest number of people. The system is remarkably adaptive because, in addition to supporing this large number of persons (between 2½ and 5 million), it makes use of the most arid reaches of the Sahelian terrain, lands which as yet have no other identified economic function, and it has responded to the demands for meat protein, especially beef, that have been regularly increasing in the interior cities and along the coast. The Sahelian herdsman is par excellence an opportunist, constantly probing, experimenting, and exploiting every viable ecologic niche. His opportunism provides a

receptivity to experimentation and change; his managerial skills provide a great resource for development. But, even more than in the case of the farmers, we must respect the caution with which the herdsman deals with proposals for change. The herdsman has to weigh any intervention against its possible repercussions in all areas. To the extent that the intervention might serve to reduce the number of persons directly supportable on the herds, we can anticipate it being received with reserve. But where the intervention supports the people, where it does not deprive them of food, where it does not put them into a situation of intolerable risk, that they will experiment with it and where it seems to pay off, adopt it.

Thus both farmers and herdsmen operate complex production systems within a fragile environment. They are conservative in that avoidance of excessive risk is very important to them. But they are not opposed to change as long as it takes place within the context of their existing economic and social structure and is consistent with their social values. The development strategy we propose has good prospects of success with these people. An alternative strategy which required major and rapid changes in their structure and these values runs the risk of failure.

E. LONG-TERM DEVELOPMENT GOAL AND STRATEGY AND THE ROLE OF EXTERNAL ASSISTANCE

If the foreign exchange component of investment is disregarded as a constraint, the pace and implementation the strategy suggested here will be determined principally by four limiting factors:

(1) technical constraints, including the sequence and timing of various activities; (2) the capacities of the countries to absorb development projects given their limited supply of qualified people and the time required for training, (3) the degree to which the countries are willing to allow expatriate personnel to fill this human resource gap, and (4) their ability to amass the domestic resources required for investment and essential recurrent public expenditures. It is impossible to predict accurately at this time just how rapidly these constraints will permit development to proceed. We have estimated, however, that if this strategy is pursued vigorously, by the year 2000 a total of 1.4 million hectares of dry farming, 200,000 hectares of irrigated agriculture and 6 million pastoralists will be covered by functioning rural development schemes. In addition, all the major hydrometerologic~~al~~ and hydrogeologic~~al~~ studies will have been completed, and river basin and mining development can be well underway. Both the physical resources and the transportation, health and education infrastructure will exist, furthermore, which will permit the Sahelian countries to move into a period of sustained growth and industrialization in the ~~twentieth~~ twenty-first century. Finally, though there will still exist a need for foreign assistance in the year 2000, the countries should have resources sufficient to reduce significantly the concessional element of that aid and to be able to foresee the time when this form of dependency will be eliminated altogether.

The strategy designed to achieve this goal by the end of the twentieth century has implicit in it a requirement for substantial amounts of external assistance during the next 15 to 20 years. Any projection of the total value of that assistance is bound to be very approximate, but we nevertheless believe there is sufficient information and experience available to forecast at least the order of magnitude involved.

Estimated costs of agricultural and livestock development projects are available, for example, based on the experience of the World Bank, which has projects in all these countries to introduce technology packages and to establish systems for supplying necessary production inputs and support services, including credit. These costs can then be extrapolated over the total average ~~and~~ numbers of pastoral families projected for the year 2000.[1] Experience with river basin development elsewhere in the world also provides us with estimates of these costs. Although less information is available on what might be done in mining and transportation, we nevertheless for the sake of completeness forecast approximate values of investments which could be made in these areas. Finally, we

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[1] These projections are taken here from a study done for the French Ministry of Bilateral Cooperation entitled Essai de Definition d'une Strategie l'Ouest (October 1975), as modified by more recent information we have acquired.

estimate very roughly the manpower requirements for most of these activities, especially agriculture and livestock which are the most important, and project the cost of necessary training. The results, shown in Table 5, show a gross estimated total investment cost of $11.6 billion over the next 15 to 25 years.

TABLE 5

ESTIMATED TOTAL COST OF INVESTMENT, 1976-1990/2000 a/
(million US $ in 1975 prices)

Agriculture b/	
Dry Farming c/	$2,500
Land Resettlement d/	1,000
Irrigated Agriculture	1,600
Research and Development	750
Livestock	
Semi-intensive Range Development	500
Other Livestock, Fisheries, Research and Development	150
Health	500
Education and Human Resources Development	500
Minerals e/	500
Transportation f/	2,000
Telecommunication	100
River Basin Development g/	1,000
Power and Energy	500
TOTAL	$11,600

a/ Foreign exchange cost is estimated as two-thirds of total cost, based on the experience of projects financed by the World Bank.

b/ Per hectare cost of integrated rural development projects ($200 per hectare) multiplied by a projected acreage in the year 2000 of 12.5 million hectares

c/ Per hectare cost of land resettlement projects ($600 per hectare) multiplied by a projected resettled land acreage in the year 2000 of 1.5 million hectares

d/ Per hectare cost of irrigation projects ($8000 per hectare) multiplied by a projected acreage in the year 2000 of .2 million hectares

e/ Dependent on surveys and initial exploration, figures could fluctuate widely.

f/ Assuming new criteria is accepted.

g/ Includes studies and pilot projects; 2nd phase construction not included.

Past experience indicates a very weak capacity of these countries to finance a major portion of this investment. They already contribute to project expenses by paying local personnel and operating cost, but their ability to purchase capital equipment and otherwise to pay for investment is very limited. As an indication of this, the combined current budget surplus of all these countries averaged only $19 million per year from 1969 through 1972, of which $16 million was accounted for by Senegal. Revenue in the Sahelian countries is inadequate, in fact, to finance at sufficient levels even recurrent expenditures for essential government services. This has a detrimental effect on development and especially on the ability of the countries to operate on a sustained basis programs initiated by various investment projects.

Ultimately, of course, it is anticipated that these projects will contribute to increased income, which will broaden the tax base and result in greater public revenues. Gestation periods may be relatively long, however, especially since there is much information to be acquired, many projects are pilot in nature, and the benefits of improved technology have not yet been fully exploited. The timing of projected-related current and capital expenditures is such, therefore, that these expenditures probably cannot be financed directly out of general revenue derived from the increments of income they create. This is especially true because budgetary pressures faced by the different governments cause them to

direct any additional revenue they acquire toward their most pressing immediate needs. As mentioned before, however, there may be some scope for establishing systems of payments which are related closely with services provided and which therefore channel newly created resources directly back into productive activities.

This may permit some repayment of capital investment, but it is probably too much to ask that it provide the initial financing for much of that investment. It is here, in fact, that the almost complete absence of financial intermediaries poses severe problems for the accumulation of private savings and their investment in productive activities. There is private investment, of course, but it is generally limited to the occasional purchase of cattle or a few farm implements, or to the investment of some working capital in commercial activities. There are few individuals or families in these countries wealthy enough to invest in substantial productive enterprises, and the absence of financial intermediaries prevents them from combining their capital for this purpose.

As a result of all these factors, it seems clear that most of the financing of investment must come from external sources. Foreign private investment is relatively important in some of these countries, especially Senegal, but it is confined almost entirely to commerce and industry. There are also several international sources of funds upon which the Sahelian countries may draw. One of these is the International Monetary Fund, where the countries have, in addition to their regular drawing rights, access to the Compensatory Financing Facility to meet balance of payments difficulties arising from temporary export shortfalls

and to the Oil Facility Special Account which was established to lend to members faced with balance of payments problems resulting from increased oil import costs. Each of these has disadvantages, however, because of restrictions placed on the countries policy-making authority or, as in the case of the oil facility, because rates of interest charged are relatively high. Combined resources available from the IMF in 1975 for these countries was $74 million compared with an overall basic balance of payments deficit in that year of $110 million. In addition, the countries are likely to be able to borrow from a Third Window of the World Bank, albeit at an interest rate of 4.5 percent, and on more liberal terms from a special trust fund established by the International Monetary Fund using its profits from gold sales. All of the countries except Mauritania also have access to the franc zone Compte d'Operation, and Mali has made considerable use of this over the past few years. Finally, as associate members of the European Economic Community, the Sahelian countries would participate in STABEX, the export earnings maintenance scheme adopted by the Lomé Convention. All of these facilities could at best, however, contribute only marginally to the overall capital requirements of the countries concerned, and, because of interest which must be paid or restrictions which may be imposed, they are probably best reserved for short-term emergency situations.

As a result, the Sahelian countries must look to long-term loans at concessional terms or grants from foreign donors to finance the bulk of their investment needs. The question remains as to the terms upon which this assistance should be given. At first glance, it appears that these countries are not

excessivly burdened with external debt. Except for Mali, the debt service ratio (ratio of debt service to exports) is not generally high, varying from 1.5 percent in Mauritania to 9 percent in Upper Volta. In Mali, the ratio is very high largely because of debts accumulated during the socialist period of the 1960s, but in fact few, if any, of these debts are actually being repaid. Because the ratio is relatively low for most of these countries does not mean, however, that they have the ability to service large amounts of debt. Export earnings are very limited and are likely to remain so for some time. Donors recognize both this and the limited ability of the government to tax increments of income in order to acquire the resources with which to repay public debt. As a result, the terms of aid have been highly concessional, which is the major reason explaining the low ratio of debt service to exports.

To the extent that a development program succeeds, it is to be expected that the ability to repay debt will increase. Therefore, the Sahelian countries ought to be in a position prior to the year 2000 to begin to pay interest on their borrowings, initially at relatively low rates. It is suggested, then, that economic assistance should be highly concessional for the first decade or so, but that as production increases as a result of these development efforts, the terms of aid be made increasingly stronger. The timing of this change in the terms of assistance needs to be carefully studied, however, as the projects promoting development are elaborated and as the balance of payments and budgetary situation of the countries change.

A. Geography and Climate

There is great diversity in the history, politics, and cultures of the peoples who make the eight West African Sahelian States of Chad, Mali, Mauritania, Niger, Senegal, Upper Volta, Gambia and Cape Verde Islands. While Mauritania, Senegal, Gambia and Cape Verde Islands have direct access to the sea, the rest are landlocked on the fringes of the Great Sahara. Each of the eight have geographical features which vary considerably: great deserts, mountain ranges, a massive inland delta, river valleys, lake basins and rain forests. The greatest resource of these countries is the good fortune that major rivers flow northward from tropical mountains in Guinea, Central African Republic, Cameroon, and Ivory Coast into the arid Sahelian regions and provide millions of cubic meters of surface and ground water in areas that receive less than 500 mm of annual rainfall.

One common feature of the area is that they all occupy the climatic zone called the Sahel-Sudano area, from about 11° north to 24° north. The Sahel is a transitional zone between the desert and the Sudanese region. It extends across the southern third of Mauritania, through Mali on the Niger River Bend, and on to the northern tip of Lake Chad. The southern edge of the Sahel runs from Dakar, Senegal; Kayes, Sansanding, and Mopti in Mali; Say, Niger; to the southern tip of Lake Chad. The Sahelian zone is theoretically divided into two sub zones which are distinguished by rainfall patterns:

1. The northerly band has between 250-300 mm of rain per year. This is enough to support some vegetation including grass and piney shrubs which are widely dispersed. This zone is used for livestock grazing by momadic peoples.
2. The southerly band has between 300 and 500 mm of rain per year. This is enough rain to support, in the most propitious times, trees such as the date palm, acacias, baobab and a cultivation of millet and peanuts, and cotton and rice (under irrigation). The area is in general occupied by sedentaries growing either millet or peanuts. Annual deviations from these rainfall patterns are ± 30-45 percent. However, without irrigation, crop yields are very poor and only extensive, ~~type~~ agriculture is practiced in the area with little or no use of fertilizer, pesticides, animal power or mechanization.

The Sudan to the south of the Sahelian band is a large intertropical region. This band distinguishes itself from the Sahel by increased average yearly rainfall of from 500 to 1000 mm with an annual deviation of ± 25-30 percent. With the exception of Mauritania, all Sahel countries ~~occupy this~~ include portions of this zone, ~~in one way or the other~~.

In the major portion of the area, the mean annual evapotranspiration is above 1900 mm. In the south, this value decreases to somewhat below 1500 mm because of higher humidity and less sunshine.

Variability of the annual potential evapotranspiration is much less than that of annual rainfall. Of the four variables from which potential evapotranspiration can be estimated, temperature is by far the least variable, followed by sunshine, vapor pressure and wind, in that order.

In general, the growing season for rainfed crops with a medium growing cycle is during July-October. Potential evapotranspiration during this period ranges from more than 600 mm in the north to less than 500 mm in the south.

The response to day length of cotton is neutral. Its ~~and similar crops~~ and of similar crops development and yield being influenced only by the sum total of the temperature. Other strictly photoperiodic crops, such as certain sorghum varieties, are believed to always bloom at the same time: growth achieved at this period (number of nodes) would thus determine yield.

The critical temperature for certain plants (48°C) can be reached on some days and difficulties may thus be anticipated during the months when average maximum temperatures rise above 40 °C. This seldom occurs during the rainy season, but the risk

must be taken into consideration in project areas where irrigation would permit cultivation all year. In the dry season minimum temperatures can influence the role of plant development, but, of course, irrigation tends to increase plant resistance to both extremes.

The prevailing winds are the hermattan and monsoon. During the dry season, the hermattan blows from the northeast. Its desicating influence on vegetation must not be underestimated, even where irrigation is practiced. The most critical period occurs before the onset of the rainy season when the temperatures are rising while atmospheric humidity is still low. The wind can cause an irreversible withering of plant life.

Soils of the Sahel

Major soils found in the Sahelian countries are hydromorphic, vertisols, halmorphic, brown and ferruginous soil types.

a. Hydromorphic

These are widespread in the region and characteristic of land subject to submergence by flooding over recent alluvial deposits or land where soil horizons are deeply water-logged during the rainy season. These soils are prone to lime-accumulation, alkalinization and salinity. These types of soils are found in

depressions and along river banks. They are good for rainy season sorghum and millet, groundnuts, cowpeas, and maize and cotton. The last two crops, though, require control of the phreatic groundwater.

b. Vertisols

This group includes poorly draining soils of low permeability. The absorption complex is rich in lime and magnesium. Sub-types include the following:

-- sandy-clay to clay soils with calcareous modules. These soils are often subject to inundation and their surface is broken up with small hillocks and hollows.

-- sandy clay soils that differ from the above by an absence of friability and sometimes of calcareous nodules. They are poor in P_2O_5. Late millet is transplanted into these soils, which are also suitable for wheat.

-- inundated prairie soils found on flood plains and submerged for several months. These soils are composed of lacrustian sediments and are suitable for rice, sorghum planted after the receding flood, fodder crops, and where properly drained, wheat and cotton.

c. Halormorphic

Halormorphic soils are found on small, exposed elevators in the midst of hydromorphic plains. They are also found

in the merging zones betwen natural levees and sandy banks. In practice, these are bare soils whose leached horizons have been carried away by erosion with horizon B at the surface and a hard, nearly impervious profile. These soils have good external drainage but an unfavorable hydraulic profile. They can be utilized for post-flood sorghum by contour banks to retain water, or for dry-farm cotton by breaking up the constant horizons through subsoiling.

d. Brown

Subarid brown soils are found between isohyets 650 mm and 300 mm. They are homogenous to a depth of about 1 m., low in coarse sand with abundant fine sand. These soils are particularly used for rainy season millet and groundnuts with natural savannah bushland or psuedosteppe vegetation servings as dry season grazing land for transhumant cattle herds.

e. Ferruginous

Tropical ferruginous soils are found south of the 650 mm isohyet. They are formed on sandy soil series and are very sandy (90 percent quartz) and poor in exchangeable elements, P_2O_5, organic matter and nitrogen. Rainy season red and white millet, cotton, and groundnuts are grown on these soils.

The Drought Syndrome

Drought can be defined as a prolonged period of dryness. An analysis of the earliest written records for the Sahel-Sudan region which date circa 16th century reveals that 21 droughts of varying lengths have been reported. Of the 21 droughts listed, 6 lasted one year; 7 lasted two years, one lasted three years; one lasted four years; one lasted five years, three lasted 6 years and one lasted 18 years. The records demonstrate that droughts are a part of the normal climate of the region, a climate where "normal rainfall" does not exist. One can ~~There is~~ only define an average rainfall over a specifi~~c~~ed period.

Droughts are a characteristic of the Sahel-Sudano region. They are a feature of the variability of year-to-year precipitation, and the fact that they will continue to occur is the one known aspect of the Sahel-Sudano climate. ~~which is~~ dependable.

The 1968-1973 Drought

The 1940s experienced average rainfall for the decade as a whole, although annual fluctuations were probably greater than usual. But the 1950s were bonanza years when the Sahel averaged about one-fifth more rain than average and the Sudanic farming zone about one-tenth more. As good years continued, both nomadic pastoralism and

and sedentary farming moved north. While the French colonial administrations (up to 1960) and the succeeding independent national governments failed to discourage such movement, the northward shift in the Sahel was further facilitated by technical aid which increased dramatically the number of water points in the Sahel (without effecting any permanent change in the pastures). Rainfall of average, and sometimes better, standard extended throughout most of the 1960s, and the Fulani (Peul) pastoralists of northern Nigeria and southern Niger drifted as far north as the Air plateau beyond Agadez.

The break came with the 1968 wet season, when rain in both the pastoral and farming belts was one-fifth below normal and one-third or more below that of the 1950s. In 1969 there was more rain, at least in parts of the savannah, but thereafter a massive drought developed. In the savannah as a whole, 1970 experienced rainfall one-fifth below normal. In 1971, rainfall in the Sahel fell to half the normal ~~rainfall~~ while the farming zone (Sudan) was down by about one-third. Thus the rainfall deficit over the four years, 1970-73, was approximately one-third in the Sahel and one-quarter in the farming zone (over the six years, 1968-73, it was something over one-quarter and about one-fifth respectively).

Discussion about permanent weather change in West Africa starts with the assumption that the 1970-73 drought was the worst ever. This assumption is highly questionable, and is not believed by most of the older people of the Sahel. Certainly the drought was the first of its magnitude since the Second World War and hence since the people of the

Sahel became citizens of independent countries with a direct right to the attention of the United Nations agencies. It occurred in a period of technical aid and of concern about the world's resources and received massive attention from the world's news media.

Sahelian rainfall, it has been said, has been predicted to decline by a change in global air pressure belts dating back 20 to 40 years. Yet, extraordinarily, none of the rainfall series for savannah West Africa support any theory of secular decline over decades. Rather do they give evidence of short-term cyclic fluctuations: 1912-15, drier; 1916-24, wetter; 1925-28, drier; 1929-39, wetter; 1940-44, drier; 1945-46, wetter; 1947-49, drier; 1950-61, wetter; 1962-67, fluctuating around normal; 1968 onward, drier. The argument for a secular change in climate ~~has resulted in~~ is based on the observation that the monsoon is sweeping less far north and consequently depositing a higher proportion of its rain near the equator; suggested evidence is the claimed rise in the equatorial East African Lakes parallel to the savannah drought. This evidence will not bear examination; the lakes reached their high point in 1964 at the end of a long period of above average and ~~normal~~ average rainfall in the savannah. Perhaps the most one can say is that it would be unwise to assume a future Sahelian rainfall pattern very greatly different from that which we have known.

We can reasonably conclude that drought is a phenomenon of the Sahel-Sudano Region and there will be "good" years and "bad" dry years. ~~A~~ Our view is that a comprehensive development strategy must take

both the wetter and drier future years into consideration : to capitalize on the "good" years; to withstand the "bad".

Ecology: Land Use

Since much of the Sahel-Sudan region is arid even in periods of ~~normal~~ average rainfall, only 7.9 percent of the region is considered arable, 25.8 percent consists of permanent grazing meadows and pastures, 11.5 percent forests, and 54.6 percent "other areas," or desert and sub-desert zones. Significant areas of cultivation exist along the major streams and in the wetter sourthern parts of the countries. The availability of high quality (deep, fertile) agricultural soil is extremely low. An extremely small portion of the region is irrigated.

In the Sahel Zone, the vegetation consists of scattered ~~A~~acias and other thorny, narrow-leaved trees and bushes. Between bushes and trees is an almost uniform cover of short grasses, generally below 40 cm in height. The Sudan zone has scattered taller trees, often broadleaved and deciduous. Between the trees are taller perennial trees, shrubs and grasses wherever physical conditions combine to concentrate and retain runoff water from the scattered rainfall.

Most recent changes in the vegetation of the region appear to have resulted from human use and misuse of the area and not necessarily from climatic shifts. ~~The ecology of the region is fragile, to say the least.~~ Ecologists and range managers are generally agreed that the disappearance of perennial vegetation in the Sahara, the development of the sand seas and large expanses of bare rock, as well as the

expansion of desertification through the adjacent subdesert into the Sahel and Sudan, are the result primarily of misuse of the ecosystems by man.

The initiation of this process results from one or more human activities including a) the cutting of woody species for firewood and other uses at a faster rate than natural regrowth occurs; b) over-grazing by livestock that results in the eradication of palatable species, or when further overgrazed by browsing animals, the elimination of all plant species; and c) the clearing of land for cereal cultivation, especially in regions of marginal rainfall where fields soon may be abandoned.

The long-term misuse of the land has caused large scale shifts to the southward of all vegetation zones. Bare rock and sand dunes of the desert have invaded former subdesert and Sahel zones, the Sahel vegetation has invaded the Sudan and the Sudan has invaded the woodlands of the south. Also, the Sahel and the immediate woodlands areas to the south are plagued with widespread occurence of uncontrolled fire that contribute to the general southward shift of vegetation zones.

Current thinking asserts that better management of the ecology can control the southerly expansion of the desert, and all sectors of development must take this critical factor into consideration.

III. B. Agriculture

Development of the Agricultural Sector

Since the majority of the farm labor force is engaged in dry land agriculture, this must be the area of concentration, and since the majority of labor in dry land agriculture is invested in food crop production, this activity must be made more efficient to release labor to produce more cash crops.

The resulting increase in cash crops should eventually be able to finance the research program, demonstration, and extension in the form of integrated rural development, provided that full use is made of self-help and payment for services and inputs apart from extension itself.

Adds nothing of value to the strategy proposed.

The deficit in food grain production in Mali, Upper Volta, Niger, and Chad is mainly a matter of insufficiency in years with a below average rainy season and is not chronic. In good years, ~~as evidenced by very low prices~~, there is definitely sufficient supply of the traditional food grains. Only wheat is persistently in deficit and production could be increased; the cost of doing this relative to producing export crops and importing the wheat needs to be studied.

In Senegal and Mauritania there have been economic advantages to importing, on average 40% of the food grains, including rice and wheat. Evidence from other countries in the region clearly indicates that the consumer will substitute from one source of carbohydrate

We've already said several times that low prices are a result of government policy, so it can't be evidence of sufficient food supply.

to another if given a sufficient price incentive. So, a ~~more~~ free play of prices in Senegal with development of rice production potential at modest cost in the Casamance and an improved package for sorghum/millet and maize production elsewhere, could over a period of years change Senegal to a situation of self sufficiency. However, this might not be a sound economic solution.

The economic analysis of the region in Section II indicates that investments in increasing rain-fed agricultural production are generally profitable and investments in major irrigation programs are much less profitable. This emphasizes the need to give priority to improvement of dry land farming and reducing the risk of low yields.

Indeed, from the economic and agricultural point of view, large scale development of river basins for irrigation in the next decade or so is not attractive nor is it likely to be profitable compared with other possibilities. The benefits must be discounted for the dislocation which will be caused to dryland and flood recession farming already underway in the basin. However, it is clear that Sahelian states are going to proceed with major hydraulic works in the river basins and that the policy of the donors may determine whether this is done state by state or in an orderly manner for the basin.

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In any case, regardless of the optimal regional strategy, an adaptive strategy will have to be found to suboptimize river basin

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development within the framework of what the states are going to do without regard to analyses done by the donors.

The strategy proposed for increasing agricultural productivity, reducing risks from weather, storage from season to season and increase in export crop production, which could help to finance the development, is believed to offer promise to eventually make the Sahelian states self-supporting in their domestic development and, with exports from other primary sectors, more or less in balance in their external transactions. The continued ability of the Sahelian states to be less dependent ~~self sufficient~~ in food depends upon their ability to organize a system to maintain a flow of new technology from research stations; to adapt this in packages for farmer use, ~~to demonstrate it~~, and provide the extension service to extend it; to supply the inputs in a timely manner; and to ensure an adequate system of plant protection and reduction of post-harvest losses.

The strategy within the agricultural sector can thus be summarized as follows:

1. Exploitation of existing resources
   a). large farm population settled on the land
   b). known technology for modest increases in food crops and export crop production
   c). better use of "wet" land (low lying, flood recession)

d). use of small irrigated perimeters

e). improvement of on-farm storage

2. Exploiting favorable markets for export crops which can effectively be taxed to finance research and extension services.

It is hoped that the melding of both the governments' and the farmers goals can be accomplished. These are listed below:

GOVERNMENT PRIORITIES

1. Domestic self-sufficiency in food production.
2. Securing a national food reserve against drought.
3. Increasing the supply of export crops.
4. Increasing ~~in import~~ import substitution.
5. Increasing the productivity of farm workers in order to increase the standard of living.
6. ~~Often to~~ Maintaining food prices relatively low.

FARMERS GOALS

1. Produce an adequate supply of food grain.
2. Reduce the risk of insufficient food supply including storage of reserves aginst drought.
3. Increased "welfare" from improved services - health, water supply, etc.
4. Often also - to keep the children at home and usefully employed.

In collaboration with the international community, this strategy can be accomplished, but it will require continuous external financing and perserverance on the part of the government of the states involved, and a real resolve to maintain a set of policies favorable to the execution of the program.

DEVELOPMENT CONSTRAINTS IN THE AGRICULTURAL SECTOR:

The development constraints in the Sahel can be grouped into three main categories: A. Physical, B. Marketing and pricing, and C. Human.

A. Physical Constraints to Increased Production

1. Rainfall: Quantity and regularity of distribution:

(a) Lack of Knowledge: Use of weather satellite to forecast intermediate range weather.

Farmers have adaptive strategies to drought which they are unable to use effectively because of lack of any accurate prediction of the effectiveness of the rainy season. If the fronts determining the rains can be identified from satellite imagery, there is some possibility that a reliable intermediate range 30-60 day forecast could be developed and broadcast to farmers.

(b) Failure to use the rain that falls optimally

(i) Breeding plants adapted to shorter season or more effective in water use (i.e., drought resistant).

Plant breeding programs for the region have been addressing the problems of producing improved varieties with a shorter growing season. These varieties would produce with greater certainty. Certain characteristics of plants, e.g., the way the leaves are arranged, provide more efficient use of water, these characteristics can be introduced into local varieties.

Plant breeding programs in the Sahelian states need to be accelerated, and the liaison with the international research network and national research centers* (e.g., sorghum/millet breeding programs in the U.S.) needs to be improved. Part of the increase in the program could be manned by African trainees and trained staff.

(ii) Improving soil water management practices. This includes tillage practices to increase the amount of the rainfall that runs into the soil -- reducing the run off. It includes practices to reduce run off such as building small levels and ridging the land. Plastic covers (mulches) can be used that permit the rain to run into the soil but reduce evaporation and so lengthen the period for which the crop has an adequate water supply.

These and other practices are outlined in the NAS study "More Water for Arid Lands" and also in the reports from the Institute for Desert Research, Sede ~~Boger~~ Boker, of the Ben Gurion University of the Negev, Israel.

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*Formerly through Joint Project 26 at Saria, Nigeria and now also through UNDP support.

(c) Failure to exploit existing resources. There are areas of low lying lands (bas fonds) and areas from which flood water recedes, which provide longer growing seasons with more reliable rainfall than on the rest of the plains. Ways of exploiting this land are well understood but need a little further formulation so that they can be dependably used in development programs.

There are also areas downstream of existing dams which could be used for irrigation, with a minimum of engineering work. The principles of this are well understood; in some cases financing of the work is needed.

(d) Failure to use means to insure the provision of food in "lean" years.

(i) Failure to store sufficient grain from plentiful harvests for use in years of bad harvest. Traditionally farmers do this ~~but~~, because farm level storage is simple and sureist. Farm grain storage needs to be studied along with methods to reduce losses, price policies that discourage and encourage storage, credit and timing of repayment to encourage storage.

Storage in the grain trade is small and is almost invariably short term, that is, the "trade" does not carry over significant stocks from one year to another because it is not usually profitable to do so.

District and national storage is necessary but only with the new anaerobic storage of fumigated grain in 550 ton capacity

containers is there a feasible method of storing with an acceptable level of probability of preservation. Past results of grain purchase and storage in the Sahelian countries, with no quality grading system and lack of trained personnel have been unsatisfactory. However, there is a working system reported to be in operation in the Savanna region of Nigeria. The question of how much grain should be held in regional, national, district and farm storages and for how long and how it should be rotated for fresh grain is a subject needing study.

(ii) Failure to store surplus water for extending the growing season. There are relatively simple ways to construct small plastic reservoirs for storage of irrigation water for use outside the growing season. The technology has been developed at the Institute for Desert Research in the Negev, Isarel (see para 1 b(ii) above).

(iii) Irrigation as a means of reducing risk of crop failure. Irrigation is used in the region at four levels.

I. Vegetable production in small beds, irrigated by hand or simple means (chaduf). This is widely practiced but production is limited by the low level of consumption.

II. Small irrigated perimeters (say under 50 or even 100 ha) usually supplied by water from a pump. Farmers have a small area in one of these perimeters usually for growing a high value crop.

III. Medium and large sized irrigation perimeters which may or

may not comprise all the land farmed by a family, and may be for one crop a year, for two crops or for year round production. ~~(see L. Cohen).~~

For project design, apart from the data on the hydrology, an economic analysis of the costs and returns of the different types of irrigation, developed in different ways, e.g., capital intensive and labor intensive, and with water supply available for different periods of the year or for the whole year is necessary.

There are also demographic and social studies to be carried out to establish whether there are enough people to man the scheme and whether and under what conditions people will farm year round with irrigation. The effect of mechanization with contractors on reducing out irrigation, as seen in Senegal on the river, needs to be established.

IV. Industrial type irrigation schemes in which the farm workers are employees. Typically in West Africa these schemes produce sugar cane in association with a sugar factory. These schemes, with expatriate management, are effective in supplying sugar for the domestic market. The cost of production should be studied to see the real (social) cost of import substitution. This would indicate whether scarce investment capital should be used in this way or in other activities.

2. Low levels of soil fertility

There is a generally low level of phosphate in the Sahelian country soils, combined with low levels of nitrate. After a few years a response is obtained to additional potash. There are also areas deficient in micro-nutrients such as boron and sulphur. Imported fertilizers are generally too costly to be profitable on any but export crops. Some countries subsidize fertilizer so that the private benefits exceed the cost even ~~in~~ if the social benefit is less than the social cost. Any attempt to increase the agricultural market surpluses will reduce soil fertility more rapidly unless some system of restoration is introduced.

(a) Use of local phosphates. Phosphates are present in most of the Sahelian countries either in the form of coprolytes or rock phosphate. A simple rock crushing plant can manufacture ~~of~~ ground rock phosphate; such a plant could be used in Niger, Mali or Upper Volta. A German proposal exists for Mali. Facilities already exist in Senegal. ~~There is no record of phosphate deposits in Chad.~~

Delays have been caused by waiting for feasibility studies of large scale, capital intensive development for export. There have been many years of tests proving the effectiveness of the West African deposits to be similar to those in other parts of the world. Installation of a simple grinding plant would unlock a

major constraint in agricultural production -- and the low fluorine content of the Malian and some of the Niger deposits makes them usable as mineral supplements for livestock. This development, which has been recognized as important for several years and has been requested by certain branches of the African governments. is of the highest priority.

(b) <u>After the provision of a source of low cost phosphate, limiting factor in fertility is likely to be nitrogen</u>. There are some available ways to improve this and some still in the research phase.

(i) Rotations including legumes. Legumes are associated with rhizobial bacteria on the roots with the capability of fixing nitrogen from the air in a form suitable for use by plants. The quanitity fixed is variable. There are food legumes adapted to the region which can be grown in rotations e.g. cowpeas and peanuts. There are also forage legumes, which have been accepted by farmers in the past - due to problems of utilization and profitability - which might be profitable at a higher level of fertility. This needs further study -- see under mixed farming, section e below. Improved cowpeas and peanut varieties are available and there may be other tropical food legumes acceptable in the area that would be profitable.

(ii) Improving nitrogen fixation. There is reason to believe that it would be possible to improve the amount of nitrogen fixed by rhizobial bacteria in association with legumes. There are also

rhizobial bacteria not associated with legumes and other nitrogen fixing bacteria which might be used with food and export crops.

This area of research will be reviewed this year by the President's Commission on Research Capabilities and World Food Needs and by the Agricultural Research Directors Committee of the OECD. These reviews should point out profitable lines of research. This project is of intermediate to long-term duration and of high priority. ORSTOM and CNRA, two research institutions in Senegal, have started a project on nitrogen fixation but with more funds and international collaboration in this -- an area of acknowledged U.S. expertise -- progress should be more rapid.

(c) Selecting crops and varieties for efficient use of soil fertility. Some species and some varieties are more effective in the use of low levels of fertility. For example, rice is more effective in the use of nitrogen than most other crops. Traditional (grass-like) cereals such as fonio and tef are more efficient in the use of nitrogen than millet.

Efficient use of low levels of fertility should be one criterion in breeding of food crops for production in this area, especially where it will be difficult to apply phosphate or to use nitrogen fixation.

(d) If the limitations of phosphate and nitrate are removed, a deficit in potash will develop after a few years. Surveys should be made to see if there are potash deposits that can be exploited

in the region.

(e) Mixed farming. The integration of livestock into the crop farming system, including growing leguminous feed for the livestock either as the hay from food legumes or as a forage legume, and careful management of the livestock manure and returning it to the land are likely to help build up soil fertility and maintain the soil organic matter to improve the mineral retention capacity of the soil (the ion exchange capacity).

3. Inefficient use of solar energy by plants either by failure of the "architecture" of the plant to absorb a high proportion of the incident solar radiation or by the use of the energy so absorbed to build excessive stem and leaf rather than grain, i.e., the balance between grain and stalk and leaf production is poor.

Both of these factors can be improved in plant selection and breeding programs already in progress, but at a pace that has not yet resulted in the widespread adoption of new varieties of the traditional food grains of sorghum and millet.

4. Pest Control. Pests of all types from the fungi and insects that attack the seeds before germination, through production and in stored grain are rampant in the region. Control of pests in food crops, even when the product can be demonstrated in adequate or excess supply, is important to raise the productivity of the farm workers and of the sector. That is, the long term response to pests

control will be a shifting of agricultural resources into industrial or export crop production and it will not lead to the regular production of surplus grains without an expensive price maintenance policy.

There is no information on whether control of the different pests would increase or decrease the overall variability in crop production; that is, in years of poor crops, are the pests as active with a crop, and is the major effect of the pest to reduce yields in a good year? In any case if the farmer was not exposed to the risk of loss from crop pests, he would be expected to use less resources (labor and land) in food grain production and more in cash crops. This hypothesis should be tested.

(i) Seed protection: the technology of protecting seed before it is planted, to reduce loss in germination due to insect and mold damage is well understood and easily extended. The input is stable and easily distributed. It should be promoted as part of the programs for agricultural development.

(ii) Protection of plants against insects may partly be done by breeding but for the most part has to be done by diagnosis, and, when the infestation is sufficient to justify treatment, by treatment. That is, there are levels of infestation below which it will not be profitable to treat the crop. There may also be ways of managing the crop - timing of planting, treatment of crop residues - which reduce the possibilities for build up of insect populations.

Means and cost of control of major insect pests should be a

subject of study. The provision of a diagnostic service should be included in the study report. Communication between extension agents and plant protection specialists will be important. This is a high priority area and research is already under way.

(iii) Bird pests. In the case of birds there is a greater possibility of breeding plants with an architecture that makes it difficult or impossible for the birds to loosen the grain from the ear or panicle. In sorghum it is also possible to have the grain quality such that birds do not like it. Unfortunately, this quality, in the past has been distasteful to humans except for making beer. There is, however, a possibility to breed sorghum with grains distasteful only until maturity. Then, with prompt harvesting, bird damage would be minimal.

Damage to cereals is even worse they mature out of the usual season; at this time birds do proportionately more damage.

Research on the habits of the birds is also being carried out in the region and this may shed light on means of control.

This reduction of birds damages is a high priority area.

(iv). Weed pests. It is probably that competition with weeds is one of the major causes of losses in field crops. This hypothesis might be tested by reviewing past research or it might need to be the subject of a new study.

With the introduction of animal drawn farm machinery, the farmer has a new possibility for effective weed control. However,

for various reasons, it seems difficult to change farming practices to use the machine hoes at a time when they can most effectively kill the weeds. The tradition is to wait until there is a "good crop" of weeds before hoeing; in this way much of the damage caused by the weeds is already done before hoeing and it is more difficult to kill the weeds the machine hoe.

Improved weed control by mechanical and even chemical means is being studied. This work may need to be intensified and evaluated economically.

(v). Fungal and bacterial diseases. Plant breeding and crop residue management are the means used to reduce the build up and effect of these diseases. Research is already underway in plant breeding programs; the basic knowledge is usually available. The problem is one component in the introduction of new varieties.

5. Farming systems. Farming has been carried on with traditional hand tools and with traditional means of management of fertility. The introduction of animal traction and fertilizer and the increase in the quantity of produce sold off the farm all disturb the equilibrium of the existing systems. Their equilibrium is also upset in some parts of the region by increasing density of population -- the Mossi plateau (Upper Volta) and the peanut basin (Senegal).

This introduces the need for a supply of farm equipment of suitable design made locally using an appropriate level of techno-

logy e.g., the machinery workshops at Ouagadougou and Boboioulasso. This provides employment as well as training a network of service men.

In Senegal and Upper Volta, there is a long history of research and development of farming systems in the agricultural research stations, which now have linkages to certain development programs. This provides a means to develop a package of technology as well as a means of informing research workers (by feed back from the farmers) of the real problems. These linkages need to be further developed within and between the countries.

ICRISAT has a very substantial program on dryland farming systems and a different but equally valid approach has been taken at Sede Bogor in Israel in the Institute for Desert Research. Linkages need to be built to bring the results of this and other "foreign" farming systems research into the national research stations of the Sahelian states.

Meanwhile socio-economic and agronomic surveys are needed to establish the place of the different types of mechanization, rotations, and systems of cultivation on farmer income and on migration out of agriculture. For example, in irrigated farming developments in Senegal on the Senegal River, tractors and combines have been introduced in order to increase returns to farmers and to reduce out-migration of farm workers. The out-migration often results in

substantial money flows back into the region, part of which is used to hire farm workers from Mauritania. What are the socio-economic effects of this type of development to the farmers and to the country?

Farming systems research would also include ways of integrating otherwise unused or underused resources into the existing dryland farming system. This would involve low-lying land, flood recession farming, and small irrigated perimeters, all providing additional resources but not changing the whole farming system. However, if the whole farm area is turned into an irrigated perimeter, the problem becomes one of changing the whole agricultural systems and the social calendar.

6. Post harvest losses

(a) There is a little knowledge of the extent of losses which occur in the different crops in the different zones. Different varieties have different characteristics as far as losses are concerned: for example, many varieties of high-lysine maize are more susceptible to insect damage in storage than the traditional varieties.

There are levels of losses to be established by type of storage, for threshed and unthreshed grain, for farm storage in the Sahelian and Sudanian Zone, for storage in commerce and storage in district

and national storage. There are losses in threshing. In certain parts of the region, however threshing machines are being introduced; their utilization needs to be evaluated.

There are also losses in traditional methods of milling and grinding, grain and in food preparation.

The FAO publication refers to a substantial study of losses in all post harvest phases in the region. Research is also being carried out at IITA, Ibadan, and at Bambey, Senegal. However, the problem is so great that more resources will certainly be needed.

(b) Design of improved for all levels. In the Sahelian regional traditional storages are probably satisfactory, although in Senegal there may be a trend to increase storage of threshed grain as a result of the new threshing machines. Farm level storage research is probably adequate at Bambey (Senegal).

The new hermetic storages for sacked grains that have been introduced in Mali and Niger at a cost of about $30/ton may be the answer for safe, low cost storage at the district and national level. This needs further evaluation. However, it should not be expected that government systems of handling and storage of grain, including the rotation of strategic stocks, can compete with the commercial sector in efficiency and price. Thus government storages will have to be subsidized somehow.

(c) Mycotoxins. There is a problem of mycotoxins, small fungi growing especially on peanuts. New quality standards set by the

European Common Market could reduce by more than fifty percent the utilization of African peanuts in animal feed. Research is needed to: 1) improve production practices which may be hard to get farmers to adapt; 2) devise a lower cost method for elimination of contaminated kernals and 3) detoxify the peanut cake by extraction with solvents or chemical treatment.

There is a considerable amount of information on this problem worldwide and the Directors of Agricultural Research of OECD have selected this as a priority area of study starting in 1976. Linkages to get the results of this research into African institutions need to be assured.

7. New Crops. There is a lack of diversity in crops and a need for:

(a) New cash crops for dry land farming to complement the peanuts, cowpeas and cotton. There is evidence that only a small part of the available spectrum of cultivated plants is being used. For instance, Sesame, although grown to a limited extent, could be more widely grown but needs selection to develop varieties which ripen more uniformly and where the seed capsules do not automatically open on ripening. These are called indehiscent varieties and have been developed in the U.S.

(b) New varieties of crops suitable for wet land farming. At present little has been done to develop the criteria for breeding

improved crops for wet land farming (low lying land and flood recession). There are traditional varieties of sorghum for the prolonged season and for out of season production. A regional program for improvement of these crops need to be established to include conventional food grain and rice, both floating and rooted. This will be important along the Senegal River, the Niger and the Lake Chad River system as well as in other areas within the region.

The organization of such a program for rice, of course, falls within the area of WARDA. For food grains the basic data should come from the International Research Network but it may reprive a separate contract outside this organization to obtain sufficient concentration of effort.

These out of season crops are important not only as an important source of food supply, but because they allow the farmer to devote more of his resources in the rainy season for the production of cash crops to increase his family's income.

(c) With the increasing areas of land under irrigation a whole new group of crop varieties is needed, selected for optimal returns imigration rather than with limited rainfall. The research infrastructure exists to do this work but it lacks trained personnel and funding to do the job. Wheat is a special case.

(d) Wheat and the wheat deficit:

There is a steadily increasing consumption of wheat in the Sahelian states. The demand is pervasive among returned immigrants,

urban populations and certain ethnic groups (e.g. the Haussa). It is satisfied almost entirely from imported wheat of international quality grades, uniform in quality and easy to mill. Except for the last 3 years, wheat has been comparatively moderately priced on the world market for the last 30 years - the period during which the demand has been building up in the Sahelian states. Transport systems are geard to supplying the industrial flour mills with imported grains.

There are well known techniques for adulterating wheat flour with sorghum and millet flour. These produce a bread with a lower content of imports that is practically indistinguishable from the existing white bread. However, they usually require new equipment in the flour mill and change in the flour production system. They have not been adopted by any of the industrial mills in the region.

There is a long history of wheat production in the Sahelian states. It is either grown on the high ground (i.e. in mountainous regions) or dry season. It is assumed that most of the existing production is consumed in place and does not enter the industrial mills. In Chad, there should be sufficient domestic wheat available now or in the near future to test its mill ability in the industrial mill.

The region certainly has the capability of producing wheat and with the possible exceptions of Senegal and Mauritania, satisfying the domestic demand. Whether this would be a sound investment or

whether the cost would be greater than that of imported wheat needs to be established. The problems of quality, uniformity and millability will also need careful attention. Industrial mills do not produce efficiently if the setting of the mills has to be continually changed to adjust to different batches of grain.

B. MARKETING CONSTRAINTS TO INCREASED PRODUCTION

Food Crop Pricing

Farmers would make more money if their grain were marketed in a more orderly way throughout the season, eliminating the peak in sales and the fall in price at harvest.

In spite of any attempts by governments to regulate or stabilize the price of food, when a surplus is produced in a favorable crop year there are no means at present by which any of the Sahelian governments can effectively intervene to support prices. Traditionally, it was quite common in a good crop year to produce twice the usual market surplus; for lack of a market at an acceptable price the excess was stored on the farms. Farmers adjusted their production in succeeding years to correct for this. This could be said to be a form of market supply stabilization because the traders generally had no capacity or interest in storage.

This system had two major faults. In the case of sustained drought there was insufficient grain in storage, and indeed low yields for 2 to 3 years, under this system produced hunger. A second major fault was that there were excessively large price differences between

districts.* Although there have been many other criticisms of the system, all studies report that it is quite efficient, that the profits are not exploitative, and governments can only handle the grain at 50-100% greater cost.

None-the-less, food crop production is and must be limited by the price formed in the market place. If governments decide that they want to increase supply, it can best be done by permitting the price to rise.

Because farmers implicitly attempt to maximize their returns to their most scarce resource, in this case labor in the cropping season, the price of cash crops, which is regulated by the governments, relative to the price of food grains, allowing for the differences in labor requirements, determines what the farmer grows with his surplus labor over and above his need for subsistence production. The relatively low prices set for cash crops in itself encourages food grain production at price levels that are acceptable to governments. Governments also influence grain prices by feeding concessional aid grain onto the market and by subsidizing imported cereals (rice and wheat).

Evaluation of Grain Price Stabilization, Security Stocks and Concessionary Supplies

The objective of seasonal grain price stabilization programs is to provide sufficient price incentive to producers to ensure an adequate supply--by purchase of grain at harvest--while not causing them to sell their own food stocks. Then stocks are released on the market when the price rises

at the end of the dry season. In general, price stabilizing programs are not designed to replace the grain dealers, because the government does not have the means and structure to do so.

Security stocks, on the other hand, are stored on a continuing basis by a government agency over a period of years in quantities sufficient to tide over a period of short supply until supplies can be procured from abroad. These reserves are apart from farm stocks and commercial stock holdings. The food reserves have to be rotated from time to time.

In practice price stabilization programs have been expensive to maintain unless accompanied by some form of production control and then only for a crop the major part of which is marketed. In that way the year to year differences in the quantity marketed are diminished by controlling the area of crop produced (the U.S. model). A country or trading area with a cereal deficit can also stabilize the price as long as it stays above the world price, by applying a levy to the imports, which can be used to subsidize whatever occassional surplus cereals need to be exported (the EEC model).

An LDC which sets cereal prices too high runs the risk of accumulating stocks in excess of what it can store and being unable to subsidize exports of the excess. It will also draw surplus stocks into the market that would otherwise have been stored on farms. If prices are set too low, the supply will be insufficient. Countries face several problems in the grain price stabilization business:

- where only 10-20% of the production is marketed a 10-20% increase in production can double the quantity available to be marketed. Curves of probable production indicate a 50% probability of getting a yield 80% of the average in the Sahel and 86.5% of average in the Sudano-Sahelian Zone. So the fluctuations in a country like Niger (about one million tons a year supply) may be of the order of 150,000 tons in 50% of the years. Normally, the surplus over and above the demand is stored on the farms.
- In order to avoid destroying the commercial trade and producing chaos in the market place, the Government has to set up a price network in relation to the transfer cost, considering the cost of getting grain to market and the cost of its storage. Otherwise the producers will all expect the government to buy their whole market surplus at harvest time (avoiding storage cost and tying up money in stocks). The cost of collecting grain from remote areas and storing it may exceed the selling price.

- When the farmer believes the government will market grain at concessionary prices later in the season or will pay the same price for grain regardless of the season, he has no incentive to store grain and may even (as in Niger) sell part of his family food reserve, expecting to buy more from the government later at a lower price. In fact, storage on the farm should be encouraged at the safest and least costly method.
- Governments have problems in buying good quality grain where no official grading system exists. Poor quality grain is difficult to store.
- Price stabilizing organizations tend to lose money in various ways but then, having no ability to write off the loss, try to recoup the loss by dealing with other commodities, speculating or even lower prices to producers.
- It is difficult to maintain stable domestic prices at a level that provides an incentive to produce
  - when food grains may be sold at concessionary prices
  - when other food grains (often wheat) and their products are subsidized
  - when the government organization has filled its storages and cannot enter the market to purchase more
  - when the government organization is suffering from lack of liquidity and cannot enter the market
  - when the government organization seeks to buy more than a small share of the total market, making the supply available on the free market insufficient for the market
  - Governments that have tried to displace the grain dealers, have found themselves unable to maintain the market supply

- In general the cereal buying agencies have had inadequate financing, inadequate accounting and lack of trained personnel.

It is very doubtful that it is feasible for the Sahelian governments to stabilize the price of grain by a buying/selling operation, considering the size of the country, the transporation problems, and the financial and technical means at their disposal.

Concessionary Food Grains

While concessionary food grains are a life saver in emergency, they have been shown to have a serious depressing effect on domestic production and a disrupting effect on the domestic market. In the countries of the Sahel, all of which have the capacity to be self-supporting in food grains, except in a sequence of drought years, the major goal should be to stimulate domestic production to encourage self sufficiency rather than to permit the development of a dependency on outside supplies at concession prices. "The solution to the world food problem lies primarily in increasing food production in developing countries." It should encourage the maintenance of farm stocks and stocks in commerce, which will constitute a reserve of sound grain many times greater than that which the government can afford to store and with less loss and spoilage and at a lower cost than can be achieved by a governmental organization. With this strategy of increasing dependence on farm storage stocks, it is essential to have an adequate road network to ensure there is access to these stocks.

Given the substantial problems invalid in the pricing system there still is a need for a study of the interrelationships between the price of food crops and cash crops in relation to the production decision. One such study is underway in the U.S. at present, using Central African Data. There is also believed to be results from studies in Nigeria. Studies of costs of production of the different crops produced in different ways and in different regions is basic. This leads to proposing a hypothetical framework for the farmers productions decisions and then to testing it in the field.

There is also a need to study the effect of government pricing policy of imported and concessionary food prices on the price of domestically produced food grain.

C. LIMITATIONS IN AGRICULTURAL PRODUCTION CAUSED BY FARM FAMILIES

Farm families may limit agricultural production by:

1. the number of days in the year which they are prepared to devote to farm work
2. lack of technical knowledge by people of both sexes and of all working ages.
3. lack of physical energy due to insufficient or poor nutrition and ill health.

1. The farm families have a distinct yearly calendar of activities which has to be changed if they are to farm year round, for example with the introduction of irrigation. There are examples where families do take to year round farming and others where irrigation projects have been difficult to settle because of unwillingness to work year round. There are large areas of flood recession land which are farmed and in other places large areas unfarmed in spite of demonstration of the feasibility, because of the apparent unwillingness of people to farm out of the traditional growing season . This is a needed area of study - the socio economics of crop production outside the traditional rainy season.

2. Lack of technical knowledge may be caused by lack of dissemination or by lack of knowledge. The latter needs to be satisfied by research and the former by extension. However, existing extension services are set up to deliver an agricultural production program to men and to a lesser extent a home-making program to women. The extension program needs to deliver information to the whole family appropriate to their activities.

Women almost always have crop production activities, which may be associated with those of the male or may be separate. Programs for women usually have to be delivered by women. This

phase has been almost completely neglected. There are currently studies on the role of women, as well as a great deal of published and unpublished information . This should be followed up by training the existing women agents and others in appropriate themes in crop production activities.

As has been pointed out elsewhere youth programs are generally lacking in the region, in part due to the social position of youth and to the difficulty for youth to innovate. On the other hand, in many areas a high proportion of the youth are "voting with their feet" and migrating. Thus there is a strong motivation for the elders to recognize that something needs to be done, if more of the youth are to be retained in the community to help to "get agriculture moving."

This is another area of needed research - the present and potential role of youth in the village, the effect of outmigration on "getting agriculture moving" (do the migrants learn new farming skills which they bring back to the community? It is commonly stated that the migrants come back and set themselves up in trading rather than principally in farming).

Are there programs that could be offered to youth, together with the necessary inputs, that would lead to a more effective development of the community?

3. There is little doubt, particularly after the experience of the last few years, that the output of the farm workers would increase if they were better nourished during the crop production season. Increasing the production and reducing the risk from drought would, of course, ameliorate this situation. Under a few circumstances it might be necessary to introduce Food for Work in order to introduce a food production program.

It is logical to assume that ill health reduces the capacity to work. There are some areas where this is clearly true, with river blindness, sleeping sickness, malaria, etc. It is also true that in other cases improved nutrition overcomes most of the depressing effect of illness on work capacity. Improvement in health in integrated development projects will be justified as a goal without needing data to justify it on the basis of increasing work capacity.

Course of Action:

A. DEVELOPING THE PACKAGE AND DELIVERY SYSTEMS FOR VIABLE EXTENSION

1. Developing the Package.

There are [illegible] international and national research centers working on agricultural problems applicable in the Sahelian countries. Results of this work are supposed to be communicated to national research centers in the region. For example, an improved quality sorghum, originating in Ethiopia, identified by the Purdue University Sorghum Research Project (AID funded), is supplied to ICRISAT (Hyderabad, India) the international center responsible for sorghum research. Seed of this variety is supplied to the national research centers of the Sahalian states by ICRISAT through AID Joint Project 26 in Saria, Nigeria or more recently through the UNDP outreach program from ICRISAT.

There is, in fact, some specialization within the Sahelian national institutes, with Upper Volta concentrating on sorghum, Senegalan millet and the Ivory Coast on Maize.

These specialized institutes tend to screen the offerings of the international center and provide seeds of the most promising varieties to the individual national institutes. In the past, the institutes then had the responsibility for running variety trials at the main station and at substations.

There still is a gap between the research institutions and the agricultural extension programs which slows the flow of information in both directions from the station to the farmer and from the farmer feeding back to the station. By giving the research institution the responsibility of running trials and participating in an intensive development zone (with an intensive extension program) such as Sine Saloum (Senegal) or the AVV (Upper Volta) the gap is closed.

For cash crops the gap hardly exists because the extension organization responsible for cotton is in close contact with the corresponding research institute and the same applies to peanuts.

A further contracted responsibility of the research institution is the multiplication of another seed to supply to the development organization, which may, in its turn, (for food grains) subject the seed to another stage of multiplication bringing the price down to a level that the farmer is prepared to pay.

This close liaison between extra-national centers, national centers and development organizations with feedback from the farmers is essential to generate and maintain the sustained stream of technical innovations, developed into demonstrated and proven extension packages, that is needed to maintain the food supply and farm exports and to raise farm incomes in the future.

In the past, the program in food crops has been neglected. At present it is being built up but, to date has delivered little in rainfed crops except new maize varieties. The system needs a thorough check up to ensure that it has no bottlenecks because in the proposed strategy, ~~the great importance of~~ increasing the productivity in food grain production -- the activity absorbing the majority of the farm labor input - is of great importance in order to release resources for production of cash crops. This will increase farm income and provide a self-sustaining means to contribute to the additional research and extension costs.

This system of development of packages requires an intensive extension area, which of itself will not produce benefits commensurate with the cost. However, dissemination of the proven package in the extensive extension area will have a very favorable cost: benefit ratio.

The research stations both extra-national and national and the intensive extension areas also serve an important training role for both African and expatriate technicians.

Actions needed under this rubric include

(a) ensuring that the research linkages internationally and regionally are really effective, which they are not at the moment.

~~(b)~~ Intensifying the efforts of research in plant breeding~~* to~~ overcome the physical constraints listed earlier. Testing the varieties that are selected for production in practical farming systems and at practical levels of fertility. Subjecting the selected varieties to processing, cooking, and taste tests before attempting to promote them. This has to be done on a national basis. It requires not only strengthening the facilities and developing contractual relationships between research and development organizations but above all, training of African workers.

(c) multiplication of the mother-seed by the research institutions under a contractual arrangement. This is, institutionally, the simpliest and most efficient method of obtaining the motherseed.

(d) Multiplication of line bred (as opposed to hybrid) seed for food grains in the development programs by the best farmers. This is necessary to bring the seed price down lower so that the farmers will buy it. It is not recommended that inputs such as improved seed be subsidized except, if necessary, when the variety is first introduced. The multiplication activity is just one part of the integrated development program.

2. Delivery Systems for Viable Extension

The goal of the system is to deliver a viable package at a low cost to farmers; the system should involve farmers and their families in decision making for operation of the program if it is to be viable and last. It is proposed that a properly conceived agricultural program, by increasing the production of export crops for sale through the state monopoly will be potentially self-financing.

The support for the need for farmer participation is based upon Uma Lele's book and the Development Alternatives Study. However, the Sahelian governments are not accustomed to the concept and it will be a difficult task to break away from the traditional extension programs which are based upon the "take it or leave it" or the contract to perform extension approach. The participation approach proposed has been used very successfully in developed countries, including the U.S.

A preliminary attempt, the REDSO/WA Bush Seminars, was quite well received by Sahelian Governments. The best that can be hoped for is to start up a single project in integrated rural development in each country to demonstrate the value.

The relationship between the delivery system and the research institution has already been described. In this way an order of priorities is established for research and the gaps are identified and covered.

Results of the research on rural development projects indicate that a program must be diffuse and extensive to have a favorable cost benefit ratio and that the packages involved with agricultural producitivity should have the first priority. Once the farm families begin to receive more income discussions are held on what other services and activities are needed by each of the communities involved. Such activities might include improved, year-round water supply, a dispensary with drugs and a technician of suitable level, education, seeds of improved varieties of vegetables for the gardens, and so on. These activities can be developed on a self-help basis with payment for service and do not require substantial outside funding. However, they are really at the heart of integrated rural development and improving the welfare of the rural population.

There is already a trend to include a broader range of services in existing agricultural projects, so the movement towards integrated rural development is already on the way.

The development organization has to be capable of delivering a wide variety of services with coordination to the farmer and the community. The traditional structure of the services in the Sahelian states is to have a "Direction du Service" in the capital city with a series of regional directors, one for each prefecture, and some sectors and sub sectors under the regional office. The whole operation is controlled from the state capital. It has been called a tunnel system with each service having its individual tunnel from the capital and each tunnel is independent and has no association with the tunnel of another service.

For integrated rural development it is necessary that the systems for delivery of services be associated and integrated at every step. It is not sufficient for the Director of Rural Development to have all of the necessary services under his office, but this must also be the case at the regional, the sector and the subsector levels. Such a thorough reorganization, with the "breaking up of kingdoms" is difficult to obtain. Ideally the chief of a sector or even a subsector should coordinate his program in response to discussion with his participants; it should be possible to draw into the program any of the specialist services needed single or as a group, to present the material or deliver the services requested.

Rapid communication is necessary at all levels and with the road network available it is clear that this should mean a radio communication down to subsector (a group of villages) level. This makes the specialist service universally on call. For example it is common in the U.S. to telephone the physician before he starts his office calls to avoid the one to fifteen minute drive or to confirm its need. The radio telephone call with the village dispenser acting as the intermediary may save a 50-mile walk. Radio is also an effective means of dissemination of information on all phases of the development program.

Apart from the physical inputs which must be ordered and delivered on time, the development organization will need to be able to give credit. The system needs to be simple and should not be exclusive. Part of the work can be done by the community, so that the organization does not tie up too many of its resources in administering the credit fund. In order to ensure a high rate of repayment credit should only be given where there is a proven profitable package of technology to deliver and repayment should be required at a realistic rate.

Timing of repayment of credit, which will require the sale of some produce, should be such as to make the marketing more uniform over time. That is repayment should not be obligatory

at harvest because that is the time when the grain price will usually be the lowest. Security in the form of stored grain may be required for an extension of the repayment time. With repayment from the sale of cash crops at fixed prices, the repayment of the credit can be scheduled at the time of sale of the crop.

This leads to the method of design of an integrated rural development program. There should be a pattern laid out showing the necessary elements and their realistic scheduling, personnel needs and so on. Ideally this would result from a review of programs already in operation and discussion with the traditional expatriate and African organizations - such as CFDT (and its succesor) BDPA, SATEC, SODEVA, SODERIZ, Operation/Sarachide and RIZ. Such a study should include some of the programs in the savanna region of the coastal countries. This would supplement the IBRD (Uma Lele) study of the Design for Rural Development, which only included one program in the Sahelian countries and some in the Cameroons in all of Francophone Africa.

This study could then provide hard data on the rate at which rural development could be launched throughotut the region in dry land and in irrigation of different types. The schedule of staffing and financing would also be obtained. The study would also show what services were missing from the existing programs and what would be required to include them.

It should be the objective of the study to provide the basic data needed for program design with a design procedure, but, because of the differences between regions and above all in people, not to prepare standardized development plans. The plans should be flexible enough to permit adaptation to the needs of the participants by the project management team.

In spite of the gaps in knowledge, there is sufficient information to start further integrated development programs and to bring in the services that are lacking in existing programs in the region. The linkages with research should be set up as soon as possible in selected areas for development, to provide the lead time necessary to develop and demonstrate the package and the design that development programs should follow.

There are, of course, some areas for which there is currently no package. Contracting with a research organization in collaboration with the extension service to produce a package, will certainly accelerate the procedure of getting a viable package.

Youth programs have been very successful in developed and in some developing countries. The possibility of delivering a program to youth of both sexes, in place within the communities needs to be thoroughly explored. Youth could serve as groups to

help with demonstration farms and learn by doing. By association with the themes being promoted by extension their position as innovators would be reinforced. Youth groups could serve as a recruiting and training ground for extension workers.

B. Training

In the past the whole agricultural program has been short of funds which has curtailed the trained staff available at all levels and, above all, their effective operation. Training is expensive and produces frustration and wastage if the trainees do not have useful employment and a budget sufficient for year round operation.

The Francophone countries have regional facilities for providing all but the last 1-2 years of the 5-6 year post BAC program for "Ingenieur de Conception" and "Doctor Veterinaire." The last two years could be provided in these schools within the region at a reasonable cost. For

ease of entry into doctorate programs, the last two years could well be offered as an equivalent to a U.S., M. S.degree or the Doctorat due 3e cycle (French). These facilities could be more fully used. The best candidate is the ENSA and University at Abidjan followed by the Yaounde ENSA.

There is a lack of a higher agricultural school to provide this training in the Savanna region, which will probably be met by provision of a school at Bambey, Senegal or by the proposed extension of the Polytechnic at Katibougou, Mali.

These institutions can train the personnel needed for

- project planning and evaluation
- project management
- training of "ingenieurs du travaux"
- administration al all but the highest levels
- junior research posts

Training abroad would still be advisable for

- senior research workers
- senior administrators
- teachers in schools for "ingenieur de conception"

There are some exceptions where advanced training is already available within the region. There are generally institutions in which research for dissertations could be carried out within the region.

Any increase in development programs will run into a shortage of cadres at this level and may suffer serious delays waiting for them to be trained.

At the "ingenieur de conception" level, 4 years after the BAC, each country has a school, although not all of the disciplines are taught in

each country. In the past lack of jobs has limited the number of students, but a serious development thrust in the region would exhaust the capacity of the facilities and would require more trained teachers.

The lower level "conducteur," the agent in contact with the farmer, is also being trained in each country in a 1-3 year program after completing the 6th grade. These are the people required in the greatest numbers but also the easiest to recruit and to train. The supply of cadres at this level could also be exhausted if a further major sustained development thrust were to be launched.

There is also a lack of U.S. personnel--and indeed lack of personnel of all nationalities but French--with skills and experience in agriculture/livestock/fisheries/forestry development program analysis, project design and development management suitable for the region.

The FSI basis for language training is inadequate and virtually only the PC is a major effective trainer in languages.

Means of training U.S. personnel include 211d grants and title 12

Graduate fellowships to work on research within the region.

Associate expert status within the FAO system or within AID

Encourage the formation of institutions such as SEDES

Livestock Sector

The livestock sector serves

- as a form of subsistence and income production for nomadic and sedentary producers
- it provides a surplus of meat and animal products for the market
- it provides an important source of export earnings for all of the Sahelian States except Senegal
- it provides an effective means of harvesting the extensive Sahelian rangeland, of converting agricultural residues and by-products into forms for human consumption, of adding to soil fertility through manure, and of enriching the diet of the population in the region.

Production of ruminant livestock by nomadic herders is primarily directed towards milk production with meat as the secondary product. It is dependent upon rainy season pasture in the lower rainfall areas (down as low as about 200 mm/year) with complementary dry season grazing in higher rainfall areas (over 400 mm/year) which have cultivated areas and agricultural wastes -- such as straw or stalks of millet and sorghum -- and grasses of higher nutritive value than the dry grasses of the low rainfall regions. In some areas the dry season pasture is provided by land released from flooding as the level of water in the rivers declines (e.g., the Niger Delta in the Mopti Region of Mali).

The herders have used the Sahelian range for centuries; on their own they appear to have done relatively little lasting ecological damage. This is largely due to their having developed herding practices compatible with the ecology. However, the herder's response to innovation, such as permanent flowing water supplies from artesian wells or mechanically pumped water, has caused serious ecological damage in localized areas.

In the period since World War II up to 1968, the number of livestock increased and the percentage off take (i.e. the percent of the herd sold or slaughtered each year) also increased. However, the per capita consumption of meat in the Sahelian countries tended to decline as the increase in population exceeded the increase in production. The number of cattle exported to the coastal countries also increased over this period.

The buildup of livestock during the period of favorable rainfall from 1954 to 1968 exceeded the carrying capacity of rangelands during the period of below average rainfall from 1969-1974. In general this is caused by an excessive population trying to subsist in the Sahel requiring an excessive number of animals for their subsistence. Historically, epidemics of livestock diseases (now mostly under control) and droughts have reduced the herds to numbers which can be supported by the available rangeland. As a result production has stagnated since 1968. Therefore, without ways to increase the capacity of the range/water and other available forages to support a larger herd, little progress can be made to increase production.

Over the same period there has been an increase in demand for meat and milk, a gradual increase in the price of meat and in the importation of dairy products has resulted. Coastal countries with their greater GNP and growth in GNP/capita were able to bid the meat away from consumers in the interior countries leading to certain social dissatisfaction. Over a number of years the increase in demand for animal protein has been satisfied by fish, much of it purchased from foreign trawlers in local ports.

The drought had an effect of accelerating marketings and slaughter of livestock in 1973 and in some parts of the region the slaughter satisfied the consumer demand. However, in 1975, the price of cereals and food roots started to decline from the high prices caused by the drought, leaving more money available for purchasing of meat. Meat prices in the coastal countries rose very rapidly as the consumers sought to increase their meat consumption. This brought about substantial price increases in the interior, exporting countries and governments considered this to be so dangerous politically that Mauretania, Mali, Niger and Chad all tried to shut off exports of live animals.

The response of all of the coastal countries * was to import meat from the world market (particularly from France, East Africa, Australia, and Latin America). This satisfied the demand for the "European" type butchers trade, releasing the domestic supply for the mass African market supplemented by imported frozen meat. The world market price was equal to or less than the price of meat in the interior capitals. So, as the interior countries restarted their exports they ran into serious price competition in their historic coastal markets. This is made more serious by the much lower cost of transportation within and from the meat exporting countries on the world market, than in the Sahelian countries.

Nonruminant production in the Sahelian countries comprise, mainly poultry, with a small number of pigs for the non-Moslem part of the population. There is considerable potential for expansion in this production, but food grain prices and supplies are not usually within

* Excluding Senegal, the only country that is strongly Moslem on the coast which insists on slaughter by the priest.

range for the production of these meats for the African market. So production has to be based upon by-products rather than food grains.

Sector Goals:

-- To increase production and the market surplus of meat and milk delivered to the domestic and export markets, within the limitations of the ecology.

-- In this process to maximize the benefits to the largest number of people, producers and consumers.

-- Through mixed farming, crops and livestock, to increase farm income and to maintain and improve soil fertility.

General Constraints:

-- Meat consumption per capita has been declining over the last 15 to 20 years. Production and marketings, having increased over the period 1956-1968, has stagnated since then.

-- Livestock herds in the main producing region - the Sahel - reached and exceeded the limits that could be supported by the usable rangeland.

-- The more rapidly growing economies of the coastal countries are producing a demand for meat that has outstripped the ability of the Sahel to satisfy.

-- The interior countries had given priority to the export of carcass meat, providing the maximum of value added, but this priority will have to be reoriented to more efficient movement of live animals as imported meat from the world market makes it difficult or impossible for the interior countries to compete.

Proposed Solutions:

1. Develop water supplies to increase the area of rangeland that can be grazed.

2. Improve the yield of pasture which has sufficient water supply to permit its increased use.

3. Develop a technical package for Sahelian (nomadic herders) that is economically feasible and sociologically acceptable.

4. Increase ruminant livestock production in the higher rainfall zones, including the use of areas infested with tsetse flies and simile (the vectors for sleeping sickness and river blindness) for sedentary and nomadic herders.

5. Develop mixed farming systems, integrating crop and livestock production.

6. Develop modern ruminant livestock production systems, private ranches and feed lots, suitable for local investment.

7. Develop poultry production.

8. Develop pig production.

9. Improve transport of livestock to terminal markets with lower costs.

10. Provide an infrastructure for livestock development programs including design of programs that can be maintained by participants and local governments administratively and financially.

11. Train personnel involved in production, marketing and processing, in development programs and in administration.

12. Develop planning tools by which to improve allocation of priorities within the sector.

I. Water supply development

Public water development on rangeland has usually lead to overgrazing and serious ecological damage. Attempts to put in a sufficient number of wells so that there is no excessive grazing pressure around any single well have failed. In theory it is possible to shut off the water to control grazing, but in practice this has been impossible administratively. Sizing the delivery of the well to the grazing capacity of the pasture has only succeeded with hand or animal drawn wells and not with mechanical pumps.

The problem is fourfold:

1. Allocation of water to a given herding group or village who will control its use, which, in effect, controls the access to the pasture. This is the historic method.

2. Develop a water supply (surface or subterranean) to match the camping capacity of the pasture; this requires knowledge of the seasonal productivity of the pasture and of the hydrogeology.

3. Organization of the hydro-pastoral development of individual areas in such a way as to provide a feasible path of migration for cattle to and from the area. This permits herds to obtain forage of at least a minimum quality to keep them in the dry season.

4. Prevention of 12 months grazing around permanent water points to ensure natural reseeding of the pasture and maintenance of its quality.
This is further complicated by the fact that villagers want

wells near the village even if it is likely to lead to overgrazing and by the difficulty of establishing the number of stock being grazed on the range.

II. Improving pasture yield

Where there is an adequate water supply, and it is allocated to a particular group who will control its use and prevent its over exploitation, it may be possible to improve pasture yield.

1. By improved range management practices, e.g. controlled grazing, burning brush control, reseeding.

2. Construction of small levees (of stones) holds the water on the land and increases the water supply for the pasture, which may be a limiting factor.

3. Improvement of nitrogen fixation, where lack of phosphate is not limiting production, may increase yields.

4. The use of improved indigenous or introduced species and mixtures of grasses, legumes, forage shrubs and forage trees (e.g. the new Australian selection of Stylosanthes hamata, and Acacia albida trees, Brachyaria mutica on low lying land and Echinochloa on land susceptible to flood but not already very productive).

III. Technical package for nomadic and seminomadic herders

There are a small number of "experimental" projects which should result in the development of a viable technical package to nomadic herders. The projects include the UNDP/AID Center at Dilly, Mali, the UNDP/AID/FAC Assale - Serbewel project in Chad, AID Chad livestock project, the IBRD Mopti Region livestock project.

The package might be based upon gaining the participation of herders by a program of reducing calf mortality by parasite and disease control and supplementary calf feed and intensified veterinary care for the rest of the herd. Then the herders could be led to participate in the development of a range management, grazing control, and water development program, after establishing the carrying capacity of the range and the livestock population.

Control of range fires and other improvements, use of salt-mineral supplements particularly in the rainy season, improving milk production perhaps with a collection scheme and a processing plant, dry season cattle finishing are all potential components of such a package. When productive activities have been launched, the herders may elect to participate in social service activities, education, training, improved domestic water supply, improved health services and so on.

IV. Increasing ruminant livestock production in higher rainfall zones.

With the higher rainfall the number of options open for developing livestock production is increased. However, there is a major problem of conflict in land use with the increasing rural population requiring more and more land for farming, sometimes removing the vegetative cover from areas on which it will not grow back naturally, removing trees for use and sale as firewood and so on. This necessitates rural planning * for land use, trying to preserve the traditional relationship between farmers and herders. Frequently the best areas with vacant land are those recently cleared of disease vectors - tse tse flies (sleeping sickness) and Simile flies (river blindness). However, unless something is done to control the use of reclaimed land it will be developed in a haphazard way. Other undeveloped areas may have no accessible water supply, but it might be installed at a feasible cost.

In this region pasture improvement with brush control, range management, reseeding and other means is often feasible provided its use can be controlled often by water development being allocated to a certain group or by allocating a land use right to a certain group.

There has been experience with grazing associations which have been viable organizations continuing in a few cases after the expatriate project management has left. However, it has always been difficult to control the grazing in such an organization. The assumption has been that if forage supply permits, the herders will sedentarise; however, it seems that there is a greater probability that the herders will sedentarise if they are also farming; such a development then is considered as mixed farming.

This is an area closer to some of the larger cities and with a road network in which milk assembly and processing schemes are feasible.

V. Mixed farming systems.

So far there are few, if any, examples of a real integration of livestock and farming in the Sudanian countries. There are many farmers who have invested their saving in livestock and keep them along with farming. Integration is considered to mean a cropping system designed to support the livestock enterprise and vice versa. This integration as a means of building up soil fertility, was recognized by the Romans and, until the advent of low priced nitrogenous fertilizer after World War II, was the backbone of agriculture in many parts of the developed world.

It involves growing crops which produce hay (peanuts, cow peas or forage legumes) in a rotation to maintain fertility; the hay and forages are grazed or fed to the ruminants, together with other crop residues and wild hay * and the manure is applied to the land, preferably by a means that does not loose the available nitrogen. The ruminants may be draft animals, cows, finishing steers, sheep or goats. Other agricultural by-products and even crops may be fed to produce pigs and poultry, again using the manure on the land.[1]

This type of development is extremely important as a means of maintenance and improvement of soil fertility, without the use of fertilizer at the present high prices.

Setting up a development program for sedentarised herders van Raay ** recommends the following steps:

1. Identification of sparsely populated areas where potentially good grazing grounds and farm lands are found in juxtaposition. If not contiguous, the grazing and farmlands should be linked by cattle tracks.

2. Selection of areas of which the potentials for grazing and cropping can be maximised at low cost.
3. Specification of rules regarding the use of grazing and farmland.
4. Execution of projects directed towards removal of the major limiting factors of grazing land in order to enhance their potential animal carrying capacity. Since the shortage of protein in the dry season and fly-born animal diseases are the most critical constraints, a heavy call must be anticipated upon public funds for environmental engineering efforts to establish nutritious pastures and eradicate disease-carriers. There are very few natural grazing grounds that need no improvement at all. While the fodder supply in the tsetse-free zones in the northern part of Nigeria is generally low, tsetse tends to be a common scourge in the more productive grasslands further South. In certain localities, it might be necessary to construct a network of watering points and to distribute protein supplements in periods of stress.
5. Selection of interested Fulani pastoralists who can be accommodated in areas of which the environmental base has been improved. Assuming that it is decided to maximise the chances of favourable responses to the new range of possibilities, the choice of prospective candidates will not be difficult. The marginality of many pastoral operations has been indicated and it has been stressed repeatedly that many semi-nomadic Fulani are keen on increased opportunities to engage

in farming. Notably, corporate units that are short of cattle, to an extent that their self-sufficiency and independence are seriously threatened, are likely to display the necessary interest and motivation. In practice, this will mean that prospective candidates should be sought especially among newly formed corporate units with less than 10 head of cattle per household member.

6. Grouping of corporate units according to their affiliation to wider kinship groups such as lineage and clan in order to facilitate social interaction and cooperative arrangements, and the subsequent allocation of a stretch of land to the group.
7. Demarcation of grazing grounds and farmlands and subsequent division into feasible operational units adjusted to the labour force and herd size of the corporate units.
8. Granting of secure title to farmland to individual corporate units; although communal grazing rights have a strong tradition, it seems commendable that the use of land and responsibility for grazing grounds also are individualised.

These projects should develop into being self-financing. Equally a crop production and farm mechanisation package may be appropriate; it might include growing of forages on fallows or other land.

Attempts to encourage farmers who are not Fulani to grow forage have run into problems, since the Fulani consider it their right to graze any areas that are not fenced after the grain harvest is completed. Fencing adds to the cost of forage production and may make it not worthwhile.

Farmers may be more interested in sheep and goat production than in cattle, and projects for developing the production of these small ruminants are being started in the region.

VI. Modern ruminant production systems.

In the higher rainfall zones, if suitable areas of land can be found and water supply is available, there is a possibility to develop small ranches, allocating the use right to the land to family or other groups, Improvements can be made and paid for and some control of stocking be maintained. Examples that have been proposed include the IBRD West Volta and Nigerian Livestock projects. This provides a means for investment in improvements while safeguarding their use.

The areas available may be infested with tsetse flies, but it may be possible to produce either zebu cattle with careful management and prophyllaxis or trypano- tolerant * cattle.

The private ranches may also need small feedlots for dry season finishing of cattle, if a suitable market can be found. Sheep and goats should be included in these plans. Sheep production is probably the most profitable livestock enterprise, but it does not provide milk for subsistence of the herders.

* i.e. Cattle with a certain degree of tolerance or resistance to sleeping sickness.

Care will be needed to ensure that these ranches are limited to the target population or officials and other investors outside the livestock sector will take ranches in their own names or in the names of nominees. When the system has been well demonstrated and the process of ranch development is taken over by governments, there will be little to stop anyone that has the money or credit from making the investment.

VII. Poultry production.

There is a considerable production of chicken and guinea fowl in the bush as well as egg production. The birds are sold live. The privileged market is also supplied with dressed improved breeds of poultry.

Interventions have included substitution of cockerels of modern breeds for traditional breeds and production with modern breeds. In the latter case, a high level veterinary care is important. There are some by-products available for poultry feed - bran from food grains, lighter grains, damaged grain, and in some areas some pieces of food roots. The use of a prepared feed may be difficult to justify for the small birds on the African market but may be used for modern birds for eggs and meat for the privileged market.

VIII. Pig production.

Pig production is popular among the animist population in Upper Volta where it is even an export product. The "European" butchers shops sell pork and sausages, but a large part of the production is disposed of outside the usual meat market channels. The relationship between the

price of meat and the price of cereals has not usually permitted feeding of grain to pigs, so the ration comprises brewers grains (left after brewing beer) and other by-products. There are a few local sources of improved breeding stock. Little is known of the health status of the pigs or the economics of production.

IX. Transport to terminal markets.

With the importation of meat at world market prices on the coast, it becomes all the more important to reduce the cost of transportation. This cost is made up of all of the costs of sending a convoy, plus export taxes (if paid), patent fees, and profit margin, corrected for losses or liquidations to minimize losses en route.

Of the difference in price between say Bamako and Abidjan about a third is convoying, 1/3 taxes and other expenses and 1/3 interest on investment and profit, assuming that the taxes are all paid. A small part of the taxes are used directly in the sector: 1.6% goes to the Livestock and Meat board and 5% to the Veterinary Service for vaccination. Formerly the total taxes per head amounted to about 6000 fM ($13.40) but some of the regional governors recently applied a new tax of 10,000 fM ($22.30) a head to discourage export and the value on which the customs duty has also been increased.

This whole situation needs to be revised in the light of the new competitive state of the market on the coast. Because the cost of getting 1 Kg. of meat from Australia to Abidjan is about equal to the cost of movement from

Bamako to Abidjan by the least cost method plus the taxes with no allowance for interest or profit.

The principles of development of trek routes and of transporting cattle by truck are well understood. In West Africa an added complication is introduced by delays in waiting for railroad cars and lack of feed in the areas where the delay occurs.

Improvement in transport of small ruminants, which currently do not face the same competition from the world market, also needs to be included.

X. Infrastructure for Development.

Past interventions in the livestock sector have mainly required an infrastructure for prophylaxis against the major cattle diseases. This has involved training a group of veterinary assistants (infirmiers) to do this work. The Veterinary Services are ill equipped to handle the range management, animal nutrition, animal husbandry, marketing, economic and social aspects of the sector. Different countries have responded to this in different ways; for example, Mali has an interdisciplinary organisation - the Livestock and Meat Board - which is responsible for coordinating development projects, and Upper Volta has its Regional Development Organisations, which integrate all the services needed for development. The ability of the different countries to plan livestock projects is also very varied.

The livestock service and other organisations in the sector have, in the past, received little more than the payment of salaries of officials from the national budget, often not having sufficient operating budget to deliver the services. Proposals that producers pay for the services received would take care of the cost of delivery and provide an incentive to the lower echelons to provide services.

The sector is taxed for each animal slaughtered so that it would be theoretically possible to finance the extension activities needed for developing production, at least in part by increases in the slaughter or export taxes.

Thus apart from problems with development and demonstration of the technical package, there are problems in the provision of infrastructure for delivering the package, with shortages of adequately trained personnel, and with payment of salaries for more officials in the services and for their logistical support.

XI. Personnel Training.

Personnel are needed in various disciplines for production, marketing and processing phases of livestock sector development as well as for veterinary service delivery and for administration. On the other side, people are needed for planning and evaluating projects.

The facilities exist for training adequate numbers of lower and medium level cadres, but there is a shortage of higher level cadres for teaching, especially in the broad range of disciplines, apart from veterinary science, that are needed in the sector.

These needs should preferably be satisfied in a regional institution in one of the Sahelian states and acceptable at least to the majority of states within the region. The training of 5th. and 6th. year post BAC students could most easily be carried on in a higher agricultural school (offering at least 2 years of agriculture) associated with a university (offering the first two years of the curriculum in science). Faculties such as zoology, entomology, botany, economics and sociology can all play a role in the training. To teach the 5th. and 6th. year -- at about the level of a U.S. M.Sc. degree - places a great strain on an agricultural school, if any number of specialist areas is to be covered.

XII. Planning Tools.

Fitting all the elements of a program together for the sector and seeing how they interact with each other and with other sectors of the economy is beyond comprehension without the use of some form of mathematical model. Currently plans are formulated and priorities allocated by whim and inspiration rather than by analysis. There is no firm estimate of what the sector will need to produce after 10 years or 20 years and how it can proceed to supply the demand.

Some form of analysis using the simplest meaningful models is needed as a first improvement in allocating priorities by governments and also by donors. Such models have improved planning capability in some developing countries.

Research Needs

1. As with the crop sector, development programs cannot await the research results. There is little knowledge of what ruminants eat - nor for that matter on what pigs and poultry eat under traditional systems of production. Knowledge of this is needed to develop improved systems of production and, where necessary supplementation of the ration. There is some knowledge of digestability of the different forages, but when animals feed selectively and include browse, the composition of the ration is uncertain.
2. A major contribution can be expected from the Malian - Dutch project of modelling plant growth in the Sahel in relation to the water available, mineral nutrition and natural conditions. This is an application of two models developed by a Dutch Israeli team on arid land pasture production and on the nitrogen balance in the Neger in Israel. Models of this nature will indicate what factors limit production and under what circumstances. This in turn indicates ways in which production can be increased. This research is also applicable to crop production.
3. The economics of livestock production systems in order to be able to identify interventions and activities for development programs. This includes production of cattle, sheep, goats, poultry, pigs, and perhaps camels.
4. The economic behavior of pastoralists.

5. The economics of trypanosomiasis control in West Africa including tsetse fly eradication, prophylaxis and trypano-tolerance.
6. The complementary grazing of ruminants. What is the effect of the grazing pattern of one ruminant species on the feed available for others.
7. Evaluation of livestock projects in order to evolve designs for livestock development in the region.
8. Evaluation and projection of demand for meat and fish in the next 20-25 years in the West African region.
9. Evaluation of long term changes in the ecology of the Sahelo-Sudanian zone in relation to livestock production.
10. Improved use of remote sensing for rangeland mapping in the region in order to simplify and speed up mapping for use in development projects.
11. Development of national and regional models for the livestock sector in order to understand better the workings of the sector and to help to develop priorities in national and regional planning.
12. Methods of drawing water, including simple pumps, solar pumps and tradional methods and their implications for watering livestock.
13. The transformation of cellulose for livestock feeds. The tropical forests have an enormous capacity for growth and many of the species have no commercial use. Can the cellulose be economically treated to serve as ruminant livestock growing or finishing ration for stock from the Sahelian countries (OECD).
14. Detoxification of sheanut cake.

    There is a considerable tonnage of sheanuts (Karité) from which the "oil" in the form of sheanut butter has been extracted. The cake is not suitable for feeding to livestock due to a toxic constituent.

Attempts made before World War II to detoxify the cake were not successful. It is quite possible that modern techniques would enable the cake to be detoxified at a feasible cost. This would be expected to increase the income of the gatherers of the nuts and provide a useful high protein animal feed supplement.

Fish Sector

With a production that has reached about 300,000 tons a year and the potential almost double this, the fish sector of the Sahelian States is important

- as a provider of animal protein
- as a source of employment and of subsistence
- as a contributor to the GNP
- as an export producer

Fish also generally serves as a substitute for meat and so its supply together with the meat supply should be considered in meeting the demand for animal protein.

Considering the small amount of resources invested in the sector by governments the output is quite amazing. The industry consists of fulltime and part-time fishermen, using different systems for catching fish according to the conditions, type of water (lake, river, flood plain, etc.) and season, plus a large sun-drying, smoking or salting industry manned by the fishermen and their families, and a transport and marketing system. The product is sold at a very modest price. The catch was greatly reduced by the drought.

Constraints

1. First and foremost losses due to insect damage when the treated fish is kept for long periods in the fishing villages because of difficulties in transportation and the lack of a regular system of collection; losses may amount to 30-50% of the catch. Under FED sponsorship a chemical preservative has been developed that is simple to use and low in cost. The use of salt and smoke or

sun drying is also effective as a preservative but the systematic delivery of salt to the fishing camps has not been undertaken.

The amount of fish being sold fresh, with ice to keep it cool, is increasing but it is a small part of the total catch.

2. Apart from losses in storage and marketing the next most important constraint is adequate fishery management at all levels in the sector. There is also a severe lack of trained personnel.

   Training of the higher cadres has been proposed in a regional school to be set up at Mopti. A pilot program was submitted by UNDP in December 1974 under CILSS, and the proposal for preparing a project for 5 years of support for the school appears in the Report of the Consultation of Fishing Problems in the Sahel, Bamako, Mali, 13-20 November 1974. This would provide training planning capability of higher cadres, who could then train medium and lower level cadres within individual States with limited support from the donors.

3. Lack of capital, infrastructure, and to a lesser extent technical packages (i.e., improvement of preservation could serve as the initial package) to provide boats, motors, and larger mesh nets that are now needed--small gauge nets were needed during the drought.

Fishing regions need integrated rural development packages, with a strong productivity component, but including help with all of the productive activities including farming, and organizing self-help for the social services which are often non-existent due to the inaccessibility of the camps.

Some Current Activities

Mali: Production about 100,000 tons a year, mostly exported dried or smoked to Ivory Coast, Ghana and to a smaller extent Upper Volta. FED project since 1971 to cover

- extension to fishermen's camps, including improved means of conservation
- maintenance of motors for the boats
- research on more intensive exploitation of the Niger river fisheries and experiments in processing and marketing (fresh fish, smoked fillets, canning, etc.)
- improvements of the fish market facilities at Mopti, Dioro, Gao and Dire
- extension and professional training of middle level personnel.

NORAD (Norweigian IDA) with FAO made a study of the possibilities of producing and marketing a protein-rich concentrate from fresh fish for human consumption in 1975.

Wood required for smoking is consuming the forests of the region faster than the rate of regrowth.

The Mopti fisheries are the most developed in the region.

Chad: The fish catch in the Lake Chad Basin is about equal to that inthe Niger River in Mali, and the problems are in general similar, apart from the complaint by the Chadians that the Nigerians, with better access to capital, are able to out-fish them and that Chad's share of the catch is declining. The main market for the dried, smoked and/or salted fish is Nigeria.

Losses may be combatted by 24-36 hours of salt treatment, using 10% of the fish weight in salt, followed by rinsing and 5 or 6 days of sun drying. Attempts to extend this process to the fishermen's villages have not been very successful, partly due to the quantity and

cost of the salt involved. The insecticidal treatment may be much less costly. LCBC/FAO has a project with a fishery research station on Lake Chad and FAO has a small training program for river fishermen.

Niger: The catch on the river Niger and the lakes (apart from Lake Chad which is discussed under Chad) is modest--of the order of 10,000 tons a year.

There was a 1½ year FAO/UNDP fishing development project in Niger to train people from Niger and Dahomey on preservation and treatment of fish.

Upper Volta: There is a modest amount of fishing in rivers and lakes, and, presumably the control of river blindness in the Volta Valleys will increase the potential catch.

FAO/UNDP has a phase of the project for Development of Forest Resources, Wild Life and Fishing devoted to fish technology including preservation.

Senegal/Mauritania: The fisheries in the Senegal River yield about 40,000 tons a year and are in a primitive state, due in part to lack of access to the fishing camps. Fish that is not sold fresh is simply dried, involving the potential losses that might be expected.

These two countries also have important sea fisheries. Senegal has a $64 million IBRD loan for this sector.

Recommendations:

1. The fisheries sector provides a potential for increased taxed revenues by Sahelian governments if production is increased and management improved. The sector is a large employer of part-time

labor. Training schools and research (LCBC-FAO supported) should be further expanded and supported.

2. Thought should be given to organizing fisheries cooperatives where new techniques can be disseminated for lessening the rate of spoilage, credit provided for new and better equipment, and where means of getting the fish to market can be worked out.

Forestry

In the Sahelian States, forestry is the responsibility of the agencies of "Water and Forestry" which includes forestry, conservation, land use planning, and often fisheries. Thus the Eauxet Forets are responsible for combatting desertification as well as the programs for provision of wood for heating, fish smoking, structural uses, etc.

A CILSS/FAO Confernece is scheduled for April 1976 at Dakar with the objectives of

- developing a coordinated regional policy for forestry and conservation
- establishing priorities for the activities within the sector
- deciding on what is technically feasible.

Problems

1. Desertification. From time to time the concept that the Sahel is suffering massive and irreversible degradation at the hand of man and domestic livestock is raised. A careful analysis by "forestry" specialists and other indicates:

   - there is no massive advancing from of desertification caused by man
   - movement of the isohytes (lines connecting points of equal rainfall) southwards, i.e., leaving a larger area with less than 100 mm average rainfall a year, is the major cause of the advance of the desert. There is no evidence that man plays any role in this movement.
   - local desertification is occurring due to man's activities, producing an effect likened to the holes in a Swiss cheese. Contributing factors include:

     . removal of the vegetative cover for cultivation and subsequently abandoning the land as unsuitable for cropping

- over grazing, particularly around permanent water points. Denuding the area of forage can kill the trees

2. Deforestation is a serious problem caused by

   - the increasing demand for firewood for cooking/heating and for industrial uses, such as smoking fish. Alternative forms of fuel may have to be sought.

   - careless cutting of trees for livestock browse for all species of ruminants

   - farmers cutting down trees which serve as bird roosts.

3. Land Use: Problems associated with an excessive density of population on the farm land and with long term planning of the use of land cleared of disease vectors (of sleeping sickness and of river blindness).

Interventions:

1. Anti-erosive Forest Belt: The concept of an anti-erosive forest belt across the region has been proposed. However, expert view suggests that

   - it is difficult and costly to plant and establish and no one species would cover the whole region

   - it would only serve as a windbreak for a few hundred meters

   - if planted at the present limit of the desert--say on the 100 mm isohyte of today, any southward movement of the isohyte would kill the trees rather than the trees preventing encroachment of the desert.

2. Feasible Interventions:

   It is necessary to wait for the outcome of the Dakar meeting to get a comprehensive view, certain activities can be identified.

   a. The need to define the role of the forestry service.

   b. Training of cadres at all levels to fulfill this role. FAO is attempting to provide a higher level course at the Yaounde ENSA. People are also being trained at

Nancy (France) and in Canada and the USSR.

Medium level courses are offered at Katibougou (Mali) and Bambey (Senegal).

Lower level cadres are trained at Bobodioulasso (Upper Volta) and in the Cameroons.

c. Reforestation activities.

Reforestation is economically viable on a village basis for production of wood for domestic and industrial use as fuel and timber. Eucalyptus and Prospopis species can be grown for this purpose. There is need to find other adapted species out of the varieties under selection.

Acacia albida plantations, with 3-4 years of protection, are also probably a viable activity on light soils. The tree does not grow well on clays. Technically the activity is relatively simple but it is hard to convince people to do it.

There are other trees of commercial value, including cashew, mango, and gum arabic.

d. Use of the forest service in a program of conservation of the vegetative cover and land use classification and management. This would include a Soil Conservation Service role, planning conservation practices as part of agricultural development programs.

Delivery System:

A forestry activity or a series of activities are rarely self-supporting or feasible for delivery alone. These activities, with the

trained people to service them must be integrated into rural development programs, entering after the productive agricultural and livestock activities have been launched.

III. C. Health.

Introduction:

Health activities should function as part of an integrated rural development program, focused on improving agricultural, livestock and fisheries production.

One of the key inputs of any development plan is people. Therefore, the development process inherently involves investing in people. An investment in people requires investing in their health. Additionally, a major criterion of the success of the development process is the improvement of the quality of life.

Against this background, we see the following health constraints for development.

a) Parasitic infections sap the energy of adults and affect their work output. Sickness often means absence from work and professional training activities.

b) Parasitic infections and malnutrition affect the energy of students at school. Sickness results in absence from school.

c) Malnutrition in pregnant women and those with infants damages the brains of children and inhibits their ability to learn.

d) There is good reason to believe that parasitic infections and malnutrition contribute to a lethargic attitude which often results in a fatalistic attitude toward life inhibiting overall development.

2) The presence of vectors for diseases such as onchocerciasis and trypanosomiasis in certain riparian areas prohibits using considerable potential farmland needed for increased agricultural production as well as certain fishing waters.

It must also be kept in mind that various activities in other sectors, in connection with the implementation of an integrated development approach, will have implications for health. Some of these implications will be discussed later in this section.

1. Major Diseases and Health Concerns

a). The Current Situation.

The principal diseases found in the Sahelian area include malaria, schistosomiasis, trypanosomiasis, onchocerciasis, guinea worm, measles, tuberculosis, spinal meningitis, and gastro-intestinal disorders. Malaria is a major problem in every country.

Certain riparian areas such as the Volta River Basin have endemic onchocerciasis. Other diseases are also prevalent in particular areas of other countries such as respiratory diseases in Mauritania and Chad. Leprosy and trypanosomiasis are particular problems in Mali.

The water which most people drink in the Sahelian countries is contaminated in some way. Additionally, there is little provision for the sanitary disposal of human waste. In most areas there is no provision for the proper disposal of garbage. Most of the population have little knowledge of appropriate personal hygiene. Most homemakers have no understanding of the necessity for careful washing of utensils and dishes and the desirability of preparing food in a clean environment. There is little understanding of how food should be stored to prevent contamination.

Malnutrition is a problem for many children and adults. Infants, young children, pregnant and lactating women are most vulnerable. The weakened condition of those who suffer from malnutrition makes them especially susceptible to disease. In the case of measles death can often occur.

The current population of the Sahel countries is approximately 25 million. Population is rising at an approximate annual rate of 2.7 percent and could reach 50 million by the year 2000. The rate of population growth is currently rising faster than the rate of food production.

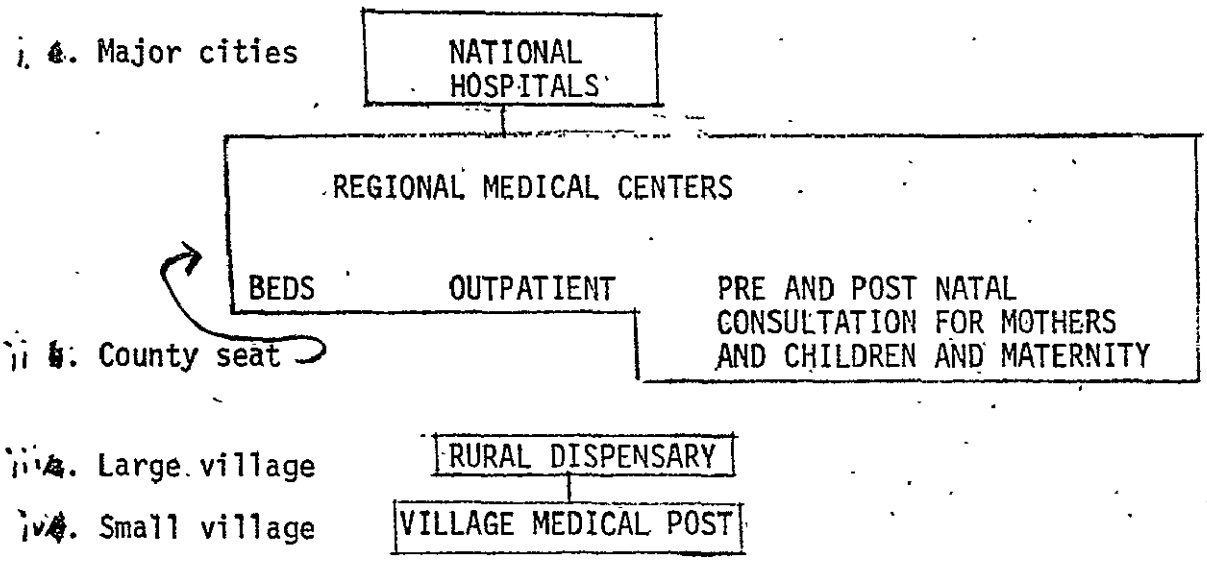
b) B. Future Considerations

Increasing agricultural output, improving cattle raising, and developing fisheries will have implications for health. For instance, if irrigation is introduced in certain areas, this has implications for the transmission of malaria, schistosomiasis, and parasites which are transmitted by water. Depending on the type of irrigation used, the onchocerciasis and/or trypanosomiasis vector can flourish. In addition, if there are projects which involve resettling people in new areas consideration has to be given to appropriate planning for providing potable drinking water, and the appropriate disposal of garbage and human waste. It is important that environmental impact studies be carried out in the early stages of planning. Provision also has to be made for appropriate rural health delivery facilities in newly settled areas. Conversely, development activities in the transportation and communication's sector will have implications for the health delivery system such as facilitating the delivery of supplies and communications between rural dispensaries and medical centers.

Looking further into the future, it is projected that as a result of the overall development process, towns and cities will grow. Plans must be made in advance for appropriate municipal water supply, sewage and disposal of garbage.

2.3.4 Current Health Care Delivery System

The health care system in all of the Sahelian countries is organized along the basic lines as indicated by the diagram shown below:



Regional medical centers are supposed to be staffed by a physician and include nurses, nurses aides and mid-wives. Often a doctor is not available. Where they exist, village medical posts are manned by a person with some minimum training in first aid.

Countries are divided into health sectors by the Ministry of Health. Vaccination teams operate in each health sector.

In most of the Sahelian countries the Minister of Health also serves as the Minister of Social Affairs. The activities of the Ministry of Health include operating social centers. The curriculum of the social centers includes baby weighing and counsel on how to maintain the baby's health, some instruction dealing with nutrition and some general health education aimed at homemakers.

Most Ministries of Education have a division which is concerned with school health programs. The extent of these programs varies widely.

The Ministry of Public Works is responsible for installing and maintaining municipal water supplies and public sewage systems in those rare cases where such facilities exist.

With the exception of Chad and Niger, which currently have no official plans, each country has a health section for their 4 to 5 year plan. These plans generally endorse the concept of an integrated health system and coordinated activities in the field of health. In practice, there is often a lack of coordination between the Ministry of Health, the Ministry of Education and the Ministry of Public Works concerning health matters.

Very few people use modern family spacing medication or devices. Official attitudes toward family spacing vary among the Sahel's government. Mauratania, Niger, and Senegal are willing to discuss the principle of family spacing and Niger and Mali are willing to try some family spacing programs. However, Chad and Upper Volta do not favor family spacing.

b) 4. Deficiencies

For curative and preventive health activities, there is a lack of personnel of all kinds and at all levels. There is a particular need for health personnel in the rural areas. The rule of thumb is that the further you get from the large cities the greater the shortage of trained personnel. The seriousness of the personnel shortage varies from country to country with Senegal having the most trained nationals. The majority of physicians come from outside the Sahelian countries.

Preventive medicine has received little emphasis during the training of most health personnel. They generally tend to take a narrow interpretation of what their specific activities should be. For instance, there are mobile vaccination teams which operate in rural areas. Generally speaking, the vaccination teams only concern themselves with innoculations and recording endemic diseases and undertake little or no activity in health or environmental sanitation.

There is a woeful lack of engineers and other trained people to handle municipal water supplies and sewage systems.

There is a shortage of facilities, and equipment for facilities, vehicles for mobile teams, spare parts and often fuel for such vehicles. There is a shortage of medicines, and a shortage of vaccines. There is also a shortage of transportation to get those supplies, which are available, out to the health facilities in the field. There is a shortage of material for municipal water and sewage systems.

As in the case of personnel, the general rule is that the further you get from the big cities the less likely you are to find available material. In countries like Chad, Mauritania, Mali and Niger the question of transport in the interior is particularly difficult. In some areas the only way to reach certain towns during the rainy season is by air.

There is a lack of coordination and planning. Ministries of health do not have adequate personnel to follow through on the implementation of a comprehensive health delivery system.

3. ACTIVITIES FOR REHABILITATING AND DEVELOPING AN EFFECTIVE COMPREHENSIVE HEALTH DELIVERY SYSTEM

lower case

Introduction

In order to remedy the deficiencies and constraints previously mentioned, an integrated health care system with emphasis on preventive medicine is required. An integrated health system would include maternal and child health, family planning, nutrition education, communicable disease control, sanitation, potable water supply, health education and curative activities. An effective integrated system could prevent the population from contracting many of the diseases which currently affect the Sahel, and would be most instrumental in helping to drastically reduce malnutrition.

The integrated health system would represent a delivery system in place for effective family planning activities when the population of these countries is ready to engage in such activities. In terms of potential acceptance, family planning activity must be part of a comprehensive delivery system which results in the improvement of the quality of life rather than just being presented as a population limiting activity.

An integrated health system needs to reach out to people and help them to understand the implications of clean water, proper disposal of human wastes, proper disposal of garbage, proper personal hygiene, proper nutrition, and family spacing. It would have a chain of personnel reinforcing each others efforts, extending from the village to the large city hospitals, and starting with prenatal care.

a) Health Delivery System Development and Strengthening

1. Additional personnel need to be trained. This includes physicians, administrators, planners, paramedical personnel, maternal and child health workers, sanitarians, and village level health workers. For all categories of these new health personnel the curricula must be reviewed and emphasis should be on training in the integrated approach to health care. For instance, personnel concerned with curative activities need to be alert to opportunities to explain why a person has contracted a disease and to refer them to another person in the system for follow up orientation. The cost of actually treating those diseases, which could largely be prevented by adequate preventive health activities, results in expenditures which could have more long range effect if used for preventive activities.

In terms of the number of personnel required, W.H.O.'s goal is that by 1980 there should be one physician per 10,000 population, one nurse per 5,000 population, one midwife per 5000 population, one health auxiliary per 1000, one sanitary engineer per 250,000 population, one sanitarian per 15,000 population. This projection appears optimistic.

In training activities there should be heavy emphasis on experimental learning, using facilities of the health delivery system, and curricula which focuses on the realistic needs of the developing health system. Often it is not necessary to bring people into the capital city for training as nurses aides, midwife assistants, sanitary assistants and village health workers. With the exception of certain medical specialists the training can take place in Africa where it will be most relevant.

The requirements mentioned below vary from country to country, but they give some indication of the time required to train different categories of personnel:

1. State Certified Nurse	3 years after	10 years of base education
2. Nurse Brevet	2 years after	10 years of base education
3. Midwife	3 years after	10 years of base education
4. Nurses Aide	6 months to a year after	6 years of primary school
5. Social Assistant for maternal and child health center	2 years after	10 years of base education
6. Social Aide	6-12 months after	6 years of primary education

7.	Village health worker	60 days	
8.	Village maternity aide	60 days	
9.	Sanitary Aide	1 year after	10 years of base education

Current personnel, including traditional health workers, need to be periodically retrained to update their technical skills. Many of these same personnel also need in-service training to orient them toward health education activities. There must be provisions for following up on the job with those who have received such retraining. Initially, a good portion of the training and retraining must be done by foreign personnel.

11.4. Existing health facilities must be renovated and new facilities need to be constructed. Particularly in rural areas, basic necessities like water must be provided for facilities.

The W.H.O. projects that by 1980 there should be medical centers staffed by a physician, nurse, midwife, and a sanitarian for population groups of 25,000. A goal of the Senegalese government is to provide rural dispensaries for every 12,000 inhabitants and one village health post for each 2,500 inhabitants.

Particular attention needs to be focused on the necessity for facilities which are appropriate to the customs of the area and which can be staffed and maintained. Large hospitals which cannot be maintained represent a financial drain on the whole health care system.

iii. Sufficient materials and medicines must be furnished so that appropriate facilities may operate effectively. Procedures for the bulk ordering of medicines and supplies needs to be established. Such procedures should result in substantial savings. Sufficient vaccines must also be made available for communicable diseases control.

iv. Provision needs to be taken to improve the management and planning of the health delivery system in each country. This will involve the training of planners and administrators. It is also necessary to design a basic information system to provide relevant data for health planning needs.

The project Strengthening Public Health Delivery Systems in Central and West Africa should be used extensively for training planners.

v. Appropriate arrangements will have to be made to ensure the delivery of materials to the different components of the health system. Additionally, appropriate transport must be provided for those personnel who require vehicles and spare parts must be earmarked for these vehicles.

vi. When there is solid indication of motivation, devices and medications for family planning must be made available.

vii. Support for the onchocerciasis control project in the Volta River basin should continue.

viii. A comprehensive time table and reasonable cost estimates needs to be developed for the activities mentioned above to renovate and update the health delivery systems in each country. A matrix can build on the data found in the health sector plan for those countries which do have long range development plans. The

Ministries of Health in each country and the W.H.O. representatives also have data available. [redacted]

As the projects are ready to be implemented, as a result of the information derived from the matrix exercise, arrangements must be made to ensure that new additions and renovated facilities for a national health system can be effectively maintained. This requires ensuring that the country concerned has an adequate budget to maintain and operate the health delivery system which exists at any given stage of development. Until the implementation of the long range development strategy generates enough revenues to maintain the system, this would mean that national budgets would need to be subsidized. If it is possible to undertake this procedure, then a sliding scale over a period of years need to be calculated.

b. Priority Action Programs

i. Even before the matrix activity takes place, work can and should be undertaken on developing intergated rural health delivery services in each country. Immediate operational priority should be given to developing a rural health delivery system which involves village health workers who are back-stopped by mobile teams operating out of rural dispensaries. These village health workers would perform simple diagnoses and dispense medicines, perform simple first aid, carry out activities in environmental nutritional and general health education. In addition to recruiting and training personnel for this type of activity, funds will also be needed to renovate rural dispensaries, for wells, pumps, and latrines in the villages.

A model for this type of activity is the Senegal Rural Health Service Project. It is estimated that the effect of the implementation of this type of rural health delivery system could prevent 75% of the diseases which currently afflict the population who live in those areas where the central development strategy will be implemented. Adequate vaccination activities must also take place in the tarket areas. The village health workers can play an important part in providing epidemiological information to those planning vaccination activities.

The Senegal Rural Health Service Project puts great emphasis on involving village people in an effective manner. The project deals with a total health delivery system of an administrative region and provides a clear link between the village and the rural dispensary. It envisions extending the benefits of a comprehensive rural health delivery system to 200,000 people per year.

It is recommended that negotiations be undertaking with the Sahelian governments to institute such a project in each country. Similiary projects are already being discussed with the governments of Mali and Niger.

C) 4. Studies

i. 4. As the integrated rural development plan moves forward, the environmental health studies will be required.

ii. 4. Assistance should continue with projects which would control onchocerciasis and trypanosomiasis. This includes vector mapping where it has not yet been undertaken and the initiation of new control projects when adequate vector location studies have taken place.

In this connection, organizations like the OCCGE[1] and OGEAC[2] should be used whenever possible since they are already experienced with this type of activity in Africa.

III. Audio-Visual Materials

How to most effectively use audio visual materials for basic nutritional, environmental, and health education is an important input for effective communications. Different approaches have been undertaken in the past ranging from imported films and slides shows to indigenously developed slide shows, posters, and flanel boards. Much remains to be done in prefecting educational materials and techniques directed to rural audiences and people of limited education who live in towns and cities.

It is proposed that a project be undertaken in each country to develop materials with priority given to materials for the rural health delivery system.

IV. Child Nutrition

There are important efforts underway in different countries to devleop indigenous weaning foods made of locally available products for children and to instruct the mother on why weaning food is necessary and how it can be prepared. The BANAS of the Ministry of Health in Senegal has developed a regional list of recipes. Similar projects should be developed in other Sahelian countries with priority being given to supplying the rural delivery system in target areas with material.

V. Family Planning

A. There is a need to know much more concerning the most effective way of promoting family planning in the Sahel.

1) Organization for Cooperation and Coordination in the Control of Endemic Diseases in West Africa
2) Organization for Control of Endemic Diseases in Central Africa.

To what degree can people be encouraged by educational activities? To what degree will a willingness to use contraceptives be affected by where people live, their level of education, their economic situation and how would these factors interrelate with educational activities designed to promote family planning? If better health conditions reduce fatalism, how will this affect attitudes towards family planning?

The DANFA Project in Ghana is undertaking this type of activity in depth and evaluating the effectiveness of actual approaches to delivering family planning services.

vi. Research Projects for Three Endemic Diseases

Onchocerciasis, schistosomiasis, and trypanosomiasis are three diseases which are related to the presence of water for irrigation activities which will be used for improving agricultural production. More efficient and comprehensive application of present technology and methodology could ameliorate the treatment and control of these diseases. Therefore, an applied research program aimed at improving existing technology is proposed. A program of basic research focused on developing new methodology and technology is also required.

vii. Measles Vaccine Study

Continued research on measles vaccine, which does not need to be kept at a certain temperature to be effective, is needed. If such a

vaccine could be developed it would eliminate vaccine spoiling when appropriate cooling equipment is not properly used or breaks down.

viii. 8. Malaria Vaccine

The task of trying to eliminate the malaria mosquito is overwhelming. The cost of prophylaxis against malaria is a continuing one. The successful development of malarial vaccine would protect the target population against one of the most devastating diseases in the Sahel. Research for this activity which is already under way should be supported.

ix. 9. Potable Water

Filtering and boiling water is a necessity for disease prevention where the water supply is contaminated. Filters manufactured in Europe are completely beyond the means of the majority of residents of the Sahelian countries. Charcoal filters have been tried in certain instances but it takes a long time to get an adequate amount of filtered water and the process is cumbersome. Since it will take a number of years before central supplies of clean water will be available on a wide scale, it is highly desirable that a cheap filter process be developed which could be used in individual homes.

The boiling of water over a wood fire can be a tedious process and represents one more burden for women who already have too much to handle. A solar heater which boils water for a household supply is presently available for $50.00. A more reasonable model needs to be researched and developed.

III.D. EDUCATION AND HUMAN RESOURCES DEVELOPMENT

Common historical, geographical and ecological characteristics of the Sahelian countries justify a regional approach to their developmental efforts but these commonalities should not conceal the many substantial differences that also exist in the region. Among the approximately 25 million people in the eight Sahelian countries, about two thirds the size of the United States, there are roughly 37 distinct linquistic/tribal groups experiencing environments ranging from desert to jungle. The basic resource of these countries is their agricultural, including livestock, potential. Since, as indicated in Table 1, about 90% of the population in these countries are dependent upon agriculture for their livelihood, any intervention directed to assist the majority of the population must be directed toward the rural sectors and must emphasize increasing local agricultural production capabilities. Given the existing imbalance between privileged urban areas and deprived rural areas, maximum concentration must also be placed on assisting the region to achieve greater social and economic equity not only in relation to the rest of Africa and the World, but between the rural and urban sectors within the region and within each of the national states.

TABLE 1

SOCIAL ECONOMIC INDICATORS

	GNP		POPULATION			EDUCATION		LIFE EXPECTANCY
	Per Capita 1972 ($)	Annual Average Growth Rates 1965-72 (%)	Labor Force in Agriculture (%)	Total Population (Millions)	Annual Growth Rate (%)	Literacy a/ (%)	Student Enrollment b/ (%)	Yrs
All of Africa (except So.Afr.)	205	--	76	318.1	2.7	17	27	44
Chad	85	1.6	91	4.0	2.4	5-10	14	40
Mali	70	1.3	91	5.5	2.4	5	12	38
Mauritania	175*	2.0	85	1.2	2.3	1-5	10	42
Niger	120	-5.1	91	4.2	3.0	5	6	43
Senegal	285	-0.7	76	4.0	2.4	5-10	23	44
Upper Volta	70	0.6	89	5.7	2.0	5-10	6	35

Source: Africa: Economic Growth Trends; Statistics and Reports Division; Agency for International Development. October 1974.

*: This figure is inflated by Mauritania's iron ore exports.

a/Ability to communicate in writing about matters of day-to-day concern.

The governments of the Sahelian countries have, without exception, indicated that priority consideration should be given to a reform of their primary school systems. The magnitude of this undertaking is one of the major reasons why it has taken the Sahelian governments so long to tackle the task. It is only the growing recognition that agricultural and rural development will not be accomplished unless the existing systems are drastically reformed that has ultimately resulted in each country's acceptance of this reform as a priority developmental objective. Donors seeking to assist Sahelian countries to achieve their priority objectives could make a major contribution through assisting, regionally and nationally, to accomplish these primary education reform goals. The magnitude of the undertaking in terms of expertise, material and coordination natinnally, binationally and multinationally would make this effort one perhaps best suited for implementation under the auspices of CILSS and the Club des Amis du Sahel.

Given the present circumstances, the schools, especially the primary schools, might more accurately be considered as impediments rather than as motivators of rural development. Fundamentally, the system in each of these countries is patterned after the French model and continues to have a colonial rather than a national or regional orientation. The systems are not relevant to indigenous cultural and manpower needs; each is grossly inefficient, and as UNESCO has indicated, each needs to be democratized in order to serve the majority of its people.

The existing educational systems are elitist and urban. In terms of cost, education consumes an average of 26% of annual national budgets and of this amount approximately 65% is devoted to primary education. While the total amounts devoted to education grew substantially during the first 10-12 years post-independence, it now appears that budgetary allocations to education have begun to reach a plateau because expenditures and rates of growth experienced earlier could not be maintained. Yet in spite of these tremendous efforts, as indicated in Table 1, the results have been extremely discouraging not only in view of the more developed countries in the world, but even in comparison with what is prevailing elsewhere in Africa. None of the Sahelian countries has achieved more than an estimated 10% literacy rate (the estimated rate for Africa is 17%), and while Senegal has managed to enroll 23% of its students, the other Sahelian countries average out at an enrollment rate closer to 10% (for all of Africa the rate is 27%). This level of human resources development correlates (1) with average annual GNP growth rates from 1965 to 1972 which range from Mauritania at 2% (substantially) influenced by iron ore exports which have had little impact on the life-style of the average citizen to Niger with a "growth rate" during the same period of - 5.1%, and (2) with rates of life expectancy which go from 44 years in Senegal (which matches the all-Africa level) to Upper Volta which is only 35 years.

Budgetary expenditures indicate that education and human resources development, certainly a major quid pro quo for development, is recognized as a priority area by the Sahelian countries and this commitment is even more profound in view of the meager resource base in each of these countries. Although national governments are committed to providing schooling for their populations, they have been locked into dysfunctional educational models. In addition to the perseverance of the meager colonial system inherited at independence, the heavy demand for highly trained leadership during the first decade of independence generally meant that inordinate resources were directed toward secondary and post-secondary institutions. This did address a need. Now, however, most countries have surpluses of graduates in the liberal arts field while there are substantial manpower requirements unsatisfied in those areas which are essential to survival -- agriculture, livestock, health, water resources management, etc. Thus, the school system is suffering from both internal and external inefficiencies which must be corrected if there are to be improvements in the well-being of Sahelian people. In spite of these problems, it is unlikely that Sahelian governments could substantially reduce their educational budgets given national and regional commitments to the formal system--commitments

made prior to independence by national leaders and regionally reinforced at conferences such as the one at Addis Ababa at the beginning of the First Development Decade where Africa-wide educational goals were set. Therefore, while as much as 2-5% of educational expenditures may eventually be devoted to alternative systems of education, including non-formal education, maximum returns from the continuing investments in formal schools is critical in order to promote meaningful human resources development. By-passing the formal school system in attempting to achieve greater efficiency and relevancy would be ineffective and would not achieve what the Sahelian countries recognize as being a major need--reform and indigenousization of the existing educational structures beginning at the primary school level.

The major constraints existing in the present educational systems in Sahelian countries will be listed below. It must be recognized, however, that these constraints are not mutually exclusive, that they are closely interrelated and assistance provided for human resources development purposes must be fully cognizant of the scope of the requirements to achieve the desired improvements. Overcoming existing constraints would assist Sahelian countries individually and collectively to achieve functionally and developmentally oriented educational and training capabilities so that their human resources could meet the demands inherent in national and regional drives to achieve improved individual lifestyles and well-being as well as national and regional viability.

Major constraints in the existing educational/human resources development context include the following:

1. The curricula of the formal system remains oriented toward the French-speaking urban civil service and away from the preparation of skilled manpower for rural development and production.
2. Access to the system is fundamentally open to those in the cities and especially in the national capitals. Those in rural areas and women in general are at an extreme disadvantage.
3. Limited ad hoc attempts to "ruralize" the primary schools in various Sahelian countries have not yet resulted in the identification of satisfactory and/or generalizable models.
4. The illiteracy rate of 90 percent in most Sahelian countries poses an acute problem in terms of mobilizing rural regions for developmental efforts. While this problem relates to general functional and non-formal education, it must also be addressed in the formal system.
5. Financial commitments to the education/human resources development sectors can be significantly increased in spite of human resources needs. Maximum or near-maximum

financial contributions are already being made for education and human resources development purposes, ~~and~~ to achieve reforms and improvements in the systems, additional resources must be obtained.

6. There is a need for in-service training for teachers and for improved teacher training programs in existing institutions in order to reorient the schools toward functional objectives and to prepare them to effectively use new curricula, new methods and nonformal education techniques.
7. Manpower statistics presently available form an inadequate basis for determining either present or future manpower availabilities or needs.
8. There is an acute shortage of trained administrators and planners required to provide the management and staff personnel needed to implement developmental programs at all levels of government including the educational, agricultural, livestock, health and planning sectors.

These constraints might effectively be considered within the context of three major categories: (1) Primary and Functional Education, relating to reforms of the primary educational system in the Sahelian countries and to enabling a functional and adult education/training

capability to receive support from the primary school system as well; (2) Non-Formal Education approaches to human resources development which include utilization of radio, various extension programs (which in many Sahelian countries might very profitably operate in conjunction with national and regional development organizations, international water resources development organizations and crop development organizations), religious and private institutions where relevant, and perhaps at least in Niger, experimentation on greater utilization of educational television capability which already exists; (3) Specialized Human Resources and Management Training Improvement focusing on manpower needs in Agriculture, Livestock, Fishing, Health and Nutrition, Water Resources Management and Management Training. The latter will be concerned with personnel requirements needed effectively to administer and direct operational and developmental activities. While the developmental orientation of categories I and II are essentially at the basic and functional levels, category III will include training and educational requirements through university and specialized institutional degree programs.

1. Reform of the Primary School System/Functional Education

Internal inefficiencies in the primary education system basically relate to the drop-out and repeater rates. It has been estimated that even in Senegal, the most educationally developed Sahelian country, where in 1970 42% of the age cohort group was in primary school and 8% in secondary schools, a majority of those students who had entered primary school dropped out before they had completed the fourth grade--the level which it is estimated must be completed if students are to maintain the literacy which they have acquired. The external inefficiency of the school system relates both to the exodus of school graduates and drop-outs away from the rural areas (and even from their own countries) and to their subsequent failure to find employment related to even their minimal levels of schooling. The magnitude of the human resources drain from rural areas has been estimated in Senegal: of 100 rural students obtaining Certificates of Primary Studies, only 2 remain in the village. Furthermore, access to any education is drastically unequal between males and females and the imbalance between rural and urban people is further complicated by the fact that even those who gain access to elementary schooling in the rural areas are generally forced to move away from their villages to larger cities if they are to continue beyond primary school. This

process in successive steps divorces children and subsequently adults from the rural sectors and urbanizes them. Education must be taken to children and adults rather than taking children and adults to education.

Earlier attempts at reforming the primary school systems have largely been confined to decree promulgations without adequate preparation. As a result they have led to high costs, to disappointment and to unproductive disruption of the existing systems. The systematic, carefully planned and evaluated approaches now being considered by several Sahelian states is the kind of process required to achieve the meaningful reforms desired.

Recommendations:

Language of Instruction in the Primary Schools: It is recommended that the Sahelian countries be assisted to develop the capability to teach primary school children in indigenous languages. While in most Sahelian States this would mean teaching in as many as three or four languages, this could be accomplished in each country (sharing materials where major African languages cross national boundaries) and materials could be produced cheaply and distributed to schools where such materials in French are now lacking or are in short supply. At present an inordinate amount of time in primary schools is spent in learning French and in studying curricula which have little relationship either to the immediate environment or to the students' future occupational opportunities. It is anticipated, and this could be determined in pilot projects, that:

a. education in local languages would require far less time to be spent on becoming literate than is now the case and would permit far more time to be devoted to studying relevant subject matter and participating in practical and functional activities;

b. access to secondary education would be determined more effectively on the student's knowledge rather than on whether or not (i) his teacher was qualified to teach French well or (ii) he was in an urban area where there was access to a French-speaking environment.

It should be noted that there is increasing evidence that once a child becomes literate in his indigenous language he is more proficient in learning a second language. Teaching French at the secondary school level might, therefore, be accomplished faster and better as a result of having learned an indigenous language first. The argument that by not learning French it will be impossible to communicate across tribal and national boundaries appears to be somewhat of a "straw man". For hundreds of years prior to French presence, the people of the Sahel criss-crossed the area communicating, trading and founding sophisticated economic and political systems. At present only 1% of the rural population in Senegal (the most developed of the Sahelian states and the one with the longest association with France) is literate in French, though all official communications are in the French language. That means that 99% of the rural population is effectively barred from official communications and from sources of information related to improvements in their styles of living and production. Furthermore, if school materials were in local languages they could subsequently be modified and used for adult programs and schools would cease to be foreign language islands in an African environment -- they could be more effectively integrated in community development type activities. Functional literacy programs and functionally oriented materials could be made available to the communities through the school

system. If local language materials were produced for schools it would be much more likely that these materials would be produced more cheaply and in quantity for the use of literate rural people who would then be in a position adequately and usefully to exercise and maintain their literacy once it ~~were~~ was acquired; they would have access to written materials which could provide them with information related to health, production, livestock management, etc.

The creation, validation, publication and dissemination of these materials would require the establishment of a curriculum development center in each Sahelian country. In some instances "swap" arrangements might be negotiated between countries which share a major language group or among those Sahelian countries which have substantial Arab speaking populations. Based on the cost of establishing curriculum development centers elsewhere in Africa it is estimated that the countries would average $3,000,000 each for the first three years. While these centers are being created, nationals in each country should begin to undergo training so that each operation could be Africanized at the earliest possible time.

Consideration might be given to the following distribution of curriculum centers:

1. In N'Djamena, Chad, INSE, already receiving assistance from UNESCO and projected to receive assistance from AID, would appear to be a logical site for one such center. The cost of expanding INSE's mission to cover this added curriculum development activity would

probably be much cheaper than the cost of founding a separate center. Materials might also be obtained from the Sudan and adapted for use in Chad's Arabic speaking regions to the north and west.

2. In Niger there has already been considerable attention given to preparing materials in Djerma, Hausa and Tamachek in relation to radio and television production programs. Niamey might, therefore, be a suitable location for a curriculum development center directed to preparing materials in those languages. The nearness to Nigeria and the potential availability of materials which have been developed in Hausa there would be another important consideration.

3. Mali has just assigned a general curriculum development function to the newly established National Institute of Pedagogy (INP). Since Mali will probably be involved in developing curricula materials in four languages, Bamako would also require substantial assistance in building into INP the necessary capabilities required.

4. Senegal has experimented with preparation of materials in local languages and could probably move into curriculum development activities within a relatively short period of time. Mauritanian representatives might cooperate with those working in the Senegalese center to prepare materials for those Mauritanians along the Senegal River who speak the same language as they do in northern Senegal.

5. A center in Nouakchott might specialize in the preparation of materials to be used in Arabic and shared with Mali's Arabic-speaking population. Access to Arabic materials prepared in North Africa would undoubtedly provide a substantial supply of materials which could be adapted.

At the same time it is recommended that an international center be established in conjunction with CILSS headquarters to provide for the exchange of materials, research and development techniques, and expertise among the Sahelian states, as well as with other Francophone and Anglophone African and non-African states.

Access to the System and Financing: The emphasis on learning French would thus be transferred to the secondary school where it would benefit those most likely to use it -- the small minority who will be enrolled in the post-primary systems. If literacy came to be perceived of as a means to improve life (urban as well as rural) rather than as a ticket to (or obligatory propulsion toward) urban areas and desk jobs, the rural hemorrhage might be substantially slowed. Furthermore, since access to post-primary education would not be fundamentally determined by French language ability, rural students, including women, would acquire much greater access than now exists.

However, even assuming that recommendations listed elsewhere in this report are accomplished, it will still be necessary for local communities to contribute to the expansion of the system's outreach. The impact and effectiveness of village contributions to local schools has been amply demonstrated in other African countries as have the drawbacks involved in such an approach. However, being aware of the problems which might be inherent in such an expansion effort it should also be possible to monitor this process carefully and to avoid or prevent dysfunctional trends from destroying the effort. In view of the economic state of the Sahelian countries it is unlikely that they will or should increase their contributions to their educational sectors. If curricula reforms, introduction of local languages, applications of new techniques and methods, in-service training of teachers to get them to use these new approaches, non-formal education and applications of educational technology are all available it may be possible to enroll in primary schools 50% or more of the age cohort group within a five year period without allocating a larger share of the budget to education. That figure would not include utilization of the primary school as an adult functional education center or as a community development center. However, to accomplish such a goal would almost invariably require that the villagers contribute to the buildings and perhaps augment teachers' salaries through food contributions.

If a given region is on a cash economy basis it might even be possible to ask that villagers also provide a portion of teachers' salaries. These prospects must be considered or construction and recurrent costs may mean that Sahelian governments can never sustain an expanded rural education system and donor countries will not do so indefinitely. The fact that the school and its staff will be serving the entire community may well make the assumption by the villages of a substantial portion of school costs acceptable and thus make the expansion of the system viable and help to insure its relevance.

If villagers participate in school/adult training centers many of the problems which have grown out of efforts to establish practical agricultural programs in rural schools might in fact disappear. The parents might decide that such activities could best be accomplished and still be educationally rewarding if done on family plots. On the other hand they may decide that school gardens are useful and should be maintained. If the latter were to occur parents would be looking upon the activity as an asset in preparing their children for the future rather than simply as being in competition for their labor. The problems plaguing school gardens (i.e., those students who plant the crops don't harvest them, lack of qualified supervision of students gardens, improper use of cash received from the sale of produce from student gardens, etc.) might be overcome if the effort were thus really integrated with village development efforts.

Efforts to "Ruralize" the Primary School System: Contraints for pilot project efforts attempting to make the rural primary schools serve rural needs have been (1) lack of pre-planning studies of socio-economic and cultural conditions of the people among whom the ad hoc reform attempts were being tried, (2) lack of a formative evaluation process with systematic modification and corrective procedures linked to the feedback loop, (3) lack of adequate control at the implementation level to coordinate and direct project activities, personnel and materials effectively, (4) lack of managerial personnel assigned to the projects on a long-term basis and committed to its objectives, and (5) lack of adequate support in policy and logistical terms from the central government. Where projects have succeeded they have most often been tied to one or two dynamic individuals and there has been an inability to institutionalize the projects so that they could be generalized beyond the scope and jurisdiction of those individuals; where the ruralization efforts have failed there is inadequate information available to determine what exactly went wrong. An assessment of personnel, teachers, students, materials, content and processes is essential to these pilot projects and without this approach it will be impossible to achieve effective ruralization of the school systems.

An inventory and an evaluation could be made of such "ruralization" pilot projects in the Sahel seeking to identify workable and generalizable models. New pilot projects, now being considered in almost all Sahel countries, could be reviewed and evaluated to determine whether or not they were prepared to correct the factors lacking in previous efforts. This could be accomplished within the framework of Sahel assistance efforts both in multilateral and bilateral projects and programs. The project presently being designed by AID in Chad (Comprehensive Human Resources Development) which will begin in FY 1978 and continue through FY 1980 at a cost of approximately $3,200,000, and will include the development of research, evaluation, and materials production capabilities, as well as the field testing and application of programs at 20 villages dispersed throughout Chad, might eventually serve as a model for Niger, Mali and Mauritania as well. In Upper Volta there are several different approaches being considered in the various Regional Development Organisms (ORD's) but these should be thoroughly evaluated and coordinated through a central research, development and learning institution in Upper Volta such as INSE in Chad. The establishment of such an institutional capability might well require a capital input of some $2,500,000 and an in-depth evaluation of the

present non-formal system in Upper Volta ~~should~~ could be accomplished for $200,000. In Senegal the situation is substantially different since there is presently a rural administrative decentralization program being initiated to promote developmental initiatives at the village level. However, it is recommended that consideration be given to assisting the Government of Senegal with pilot project approaches to integrated rural development by evaluating the roles of various agencies functioning under both the formal and nonformal systems supervised by Human Development (Promotion Humaine). These activities should be assessed also in terms of how they can coordinate with the administrative decentralization program. The cost of a pilot project evaluation program might be in the neighborhood of $1,000,000. These combined rural development pilot projects in the Sahelian countries could yield a solid basis for ruralization of the educational system on an evaluated and generalizable basis.

The coordination and exchange of findings on these pilot projects and on activities contained under Access (above) could be handled by a central organization which could function under the auspices of CILSS.

Illiteracy. Given the general average of over 90 percent illiteracy in Sahelian countries, a functional literacy program would appear to be essential in order to promote developmental programs and to improve the prospects and possibilities for communication and information flows directed toward improved life styles of the rural and female

populations. Curricula reforms in the primary school and primary education in indigenous languages should help to prevent the reversion to illiteracy after leaving an incompleted primary school program. Availability of local language training and appropriate adult education materials available through the schools, and having teachers trained to teach adults as well as children (see Teacher Training) should add impressively to the school system's outreach. However, it is also recommended that these formal school programs be closely integrated with non-formal and agricultural production programs aimed at increasing food crops as well as cash crops, livestock production projects, fishing and handicraft programs. At curriculum development centers materials could be produced with inputs from relevant agricultural, livestock, etc., ministries to make inexpensive and practical printed materials to serve adults to become literate and to maintain their literacy.

Teacher Training

In-service teacher training programs have already been conducted in Chad and over a four-year period 2,600 teachers were retrained at a cost of nearly $2,000,000. Such a program should be undertaken in other Sahelian countries and should include special programs for the training of adults, and for utilizing all potential learning and

and training resources available to schools to permit them to enrich and expand their functional activities. Contacts with programs seeking to increase food and crop production should be established to determine how best to integrate their functions at the school level. This same functional orientation should be built into teacher training institute programs and student teachers should be trained in new techniques in conjunction with non-formal and non-academic programs and resources so as to increase the outreach capability of the schools to permit them to serve more pupils so as to expand rather than compromise the quality of education. Techniques and educational processes are already known which can help the teachers to achieve greater cost-effectiveness ratios in the educational system, but they should be tried and proven in the Sahelian states prior to being introduced into the teacher training institutes as part of teacher preparation programs. Programmed instructional techniques might be appropriate, peer tutoring, supplementary radio education programming, flexible scheduling, etc., can all help to achieve this goal. Since the cost of education is essentially the cost of teacher salaries, these techniques could play a critical role in expanding enrollments without substantially greater costs. Techniques which are presently

being developed in South Korea where the student-teacher ratio is often (but not always) above 70:1 might be adapted to the Sahelian context.

2. Non-Formal Education

Non-formal education can, with and without the formal school system, make a major contribution to the education outreach of Sahelian governments. While functional literacy should be a major education goal, functional non-formal education programs should be promoted in conjunction with literacy programs.

The curriculum development centers established to serve the formal school system would also be able to provide substantial support to non-formal educational activities.

At present the most cost-effective and efficient means of conducting non-formal educational programs is by radio. Limited radio education programs are already operating in Senegal, Upper Volta and Niger but their scope is far too limited and their resource and personnel bases restricted. Nevertheless, experimentation underway in the Niger program has indicated that radio education programs have been effective even in reaching herding populations in the desert regions and this model should be evaluated and expanded not

only more generally over Niger but in the entire Sahel region. The radio education project would include printed materials (pictures for non-literate populations accompanied by written materials for those literate); a trained leader selected from villages involved in the program who will help to interpret the radio message, and to guide in functional implementation of projects, and to form a feed-back link to the radio school; basic materials (paper, pencil, chalk-board and chalk) and an organizational structure through which the leader could receive information and guidance related to special problems experienced by his group. An appropriate model for rural education is Accion Cultural Popular (ACPO) in Colombia. In addition to having completed 25 years of radio education programming, ACPO has a complete functioning system with some 400,000 rural peasants enrolled in its programs. ACPO also is willing to provide training to interested foreign officials.

The development of radio capabilities and the production of necessary materials for enrolled listerners, as well as materials and training sites for the training of the leaders, would require substantial addition to existing skeletal organizations.

The Association of Radio Clubs of Niger is probably the most developed and innovative in the Sahel region and should undoubtedly be assisted to develop a capability to serve the entire country. The development and installation of the necessary administrative, professional, technical and service level staffing for such a national outreach capability would require an initial investment of perhaps $900,000 per year, excluding additional equipment needs. This kind of center might also be considered for Chad and Mali given their size and diversity. For Senegal, Upper Volta and Mauritania (especially since Mauritania might well cooperate with Mali to cover those sparsely settled regions along their joint national borders) "partial" capabilities might be more appropriate. Initially these partial capability installations would cost some $600,000 per year excluding equipment. Once the training of indigenous personnel has been completed and foreign technicians and operators are withdrawn it is anticipated that these estimated costs would be reduced by at least 50%.

The training of the radio leaders would constitute a critical component of the radio education program and would be a major component of the government's educational technical outreach. It is anticipated that these leaders would provide the first human resource link between villagers and government representatives in agriculture, education, livestock, etc. Their services could be obtained for minimal

remuneration and they could permit agricultural extension workers and school teachers to cover a greater percentage of the population than would otherwise be possible.

In terms of utilizing educational television, it should be noted that Niger again has the most sophisticated installation to be found in Francophone West Africa, excluding the Ivory Coast. However, the cost-effectiveness of this installation has yet to be accurately determined. ~~and~~ It has been, and is being funded almost entirely by the French assistance program (FAC). It is not recommended that additional resources be channelled into this operation until its ultimate cost and effectiveness have been determined.

Other non-formal education approaches such as basic literacy newspapers, transportable and inexpensive records and record players which can be incorporated into radio education activities, etc., can and should be evaluated and pilot tested through the radio education centers. These centers would also have the capability to perform ongoing evaluations of their programs, to make modifications as required and to maintain contact with listeners through the leaders.

3. Specialized Human Resources and Managerial Manpower Training/ Manpower Surveys. Existing manpower projections should be reviewed carefully for each Sahelian state and a revised compilation of needs, indicating the problems (e.g., the statistical unknowns and soft data), should be prepared as a guide for manpower planning. In establishing the existing manpower base, an attempt should be made to determine the extent to which trained manpower are being employed in areas corresponding to their training and education.

In considering future manpower needs, both for the presently projected levels of development and for the levels which might result, careful consideration should be given to Sahelians presently undergoing training and post-secondary education abroad. The importance of this component is indicated by the fact that Chadian officials now estimate that there are approximately 1,500 persons outside of the country (most of whom are in university level programs in France), while in Niger it was estimated that at least 400 were presently abroad. Even in Mauritania some officials thought that as many as 100 might be studying abroad. Obviously this potential reservior of trained personnel will not fit into all the skill categories which Sahelian countries require, but a substantial number of them will and others may, with additional training, fit identified manpower needs.

In conjunction with the manpower surveys a special effort should be made to determine how many Sahelians have remained abroad following the completion of their training and education programs. A repeated observation heard in the Sahel ~~in~~ is that the number is substantial. In part this is attributed to difficulties they experienced, after completing their degrees and training programs, in obtaining positions in their own countries relevant to their studies. Within the context of projected development plans, efforts should be made to identify these people, to determine how they might fit into national and regional development schemes, either with or without additional preparation, and their recruitment, placement and repatriation should be attempted on a priority basis.

Agriculture:

A primary need is to obtain basic manpower needs within the agricultural sector for all Sahelian countries. In addition to this a detailed survey is needed of educational and training institutions which will indicate their present enrollments and student outputs by program and by specialization and finally the extent to which these institutions could be expanded and at what costs.

In attempting to analyze and project agricultural manpower needs, there is a fundamental problem in identifying what job titles mean and in establishing their equivalencies among the nations in the region. However, while many countries have, since independence, changed the titles designating levels of professional competency, they have retained the pre-independence ranking system and job qualifications.

Rank	Title	Qualifications
A 1	Agricultural Engineers:	Trained principally in France, but also in the U.S.A In Francophone West Africa only Dakar and Abidjan have the capability to provide education at this level at their ENSA's (National Superior Schools of Agriculture).
B 1 & B 2	Counselor Director (Conducteur)	In West Africa they can be trained in agriculture at Katibougou, Mali; in Rural Engineering at Saria, Upper Volta; in Agricultural Cooperation at Douala, Cameroon. Those in Livestock can be prepared at Niamey (School for Livestock Assistants and Nurses).
C	Technical Agents (all specializations)	All Sahelian countries have these schools but most of them are in need of substantial up-grading and expansion. Almost all of them are presently increasing their output by as much as 50%.
D	Monitors	All countries also prepare their own monitors who serve as agricultural extension workers and as teachers of agricultural subjects in primary and lower secondary schools.

Rank	Title	Qualifications
E	Motivators (Animateurs, Encadreurs), Asst. Monitors, etc.	All countries train at this level. Preparation varies substantially from country to country. At a minimum literacy is required followed by a training program of 3 to 6 months, but usually a primary certificate plus 2-4 years of specialization.

A second major problem relates to levels of staffing needs projected by French and U.S. agricultural experts. On the U.S. side it has been estimated that agricultural manpower needs might be projected on the basis of the following index:

For Dryland Agriculture: Based on 100,000 farms, there is required:

400 monitors (agricultural extension agents) (D Rank)

Preparation: Primary plus 2-4 years of specialization

54 agricultural engineers

Preparation: Secondary plus 3-4 years (B Rank)

14 agricultural engineers

Preparation: Secondary plus 5-6 years (A Rank)

Assuming that there will be 14,000,000 hectares of dryland farming under cultivation by the year 2000 and that the normal farm is 5 hectares, the total number of dryland farms in the Sahel would be 2,800,000. At present, there are approximately 10,000,000 dryland hectares under cultivation

for a total of 2,000,000 farms. Allowing only for a projected increase of 800,000 farms, adequate staffing by agricultural personnel would require

3,200	monitors	(D Rank)
432	agricultural engineers	(B Rank)
112	agricultural engineers	(A Rank)

The estimate for Irrigated Agriculture:

Based on 100,000 farms it would require

2,000	monitors	(D Rank)
270	agricultural engineers	(B Rank)
60	agricultural engineers	(A Rank)

Assuming that there will be 200,000 hectares under cultivation in the year 2000 and that the normal irrigated farm is 2.5 hectares, there would be a total of 80,000 farms added to the existing 80,000 which have approximately 100,000 hectares under cultivation. Based only on the increased acreage this would mean additional agricultural personnel as follows:

1,600	monitors	(D Rank)
216	agricultural engineers	(B Rank)
48	agricultural engineers	(A Rank)

Again, however, it should be noted that present agricultural personnel staffing for irrigated lands is no better than it is for dryland agriculture, and it must not be assumed that the recommended level of staffing now exist for land already under irrigation.

Information related to the numbers now employed in agriculture in each country by level is not available. However, it is certain that no country presently has the manpower listed above.

As an example, the U.S. projections, if applied to one country would give the following results:

NIGER

		Present Staffing	Recommended Staffing	Short fall
Engineer	A1	15	108	88
Engineer	A2	5		
Counselor	B1	59	410	284
Director	B2	67		
Technical Agent	C1	99	--	--
Agriculture Extension Agent	D	421	2,160	1.739
Other	E	87	--	--

Obviously the difference between existing staffing levels and those recommended is profound.

In its anti-drought strategy report on the Sahel, French experts in SEDES (Société d'Etudes pour le Développement Economique et Social) made the following recommendations related to manpower needs in agriculture:

There should be made available immediately 230 agricultural engineers (A) and 460 technicians. The production of agricultural engineers (A Rank) should be doubled within the next 5 to 6 years.

By the year 2000 the following personnel would be needed:

1,300 agricultural engineers (B Rank) for the irrigated sector;

2,600 agricultural engineers (B Rank) for dryland agriculture;

2,600 higher technicians in livestock; (B Rank)

13,000 to 16,250 agricultural technicians and veterinary (probably C Rank) nurses; and there should be one leading demonstration farmer trained to work with every 10 to 30 farms.

(Note: Monitors as classified above were excluded)

At the central administration levels the number of experts in agriculture, rural engineering and livestock should be doubled within 5 to 6 years. (Ph.D. level)

In terms of institutional needs in each state, SEDES recommends:

one school to ~~form~~ train rural mechanics capable of graduating 20 per year (probably C Rank);

one school to train agricultural engineers capable of graduating 40 per year (probably B Rank);

one school to train higher technicians for livestock, capable of graduating 25 per year (probably B Rank);

one school for training agricultural technicians, graduating 100 per year (probably C Rank); and

one school to train livestock nurses, graduating 50 per year (probably C Rank);

The first objective is for each state to establish as soon as possible, through foreign recruitment, a professional faculty and staff for these schools (A Rank).

Projecting regional needs for dryland agriculture based on the U.S. estimates of Niger's dryland agriculture needs for the year 2000, A Rank requirements would be approximately 556 (SEDES estimates about 460), and B Rank about 2,600 (SEDES also estimates 2,600). Calculations for Ranks C and D are not possible on the basis of SEDES categories. For irrigated agriculture needs the projections would be 48 for Rank A and 260 for Rank B. To compare these estimates to those of SEDES requires that they be multiplied by 5 in order to equal the amount of land SEDES estimated would be under irrigation by the year 2000. (SEDES estimates a total of 1,000,000 hectares under irrigation by 2000 while this report estimates a total of 200,000 hectares under irrigation). If this was done, U.S. projections would total 240 for Rank A and 1,080 for Rank B. SEDES make no separate estimates for Rank A, but does estimate Rank B at 1,300. In effect the rough estimates made in this report are fairly close to those made by SEDES.

It must be noted, however, that based on present levels of operation, Sahelian estimates of needs are in keeping with their present levels of staffing. Mali, for example, estimates that its rank B agricultural staff supply by 1980 will be 175 and its demand will be 170; its veterinary nurses supply will be 290 while its need will be 363. These projections are based on what Mali feels it can afford at presently projected levels of agricultural activity; they do not reflect improvements in levels of development beyond what was estimated as possible in 1974.

If there is to be substantial developmental inputs into the Sahel, and projections made by SEDES and this report become more realistic estimates of what will actually be needed to up-grade the existing impoverished agricultural manpower staffing patterns, as well as to accommodate new expansions, then all existing schools in the Sahel region must be increased as indicated by SEDES. Initially, for example, the Rural Polytechnical Institute (IPR) at Katibougou, Mali, is being expanded by 60% and at a projected cost of $1.5 million, but funds are not yet available to support this enlargement beyond 1976. The same is true of the School for Veterenary Nurses (EVI) in Mali where an expansion is contemplated to more than double present enrollment at a cost of $1.1 million, but again it is not known if funding will be available.

As noted earlier an inventory needs to be made of all basic and intermediary agricultural teaching and training institutions in the Sahel to determine their abilities to expand and to determine the costs involved.

At the higher level it appears definite that university level capability is required in the Sahel to prepare agricultural engineers (Rank A). While Dakar's program should be expanded, if possible, it should be determined if the additional capability should be located in Niamey (at the recently initiated faculty of science and agriculture) or even in N'Djamena where an agricultural faculty is also being launched. Consideration might also be given to expanding the capability in Abidjan if the Government of the Ivory Coast were willing to serve Sahelian needs. However, this might not be as suitable for the Sahelian region's training needs since the school is located in the jungle region.

There must also be roughly a doubling in the capability to produce Rank B agricultural staff which may be accomplished by expanding the capability in Katibougou, Mali, and perhaps by offering a Rank B option in universities producing Rank A candidates. This would include those studying in livestock and veterinary sciences.

Managerial and Administrative Education and Training

As indicated in previous sections of this report, there is a pervasive need to prepare adequately qualified managers and administrators to serve at all levels throughout the governmental structures of the Sahelian countries. Unless this basic manpower requirement is addressed at the provincial and local governmental levels, as well as in the capital cities, it will be difficult to improve substantially the existing developmental efforts and it will be impossible to carry out with any degree of effectiveness expanded developmental programs.

As noted in the manpower survey section, students overseas are one obvious source of potential recruitment for qualified managers and administrators -- students presently enrolled as well as students who have failed to return following the completion of their programs. While undoubtedly a substantial number of these students and former students are and have completed liberal arts and law programs, it is also true that worldwide a large percentage of graduates in these areas form a substantial core of the administrative cadre. In the Sahel their utilization and effectiveness could be greatly enhanced by appropriate "topping up" in administrative training which could be included in or following after their degree programs.

Within most Sahelian countries there are, in addition to university programs, institutes of administration (National School of Administration), with degrees comparable to B.A. university degrees, which seek to provide the civil service manpower needs of their respective countries. Unfortunately, however, these institute and university programs rarely concern themselves with middle and lower level administrative manpower requirements and especially not for those who serve in provincial, municipal and rural components of government. A crucial need in all Sahelian countries is to provide administrative training programs in interior areas which will not only seek to educate and train but which will also serve as vehicles for provincial levels of government to communicate their particular needs and problems to central government officials. A profound problem in the Sahel region, as in many other countries, is that inputs into the system flow almost uniquely downward from the central government with little chance given to provincial governmental units to insert into the system any more than responses to central government demands. Therefore, the problems which do not fit on central government forms are often not considered. In a situation where more rapid development is occurring in rural areas (and where increasing numbers of problems will not fit on forms), it is imperative that provincial bureaucracies be better qualified to handle their own problems, that the central bureaucracy be able to handle the new inputs which will be generated in rural areas, and that the central government officials become aware of problems, processes and personalities outside of the capital city and/or their particular regions of origin.

A program of in-service training seminars in provincial and other interior cities is presently being designed in Chad which may prove to be a useful model for consideration by other Sahelian countries. Intensive courses will be conducted which relate to provincial and local administrative management problems and a number of the course presentations will be given by faculty from the capital city as well as by qualified government officials who will teach on a part-time basis.

In addition to up-grading administrative officials in the interior it will also expose central governmental officials, and professors from the universities and institutes, to the administrative realities existing in the rural areas. None of these training programs will take provincial people into the capital city -- even when courses are structured to last as long as three months. Training conducted at provincial sites has the added advantage of enhancing concern over improper administration practices there and might also provide for better contacts and understanding between the provincial capitals and their outlying regions. The cost of provincial in-service training programs in Chad, which will run from 1977 to 1980, will cost an estimated $600,000. It is assumed that costs in other Sahelian countries would be comparable.

Surveys should be conducted in the Sahelian countries to ascertain which institutions, universities, schools and training programs serve which sectors of the national civil service, and plans should be prepared to ensure program administrative training for government personnel so as to fill existing as well as potential gaps which may occur as a result of rapid rural development.

III.E. MINERALS SECTOR

a. GENERAL

There is only superficial data on the mineral resources of the Sahel. In Senegal, deposits of iron, phosphate, titanium, salt and gold are known. Phosphate, titanium and salt deposits located near Dakar are being worked, but the only inland mines exploited are the gold deposits. Iron deposits also exist in both sides of the Senegal-Mali border. None of the identified deposits in Mali of iron, bauxite, manganese, zinc, and phosphates are being worked. One gold deposit near Bougouni and a salt deposit near the Algerian border represent the total exploited mineral resources of Mali. Niger has known deposits of iron, uranium, tungsten, tin, coal, and salt, most of which are being exploited. In Chad some salt is being extracted and two natron (hydrated sodium carbonate) deposits have been identified northeast of Lake Chad. Some oil exploration is in progress off the coast of Senegal and northeast of Lake Chad but so far no important finds have been announced. Iron ore is mined in northwest Mauritania and provides a substantial source of foreign exchange.

b. FERTILIZER MINERALS

1. Phosphates

The low level of phosphate in the soil of the Sahel is one major restriction on the increase of agricultural production. Phosphate is mined commercially in Senegal and in Southern Togo. In Senegal the raw material is made into fertilizer mixtures and a superphosphating installation is planned for Togo.

Beds of coprolitic (fossil) phosphate have been found in Mali and Niger suitable for crop production. The deposits are low enough in fluorine to be used also as a component in mineral supplements for livestock.

Substantial deposits of phosphate rock (possibly apatite) have been discovered in the area of the junction of Niger, Upper Volta and the Republic of Benin with portions of the deposit in each country. The material is suitable for crop fertilizer, but may have too high a flourine concentration to allow its use in livestock food supplements without further processing.

Large scale industrial exploitation of these and other phosphate deposits which may be located later has been under study for several years. But such industrial enterprises will take time to materialize. Feasibility studies and negotiations for private investment ~~firms~~, putting up the necessary structures, bringing power to the sites, providing mining, transport, and production equipment will delay the availability to the farmer of low cost fertilizer. It is, therefore, recommended that immediate steps be taken to provide the Sahelian governments with the minimum equipment for small, local installations for the processing, packing, and distribution of crushed phosphate rock to be used by the area's farmers. To

encourage the initial use of the fertilizer, it may be advantageous to distribute it at no cost during the first year or two with the understanding that payment would be made only if the use of the fertilizer resulted in an increased crop yield. The cost of equipment and subsidizing of the initial distribution would be a suitable use of external assistance funds in the context of the agricultural development effort. Financing of this small, local production should, in no way, prejudice the industrial exploitation if further study proves its feasibility.

2. Other Fertilizer Elements

Increased crop production will require the addition of nitrogen and subsequently potash to Sahelian soils. After a few years of adding phosphate and nitrogen, a need develops for the application of potash. There are no presently identified sources of potash and nitrates in the region. There is, however, a possibility that they would exist in fossil saline lake beds. Prospecting for potash and nitrates should, therefore, be given a high priority in any general mineral surveys being contemplated.

Since nitrogen also can be obtained from LP gas, Nigeria can become a supplier of ammonia to the region.

C. OTHER MINERAL RESOURCES

Most of the identified deposits in the Sahel other than uranium are of low concentration. Their distance from evacuation points (ports, railheads, roads), the lack of electric power for

exploitation and ore concentration, add up to make mining in the Sahel unattractive to private investment. There has not been enough interest to adequately investigate the known deposits to assess their full potential. Recent interest has, however, been focussed on uranium and indications are that uranium producers may be willing to finance part of the costs of power dams in uranium producing areas. This may not prove to be an undiluted blessing since it may lead to pressure for the construction of dams in the major river basins before full data are available and before indicative plans for basin development are completed.

Except for oil, if found in commercially exploitable quantities, and uranium at the present market price, the role of other minerals in the economic development of the region may be minor unless there is a sharp rise in world prices for these other minerals. Private investment in the presently known low grade deposits would not justify the governments' investment in the necessary infrastructure. The taxes and royalties imposed would need to be low to attract foreign investment.

With satellite and magnetometer techniques now available preliminary surveys can be made at relatively low cost to locate possible areas of commercially exploitable deposits. Donor assistance to Sahelian governments for a region-wide survey would be justified within the framework of a long range development program. As the programs of road construction, railway improvement and expansion,

and the development of river transport progress, those sites identified in the preliminary survey close to access arteries could become attractive enough to encourage the expenditure of private funds for more detailed exploration.

d. Proposed Projects

Preliminary mineral survey

Estimated cost: $2,000,000

Small scale phosphate production and distribution

Estimated cost: $2,500,000

III.F. INFRASTRUCTURE

1. Transportation.

a. Existing Road Network

It has long been recognized that the lack of adequate transportation facilities is an inhibiting factor in the development of those areas of Central and West Africa remote from the coast. Irrespective of the many other steps which may be taken as incentives to increased production (development of water resources, a progressive price policy more favorable to the farmer and herder, or an expanded agriculture extension service), the inability of the producer to get his produce to the market will discourage him from producing more than he needs for his own subsistence. Means of efficient and reasonably priced transportation must be provided to move crops and animals from the producing areas to the markets and to bring surplus crops to storage points in deficit areas in bad years. The present road network in the Sahelian countries is inadequate to serve as a tool in a development program, either for the short term or long term.

Mauritania has only one paved road from the Senegal River port of Rosso, near Richard Toll, to Nouakchott and thence, northward about 100 km, terminating at Akjoujit. From there a gravel road penetrates a short distance before becoming a dirt and sand track ~~track~~ closely paralleling the border of Spanish Sahara. It branches into two tracks, one leading to Algeria and the other, through

northern Spanish Sahara to the Morocco border. Of the total road system of 6,000 km approximately 3,200 km are national routes and the rest are dirt tracks. Most of the roads are in poor condition. A new road connecting Nouakchott with Kaedi is under construction and the IBRD is financing a feeder road project to connect with areas close to the Rosso-Nouakchott road.

Senegal, though it is the smallest of the Sahelian countries, has 9,100 km of roads of which about 2,200 km are paved and another 3,000 km are all-weather gravel roads. However, nearly the whole of this system serves the western one-fourth of the country and is oriented toward Dakar. Some feeder road projects are being financed in limited areas between Richard Toll and St. Louis and within a radius of 100 km east of Dakar.

Mali has some 13,000 km of roads but only 1,650 km are hard surfaced, connecting Bamako with regions to the south and east to provide access to Upper Volta and the Ivory Coast. Another 3,000 km are all-weather gravel and the remaining 8,000 km are a scattered network of poorly maintained secondary gravel roads and tracks. The existing paved roads were built to low standards and are mainly in poor condition. The stretch from Bamako to Segou is now being reconstructed with IBRD financing. The Bamako-Bougouni section was scheduled for improvement with AID funds but bids exceeded the authorized loan funds and the future of this project is now uncertain.

The IBRD is planning an extensive feeder road project in southwest Mali to connect agricultural areas with an existing paved road and the Mali-Senegal railroad.

Upper Volta has 4,450 km of primary roads of which only about 500 km in the vicinity of Ouagadougou and Bobo-Dioulasso are paved; some 1,000 km of other classified roads; and 8,000 km of rural tracks. Only the primary road system is maintained. The rest of the classified roads have deteriorated until they are passable only in the dry season by heavy trucks and four-wheel vehicles. Rural tracks are usable only for foot traffic, bicycles and pack animals.

Niger's highway system consists of 7,300 km of roads with only 1,000 km being paved, running east-west as part of the projected Trans-Sahelian highway. Canada is financing the reconstruction and paving of the section of the highway between Zinder and Nguignu. When completed this will provide a paved road from Niamey to the Chad border.

In Chad only 230 km of paved road exists, running south from N'djamena, out of a total of 7,230 km of classified roads. Another 25,000 km of unclassified tracks serve the rest of the country.

b. Existing Railroads

The existing railroads, while mostly adequate in equipment, are so inefficiently operated as to be of little assistance in the development process.

A privately owned and operated 670 km railway in Mauritania connects the iron ore deposit near Bir-Moghrein (Ft. Derick), east of the Spanish Sahara, and the port at Nouadhibou on the southern border of the Spanish Sahara. It carries almost exclusively iron ore and a limited amount of imported general goods.

The main trunk railway line between Dakar (Senegal) and Bamako (Mali) is 1300 km long and carries 40 percent of Mali's exports and 60 percent of its imports. There are also 370 km of branch lines. About 65 percent of the line's traffic includes ground nuts and phosphates. The importance of the railroad for passenger traffic has declined with the expansion of the road network.

The Governments of Upper Volta and the Ivory Coast jointly own and operate an 1,145 km railway linking Ouagadougou and Abidjan. The railroad carries about 3 million passengers and one million tons of goods annually, with Upper Volta originating about half the passenger and freight traffic. Local traffic on the Upper Volta section of 518 km was only 63,000 tons in 1973 but was increasing rapidly.

Outside the Sahel the Parakou-Cotonou railroad in the Republic of Benin, parallel to the Parakou-Cotonou road, serves Niger as an outlet to the Atlantic via the Niamey-Gaya-Parakou road. The Trans-Cameroon railroad from Douala to Ngaoundere has recently been upgraded. When road connections now projected in Chad and Cameroon are completed this could provide an outlet for Southern Chad. Access

to Nigerian markets from N'djamena could also be facilitated via the Nigerian railway system when an improved road through Northern Cameroon is constructed to the railhead at Maiduguri and the Nigerian system is improved. The Nigerian railroad with its terminal at Nguri could be important for traffic from eastern Niger, as well, if the improvements were made and the congestion at the ports of Lagos and Port Harcourt relieved. An extension of the Conakry-Kankan line in Guinea to Bamako would provide a short route to the Atlantic for Mali, but the existing line is in such poor condition as to require major reconstruction. Although these railroads are not within the Sahelian countries, studies of the effects of investment on their improvement should be included in the Sahel development program.

c. Highway Development.

Despite the universal recognition of the inhibiting effects of the inadequate highway transportation system, assistance donors have been reluctant to invest in the construction of roads which the Sahelian governments believe are essential to the development of the region. One important reason has been the difficulty in developing objective criteria for the economic evaluation of certain important intangible benefits resulting from the construction of roads into undeveloped areas. The traditional user benefit method will rarely result in a positive indication of feasibility for a

new road to connect a major market with an area which now produces little or nothing. Attempts have been made to assess the future benefits from agricultural products which are expected to develop and the overall costs of developing this production. The complexity of such an anlysis and the short time frame relative to the development period have usually returned pessimistic answers to this type of analysis. Where a positive result is obtained, the vague and mainly unsupported inputs have not been sufficiently convincing to encourage the investment in construction in areas where costs are high because of environmental and political obstacles.

In a paper prepared by the Western Africa Projects Department of the IBRD (A Note on Transport Problems in the Sahel, August 1975) a list of 13 road investment projects in the Sahel, proposed by the CILSS, is reviewed. Using traditional user benefit techniques the IBRD found only a limited number of viable projects, mostly consisting of either rehabilitation or improved maintenance of existing roads. Utilizing this traditional approach would totally eliminate the construction of even the lowest standard of road into an undeveloped area. The approach requires that development precede the investment, creating a virtual stalemate since the development waits on the availability of transport to the outside world. The solution favored by the IBRD is to plan national and regional road networks, divide them into discrete sections, and study the sections by the traditional user benefit method. The sections which turn out to be economically

viable are then recommended for construction. As development proceeds additional sections are built, eventually resulting in an integrated network. The approach is cautious, conservative and allows road investment to follow rather than lead the development process.

A new approach to assessing the viability of road construction appears to be needed if transportation is not to continue to inhibit the development of agriculture, industry, and commerce in the Sahel.

The answer to the dilemma would seem to be the development of a new, more imaginative, more humanistic method of analysis which differs from the traditional economic evaluation: a method which would seek to quantify or otherwise assess the intangible benefits to be expected from opening up communication to relatively isolated populations; to assess the benefits of better health services, better educational opportunities and the cultural impact of closer and more frequent contact with more developed regions and outside world in general. Such an evaluation would have to cover a long enough term to allow for these factors to become effective.

It is proposed that a study be initiated on a priority basis to develop such methods of analysis and evaluation. Preparing the terms of reference for such a study will be no easy task since there are few instances of roads constructed in equivalent areas and which have been in operation for a sufficient time to serve as data bases for the study.

Should this study prove successful in developing the sought after method very large investments in primary, secondary, and feeder roads would be justified. Over the next five to ten years feasibility studies will be required for individual road projects, but design and construction work could begin as each positive study emerged. The result would be an integrated road and rail system which would permit the movement of products of the Sahel, the import of goods required by the developing economy and the availability of a transport system to even out the maldistribution of food during emergency situations.

In developing a road network plan for the Sahel, one must be aware that ~~some~~ most existing roads were constructed to meet the political, military and trade needs of the former colonial powers. Patterns of trade and the movement of goods which may have existed in precolonial days were interrupted. Whether such trade patterns could be renewed to the advantage of the Sahelian population is a matter that deserves study. It may be that economic justification can be found for such routes which would also be useful for the movement of food stocks in drought years and further facilitate the distribution of emergency supplies in the event of catastrophic drought conditions.

d. <u>The Improvement of Highway Maintenance</u>

Nearly every highway constructed in West and Central Africa has suffered deterioration in a much shorter time than would be

considered normal in more developed countries. The highway departments of these states have been unable to cope with the problem of routine maintenance of roads of all classifications. To a large extent, this has been due to lack of equipment, poor maintenance organization management, and a lack of trained personnel. To remedy this situation several donors, among them the IBRD and AID, have financed large highway maintenance projects which included the supply of equipment, training of personnel, assistance in setting up maintenance organizations and the supply of technicians to train managerial staff. None of these projects addressed the grave problem of recurring costs. Governments have not been prepared to allocate scarce resources to provide adequate budgets for their highway maintenance departments. The result has been insufficient funds for salaries, spare parts for equipment, and materials for maintenance.

In an effort to provide economic justification for certain roads, donors tend to underdesign them and require the host government to limit loads to the design standards. As traffic grows it is natural for truckers to increase the loading on their vehicles and to use larger vehicles which could not previously operate on unimproved roads. To expect the governments to effectively police the underdesigned roads is to expect what is rarely possible even in industrialized countries. The result is the hastening of road deterioration or an increase in maintenance

effort. If the new method of analysis proposed above can be developed, it may be possible to justify the construction of roads to a higher design standard and to relieve the maintenance burden on the highway departments.

Finally, the tendency of the governments is to utilize the resources of their highway departments for construction rather than maintenance. Having decided that a road is important and being unable to obtain external financing for it, the government will divert scarce resources from maintenance needs. Here again, the ability to justify external investment in those roads which will assist in long-range development, even though they do not appear attractive by traditional standards, will tend to reduce such diversions of resources.

e. Railway Development

Since all, except one, of the railroad systems discussed above are government owned there is a continual conflict between the desires of the governments to maximize profits of the railroads and to provide more efficient road transportation. The situation is complicated by the fact that except for Senegal, the other Sahel countries do not control the entire rail route to the coast. Mali is dependent on Senegal for operation of the Bamako-Dakar route beyond Kayes; Upper Volta needs to rely on the Ivory Coast for its rail connection below Bobo-Dioulasso, and Niger is entirely dependent on Benin for its rail connection to the Atlantic.

Presently all these railroads operate at less than maximum efficiency. The IBRD attributes this inefficiency not to a lack of track or equipment capacity, but rather to a lack of management competence. The causes are a mixture of problems and lack of financial support. It is certain that improvements in the operating capabilities of the railroad would increase the effectiveness of the transport sector as a means of hastening development in the Sahel. The reduced cost of transport of bulk cargoes and possibly cattle could be a positive factor in helping to change the present regressive food price policies.

Studies made by various donor groups have come up with negative results relative to the extension of existing railroads, improvements in trackage and equipment or in the construction of new lines. Whether or not these results would still remain negative if efforts to increase the railroad operations were successful, remains to be seen. A major effort should be mounted as part of the Sahel development program to remove the present constraints on the operation of existing lines. At the same time, as their efficiencies increase, studies should be carried out to determine the feasibility of expanding railroad operation in the Sahelian and contiguous countries to prevent the increased rail traffic from becoming a new bottleneck to progress.

f. The Road Transport Industry.

Attention up to this point has been focussed on the infrastructure element of the road transport sector. The transport industry is, however, no less an important element in the development process and its present status represents a development constraint which must be overcome before the benefits of investments in infrastructure can be realized.

The industry is characterized by a confused and unrealistic rate policy, inefficiency in management, and additional high costs due to poor vehicle maintenance and non-availability of spare parts on a regular basis. In most of the countries of Central and West Africa each government operates a single, major road transport company in competition with many small companies and individual vehicle owners. The monopolistic situation results in some instances in unrealistically high rates intended to bring in large profits to the government enterprise. In other cases it results in unrealistically low rates intended to keep the cost of transport of agricultural products and imported goods low. In either case the development of an efficient competing private transport industry is discouraged.

Where the government also operates a railway system over a parallel route it finds itself in the dichotomous position of attempting to support, by contradictory rate policies, two competing services. Thus, for example, while the government of Benin is re-

constructing the Cotonou-Parakou-Malanville highway, it is at the same time protecting the parallel Cotonou-Parakou railroad by charging high tolls on the road bridges on the pretext that the existing underdesigned bridges are being damaged by heavy laods.

The lack of foreign exchange and the existence of monopolies on the imports of vehicles and spare parts result in the inability of operators to maintain their fleets in optimum condition. The high cost of parts, even when available, tends to discourage vehicle owners from making needed repairs, thus accelerating vehicle deterioration and increasing the accident rate.

All these factors tend to inhibit the development and growth of a healthy transport industry capable of providing efficient service at reasonable prices. Unless and until the Sahelian governments in concert are able to develop common rate and management policies whose objective is the establishment of an industry geared to make the best use of an improved and expanded infrastructure, transport will continue to inhibit agricultural and industrial growth and impede the distribution of food in times of crisis. The Sahelian governments, therefore, should establish a regional transport authority whose purpose would be to regulate the transport industry in the interest of area development.

The regional authority would have to work in close conjunction with the governments of contiguous countries to negotiate favorable conditions for transit through their territories and to discourage the imposition of destructive licenses and tolls.

To promote better vehicle maintenance as a means of reducing deterioration and accidents and increasing transport efficiency, the governments need to adopt more lenient policies with respect to the allocation of foreign exchange and the reduction of import levies on spare parts.

g. River Navigation

This form of transport, which once occupied an important position in the trade of West Africa, has lost ground as road and rail transport expanded. However, with the plans for development of the area's river basins playing a large role in the Sahel long-range development, attention should be directed to the possibility of river navigation supplying low cost routes for certain bulk cargos. Although the region contains three major river basins, year-round traffic is not possible because of low water in the dry seasons and the presence of rapids and other channel obstructions These difficulties have tended to shift traffic to the more reliable road and rail facilities or to inhibit entirely the flow of products which can not afford the higher land transport costs. On the Senegal river, during the navigable season, the organized waterway service consists of only a few motor driven craft and barges. A few primitive river ports provide manual loading and unloading facilities.

There is practically no use of the Gambia River for transport of goods and the 1,650 km of inland waterways of the Niger and its tributaries in Mali are navigable only seven months of the year. Traffic beyond Gao to the river mouth in Nigeria is impossible because of rapids and rock outcroppings and the operation of the Kainji Dam in Nigeria is solely on the basis of its power generating requirements. Similarly traffic up-river to Niamey is closed off by a low bridge between Gaya at the Niger side and Malanville on the Benin side of the river. Based on present traffic and normal projections for future growth the raising of the bridge and construction of bypass facilities at Kainji are not economically justified.

In Chad, water transport uses the Chari River between Lake Chad, N'djamena and Sarh, near the Central African Republic border; but this means of transport accounts only for 5 percent of the total transport of the country.

h. Air Transport

Present facilities appear to be adequate to handle traffic expansion in the near and middle term. Only a very rapid expansion in tourism or the development of high value export crops which could bear the high cost of air transportation would justify large investments in infrastructure and air fleets. Air transport facilities are not viewed as a development constraint and their expansion will automatically keep pace with development needs and can be financed from revenues generated by the increased traffic.

i. Proposed Projects

The following projects and studies in the transportation sector should be undertaken as soon as funding is available. The long-term road construction program, which will flow from the feasibility studies, is expected to require substantial donor assistance.

1. A study to develop new methods of evaluating the economic feasibility of highway construction projects connecting relatively underdeveloped agricultural areas with potential markets.

   Estimated Cost: $3,000,000

2. A study to identify trade routes which existed prior to colonial intervention.

   Estimated Cost: $1,500,000

3. Feasibility Studies should be undertaken to identify roads in a highway network.

   Estimated Costs: Undetermined.

4. Studies in each Sahelian country to determine recurring maintenance costs of highway departments.

   Estimated Cost: $10,000,000.

5. Proceed with design and construction of projects on the CILSS list.

   Estimated Cost: $55,000,000

6. Study railway systems in Sahelian countries.

   Estimated Cost: $11,000,000

7. Study establishing a Sahel Interstate Road Transport Authority.

   Estimated Cost: $ 4,750,000.

8. Study of import controls of vehicular spare parts.

   Estimated Cost: $ 500,000.

III. F. 2. TELECOMMUNICATIONS

a. General Overview

A modern telecommunications network is a requisite for the conduct of the business of a developed, industrialized society. However, the lack of such a network is not now viewed as a constraint to the long-term development of the Sahel and its construction should not be made part of the development strategy. Modern communication circuits among the major population centers and between these centers and the outside world already exist or are in the process of implementation. Further expansion within the region will take place organically as the demand arises and any such expansion of service should be financially self-sustaining.

External assistance is, however, required in the telecommunications sector for non-commercial networks for data gathering, education and the administration of health and agricultural extension programs. These networks can be of the simplest type of two-way radio circuits between outlying areas and district and national headquarters. To service a hydrologic data gathering and reporting system required for river basin development planning, approximately 300 single-sideband transceivers will be needed for the major river basins. The education system can effectively use the existing national broadcast system which may have to be expanded to reach villages now out of range of existing

stations. The cost of such expansion would be modest. The major expense would be for the recurring costs of programming. For the agriculture extension service, the need is for communication between extension agents and the Ministries and organizations responsible for agriculture development and crop purchase, storage and movement. The same network could be used in crop protection work. For the health service, two-way communication should be provided between rural dispensaries and the next higher echelon of medical care. Medical emergencies could probably be handled through the existing telephone or radio circuits of the sub-prefecture in the towns in which the dispensaries are located. However, it is certain that provision of an independent network would be invaluable for routine business, for consultation with medical staff at the next echelon hospital, and for the transmission of instructions and training lectures from the hospitals or Health Ministry.

Each of these networks must be provided with a mobile maintenance crew trained to repair equipment and to keep it in operation. The initial cost of equipment and the recurrent cost of the first 5-10 years of spare parts, staff training and salaries of the maintenance crews should be funded under the development program.

b. Proposed Projects

1. Set up a telecommunications network to tie in with the gathering of hydrologic data.

Estimated Cost: $7,750,000.

2. Study needs of agricultural extension services for a telecommunication network.

Estimated Cost: $1,000,000.

3. Study the public health services' needs for a telecommunication network.

Estimated Cost: $1,500,000.

III.F.3. WATER RESOURCES

Both the IBRD (World Bank) Group and the FAO have undertaken definitive surveys of the agriculture and irrigation potential of the semi-arid zones of West Africa, based on the three major river basin systems -- Senegal, Niger and Lake Chad. The World Bank has completed the Senegal Basin report (August 1975) and a draft of the Niger Basin (June 1975), while FAO has a multivolume report on Lake Chad (1974) and a draft of the overall Sahel regional (1975). (See Annex 1)

A. The Potential Role of the Major River Systems in Sahel Agriculture.

There is a need for rapid increase in the food crop production which has not kept pace with population growth in the Sahelian countries, even prior to the recent drought. While there is considerable scope for expansion and improvement in rainfed crop production in the higher rainfall zones of the Sahelian countries, because of the arid conditions in most of the region, there are large areas, particularly along the Senegal River in Senegal and in Mauritania, along the Niger River in Central Mali and in Niger from Tillbery to Gaya, and in the Lake Chad Basin, where rainfall amounts are insufficient to grow food crops on a reliable basis and irrigation is the only viable alternative.

Experience in the "groundnut basin" of Senegal is a demonstration that productivity improvement from investment in rainfed production has barely - if at all - kept pace with population growth and that income increases have been insufficient for significant improvement in the quality of life of the people living in the area. Certainly there remains settlement of new lands freed from disease vectors or otherwise made available for cultivation through technology, but this is a limited possible solution because poorer soils and lower rainfalls are constraints and moderately

large farms are necessary to produce the income levels needed as an inducement for resettlement. Thus, such settlement requires just as high an investment per family as is needed to obtain the same income level from irrigated holdings.

Based on the World Bank, FAO, AID, and UNDP studies to date, it is clear that, although the extent of irrigable land in the principal Sahelian states' river basins is not yet known, considerable advanced planning has been undertaken in the three principal basins - Senegal, Niger and Lake Chad (the less important Volta Basin is considered by donors within the framework of the Onchocerciasis control program). In the absence of definitive land capacity and irrigability studies, most of the planning is based on estimates of 430,000 ha. in the Senegal basin (OMVS program) with IBRD current costs for development running at an average of over $5000/ha; 2,700,000 ha. in the Niger basin (IBRD rough preliminary estimate);and 680,000 ha. in Lake Chad basin (FAO 1974 survey of prospects).

The Bank, FAO, and most other donor evaluations for a development strategy in the agriculture sector recognize that in the higher rainfall areas of the Sahelian countries, rainfed agricultural production must be expanded to assist in meeting the food requirements of growing populations. There are, though, large areas where rainfall even in normal years is insufficient to grow food crops without irrigation. In addition, the recent drought years resulting in huge imports of food grains on an emergency relief basis has demonstrated that traditional rainfed production alone can not sustain the human and livestock

population of the affected countries. Development of substantial areas of irrigation will be needed over the long range of time to produce additional food crops to stabilize overall production and, additionally, irrigated crop residues for livestock feed to help to maintain the cattle herds which were decimated by the recent drought.

Average annual rainfall throughout the lower Senegal basin in Senegal and Mauritania, the Niger inland delta in Mali, the Niger course in eastern Mali and part of Niger, and the Lake Chad basin north of N'Djamena in Niger, Nigeria, Cameroon and Chad is below 500 mm, and in a major percentage of these areas there is quasi-desert. With high evapotranspiration rates and severe variability of rainfall, very low yields of under 400 kg/ha. of drought-resistant cereals such as millet are obtained now. While some improvement of these yields is feasible through better practices and the use of modern inputs the ultimate potential remains very low, probably less than the 1000 kg/ha. now realized from rainfed production in the higher rainfall areas of the region. This is the reason that where-ever in these parts of the Sahel there is no irrigation, rainfed farming is restricted to very low-level subsistence type operations or flood recession cropping that is very high risk and limited in time and growing season.

If the Governments, assisted by a wide range of donors, pursue the rainfed alternative in the Savannah or Sudanian portions of the region,

irrigation development will not detract from worthwhile investment in rainfed production.

Irrigation, of course, is possible from wells to tap groundwater, from ponds to trap and hold surface water, and from diversion of unregulated river flows, as well as from storage reservoirs on the rivers. All of these types of irrigation, both for rainy seasons supplemental water and for dry season additional crops, deserves study and pilot utilization when it proves feasible. It may well be that for long-range solution to the problem of food deficit in the Sahelian states, upstream regulation for dry season pumping and gravity flow irrigation must be employed,but this is the most costly solution and the one requiring the most thorough understanding of physical and socio-economic data before it is undertaken.

It must be kept in mind in planning the program of studies and projects for long term utilization of water resources in the region, that in such an area of water shortage that there are multiple uses for the available water: many of them mutually exclusive and competing. Before final decisions are made on priority assignments for water utilization, particularly of the water in the major rivers, a number of basic studies and policy decisions are necessary. Among these are: the quantity and quality of groundwater and its relationship to the major rivers and lakes; a full understanding of the existing riverine regime, including likely maximum and minimum flows; knowledge about the life cycles of commercially important fish and the effects upon them of changes in the river regime; full awareness of mineral deposits - location, availability, and quantity - to both avoid flooding them and to

establish hydropower priorities vis-a-vis other water uses; the role of water transportation, both in light of other complementary and competing modes and of competing water uses; and the likely efforts on disease vectors and other environmental impacts of both changes in the river regime and the introduction of large-scale year-around irrigation.

If studies of the river and lake basins proceed and the full potential becomes clearer, while at the same time efforts are intensified to obtain maximum production from rainfed and flood recession agriculture, livestock and fisheries through improved husbandry and increased modern technology, it is conceivable that one would find that sufficient water is available from surface and ground sources to have some water resources projects in which priority is reserved for other uses than irrigation. If this proves to be true, then large blocks of firm hydro-power for agro-industry, mining exploitation and refining, and urban activities can be planned; extensive water storage and releases for maintenance of through navigation can be contemplated; and consumptive use of water by industry can even be considered. However, until the basic data-gathering studies are completed and a number of years of experience with large-scale modernization of rainfed agriculture, including through a drought cycle, is evaluated, it is clear that planning consideration must assume over-riding priority of surface water for irrigated agriculture and fisheries for food production, with secondary priority for domestic water supply and livestock.

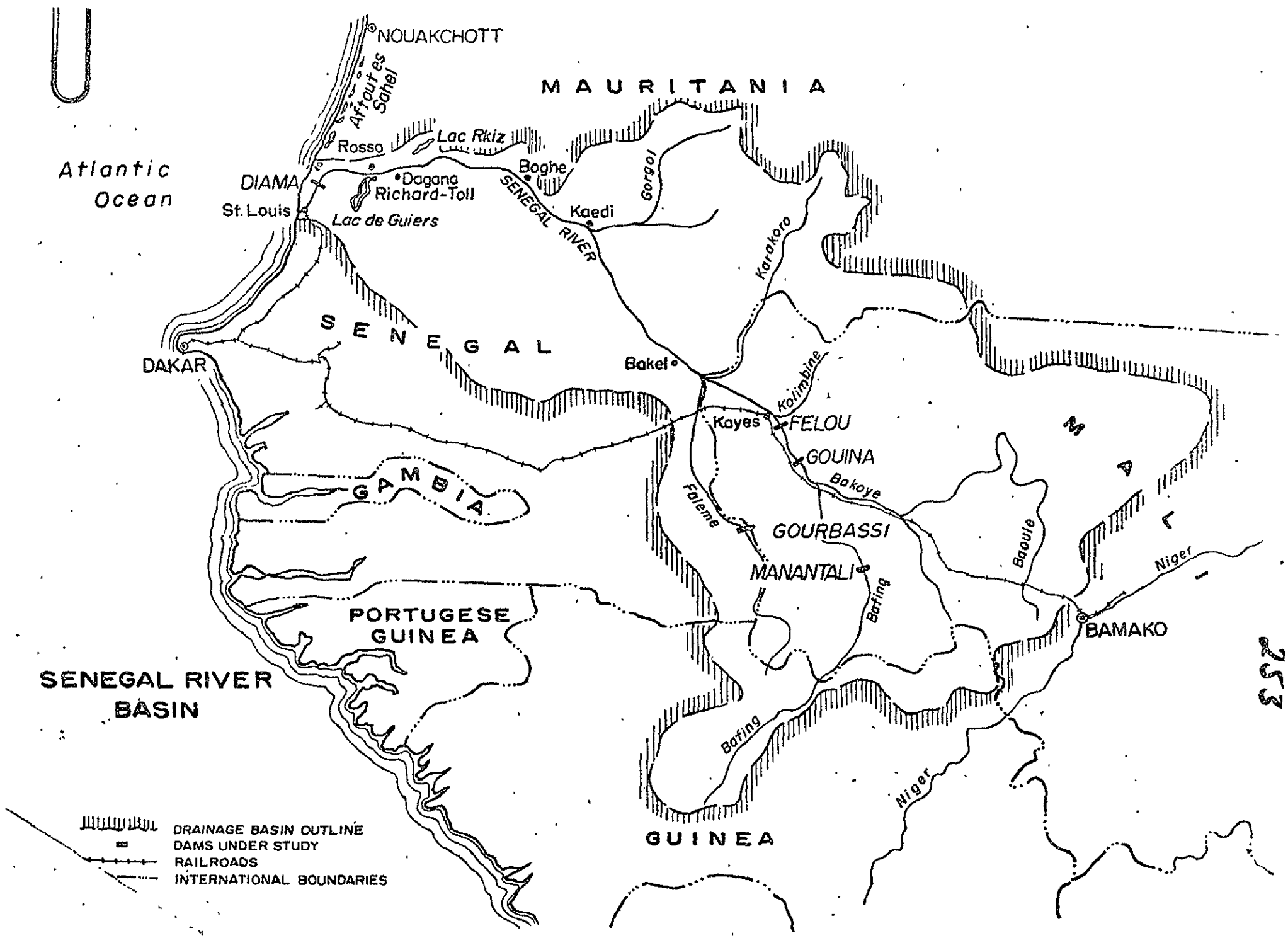
In all of the basins examined - Senegal River, Niger River, Lake Chad - there are fundamental data-gathering studies and surveys that have not yet been made on a satisfactorily reliable basis, and which are essential to any planning of rational use of the water in the river system. Without such reliable basic data, almost any isolated or ad hoc project development will lead to uneconomic under-building or over-building of project sites and will virtually insure a fiasco of misutilization of the scarce and invaluable resource of surface water.

Among these fundamental studies and surveys are those involving the physical and human facts of the basins: how much water is there in the basin system? Where is it? and when? How much arable, irrigable, and non-irrigable land is there? Where is it? What can be grown on it with and without irrigation? What is the run-off on various soils in various rainfall conditions? What is the evapotranspiration rate? How many trained people are available in the skills needed? How many can be trained in what time frame? Where should they be trained? What is the current environment? How will it be altered by changes in river regimes and through the introduction of all-season irrigation? What project modifications are necessary to control or eliminate disease vectors? What transportation and communication infrastructure are necessary for basin development? How much groundwater is present? Where is it? What is the relationship to

the surface water? What commercially exploitable mineral deposits are in the basin? How much water and electric power are needed to exploit them? Where are the deposits in relation to the river systems? What market, price and storage changes are needed if agricultural production is greatly increased? Do the governments support the social changes implicit with basin development? Can the government bureaucracy provide the necessary services to build and operate basin development projects? If not, can personnel be recruited and can budgets be expanded or subsidized to cover needed expansion?

It is evident that in order to fund and staff the studies and surveys needed to provide reliable answers to these fundamental questions -- that must be answered if indicative plans are to be formulated for utilizing the potential of the basins -- a massive effort must be organized. For such an effort to succeed, it must have the support of the governments of the basin countries and must be backed by the funds and the technical inputs of a major proportion of the donor community, both bilateral and international.

Fortunately, the countries of the region and the United Nations Development Program (UNDP) have already recognized that the basins represent a great potential resource that can only be developed for the maximum benefit to the region if they are recognized as a system in which any developmental activity effecting a part of the system will have some effect on the other parts of the system. Accordingly, in the Senegal, Niger, Lake Chad and Volta basins, international basin authorities have been established with membership by all or most countries riparian to the surface water system.


NOUAKCHOTT
Affout es Sahel
MAURITANIA
Atlantic Ocean
Rosso
Lac Rkiz
DIAMA
Dagana
Richard-Toll
Boghe
St. Louis
Lac de Guiers
SENEGAL RIVER
Kaedi
Gorgol
Karakoro
SENEGAL
DAKAR
Bakel
Kolimbine
Kayes
FELOU
GOUINA
Bakoye
GAMBIA
Faleme
GOURBASSI
MANANTALI
Baoule
Niger
Bafing
BAMAKO
PORTUGESE GUINEA
SENEGAL RIVER BASIN
Bafing
Niger
GUINEA
DRAINAGE BASIN OUTLINE
DAMS UNDER STUDY
RAILROADS
INTERNATIONAL BOUNDARIES

b. The Senegal River Basin

The Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) or the Organization for the Development of the Senegal River was formed in 1971 when Guinea withdrew from the eight-year old Organization of the Riverine States of the Senegal River. In January 1970, the Council of Ministers of the organization analyzed the various studies completed up to that time and decided that the time for study had produced sufficient data to formulate a plan for the integrated development of the basin. In July 1972, the Council of Ministers confirmed that the first stage of the integrated development should be based on a regulated flow of 300 m /sec at Bakel, Senegal, with the following major mainstream projects:

1) a multipurpose high regulating and storage dam at Manantali on the Bafing tributary in Mali;
2) a low-level barrage in the delta at Diama, Senegal, to prevent salt water intrusion during low flow and to store water for irrigation;
3) a river and seaport at St. Louis, Senegal, and a river port at Kayes, Mali;
4) the improvement of river ports along the river at Rosso, Boghe, Kaedi-Mauritania, Richard Toll, Dagena, Podor, Matam, Bakel-Senegal, and Ambidedi, Mali.

In July 1974, OMVS convened a donor's conference to obtain funding commitments for this program, plus a fifth item: development of irrigation works comprising some 430,000 ha. over a period of 40 years. The Beyrard report of 1974 estimated that this program would require 35 years and about $3.7 billion of investment to complete.

Sufficient donors agreed to early construction of the Diama dam to provide funds for final design, which is now under way. This project is scheduled for completion and initial use in 1980. Based on donor funding offers through OMVS to fund irrigated perimeters for the Senegal Societe d'Amenagement et d'Exploitation des Terres du Delta (SAED), the potential for double crop irrigation development associated with Diama is expected to be used up by the early 1980s. Despite OMVS' determination to provide upstream storage by building Manatali, there has been no clear concensus on the size, location or function of an upstream storage dam. Still, it is clear that a regulated water supply from storage is essential for multiple crop irrigation beyond the 30,000 ha. that can be provided by Diama dam.

After many years of contradictory reports on the attractiveness of Manatali, the People's Republic of China submitted its technical conclusions on Manatali dam in March 1975. However, the report could not be studied as it ~~Unfortunately, the report~~ is in Chinese, and the principal basis for summarizing it is an oral report to OMVS and accompanying drawings and maps. The Chinese are not interested in participating in funding further investigations, final design, or construction, but have estimated project costs at $250

million and state that the dam would provide 771 million KWH of power at 90 percent guarantee, river navigation from Kayes to St. Louis from June to November, water for double crop irrigation of 428,000 ha. and flood recession agriculture for 100,000 ha during the interim period of development.

The Federal Republic of Germany has agreed to fund additional investigations and final design.

Various studies and reports by the World Bank (IBRD), the U.S. Bureau of Reclamation (USBR), and AID consultants have seriously questioned the economic wisdom of building Manatali and, while recognizing the need for upstream storage to provide irrigation for more than one crop, have urged serious investigation of alternative sites and projects. The economic objections to Manatali are based on the belief that actual cost to construct will be more in the magnitude of $400 - 600 million, that incomplete flood control from Bakel downstream is provided, that firm power (as distinguished from dump energy) is only about 17 MW and could not justify transmission to Dakar or for major industrial use, that the increased development cost per hectare for irrigation in the lower Senegal basin cannot be justified by the likely increased production, that other, alternative sites may be more economic and should be investigated.

There are a number of unresolved technical problems connected with Manatali, too, and it is not apparent from the OMVS terms of reference that the German- funded design studies will resolve these: (a) stream flow records used by Senegal-Consult and by Beyrard for preliminary studies are internally inconsistent and contradictory and actual stream flow above, at, and below Manatali are unknown, making design of a dam extremely risky; (b) the actual volume of the 100 year flood the dam is to be designed to control is not known and cannot be predicted with any reasonable assurance based on existing inadequate, unreliable and spotty records; (c) calculations of future flood and low flows downstream is guesswork because of inadequate hydrologic records, and design of irrigation, navigation and fishery works below Bakel has an unknown, if any, margin of safety; (d) the effects of releasing "clean" water from Manantali to provide an artificial flood for flood-recession agriculture has not been investigated, but it is certain that major bank erosion and streambed degradation will take place for a great distance downstream; and finally, (e) little or no consideration has been given to preventing the introduction of onchocerciasis by the turbulence below the dam or of schistosomiasis and malaria from the still waters in the reservoir.

Although the relative low cost of Diama has led most observers to acknowledge that there is no reason to oppose its construction, there are a number of negative considerations to

building it that have not been addressed in available reports: (a) the final design is preceding ahead of the environmental study which is intended to provide data for incorporation in the design; (b) since the primary purpose of Diama is salinity repulsion, it is fairly obvious that its early construction pre-empts a major justification for Manatili - since minimum flow of 100^3M /sec at Bakel is needed for salinity repulsion, Manatali's 300 M^3/sec is sufficient to provide this in addition to irrigation and navigation -- and that if upstream storage of sufficient volume were built first, Diama with its impediment of navigation and anadromous fish would not be required; (c) Diama will require costly ancillary works to provide navigation locks and preservation of commercially desirable fish and mammals; and (d) the reclamation cost of self-saturated delta lands to be irrigated from Diama reservoir may be excessive and much of the land in question may never be put into crops.

The tenor of the above remarks indicates the nature of the primary difficulty of dealing through OMVS and utilizing that organization as an implementing agency for investigations and project implementation. Under pressure from its member governments, the OMVS Secretariat has decided that sufficient basic study and data gathering has been done in the Senegal basin and now is the time to implement a plan of major capital project construction in river control, irrigation, navigation, hydro-electric power, and ports. Just as it was becoming possible to obtain donor support for the large number of essential physical, sociologic, and economic

studies to compile essential data, OMVS has launched a concerted drive for funding of capital construction.

While the need for the capital projects is undeniably urgent, rational planning for optimal utilization of the land and waters of the basin and preparation of well-documented project justification is only feasible if the minimum needs for meteorologic, hydrologic, soils classification, hydrogeologic, sociologic, economic and environmental basic information is available. Without this fundamental data the chances are overwhelming that projects will be counterproductive in the long-run; that the limited number of dam sites will be overbuilt or underbuilt (with equally adverse "white elephant" reactions); that the agricultural projects will represent uneconomic use of land and water; and that extensive damage to the basin's fragile ecology will be either irreversible or reversible only at excessive cost.

In order to cope with this fait accompli, it will be necessary for the donors, in concert, to help the member countries to make the hard political decisions needed to slow down implementation of production projects by limiting them to ones that can clearly fit into any rational development plan with minimum or no alteration of physical and social environment and to concentrate on massive data-gathering efforts and the training of personnel for government agencies, the OMVS Secretariat, and the non-governmental sector to both continue the data-gathering efforts and to manage the land and water resources production projects as they are implemented.

The Senegal River, some 1800 km long with a drainage area of about 290,000 square kilometers, is the second largest in West Africa, and yields an annual average flow of over 20 billion cubic metres. The river basin occupies more than 19 percent of the area of Senegal, almost 13 percent each of Mali and Guinea, and about 7 percent of Mauritania. The basin is divided into three distinct geographic regions. The lower 200 km from St. Louis to Richard Toll comprise the delta, a completely flat area with sea water intruding up to the full length of the reach at low flows. The next 600 km to Bakel is along the Mauritania-Senegal border and is a 10-20 km wide alluvial plain, the valley, surrounded by semi-desert. The upper 1000 km constitutes the upper basin, an area of mountains and hills that is the origin of almost the entire river flow. There are no significant flows in the tributaries entering the Senegal below the confluence with the Faleme, some 825 km upstream from the Atlantic Ocean.

Average annual rainfall in the basin varies from under 250 mm in Mauritania to over 2000 mm on the Guinean Headwaters of the Bafing tributary. In the south the rainy season occurs in the April through October period, while in the north it lasts only from July to September. The annual floods in the lower reaches occur only in the July-December period. The highest monthly flow generally is in September and may reach about 3,500 M^3/sec at Bakel, while the lowest monthly average flow is in May and can be as low as 10 M^3/sec.

As noted by USBR, IBRD, AID and many other reports over the past several years, the most glaring weakness in basic data for any kind of water resource planning in the Senegal basin is the scarcity of hydrometeorologic records and the unreliability of those hydrologic records which are available. To a casual observer, OMVS refers sweepingly to the vast hydrologic records on file in their documentation center at St. Louis. However, on closer examination one finds that, first of all, what readings there are have been compiled by and retained in Paris by ORSTOM: the three member countries' hydrologic services are virtually non-existent; moreover, OMVS has no hydrometeorologic network of its own to obtain regular rainfall and river flow readings every day for years without end. The various stations placed and read by ORSTOM and others sometimes have one to three years of continuous daily records during a hydrologic campaign or specific study, perhaps ten or fifteen years ago, others have continuous records for many years, but readings only once or twice a month with many months missing and completely inconsistent readings that have little or no reliability from gauges that have not been recalibrated for 5-25 years, instead of monthly. OMVS clearly requires a skilled hydrometeorologic staff and its own or reliable national network of rainfall and river gauge stations. A communications system for receiving daily real-time advice of both rainfall and river stage at key stations can be provided for flood warning,

planting preparation, and operation of reservoirs. (There are reportedly 28 river gauges, and 52 precipitation, 11 synoptic, and 18 climatological stations in the basin; however, the river gauges are in various stages of breakdown, disrepair and out-of-date calibration and many of the meteorologic stations do not report daily. OMVS has no access to the information on a real-time basis, often waiting years for publication of a yearbook, if ever receiving the data, and has no present capability for evaluating data or employing stochastic hydrologic techniques.)

For rational planning of land and water utilization in the basin, it is imperative to have an understanding of groundwater resources to evaluate the economics of this alternative to surface water for domestic, industrial and agricultural use. At this time, groundwater studies in the Senegal basin have been limited to merely mentioning the possibility of the existence of groundwater under parts of the area and to a few unsystematic dug and drilled wells. If actual data for determining the quantity, quality, and cost of using groundwater, as well as the interrelationship of groundwater aquifers to surface water exist, they could not be found by USBR, IBRD, FAO or AID. A groundwater study program for the Senegal basin should be undertaken at the earliest possible time.

The present high price of oil has significantly changed the competitive position of remote hydroelectric production and transmission in relation to oil-fired thermal generation. As it is unlikely that demand in the basin will justify economic size nuclear plants in the short and medium time range, and it will be some time before solar energy technology can provide economic power plants to meet national base demands, more attention should be given to hydropower in the basin. The first requisite ought to be a basin-wide energy survey and demand growth projection. Then, particularly if much of the water requirements for agriculture production can be met from rainfall, groundwater and ponding, higher priority may be justified for power operation of multipurpose dams on the rivers. As the preliminary design now stands, Manantali, for example, would produce only 17 MW of firm power against an installed capacity of at least 100 MW, but with changed priorities the firm power production could be moved to or above the planned installed capacity. Also, once upstream regulation is provided run-of-the-river structures could both provide power and diversions for gravity irrigation.

OMVS' navigation proposal clearly requires more examination, as suggested by USBR. While Mali's primary interest in the mainstream appears to be navigation, a more rational and economic scheme than the present one is likely if good maps (1:20,000 scale) were prepared and the navigation proposals were developed by engineers with experience in design and construction of river stabilization works and transportation economists knowledgeable in river traffic.

While the AID-funded environmental study is certainly a step in the right direction, it can only produce a general survey and each major structure on the rivers and irrigated perimeter should include an environmental assessment. The overall AID study would be more convincing if each discipline were handled as an independent study and AID or OMVS made a synthesis of the findings into an overall report, instead of having a contract with an engineering firm to hire biologists, zoologists, foresters, health experts, social anthropologists and other ecological scientists. In addition, there are several significant environmental factors which are of vital importance for evaluation prior to designing any of the proposed water control and irrigation works on the basin, and which do not appear to be adequately addressed in the AID study: the role of silt deposition on lower basin land fertility, stream bed degradation and aggradation, quality of return flows to the river and effects of continuing reuse, the effects of competing uses of Senegal water on the Dakar water supply, shoreline erosion, aquatic weeds and disease vectors which will thrive therein, archeological sites and mineral deposits that might be flooded, the socially acceptable rate of change, and human relocation/resettlement.

As noted earlier, optimum development of the basin can only be effected by treating the complex of surface water, subsurface water, land, people, and other factors as a system. The approach for an international river basin in four countries requires a single international organization that represents all countries involved to coordinate studies and projects. OMVS is a start toward such an

organization. But, as of today, OMVS has a number of institutional weaknesses that prevent it from having the technical, managerial and financial competence to adequately fulfill this role. Only thirteen professionals now staff the OMVS secretariat, and, while the High Commissioner, Secretary-General, Technical Director, and one or two others are competent and highly skilled bureaucrats, the balance of even this staff is weak. If OMVS is to serve as the vehicle for Senegal basin development, there must be a massive institutional development program to provide the competence to do so. In the case of the Mekong Committee, UNDP funded such a project, and for the Indus Commission it was IBRD, but neither of these organizations is prepared to do this alone for OMVS. It therefore appears that the donor community, through Club des Amis du Sahel and CILSS must undertake this program. It will require secondment of up to 25 professionals in such fields as civil engineering, economics, agronomy, livestock, sociology, hydrology, meteorology, geology, electric power engineering, navigation, international water law, irrigation engineering, accounting, contract management, statistics and systems analysis. The member governments must agree to provide promising people to be counterparts for the foreign technicians for one to five years of on-the-job and other training to eventually take over the secretariat positions. A salary schedule at least equal to that of the best paid member government civil service -- and probably about 10% higher -- must be funded, and a program of training future staff members must be undertaken (the Mekong Cadre scheme is a good one: train three professionals up to M.S. level for each slot, with the

Secretariat selecting one and the others returning to their home governments for employment).

Finally, a really vast program of investigations and studies to accumulate the basic data on basin land and water resources must be undertaken at once, along with accompanying large-scale pilot projects for continuing evaluation and monitoring as the ultimate development plan for the basin is evolved.

An illustrative program of projects to strengthen the OMVS Secretariat and OMVS planning capability follows.

Hydrometeorology Study

Estimated Cost: $1,850,000.

Hydrogeologic Analysis

Estimated Cost: $1,135,000.

Staff enhancement of OMVS Secretariat

Estimated Cost: $1,750,000.

Indicative basin development planning

Estimated Cost: $ 150,000

Preparation of new basin-wide mapping at a scale of 1:20,000

Estimated Cost: $12,000,000

Inventory (desk study) of promising tributary projects in Mali and Senegal

Estimated Cost: $ 100,000

Study of low-head, high capacity power houses

Estimated Cost: $130,000

System Analysis and Water Resource Planning

Estimated Cost: $538,000

Power and Energy study for basin service area

Estimated Cost: $600,000

Feasibility study of first priority project selected from desk studies

Estimated Cost: $1,700,000

[redacted] Construction and final design costs of first priority project selected from desk study.

Estimated Cost: [redacted] $420,000,000

Design and construction of river ports: St. Louis to Kayes

Estimated Cost: $1,440,000.

Coordination and dissemination of agricultural research information

Estimated Cost: $345,000.

Basin-wide fisheries study

Estimated Cost: $1,220,000

Establishment of pilot on -farm fishing areas

Estimated Cost: $4,600,000

Experimental program for Kenaf production

Estimated Cost: $350,000

Basin-wide minerals survey

Estimated Cost: $1,610,000

Non-formal education program for farmers in irrigated perimeters

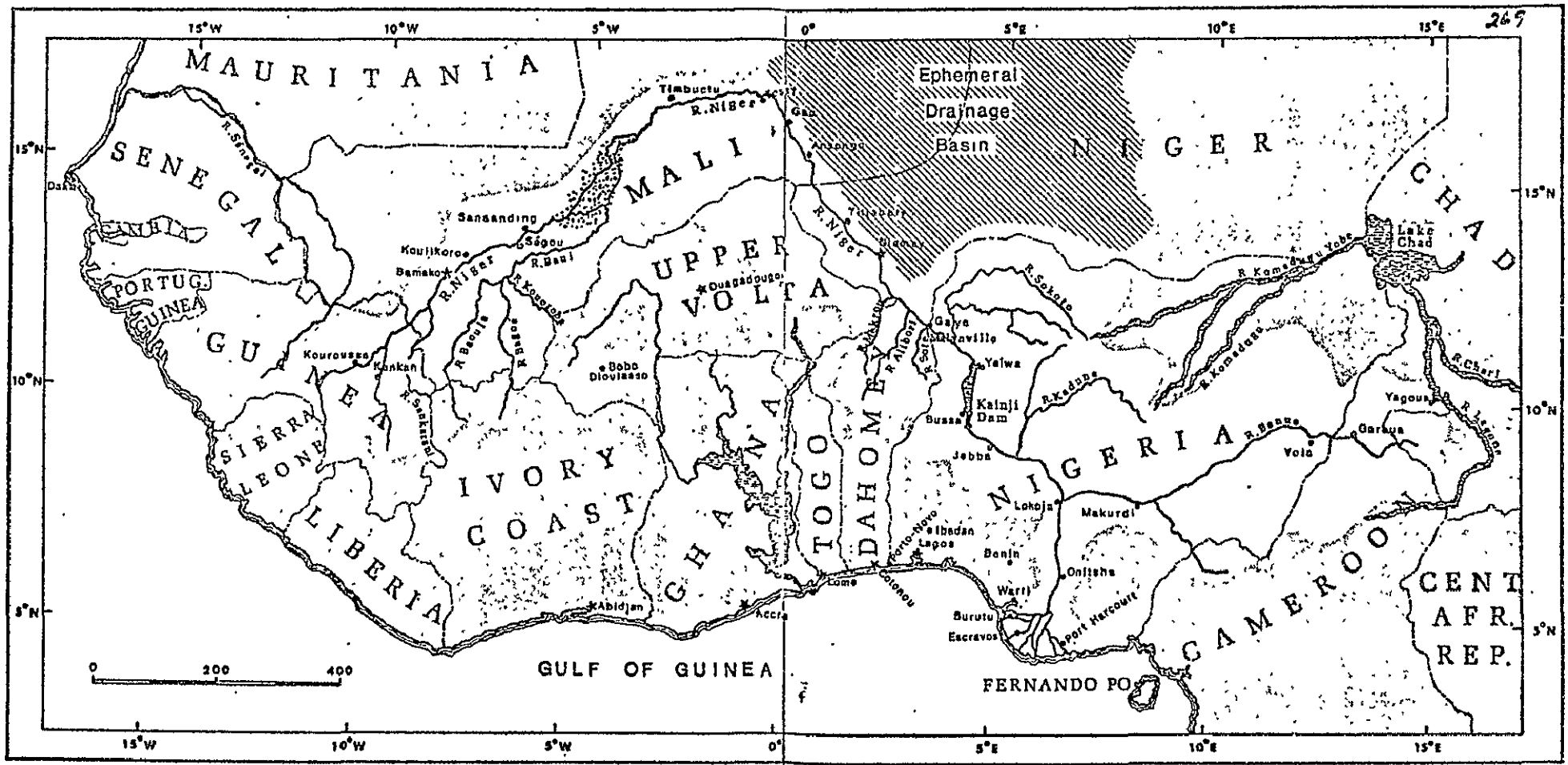
Estimated Cost: $1,710,000

Control of Malaria and other vectorborne diseases

Estimated Cost: $5,000,000

Development of water filtration system using local materials.

Estimated Cost: $450,000.



NIGER RIVER BASIN
Fig. 3.1

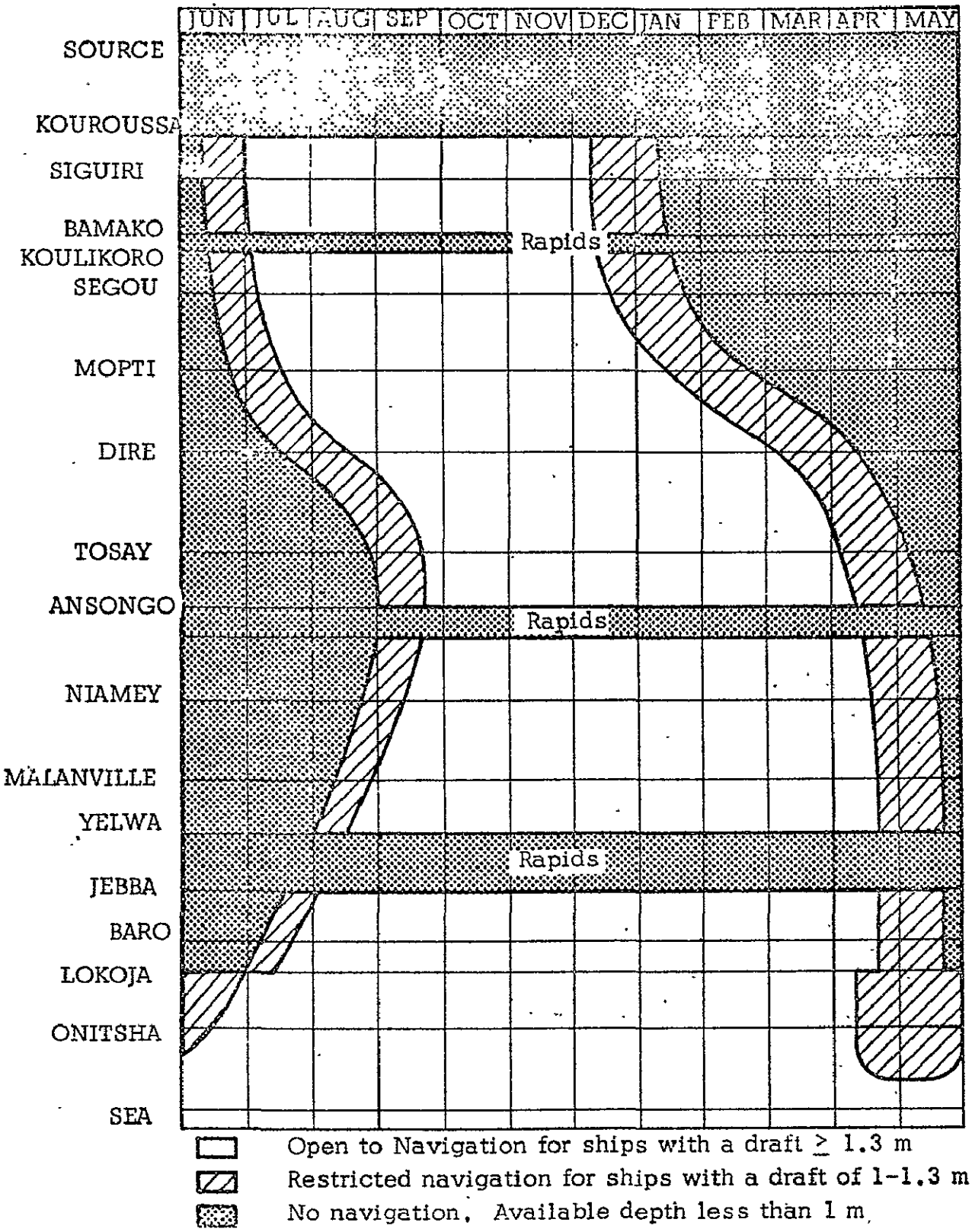


FIGURE 1.4-1 Navigability of the Niger

Source: Holmes and Narver 1968.

C. Niger River Basin

The physical basin of the Niger River is shared by nine countries: Guinea, Mali, Upper Volta, Ivory Coast, Niger, Chad, Cameroon, Dahomey, and Nigeria.

Less than a million years ago the upper Niger entered a vast inland lake in the Timbuctou-Araouane region of Mali (Arouane is about 225 km north of Timbuctou) and drained westward through the Vallee du Serpent, north of Bamako, into the lower Senegal valley. Later the lake began shrinking because of hydrometeorologic changes and eroded through barriers to the southeast to flow into the lower Niger through its present valley. The remaining evidence of this is the vast swamp of what was once the Upper Niger delta draining into the lake and is now the "inland delta" stretching from Segou to Timbuctou and the series of shallow lakes south and west of Timbuctou.

The Niger River basin has an area of about 1,000,000 km^2. The basin is noteworthy for its length and its narrow width. The mainstream Niger River is approximately 4000 km long, but the width of the basin varies between 300 and 500 km, only. The Niger's source is in the high rainfall area of the Fouta Djallon Mountains of Guinea, only some 500 km from the Atlantic Ocean. Thence the river flows far inland, first to the north, then in a north-northeasterly direction to the very edge of the Sahara Desert, whence it is deflected by a rocky ridge and flows in a south-southeasterly direction through Mali, Niger, Benin and Nigeria to the Gulf of Guinea. From its mountain source, the Niger passes out onto a high plain in western Mali, then follows a course of some 1,400 km across

arid and semi-arid Sahelian lands before it again traverses humid and tropical belts in Nigeria near its mouths.

A number of tributaries from higher rainfall zones in the south extend the basin to include relatively small areas of Ivory Coast, Upper Volta, and Benin (Dahomey). In central Nigeria, the Niger is joined by its largest tributary, the Benue River, which drains high rainfall areas of western Cameroon and a small portion of Southwestern Chad. From the confluence with the Benue, the Niger flows another 550 km southward, terminating in a complex delta system of islands and divergent channels extending inland some 150 km from the Atlantic coast.

The hydrologic character of the Niger is a favorable one for the hundreds of miles of arid country through which it maintains a perennial flow. Because of the seasonal pattern of the rainfall, because of a small portion of the basin contributing to the rivers net discharge, and because of the great distance most of the water must flow from its source, the Niger flows downstream are characterized by very wide seasonal variation. Low flow discharges limit the river's potential, or at the least impose relatively high development costs for most uses of the water, particularly in the middle reaches of the basin.

HYDROLOGY

Since the AID-funded Holmes and Narver, Inc. report in 1968, it has been customary to follow their division of the mainstream into four hydrologic sections: Zone I-Eastern Guinea and Western Mali, above the interior delta; Zone II-the interior delta in central Mali; Zone III-from the interior delta to Niamey, in eastern Mali and northwestern Niger; Zone IV-below Niamey, in southwestern Niger, northern Benin (Dahomey), and western Nigeria.

Zone I, above the interior delta. Ninety percent of the average annual inflow to the interior delta (70 billion m^3) occurs in the June to November period. At Kouilikora, just downstream of Bamako, the reported mean monthly discharge from 1907-1959 ranges from a maximum of around 5500 m^3/s during September to a minimum of about 300 m^3/s for April, or from about 360 percent to less than 20 percent of the mean annual discharge. Similarly, the Bani tributary, discharging into the Interior delta, has nine years of reported flow measurements that indicate a mean monthly discharge about 2,550 m^3/s during the months of September and October, while a minimum of only about 50 m^3/s flows in March.

Zone II, the interior delta. The interior delta has a profound influence on the flow regime of the river, extending more than 1,500 miles to the ocean. Its swamps, multiple channels and lakes provide a natural holding reservoir which has a beneficial regulating effect on downstream discharges, but, as will be

the case for any artificial reservoirs created in the Sahel, the river regulation is obtained only with the sacrifice of large water losses to evaporation and, probably, seepage into groundwater. As contrasted with the seasonal distribution of inflows, discussed in Zone I, above, the monthly mean outflow rates, as often measured at Dire from 1924 to 1960, ranges from a maximum of only about 2,300 m^3/sec to a minimum of about 100 m^3/s, or between 193 percent and around 8.5 percent of the mean annual discharge. Moreover, the time of the peak flows is delayed from September-October to December. An examination of the most reliable records available shows that the delta outflow is about its mean annual rate for nearly six months of the year, while the inflow is above the mean annual rate for less than four months. Yet, the benefits of this flow regulation has a high cost of water loss in the interior delta of about 65 percent of the inflows. (Unfortunately, the record of gauge readings and calibration of flow meters is so unreliable that it is very risky to place too much reliance on the precision of data, but the magnitude of the losses in the delta is clear, because this loss closely approximates the evaporation potential of the area and would indicate that little if any groundwater recharge is taking place).

Zone III-interior delta to Niamey. For more than 900 km from the interior delta to Niamey, tributary inflows virtually balance evaporation losses and the annual flow is reasonably uniform. The

The time of the flood wave from Dire to Niamey is about a month, so the peak normally reaches Niamey during January or February, delayed some three months from the time of the peak inflow to the interior delta and some three months or more after the end of the local rainy season. Channel storage effects serve to further regulate the flow; therefore, the maximum monthly discharge is reduced to about 2,700 m^3/s or only some 168 percent of the apparent mean discharge. The minimum is about 125 m^3/s or just 12.5 percent of the mean discharge. At Niamey, the discharge is above the mean rate for sevel months or more and is less than 50 percent of the mean for only about three months of the year.

Zone IV - below Niamey. Below Niamey, the tributary basins receive enough rainfall to produce substantial inflows to the Niger some months before the mainstream flood wave from the upper basin, so that at Malanville/Gaya the flow has increased over that at Niamey by about 30 percent and the annual distribution has two peaks, one in September or October and a second in February. Below the confluence of the first major tributary from the west, the Sokota about 65 km into Nigeria, the September-October flood produces a peek exceeding that of the later February flood, and thus dominates the regime from there to the sea.

The average annual rainfall in the basin varies from 2500 mm in the highest part of the catchment in the parts of Zone I and shades down to 750 mm at the entrance to the interior delta. In the interior delta there is rainfall of 250-750 mm, while through Zone III the variation is from 250 mm near the Mali/Niger border to about 1000 mm

at Kainji, Nigeria. Downstream from Kainji the annual rainfall increases rapidly toward the coastal delta where it reaches 4000 mm.

As in all river systems, the potential irrigability of land in the Niger basin depends on two principal technical factors and two economic ones: technical-water and land; economic-cost of irrigating the land and the value of crops that can be grown. Additionally, there are a number of institutional and human resource factors; however, these are less rigid than the physical and economic factors which are fixed by inherent conditions and are subject to improvement. As noted by the IBRD 1975 report, no evidence is available of any systematic surveys of either soils and land resources in the basin or of the technical and economic factors for developing them. According to J. Agoullon in an article published in the May 1974 L'Agronomic Tropicale, the total area in the basin under controlled irrigation, flood recession cropping, and controlled flooding is about 252,000 ha. M. Agoullon and IBRD believe that the potential irrigable land in the mainstream countries may exceed 2.7 million ha. But detailed identification of these lands is clearly a priority need in any review of food production capability, particularly in Zones I, II and III in Mali, Niger, Benin and parts of Guinea.

Hydroelectric development in the Niger has considerable potential. Existing facilities include two small ones near Bamako and a large one (Kainji dam) in Nigeria, as well as a small one in Guinea. In advanced planning stages are the Selingue dam

on the Sankarani in Mali (45 MW), the Kindaji about 100 km upstream of Niamey in Niger, a run-of-river project (24 MW) at the "W" bend in Niger, a dam on the Mekrou in Benin, and two additional large projects in Nigeria (Jebba, 300 MW, and Shiroro 80 MW).

Much of the interest to date in using Niger water has been for inland water transport in various reaches of the main-streams from Kouroussa to Bamako, from Koulikoro to Amsongo through the interior delta, from Tillaberg, Niger, to Yelma, Nigeria. The other reaches are not open to navigation because of rapids and the Niamey to Yelma reach is obstructed by the Manvill-Gaya bridge which has only a 0.6 m clearance at normal high water.

THE RIVER NIGER COMMISSION

The first move toward international cooperation for development of the Niger basin's resources was made in October 1963 when eight of the nine riparian countries agreed to create the River Niger Commission. At a subsequent meeting in November 1964, the ninth country, Guinea joined and an Agreement was concluded which still forms the basis of the existing Agreement. It was modified in February 1968 and more significantly revised in June 1973 to give the Commission stronger executive powers. A Council of Ministers was formed in substitution for the previous Assembly of Commissioners and the post of Administrative Secretary was raised to that of Executive Secretary. Still, however, the Commission is hamstrung because the Council meets only once a year and this meeting requires frequent postponements in order to obtain attendance by a quorum of five states.

The functions of the Commission fall into four broad categories:

i) preparation of general regulations and, in particular, regulations for river navigation;

ii) coordination and liaison between Member States;

iii) information assembly and dissemination of both data and project progress;

iv) arranging bilateral and multi-lateral assistance for the execution of projects and studies and entering into agreements for such work.

These functions are reasonably general and the wording of the Agreement permits a flexible interpretation. Little has been accomplished, though, and few studies are funded through the Commission. The Commission has not even been able keep a current record of plans and projects by Member Governments or regional institutions that concern the water resources of the basin. This is primarily because the Secretariat has no source of significant income or institutional support and is virtually non-existent. Only three professionals are employed in the Secretariat full-time. One, a transport economist, is furnished bilaterally by AID and one - Niger's only PhD in agronomy- is the director of the documentation center. This staffing limitation plus the Executive Secretary's limited technical knowledge (he is a foreign service diplomat seconded by Nigeria) make it virtually impossible to establish the broad interdisciplinary capability the Secretariat needs if it is to fulfill its function and gain in prestige and authority. There is currently no staff working in the essential fields of water resources engineering, hydrology, irrigation engineering,

agronomy, fishery biology or any of the other areas of technical competence necessary for planning and implementation. The Executive Secretary recognizes this fundamental constraint to the functioning of the Secretariat and, although his tour of duty is soon to expire, he has sought Council authority to hire qualified riparian personnel in hydrology and other disciplines and seek multilateral and bilateral secondment of experts. Funding of a greatly expanded Secretariat staff should be a priority concern of donors interested in Niger River basin development.

In this situation, a body charged with coordinating development planning and funding projects is needed, and if the River Niger Commission is to be this body, it must progress toward a stronger and more comprehensive approach to basin planning and foreign assistance to be provided in order to help the Commission attain this competence.

Any international organization similar in scope to the Commission encounters many problems in carrying out coordination and planning functions; moreover, the problems here are compounded by the large number of Member states, some of which-Guinea, Mali, Niger, Benin and Nigeria-have major riparian interest in the mainstream, and the others have only small areas of their country in tributary sub-basins. It must be kept in mind, however, that it is usually much simpler to reach agreement on international water issues before they are imminent and competing uses and national interests are at conflict levels. The growth and strengthening of the Commission and its Secretariat should be encouraged in these early stages of

basin development. Ideally, the technical capability should evolve through successive stages of data collection, analysis, and basin planning; however, the River Niger Commission Secretariat first needs massive assistance in the broader development of its staff. Later, the Commission may well aspire to executive agency status for the implementation of river basin development projects.

As important means to strengthen the technical capacity of the Secretariat would be for donors to help it through a comprehensive review of available information on the basin and to develop both a strategy for development and a program of future activities to fill information gaps and move toward project implementation.

One essential move to demonstrate riparian government interest in strengthening the Secretariat so the Commission could fulfill its intended functions would be an agreement on a formula to establish a firm and adequate financial basis for the Commission's continuing activities.

Before suggesting a program of studies and pilot projects for the Niger basin, it is necessary to note some of the constraints to development in the basin. As far as irrigation is concerned, the ultimate constraints appear to be, by hydrologic zone, as follows:

Zone I - Land for flood season cropping and water during the low-flow season for perennial cropping

Zone II - Water for low-flow season cropping and extent of inundation for flood season cropping.

Zone III - Land for all forms of irrigation.

ZONE IV - Land for most forms of irrigation development.

The example of the Office du Niger, which is the largest and, to all intents and purposes, the most successful irrigation project in West Africa, is generally considered a monumental failure because it has fallen far short of its overly ambitious original goal. The greatest difficulty, clearly, has been in inability to attract people to settle in the project area and resultant attempts at forced resettlement. This experience points up the very high priority of providing lands and the reverse of the coin - the over-riding need to provide adequate resettlement packages for people forced to move from reservoir sites and the construction of other project facilities.

ILLUSTRATIVE PROGRAM

An illustrative program of projects to increase the store of basic information on the Niger Basin and create a reservoir of professional staff in the Niger Basin Commission Secretariat who are experienced in river basin and project planning follows:

Hydrometeorologic Network and Operation

Estimated Cost: $2,600,000

Hydrogeologic Survey

Estimated Cost: $2,050,000

Land Classification and Soils Studies

Estimated Cost: $575,000

Basin-wide mapping project

Estimated cost: $19,000,000

Inventory (desk studies) of promising mainstream and Tributary Dams and Diversions

Estimated Cost: $260,000

River Niger Commission staff enhancement of Secretariat

Estimated Cost: $1,750,000.

System Analysis and Water Resource Planning
Estimated Cost: $538,000

Power and energy study for basin area

Estimated Cost: $1,620,000

Pilot irrigated agriculture project

Estimated Cost: $15,000,000

Feasibility Study of first priority project selected from desk studies

Estimated Cost: $1,700,000

[redacted] Construction and final design costs of first priority project from desk studies.

Estimated Cost: [redacted] $400,000,000

Basin-wide minerals survey

Estimated Cost: $ 2,520,000

Support for Secretariat Cadre Development

Estimated Cost: $650,000

Non-formal education for farmers on pilot irrigation projects

Estimated Cost: $1,710,000

Coordination and dissemination of agricultural research information

Estimated Cost: $400,000

Aquatic Weed Study

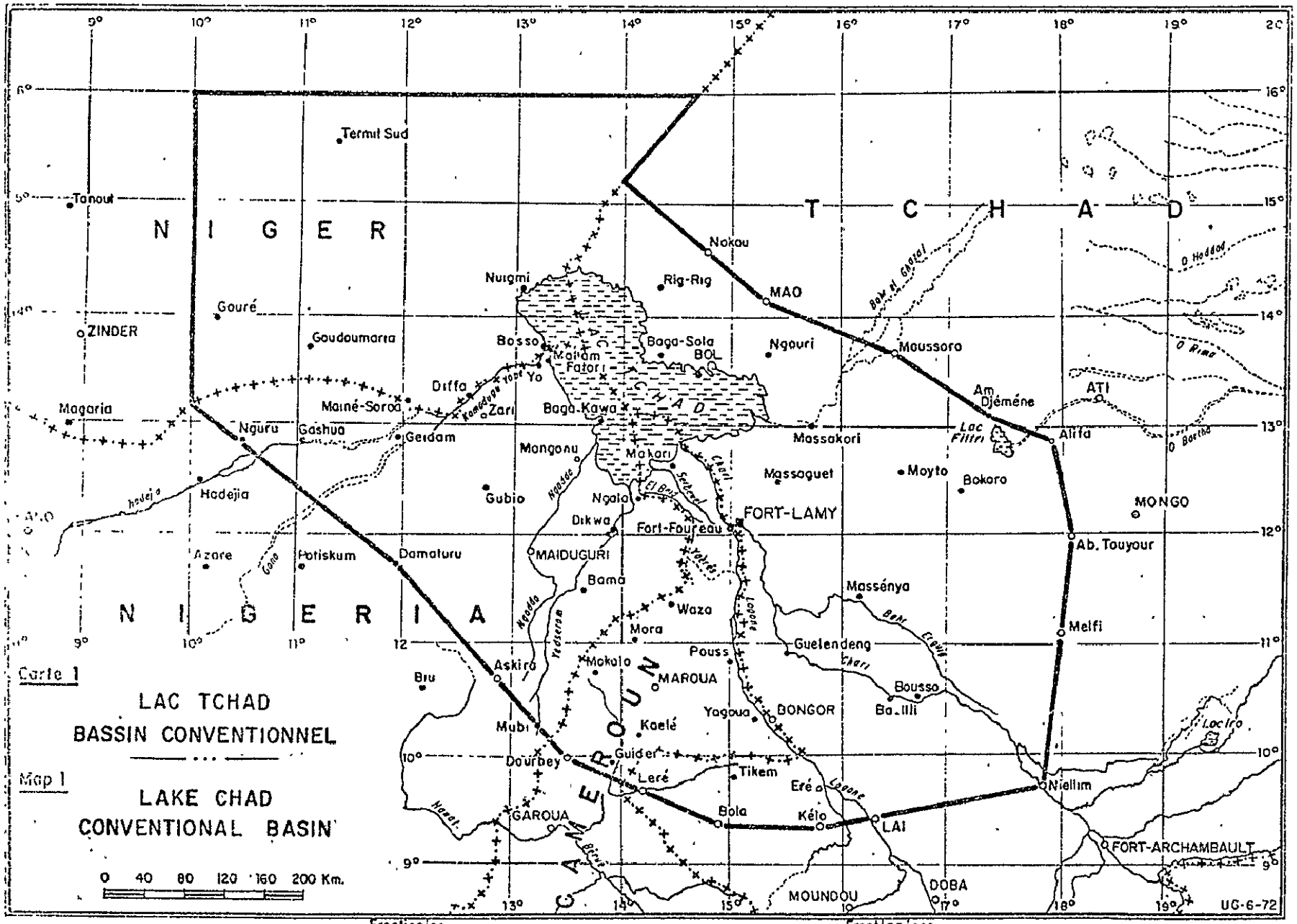
Estimated Cost: $750,000

Basin-wide resettlement study

Estimated Cost: $1,880,000

Design and Construction of river ports and fleet

Estimated Cost: $2,390,000.



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Frontispiece

d. Lake Chad Basin

Lake Chad is a unique physical reality -- a fresh water lake with no apparent outlet located in the heart of an arid semi-desert to desert zone. The rivers entering the lake bring on about 3 million tons of sediment per year and an equal amount of dissolved solids (salt and silica). The water is, however, fresh and quite suitable for irrigation of almost all crops. Despite many inquiries and studies over the past hundred years, researchers are still searching for an explanation of the lake's freshness.

Many theories have been advanced concerning the phenomenon of Lake Chad remaining fresh water, while more or less comparable bodies of water in similar circumstances -- Great Salt Lake, the Dead Sea, the Salton Sea, Lake Aral, the Caspian Sea -- are all extremely saline and unsuited for irrigation of any crops without desalinization. Almost all of these theories that had any generally accepted credibility have been disproved by what has happened in recent years: during the drought, the lake split into two parts, but over the last two nearly normal rainfall years, the Southern half has virtually returned to its original shore line, while the northern half has continued to dry up and increase in salinity. This seems to indicate that the lake is virtually totally dependent on the inflow from the Chari and other rivers

plus surface rainfall for its water and is not recharged through an interchange with geologic deposits of ground water; however, if this were true, there is no explanation of why, with having salt inflows annually and tremendous annual evaporation the lake is not increasingly saline. One postulation now worth more study is a process of ion exchange between the lake water and sediment deposits, and another is a sluggish underground stream outlet connected with the Niger (but this stream has never been pinpointed for location if it exists).

The geographic basin of Lake Chid is an extensive, almost circular region, covering some 2.5 million km^2 and located between latitudes 6° and 24° N and longitudes 7° and 24° E. It is -- as far as is now known -- a self-contained drainage area, except during periods of extreme flood, when flood-waters from the Logone River escape from the basin by spilling over the Gauthiot (formerly MacLeod) cataracts in a southwesterly direction into the Kebi River and thence into the Benoue, a major tributory of the Niger River.

Almost half of the basin is a flat, featureless plain lying below 400m altitude. The rim of the basin is mountainous, apart from the Kebi outlet near Lere, Chad and the western border in the vicinity of Zinder, Niger. These mountain rims

of the basin include the Tibesti in northern Chad rising to 3,400m; the Hoggar in the extreme northwest in Niger and Algeria rising to 2,450m, Diebel Marra on the Chad-Sudan border reaching 3,020m and the Adamaoua in Cameroon and Central African Republic reaching over 2,000m. In the extreme southwest, perhaps forming another portion of the rim, is the well-watered, verdant Jos Plateau of Nigeria between 1000m and 150m, but the streams originating here and flowing toward Lake Chad all dry up and disappear in the Sahelian sands enroute. An isolated and distinctive feature is the 130m volcanic rock outcrop on the south shore of Lake Chad, known as the Hadjerel Hamis.

THE CONVENTIONAL BASIN

The area covered by the 21 May 1964 Convention establishing the Lake Chad Basin Commission is within the geographic and hydrologic basin, but it is southwest of its center and only covers about one-sixth of the total basin area -- omitting all portions of the basin in the Central African Republic, Sudan, Libyan and Algeria, and also leaving out more than half the area

of Chad in the geographic basin and nearly half of the Nigerian and Nigerien portions. Still, with the exception of the headwaters of the Chari and Logone rivers in Central African Republic and a few regions of Chad south of Sarh, the Conventional Basin includes all of the areas in the geographic basin in which it is likely that surface water resources can be utilized for economic and social development projects.

The actual areas of the Conventional Basin by Member Country is: Cameroon 37,500 km^2, Chad 178,300 km^2, Niger 121,500 km^2, and Nigeria 90,000 km^2, which includes the water areas of Lake Chad, about half of which is in Chad, a quarter in Nigeria, one sixth in Niger, and one-twelfth in Cameroon.

The physical setting makes the Lake Chad Conventional Basin an area of rather marginal conditions for agriculture. The sandy soils retain little water and only such crops as millet, cowpeas, and peanuts can be grown in them without some form of irrigation. The clay soils are heavy, often water-logged, and drainage is poor. They support only rice and rainy season or flood recession sorghum. Cotton can be grown where there is flood control. In general, these same types of soils also occur along the watercourses, but their agricultural potential

is greater because of the presence of water. But, on the whole, the low mean annual rainfall throughout the Conventional Basin is a severe constraint to crop yields. Since irrigation could significantly increase the yields, any development plan for the area must assign priority to the development of irrigation from surface water.

The FAO/UNDP report prepared for the Lake Chad Basin Commission (CCBC) in 1974 prepared an inventory of irrigation possibilities in the basin. This report found that present irrigation, including projects now in development stages, consisted of 8,100 ha. in Cameroon, 11,000 ha. in Chad, 275 ha. in Niger, and 3,850 ha. in Nigeria. It identifies the following totals that could be developed by 1990 through controlled flooding, nonpermanent irrigation, and permanent irrigation: 200,000 ha. in Cameroon, 18,000 ha. in Chad, 7,000 ha. in Niger, and 18,000 ha. in Nigeria. Moreover, the total areas with soils suitable for irrigation and in which actual irrigation schemes could likely be developed are: 320,000 ha. in Cameroon, 180,000 ha. in Chad, 30,000 ha. in Niger and 150,000 ha. in Nigeria. This is only a small percentage of the 2,350,000 ha. of irrigable soils area in the basin, but the availability of water is a clear

ultimate constraint in this basin.

There does not appear to be any significant potential for upstream storage in the Conventional Basin, with the only possibilities in the Central African Republic, which is not a member of the LCBC.

Thus, any major irrigation must be obtained from the lake or smaller lakes and ponds, from diversions and canals, from channellization and controlled flooding, or from groundwater.

HISTORIC CONSIDERATIONS OF BASIN HYDROLOGY

The lake Chad basin collects water from a roughly circular area over a thousand miles across and apparently holds one of the world's largest reservoirs of groundwater. The lowest area of the basin is not the existing lake, but the Bodele depression in north-central Chad at about 150m above sea level. This depression is connected to Lake Chad, elevation 282m above sea level, by a reasonably straight channel, the Bahrel Ghazal, which provides overflow for the lake and some inflow of rainy-season run-off.

The principal surface water supply to the Lake comes from the Chari River and its main tributary, the Logone River, which

drain the wetter southeastern part of the geographic basin. In normal rainfall years, the basin seems to be in approximate hydrologic balance. Some 46 billion m^3 of water is added to the lake each year: 40 billion m^3 from the Chari-Logone system, another 3-4 billion m^3 from rainfall on the lake, and the balance from the small rivers in Niger and Nigeria plus possible groundwater flows. More than 41 billion m^3 are lost from the lake by annual evaporation from the surface and the rest is lost through seepage through shoreline sand dunes and groundwater recharge. Unfortunately, not nearly enough is yet understood about the water balance of the basin to satisfactorily explain the lake remaining fresh or the interrelationship of the lake and the groundwater reservoir.

Lake Chad is quite shallow, with an average depth of only 3.5m and maximum depths not exceeding 8m in high water level years. There is, thus, a delicate balance of the whole system which has been dramatically demonstrated during the 1970-73 drought and events of the two normal rainfall season since. If major consumptive uses of water in the system or large-scale storage before the water reaches the lake are introduced, a series of dry years could bring about irreversible changes in lake level, salinity, and fish production.

The normal year lake levels are nearly a meter higher in December and January than in June and July and the difference between 100-year wet and dry years is about four meters (greater than the average depth), meaning an area variation of from 10,000 km^2 to 25,000 km^2. During 1973, after four low flow years in the Chari, the lake split into two separate bodies of water; moreover, after two more or less normal flow seasons, the southern half is back to its pre-drought shore-line, but the northern half is continuing to shrink and salinity is slightly up. During the low water years the south half of the lake exposed much of the bottom to sunlight and great growth of aquatic weeds took place. Now, the weeds have grown with the rising levels of water and continuing to block boats for fishing and for transport to the east shore polders near Bol.

A unique feature of Lake Chad, when compared with other semi-arid zone lakes, is that the water is not saline. The recorded salt content of the south half is 60-170 parts per million and of the north 200-250 ppm. This is excellent for general irrigation, although the polders near Bol require regular flushing with lake water to remove accumulated salts from surface soils.

The Lake Chad basin constitutes a water resource in the heart of Africa with about double the water supply of the Colorado River in the United States. Part of this resource is potentially available as stream flow, part is available as groundwater, and part is stored in Lake Chad, Lake Fitri, and Lake Iro (two small lakes southeast of Lake Chad).

Any contemplation of more intensive use of these water resources must consider maintenance of the fragile water and ecologic balance of the Lake Chad system. It is vital to remember that fish are an essential protein source in the basin -- tons of fish consumed is far greater than that of beef and small ruminants. Over 100,000 tons of fish are estimated to be harvested from Lake Chad, alone, each year. Thus, any modernization of agriculture and grazing that interferes with fish production is probably ill-advised.

In the wetter climate of the Pleistocene period the Lake Chad basin was occupied by enormous inland lakes, one about as large as the Caspian Sea and far larger than Lake Superior. The Chari River built up a huge delta, over 40,000 km^2, in association with a lake with shores at 380-400m above sea level. Another, more recent, lake covered the entire basin area below 320 m above sea level.

The hydrology of the Chari-Logone river system is dominated by the landscape associated with these pre-historic lakes. Much of the river water floods overbank in the old delta area several hundred km south of the present Lake Chad and floods on both the Logone and Chari cause considerable crop damage and interrupt the limited communications system.

Another potential problem affecting the water balance of the basin is a physical anomaly in the basin rim. The head-waters of the Benue tributary of the Niger make a large indent in the shape of the Lake Chad basin. The Mayokebi appears to have progressively captured and directed flood flow of the Logone basin. A more permanent channel could capture and divert much of the mainstreat Logone and alter the hydrologic and ecologic balance of the basin, perhaps changing the salinity of the lake, as well.

In the light of the geologic history of the basin and its present fragile water balance, there is even more reason than its other international basins to look at the entire system before initiating major development projects so development activities can be organized within a framework of a comprehensive plan which considers the total available resources.

LCBC

The LCBC, despite much frustration on the part of donors so far, is in the best position of any of the three basin commissions to coordinate basic studies and implement development projects in its designated area of operation.

First of all, the LCBC Secretarial has an assured adequate income through the Development Fund into which the Member Countries contribute one-tenth of one percent of their annual national budget. During the 1973-75 period, this [redacted] produced an income of U.S. $4 million equivalent with expenditures for project contributions of about U.S. $440,000. In addition, the Member Countries fund, on the same % formula as their budget contributions to the Development Fund, the Secretariat operations budget of about U.S. $133,000 per year. These contributions work out to 62% from Nigeria, 27% from Cameroons, and the balance about equally from Niger and Chad.

Secondly, the LCBC Secretariat has a fine, although small, professional staff that is experienced in administering and monitoring production projects. The Director of the Agriculture Division is an efficient, competent international civil servant who has done an outstanding job of organizing the model system of

of experimental irrigated agriculture farms in the Sahel. The Director of Engineering is a capable telecommunications engineer who could easily direct a water resources planning and data-gathering operation if his division were so staffed. Staff members in fisheries, livestock, forestry, and minerals are knowledgeable and have the capacity to monitor a greater number of donor-funded studies and projects.

The principal constraint to the LCBC actually becoming involved in basic physical social data-gathering has been the rational position taken by the present Executive Secretary, a very capable administrator from Nigeria, whose term will expire this year. Since there have not been funds available from donors in past years for large-scale studies, the Executive Secretary has responded to Member desires and mandates for "production projects" by eschewing basin-wide planning for using LCBC to coordinate and administer an ad hoc series of irrigated agriculture projects, regional telecommunications, international road connections, livestocks and fodder improvement schemes, and well-drilling. Since many of these projects have been clearly additional to regular bilateral aid levels and most of them, although somewhat slow in implementation, have been reasonably successful, LCBC has earned considerable confidence from the

Member Governments. This, though, has reinforced the Secretariat's resolve to avoid long-term involvement in basic hydrologic, agriculture, and socio-economic data-gathering studies and to continue with larger and larger scale projects with greater capital inputs.

Nevertheless, if a multi-donor long-term commitment to basin planning, pilot projects and improved communications were made, there is every reason to believe that the incoming Executive Secretary, the Secretariat, and the Member Governments would welcome cooperation in building a permanent capacity into LCBC to study, analyze, plan and implement basin-wide development of water and land resources.

FLOW REGULATION

In an effort to try to regulate flooding on the Logone and reduce the chances of transbasin diversion of flood waters to the Mayo Kebi, Chad and Cameroon have been considering a jointly sponsored dam on the Vina tributary in Cameroon. AID has been approached for assistance. This might make good sense despite the small drainage controlled, but should only be undertaken in connection with LCBC studies of total hydrology and water balance and as a part of an integrated Lake Chad basin development plan. This project, besides providing flood reduction in the Logone valley and releases to furnish dry season flow augmentation,

will also have a considerable influence on the hydrologic and ecologic balance of Lake Chad (although wetter positive or negative is subject to further study) and will likely seriously reduce the water available for flood recession crops and forage on the Yaeres plain in extreme northern Cameroon.

Other dams for small upstream storage and flow regulation that have been proposed are the Gore site on the Pende Chad near the border with the Central African Republic and on the Logone near Moundou, Chad. These projects would involve many of the same hydrologic and ecologic problems that must be resolved for the Vina dam. It has also been suggested that a dam on the Mayo Kebi for hydroelectric power at the Gauthiot cascade be built; however, the problems inherent in making permanent such transbasin diversion from the Logone have already been noted.

DIVERSION
~~DISCUSSION~~ AND CANALS

There is considerable interest, too, in diversion for irrigation and canals to channelize flood flows. One promising proposal outlined by LCBC in 1972 concerns development of depression storage between Geidam and Gashua on Komadugu Yobe in Nigeria and between Geidam and the lake in Niger and Nigeria.

They estimate some 10,388,500 m^3 could be stored for irrigation through there months after the rainy season. A small division dam on the Komadugu Yobe is under construction to expand the Diffa experimental irrigation farm, now.

Similar projects are under consideration on the seasonal rivers in Nigeria: Hadejiagid El Beid.

Diversions for gravity irrigation are presently in operation at the following sites in the basin: Cameroon - Yagona, 3000 ha; Chad - Yagona, 2500 ha; Niger - Diffa, 275 ha; Nigeria - Gambora 1000 ha, Yau-Daya-Abadan, 1600 ha, Maiduguri; 1500 ha. Proposed diversions for irrigation are: Cameroon -- Ft. Foureau, Logone Birni, and Maltam-Makari; Chad -- Deressia flood plain and Mandelin; Niger -- only expansion of Komaduyu Yobe irrigation; Nigeria no additional.

IRRIGATION POTENTIAL FROM LAKE CHAD

LCBC in 1972 that by 2020 some 260,000 ha will be irrigated by using water from Lake Chad. If one uses the LCBC estimate of water requirement as 0.5 liter/sec/ha, this would make year-around irrigation requirement 7.8×10^9 m^3 and this would lower the lake level by 76 cm which -- assuming a return to pre-drought levels -- would be the maximum tolerable without perpetuating the split into two lakes, which would eventually cut off Niger and Nigeria from fresh water frontage.

There are already 4000 ha. of reclaimed polders in Chad near Bol and some pumping for irrigation near Nguigmi, Niger, Bol, Chad, and Mallau Fortori, Nigeria. The effects on the hydrologic and ecologic balance of the lake if these withdrawals are increased has not been examined.

The LCBC reports do not inquire into the feasibility of major channellization of the Logone and Chari to prevent excessive losses from infiltration and overbank spills. Such a scheme is worth considering as an alternative to upstream storage. It would involve greater storage in the lake and require levees at some points to contain the lake, but could provide enough water for pumping from the lake for another 140,000 ha. Of course, the ecologic impact on areas presently flooded by overbank spills would have to be evaluated before seriously considering this scheme.

STRENGTHENING THE PLANNING CAPACITY OF LCBC

If orderly development of what appears to be very limited water resources in the Lake Chad basin is to happen, the donor community must help the LCBC Secretariat to expand its technical and staffing capacity to obtain basic physical and social data,

analyze this data, and prepare sound plans for development by considering the ground and surface water as a system. This would give both economic and social weight to the hydrologic balance and the ecologic impact of proposed production projects.

It is clear that the Lake Chad basin area does, indeed, need continued emphasis on transportation and communications projects, because these infrastructure activities are essential if existing and proposed production is to have access to markets. For example, Chad -- a country as large as Texas and California combined -- has only 230 km of hard surface all-weather road, with no reliable overland vehicular connections to the rest of the world. In the absence of other more suitable regional institutions to sponsor and monitor implementation of regional telecommunications and international highway projects, LCBC is well-suited to continue this task. But such a role must not be at the sacrifice of the primary task of understanding the vital water resource of the basin and planning and implementing a program of rational development of that resource. Only an organization such as LCBC can perform these tasks.

ILLUSTRATIVE PROGRAM

The Lake Chad basin requires a number of special activities and uniquely skilled staff in its Secretariat because of the especially fragile nature of the hydrologic balance in the basin and its impact upon the ecology. In addition, many of the basic data-gathering activities and pilot projects common to the Senegal and Niger river basins are also applicable to the Lake Chad basin. An illustrative program of projects to provide much of the needed basic information on the basin and to create the professional staff with experience to recommend decisions on planning that will produce a major contribution to increased food production and economic and social development follows:

Hydrometeorologic Network

Estimated Cost: $1,930,000

Hydrogeology survey

Estimated cost: $1,335,000

Study of water balance of basin and explanation of fresh water lake

Estimated cost: $205,000

Land classification and soils studies

Estimated cost: $575, 000

Basin-wide mapping project

Estimated Cost: $ 13,000,000

Inventory (desk studies) of promising dams and diversions

Estimated Cost: $100,000

Study of low-head, high capacity power houses

Estimated Cost: $150,000

LCBC Secretariat Staff Enhancement

Estimated Cost: $1,750,000

System Analysis and Water Resource Planning

Estimated Cost: $540,000

Power and Energy study for basin area

Estimated Cost: $600,000

Basin-wide fishery study

Estimated Cost: $1,250,000

Establishment of pilot on -farm fisheries areas

Estimated Cost: $3,135,000

Basin-wide minerals survey

Estimated Cost: $1,640,000

Non-formal education program for farmers

Estimated Cost: $1,710,000

Pilot irrigated agricultural projects

Estimated Cost: $10,000,000

Feasibility study of first priority project selected from desk studies

Estimated Cost: $1,700,000

[redacted] Final design and construction cost for first priority project

Estimated cost: [redacted] $50,000,000

Aquatic weed study

Estimated cost: $750,000

Basin-wide transportation study

Estimated cost: $400,000

Legal advise for preparing a statement of principles of water utilization in the Lake Chad Basin

Estimated Cost: $115,0000.

III.F.4. POWER AND ENERGY

The present utilization of energy in the Sahelian countries is representative of their United Nations catagorizition of "least developed" countries. Most of the energy utilized in food production is human, so that simple expansion of animal energy use on-farm would represent increased efficiency and increased production - provided that markets become available and prices are sufficient to compensate the farmer for use of animal power.

In so far as energy from fuel for power and heat is concerned, wood represents 90 percent of total energy consumption in the region. Use of wood as a fuel is beginning to have detrimental effects on forest and tree resources. Upper Volta and, to a lesser degree, Mali may be on the verge of significant deforestation. Desertification has clearly accelerated around urban conglomerations throughout the region, where reforestation programs are primarily required. Such programs could require up to 3 million ha. of managed forests by the year 2000. This would cost more than US $ 1.3 billion over 30 years.

Table I - Annual Consumption of Fuel Wood
(from Yearbook of Forest Products 1969)

Country	Total (million cubic meters)	Per capita (cubic meters)
Chad	2.60	0.70
Mali	2.36	0.47
Mauritinia	0.46	0.45
Niger	2.00	0.50
Senegal	1.90	0.48
Upper Volta	3.20	0.60
Total	12.55	

If the region sustains a moderate population growth rate, by the end of the century it is likely that energy consumption of non-wood sources will become seven to ten times the 1970 level. These countries are almost all in the United Nations category of "most severely affected" by the recent oil price increases, which have made energy a major drain on foreign currency. This trend is likely to worsen, since the foreign currencies needed for energy production and distribution will probably increase at rates between 9 and 11 percent, while exports are projected to grow at a rate of less than 6 percent, unless very major mineral finds are exploited. The resultant conclusions point to a serious dilemma for the Sahelian countries.

Table II - Annual Consumption of Petroleum Products (1970) (from UNSSO, 1974)

Country	Quality (MT)	Thousands of Tons of Coal Equiv.	Value ($000)	Unit Cost ($US/T)
Chad	69,345	87	8,581	124
Mali	71,300	99	3,975	56
Mauritania	116,551	156	3,782	32
Niger	51,623	75	2,239	43
Senegal	416,870	523	9,549	23
Upper Volta	50,843	69	3,774	74
Totals	776,532	1,009	31,900	41

Table III - Energy Consumption Per Capita

(from MIT, Energy & Minerals Resources, Annex 9, 31 Dec.1974)

Country	Fossil & Hydro (million BTU)	Wood (Million BTU)	Wood as % of Total
Chad	0.44	6.44	93
Mali	0.55	4.30	89
Mauritania	1.56	4.30	73
Niger	0.36	4.60	93
Senegal	3.80	4.40	54
Upper Volta	0.26	5.50	95

Local resources can be developed to reduce these balance of trade problems, but, unfortunately, the prospects for the medium-term are not promising, although, for the long-term the eventual harnessing of solar energy and wind energy appear to offer hope. The existing known reserves of oil and gas are meager.

Prospecting rights are being exploited in Chad by Conoco, SIREP and Shell (Conoco and Shell have found some gas and oil in the Doba basin and north of Lake Chad, but commercial possibilities are not known); in Mali by Texaco, Sonarem and Mobil (with no results, so far); in Mauritania by ESSO and AMOCO offshore and Tenneco, Shell, Planet, and Agip on land (no reported finds, to date); in Niger by Texaco, Continental, Bishop, and Global (with uneconomic small finds, so far); in Senegal by ESSO, Copetao and Shell in the south and offshore (finds, but not exploitable as yet); and in Upper Volta no interest has developed because of poor prospects. On the basis of available information there is little

prospect of early large exploitation of oil, although some gas might eventually be produced. One possibility for low-cost solution to energy needs would be reliable if Libya and, to a lesser extent, Algeria would cease burning off gas from their Sahara oil production and either bottle LPG or pipe trans-Sahara, gas for liquefication in the Sahel. If this were accomplished, it could provide a low-cost fuel to greatly reduce dependence on wood.

Some of the balance of trade problems could be alleviated if the Sahelian countries could obtain special oil-pricing agreements (as Senegal may be succeeding in doing with Iran) or could arrange to buy hydroelectric power from excess capacity available in the coastal area at long-term stable prices. This latter possibility is bright, given good will and regional cooperation, because Ghana and Guinea are developing projects for 768 MW and 625 MW respectively, which can produce electric power greatly in excess of domestic needs for a number of years. High cost of transmission could be substantially reduced by using high voltage DC lines, similar to the Pacific NW-California tie line. At this time, a transmission line from Kainji in Nigeria to Niamey is under construction.

While more than half of Niger's exports are now from uranium mines exploited by a French-German-Italian combine, and there are important known reserves in Chad, Niger and, to a lesser degree, Mali, it is unlikely that area demand will be sufficient for many years to justify an economically sized nuclear power plant. Export income to offset fuel imports and development costs are a more appropriate use of this resource.

The hydroelectric potential of the Senegel and Niger rivers is substantial, but not impressive for major rivers. Although annual flow is a considerable volume, the total fall through the Sahelian countries is small and economic dam sites are very few and far between. For example, the Kandadji dam site in Niger could produce up to 200 MW of firm power, but since to do so, the dam must be 30 m high and 12 km long, the power production cost would be as high as that of current oil-fired generation unless a very large percent of the dam cost could be charged to irrigation, navigation and flood control.

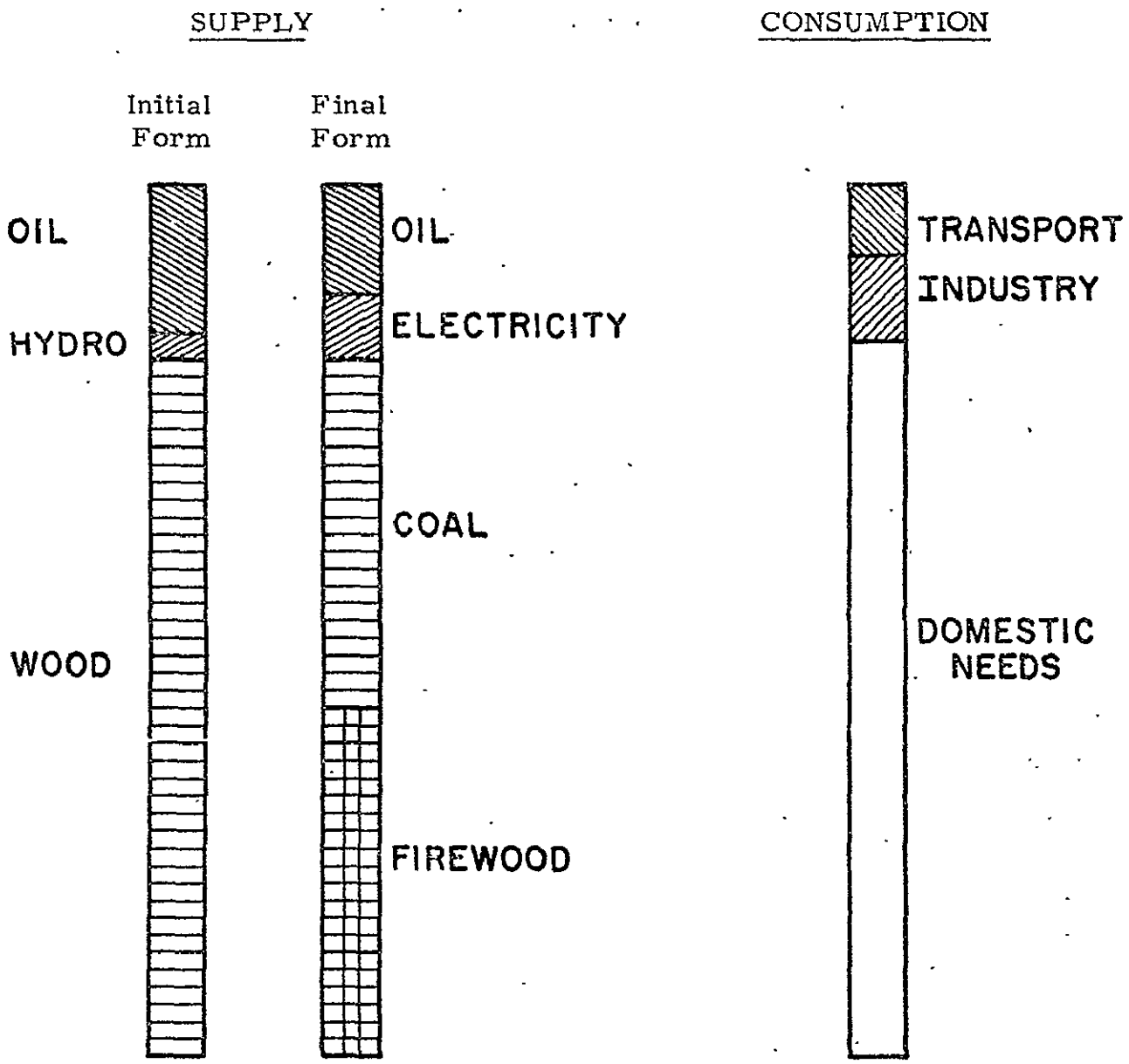
While run-of-river hydroelectric projects, using low-head, high-capacity turbines might be a feasible medium-term solution to the region's predicament in the sector, it is not now known if this technology is appropriate to the available sites. Construction of major resources and power plants now would be extremely ill-advised until better hydrometeorologic data and ability to forecast environmental impact are available, but as soon as such information can be obtained, feasibility studies are appropriate. Assuming that the essential basic data can be gathered within five years, then by that time, the significance of river regulation to agricultural production will be clearer, so that the relative priority of the rivers for agriculture, hydropower or navigation can be determined. It is conceivable that a more rational use of scarce river water may be to develop hydroelectric plants leaving primarily other water sources for agricultural needs.

There is some known geothermal resource in the Tibesti region of Chad and in Mali between Mopti and Timbuctou. These should be exploited for power production.

Solar energy has a great potential for heating and power. The average duration of insolation is between 8 and 10 hrs a day in most of the region. Under these conditions, the average solar energy impacting on the region is about 560 calories/cm^2/day. Although solar energy institutes exist in both Niamey and Bamako, most of the research and development will take place in the developed countries. The Sahelian institutes should follow these developments closely and all economic technologies should be installed on a pilot basis as soon as practicable.

Wind energy also has great possibilities in the Sahel. Annual average speeds are from 2 to 4 meters/second which makes windmills for pumping, electricity generation, and motive power quite feasible. Wider on-farm use should be an early investment priority, and implementation of new technologies for municipal and industrial power generation should be undertaken as pilot development projects.

Development of increased capacity to formulate and implement energy policies is critical for long-term planning in the region and by the governments and institutions in the region. National energy policies should consider the long recovery times occasioned by different forms of land over-exploitation . Balance of trade problems could hamper development and also should effect the choice of energy policy. Clearly, regional cooperation and coordination of energy policy is desirable. Coordination of urban growth and energy policy is needed to optimize utilization of local resources. A primary tool to assist the governments and regional institutions to obtain knowledge of the techniques of making and implementing energy policy and training their own technicians in these concepts is the power and energy surveys proposed to be implemented through each of the major river basin development commissions in the region and described in the water resources sector section of this report.



Present Pattern of Energy Consumption and Supply

IV. ANNEXES - TABLE OF CONTENTS

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2. More Information on Some Proposed Projects

   a. Economic
   b. Social
   c. Minerals
   d. Transportation
   e. Telecommunications
   f. Water Resources
      (i) Senegal River Basin
      (ii) Niger River Basin
      (iii) Lake Chad Basin

3. Bibliography (not attached)

A SUMMARY OF RECOMMENDATIONS ON RIVER BASIN DEVELOPMENT IN THE SAHEL BY OTHER STUDIES

1. Ed Fei Report: Economics of the Sahel, 1974 (A.I.D.)

"Using a rule of thumb, we found that the economic return will not be high in some areas and negative in gross terms in total. For example, the cost of growing millet will be very high.

"This does not allow to calculate the amount of food needed in year 2000/2025, I have developed a methodology based on rate of growth of various cohorts of population, consumption unit, and productivity under various alternatives.

It appears that the Sahel-Sudano countries with the rate of growth of their populations will be faced with a food shortage, and the strategy recommended is dry land farming without intensive irrigation." p. 46

2. FAO: Prospects in Lake Chad Basin for Agricultural Development, 1974 (LCBC)

"With regard to this, it should be recalled that the original scope of the project was to develop irrigated cultivation so as to better exploit the water resources of the Basin. But it must be realized that for a long time to come, the great majority of the rural population of the Basin will only be in a position to practice dry farming and that dry farming will continue to produce the largest part of agricultural production. Given the present state of affairs, a development programme oriented solely towards irrigation would only reach a small proportion of the rural population and would be of limited effect. This is why rainfed as well as irrigated crops will be stressed." p. 63

3. U.S. Bureau of Reclamation: Senegal River Basin Water Resources Development Analysis, 1975 (A.I.D.)

"The urge to alleviate the sufferings of the present drought should not blind us to the facts that building major projects, changing cultural patterns, training personnel, and establishing institutions to plan, construct and operate major projects take time....The concerns expressed by Hubbard, Lubin and others after review of Beyrard and/or earlier reports are supported by the findings of this study....Major concerns of the earlier reviewers of the Beyrard report emphasized three areas of deficiency in presentation:

1. A training program to develop the large staff of technicians and managers who would be needed to plan, implement, and operate the development programs.
2. A coordinating and managing organism to handle the complex machinery of program implementation.
3. Engineering and technical data to permit checking the accuracy of its premises, validity of its analysis and reasonableness of its conclusions and recommendations.

....The Beyrard report emphasizes economic and financial analysis but is deficient on technical data in support of its proposals. If the needed technical data exist, they should be compiled and made readily available; if they do not exist, they need to be developed. During the data investigative period, organizational development, management and technical training, and agricultural research can be intensified. Principal specific deficiencies or requirements in functional areas noted include:

1. River regulation /_ hydrology_/ - Recent drought period streamflow data at proposed dam sites and key points on the rivers, and new streamflow correlations to verify or improve past estimates....
2. Ground Water - Its location, characteristics and aquifer capabilities.
3. Floods - Probably maximum precipitation....Quantification and identification of areas of inundation for various frequency of floods.
4. Sedimentation.
5. Mathematical models.
6. Land classification.
7. Crops and Livestock - crop yields by varieties, levels of inputs, wet and dry seasons, and with and without irrigation. Costs of production.... Map locations of present and proposed crop areas and type of farming methods.
8. Drainage.
9. Power - A complete reanalysis of generation capacities and capabilities, load characteristics, and transmission options....
10. Navigation
11. Environment - Considerably more data and analysis on development effects on fisheries, wildlife, vegetation, recreation, and archeological and other resources
12. Social factors
13. Industry, mining, tourism, commerce.
14. Geology
15. Dam designs - Additional flood hydrology and geologic data, and clarification of specific design details and conditions.
16. Cost estimates - Updating

17. Economic and financial analysis - Economic justification and financial feasibility cannot be determined from information presently available. Additional detailed studies are needed."

pp. 7-9

4. Holmes and Narver, Inc.: Niger River Commission Study, 1968 (A.I.D.)

"There probably exists no very exact information on the amount and possible productiveness of lands in the Niger Basin which might be brought under irrigation. There are many scattered areas along the smaller tributary and subtributary streams. Some parts of these might be developed for irrigation by merely controlling their annual flooding. However, little is known of the fertility or water relationships of their soils nor of the details of their topography affecting the feasibility of controlling their flooding and drainage. Generally, it was indicated to this study team, in its conferences with agricultural experts in several countries visited that, where experiments and field tests for such irrigation was underway, they had not been sufficiently successful or conclusive to project any important developments. It occurred to us also that any very extensive flood irrigation development would require mechanical preparation of the land, which seemed a rather remote possibility considering the machines and power that would require. Also, any important extent of irrigation, by pumping of either surface or ground water, must await the availability of a great deal more power and at a much lower cost than is likely for some years to come.... Overall, the development of irrigation agriculture in the Niger River basin will be affected by two major socioeconomic factors. One is that in many places where irrigation is possible, a fairly successful dry-land agriculture can also be carried on with less capital investment and less labor. The other is that, while the economy of the region is and will continue to be, for at least some generations,

to be based primarily on agriculture, its people are traditionally nomadic and semi-nomadic herders.... For at least the next few decades, cropping enterprises may best be developed in conjunction with livestock enterprises..... Irrigation in the Niger basin cannot be visualized as at any time in the near future resembling that along the Nile in Egypt, where intensive irrigation farming is founded on the experience of many centuries." pp. 5-6 and 5-7

5. UNSO: An Approach to Recovery and Rehabilitation of the Sudano-Sahelian Region. 1975 (UN)

"Finally, consideration has been given to various proposals for the construction of large dams. Such programmes appear to provide the most promising prospect for protection against future drought, as well as for significant increase in water availability for the entire economy with the consequent structural changes. They undoubtedly offer a vast potential for controlling a resource that so critically limits the development possibilities of the area. However, their high cost and heavy demands on the physical and human resources of the countries concerned strongly suggest the need for the most careful technical and economic evaluation, and make it imperative that utmost care should be exercised in order to avoid major investments in premature or excessively costly projects.... It should be added that, in general, in case of projects involving large-scale irrigation schemes, there is always a need for caution. The results obtained from such projects in the past have been, in a number of instance, quite disappointing. On the one hand, in some cases, the farmers using traditional methods have not been trained on modern irrigation techniques. On the other hand, the high cost of construction and maintenance has prevented, in a number of instances, the farming which irrigation has made possible to be profitable..." pp. 48-50

6. IBRD (World Bank): Special Sector Survey, Irrigation Potential of Semi-arid Zones of West Africa: Part I - Senegal River Basin Irrigation Development. 1975

"In analysing the rate of return for Manantali Dam for upstream storage, the Bank assumed a cost of US $300 million (conservative) and the cost of irrigation systems at $4,000/ha. The analysis showed that at a moderate rate of irrigation buildup of 255,000 ha. in 40 years, the rate of return would be only 4.8% and at an accelerated rate of buildup of 300,000 ha. in 30 years it improved to 7.7%. This analysis indicated that even with the greatly accelerated rate of development of double-crop irrigation systems, a dam project of that cost did not approach an acceptable rate of return. Moreover, the Bank staff found this rate of irrigation was unlikely to be attained because of the unknown response of basin population to modern irrigation farming and possible financing, technical staffing and managerial constraints." p. 18

7. AID: Development Assistance Program, 1976-1980: Central-West African Region, Vol. 1: Overview and Program Conclusions. Nov. 1975

"The U.S. is not likely to be a leading contributor to the large capital intensive investments being planned for the main waterways in the Region.:. Given the interests of other donors, and taking into full account the present Congressional charge to AID concerning large capital projects, the particular goals of AID in water resource development should be:

1. To immediately build up farm level experience in better methods of water use.
2. To encourage a variety of approaches to better water use and help choose through pilot projects appropriate methods for each region.

3. To help national governments and regional organizations develop a planning and evaluation capacity for water resource use.
4. To help the governments concerned with the several river basins develop improved methods of coordination of the development of the water resources of the area.
5. To assist the governments plan water resource use for regional crop and development needs on different parts of the countries concerned.

...At the individual project level the U.S. should provide assistance for several small scale water use projects, provided that these projects can be used as a basis for training at several different levels. We recommend the encouragement of the close evaluation of these projects with a view to improving future large scale irrigation design. At the same time, AID's own interlinked evaluation will provide a basis for assessing our own further involvement on this area." pp. 101-102

8.J. Giri: An Analysis and Synthesis of Long-term Development Strategies for the Sahel. 1976 (OECD)

In discussing development of irrigated crops, M. Giri concludes as follows: "However, certain questions are evident:

- Is it possible to finance such very large investments between now and the year 2000, and are the international aid sources which would have to be approached for substantial contributions prepared to make corresponding (sic) effort?
- Are such large-scale investment projects practicable? Is it possible to find human and institutional resources required to carry them out? Above all, is it possible to find the individuals to exploit them? Can people accustomed to dry land farming or after-flood

sowing be converted to irrigated farming methods? Is it possible to find the necessary agents to train and advise the farmers?

- If all the investments cannot be made, should not the irrigation operations be ranked accordint to cost?
- Are such huge investments in fact justified? Would it not be possible to safeguard the Sahel from drought at lower cost by further development of dry-farmed crops with year-to-year storage facilities, with less development of irrigated crops? Where is the economic optimum or, more simply, what optimum could actually be achieved with the technical, financial and human resources at our disposal?

Lastly, the important problems of marketing the cereals grown on irrigated land has so far hardly been considered.

We lack the data needed to reply to all these questions." p. 41

Annex IV.2.a

Economic Studies

Many of the constraints and problems which are more or less purely economic in nature are very closely related to fundamental policy issues deeply imbedded in the political fabric. As a result, they are commonly held not to be the concern of the donors. Nevertheless, they frequently are so critical to the success of a development program that the donors must have an interest in these issues. Given this very sensitive political problem, little is to be achieved by simply recommending what appear to be desireable policy changes. especially given the paucity of information upon which to base those recommendations. The inadequate data base also makes questionable efforts to force through acceptance of these recommendations as part of the negotiations related to a loan or grant. Instead, it would be more desireable to try to influence policy through a mutual exchange of information and experience over a fairly extended period of time. An ideal medium for accomplishing this is the participation in various economic studies of both qualified expatriates with technical expertise and indigenous personnel in positions of influence and authority. This has the additional benefit of helping to augment and to consolidate information needed for sound policy decisions. The following are some suggested studies.

1. The alternative costs and benefits of reducing the risk of severe deprivation for these countries by holding reserves in various forms.

These would include foreign exchange reserves, centrally stored stocks of food, local grain storage at the village level, and pasture and forage held in reserve. The study would consider the cost of transportation and distribution for each method, including that of maintaining excess capacity for emergency situations. All costs would be calculated in relation to the probability of food consumption falling below a given level.

2. Alternative methods for financing recurrent expenditures, especially those related to rural development.

   This study would look carefully at the experience which has been gained in different countries in decentralizing both the collection of revenue and administrative incentives, in order to make more effective the delivery of government services to the rural sector. Particular attention would be paid to the effect of tying user charges to the provision of services.

3. Analysis of the tax system of each country, especially with respect to how it might be simplified and modernized and how collection rates might be improved.

   Most of the tax systems of the Sahelian countries are highly complex and inefficient. In several of the countries, studies have already been done recommending ways in which the tax structure might be altered, but there has been relatively little attention paid to studying the marginal costs and benefits of improving

collection. This is important because of the detrimental effects of low collection rates on taxpayer morale, in addition to the more general problem of inadequate public revenue.

4. Economic analysis of production, processing, marketing, and consumption of food crops with special attention to the system of pricing and other incentives used by the governments and their effects.

   This would include an analysis of the comparative cost of different crops and productive and marketing techniques and if the responsiveness of both producers and consumers to different incentives. It would thus serve as a guide to public authorities responsible for price and tax policy as well as for other types of incentives.

5. Economic and social analysis of the causes and effects of worker migration, both between and within countries.

   This would include the disruptive effects of workers leaving rural areas at critical times of the year. It would also examine rural-urban labormarkets and the problem of unemployment and underemployment in the cities. Special attention would be paid to the effects of government policy related to wage legislation, rural and urban food prices, etc.

6. Impact on economic development of the monetary and fiscal systems found in each country which historically, and in most cases currently, have been closely tied to the French franc zone.

Comparisons would be made with English-speaking countries in Africa which have pursued more independent policies. Special attention would be paid to the constraints placed on the development of financial intermediaries capable of contributing to development.

7. Economic study of the role of risk for individual households, whether as producers or consumers, and for the governments.

   Relatively little is known in this area, yet it is vital to development in the countries concerned. The study would look at the effect of risk on the allocation of resources by farmers and herdsmen and on their acceptance of innovation. It would also consider the relative importance which government officials attach to risk avoidance and how much weight should therefore be given to this objective in designing projects or programs.

8. Location analysis of traditional marketing systems.

   This would examine the special configuration of the marketing network, including hierarchal levels of trade. It would be very useful for identifying transportation projects and marketing interventing which might otherwise be obscured because of the absence of modern indicators of trade flows, such as highway traffic courts.

9. Alternative economic policies to encourage the commercial production of subsistence foods.

   Special attention would be paid to the influence of

end missing →

10. Analysis of the rate of dependence reduction as a national objective.

This study would examine alternative definitions of self-sufficiency to see what they imply, how they might be realized, and what would be the likely trade-offs in terms of other objectives, such as growth.

11. Study of transport policies and how they effect economic development.

This would examine rate structures, and their effects in both public and private enterprises. It would also consider investment criteria and how the concept of user benefits might be modified to allow for emergency uses of transportation facilities and for their developmental effects.

12. Alternative criteria for the evaluation of health and education projects.

This study would develop methods for determining the implicit valuation which people place on health and education services, even though they contribute nothing to the output of goods and services.

A SOCIAL ANTHROPOLOGICAL/ECOLOGICAL RESEARCH PROGRAM FOR SAHELIAN DEVELOPMENT, TO BE UNDERTAKEN OVER A FIVE-YEAR PERIOD

Each of the following research efforts should be done in association with local research institutes and personnel. Where these are lacking, it is then the donor's responsibility to undertake support for administration, infrastructure, and training. For much of this, on-the-job Training is recommended.

1. Pre-project studies. Throughout the Report, there is repeated mention of the strength of the traditional Sahelian herdsmen and farmers, identifying this strength (knowledge, skill, willingness to invest labor) as the basic resource for equity-based rural development. Also, these strengths are not randomly distributed across the region, but vary within groups and from group to group. Two general kinds of study are implied by these variations:

a. to identify the characteristics of exceptionally successful herders and farmers within groups (what are the factors which lead certain individuals consistently to outproduce others: i.e., better land, better use of tools, better capacity to mobilize labor in production, increased ability to moderate consumption, better entrepreneurial grasp of the characteristics of the market, etc.); similarly, one could indentify the characteristics of those individuals who regularly appear unsuccessful. Once the analysis has been done, a number of actions suggest themselves, relating to the possibility of raising the overall capacity of the group to produce or to invest more effectively.

b. to identify populations which seem to make more effective or productive use of resources than others, or whose use of the environment appears to be less degrading. For example:

(1) Across the region, certain ethnic groups are reported to have weathered the drought with less loss than others. The Dogon, for instance, claim to have had surplus harvests even during the most rainfall-deficient years. Why are the Dogon so markedly more productive than their neighbors? What can we learn from a study of Dogon productive sociology and productive economy that might be diffused to other people? A study of the Dogon would focus on:

(a) microhydraulic agriculture

(b) the ideology of farming--i.e., motivations for what appears to be "conspicuous display" of harvests in huge granaries

(c) labor mobilization in production, etc.

(2) The Kabre, of Togo, represent another population which has an enviable reputation as productive farmers. To what extent is this reputation derived from local ecological conditions which are inherently non-diffusable, and to what extent does it derive from factors which are subject to extension?

(3) Similarly, there are herding populations which suffered far less of a loss than others. Was it their use of terrain, herd management practices, mobility, etc., which facilitated survival? Can these practices be disseminated among other peoples?

c. Although most of the discussions have centered on agriculture and livestock, there is also concern with health and education. The major problem relating to health has been designing systems which are effective in the delivery of modern medicine to the bush at a low cost. Various proposals for the training of paramedical or medical auxiliary personnel have been put forth; all

of them are either inadequate or too costly to make a real improvement in access to medicine on the part of the remote villager or pastoralist. Yet there exists a traditional health delivery system with representatives in the smallest villages and camps: these persons (who in Niger include barbers, herbalists, and marabouts [paralleling surgical, medical, and psychiatric specializations]) have vested interests in success, and provide a ready-made resource which enjoys some confidence on the part of the people, and, unlike many paraprofessionals, is willing to live in deep bush. Therefore, a series of studies is called for describing the traditional medical system, in terms of personnel and ethnomedical practice, in order that one can assess the potential of the system to be upgraded, and made part of a program of improved rural health.

Similarly, there exist well-established traditional educational systems, ways of passing on the knowledges and skills crucial for survival in these harsh, marginal environments. We know very little either about the content or the methods of instruction of these systems, yet it would seem clear that we have much to learn from them, especially about the design of effective non-formal educational programs, aimed at improving the quality of life of the rural poor.

d. Nomadic-Sedentary Relationships. A great deal more understanding of the complex interrelationships between herding and farming populations is needed, especially the ways in which multiple use of the same terrain is regulated. We need to know a good deal more about political, economic, and social exchanges among these peoples. These understandings will alert us to proposals that might disrupt the system and cause a reduction in the amount of useful energy which may be generated by it. We need to understand the ways in which conflicts between groups are resolved--for example, when herdsmen and farmers compete for the same land, or when two groups of herders compete for water

rights. What use is made of traditional authorities? Of customary law courts? Of the modern government's mechanisms for dispute resolution?

e. ~~Among herding peoples~~, we need to know a great deal more about the nature of the herd, distinctions between ownership rights and usufructory rights.

f. Finally, we may list a series of studies which need to be done at the pre-project level:

(1) the economic and productive roles of women and children in different ethnic and ecologic situations;

(2) religious and ideological values and their relationships to production;

(3) inventory of tools and material resources;

(4) aspirations of youth;

(5) perceptions of access to markets;

(6) labor migrations: rural-rural, rural-urban, urban-rural;

(7) locational analysis or central place theory, to identify the relationships between marketing and settlement patterns.

(8) etc.

Project-related studies.

a. incentives and constraints for herdsmen to increase commercialization of livestock.

b. incentives and constraints for farmers to undertake animal husbandry in the higher rainfall areas.

c. assessment of the experiences of animal traction/embouche paysan projects, such as in Northern Dahomey.

d. the effects of land improvement--i.e., bas fonds development--on traditional access to land. Are these improved lands equitably distributed

or do they become the privileged property of traditional élites? (Note that the same questions can be asked of any technological intervention: what are its effects on existing social structure?)

e. Where we are dealing with "new lands"--i.e., associated with onchocerciasis programs, tse tse clearance, etc.--we need to know who will have access to these lands, what will happen to traditional movements of peoples, how will they affect relations among farmers and herdsmen, etc.

f. Where dams are contemplated, we need to know what the implications of population relocation will be, what provisions are made for drawdown cultivation in the reservoirs, etc.

g. We need to know what the effects of refugee status--camp life--are on the pastoral populations (Tuareg and Fulani) and the implications of this for resuming a herding way of life. What have been the effects on children?

Annex IV. 2.c

MINERALS

1. Preliminary Mineral Survey

   Utilizing available satellite data, conduct a magneometer survey of areas of interest. Analysis of the data will identify possible deposits suitable for detailed ground exploration.

   Time Frame: 2 years

   Estimated Cost: $2,000,000

2. Small Scale Phosphate Production and Distribution

   Supply of equipment to Mali, Niger, Upper Volta, and Mauritania for the mining, crushing, and bagging of phosphate rock for fertilizer. The equipment will consist of front loaders, small crushers and baggers. Two plans in Niger and one in each of the other three countries are contemplated. Technical assistance will be required to set up the plants and start operations. Budget support will be required for free distribution of the fertilizer during the first two years. It is assumed that the governments will carry the costs of transporting the material.

Time Frame: 2 years for supply of equipment and plant setup. 2 additional years of budget support for free distribution of fertilizer.

Estimated Cost:

Equipment supply, plant setup and technical assistance: $3,500.000

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TRANSPORTATION

Annex IV. 2.d.

1. A study to develop new methods of evaluating the economic feasibility of highway construction projects connecting relatively underdeveloped agricultural areas with potential markets.

   Objective: To attempt to develop techniques for more reliable prediction of future benefits resulting from the impact of roads on area development. To find methods of including in the feasibility equation not only the traditional user benefits, but in addition, the benefits resulting from health services, educational opportunities, closer cultural contact with more developed regions, and the freer mobility of foods to smooth out irregularities in available supplies and to permit lower cost distribution in emergency situations.

   Methodology: The study should be executed in two phases. Phase I will be the development of a scope of work for the study. It will be a complex task to define the detailed targets of the study, the criteria to be established, the factors to be included in the benefit and cost sides of the feasibility equation and the alternative approaches to the task. Phase II, the study itself, should include as part of its data collecting task the identification of any development road projects in other areas which have

been in operation for a sufficiently long time to begin to show an impact on development. It must be clear, however, that in arriving at the sought-after new analysis methods a very long time span must be considered before the effects of road construction can be felt in developing areas.

Time Frame: Following the formulation of the scope of work it is estimated that an interdisciplinary team of 8-10 technicians will need 2-3 years to complete the study.

Cost: Estimated at $3,000,000.

NOTE: There is no assurance that techniques to quantify intangible benefits can be developed. Other objective techniques for assessing these benefits in qualitative terms may prove useful.

2. A study to identify trade routes which existed prior to colonial intervention in the area and which were disturbed and abandoned in favor of routes which suited the military, administrative and trade needs of the colonial power.

   Objective: To determine whether the reopening and improving of these routes would react to the advantage of Sahelian development. To investigate the entire pattern of road networks proposed by various donor organizations and by CILSS and to propose a rational network for intra-Sahelian traffic and traffic connecting the Sahel with existing and potential markets.

Methodology: The study should ignore the economic feasibility of road construction. This would be the task of individual feasibility studies for roads identified in the study, utilizing the techniques expected to be developed in Study No. 1. The present study should concentrate on the rationality of trade routes as a means of reaching existing markets and developing new ones for the products of the Sahel. In this way Study No. 2 can proceed simultaneously with Study No. 1.

Time Frame: Two years.

Estimated Cost: $1.5 million

3. Utilizing the results of Study No. 2, a series of feasibility studies should be undertaken for the identified roads in the proposed network. The series of studies should utilize the methods developed in Study No. 1 and should include not only roads for which feasibility studies have not been made, but also those roads which were previously rejected by the application of traditional user benefit methods.

   Methodology: The series of feasibility studies are not interconnected and can be carried out independently and financed by various donors. They should, however, wait on the results of Studies No. 1 and No. 2 so as to include the maximum number of routes and obtain the maximum benefits.

Time Frame: Based on the above the series of studies should not be started before 1980. The entire series could take as long as ten years but individual results would emerge at various times during the ten year period allowing construction of feasible roads to begin as soon as financing becomes available.

4. Studies in each Sahelian country to determine the recurring maintenance costs of their highway departments.

   Objective: To determine the annual levels of external financing of highway maintenance budgets which would be required to support an effective highway maintenance program so as to maintain the integrity of the existing highway system and of new roads as they are constructed.

   Methodology: The study should include in addition to wages, equipment and material the costs of training maintenance staff, equipment mechanics, and management personnel. It should determine the length of time during which the various levels of external aid are to be continued. It should identify the non-fiscal constraints which now prevent the highway maintenance departments from functioning effectively and propose remedies.

   Time Frame: If carried out simultaneously in all six countries, the studies can be completed in one year.

   Estimated Cost: $10 million.

5. Design Engineering and Construction Projects

CILSS has prepared a list of twelve major road projects in the Sahel. These are shown on IBRD Map 11294 of February, 1975 annexed to the IBRD report "A Note on Transport Problems in the Sahel" dated August, 1975. Pages 42 through 46 of this report list four major road projects identified as deserving of priority financing by Lamarre-Valois, the Canadian consultant commissioned by the IBRD.

Cost: Estimated at $55 million.

6. Railway Management Improvement

Phase I. A study of the railway systems in the Sahelian countries to develop a program for improving the efficiency of operation of the existing facilities. To study the possibility of setting up an interstate authority including contiguous non-Sahelian countries with railroads providing access to markets outside the area. The authority would deal in the setting of uniform rate schedules and coordinated operation of interconnecting railroads and road-rail combined transport.

Phase II. Training and technical assistance in carrying out the recommended program and in assisting during the first years of operation of the authority.

Time Frame: Phase I, 8 - 12 months.
Phase II, 3 - 5 years.

Cost Estimate: Phase I - $1,000,000
Phase II - $10,000,000

7. Railway Improvement and Expansion Study.

If Phase II of the preceding study results in a steady increase in traffic, the existing rolling stock and railway infrastructure could become a bottleneck for future development. It is not expected that the Sahelian governments will have the capital available for improvement of the existing infrastructure or expansion of the trackage and rolling stock. A study of the required improvements and expansion should be undertaken as soon as the positive results of Study No. 6 begin to take effect. Full feasibility studies of the indicated improvements and expansions would follow with the object of obtaining external financing.

Time Frame: Two years, beginning with year two of Phase II of Study No. 6, i.e. at year three of the long range development program. The following feasibility studies would be scheduled depending on indicated priorities and size of project.

Cost Estimate: $1,000,000, not including follow-on feasibility studies.

8. Interstate Road Transport Authority

Phase I. A study to recommend the structure, responsibilities, authority, and operating procedures of a Sahel Interstate Road Transport Authority. The purpose of the authority would be to set up uniform rates based on economic factors tending to promote the development of the agricultural, industrial and commercial sectors and the establishment of policies concerning relationships with competing and connecting railways and with contiguous countries controlling the access routes to external markets.

Phase II. Training and technical assistance in setting up the Authority and assisting in its operation in the initial years.

Time Frame: Phase I, 1 year. Phase II, 3 years.

Cost Estimate: Phase I - $750,000. Phase II - $4,000,000.

9. Vehicular Spare Parts Project

Existing import and tax policies of Sahelian governments relating to spare parts inhibit the free importation of parts at reasonable prices. This results in rapid deterioration of vehicles, high accident rates and consequent increased transport cost. A study is required to prepare and recommend a rational program for the relaxation of import restrictions and the reduction of import duties. Since this will result in a loss of tax revenues and an increased drain on foreign exchange reserves the study should recommend steps for replacing

the tax loss and added FX requirements including possible external budgetary support. Consideration could also be given in the study of methods to encourage governments to allow the major vehicle importers and assemblers to maintain regional spare parts stocks in bonded or free port areas until they are shipped to final destinations.

Time Frame: 1 year

Estimated Cost: $500,000.

10. River Navigation Studies.

Within the context of river basin development there will be studies made of the economics of river navigation. The results of Study No. 1, which is an attempt to discover new methods of economic evaluation of roads into undeveloped areas, should be applied to the analysis of river navigation projects. This may point to feasible projects which would have been judged non-viable under the traditional analyses.

TELECOMMUNICATIONS

1.- Concurrent with the setting up of a hydrologic data collection system, establish a telecommunications network to relay the data from collection points to centers in each country and the assembled country data to the various river basin commission headquarters.

Time Frame: After selection of the sites for data gathering equipment, the design of an integrated telecommunication system to cover the Senegal, Niger, Gambia and Chad basins will require about one year. An estimated 300 single sideband transceivers would be needed to provide the simplest type of network for ease of operation and maintenance. Supply and installation of equipment would require 3-4 years.

Estimated Cost: Engineering Design-$500,000 equipment supply, installation, spare parts-$5,000,000. Training in operation and maintenance-$200,000. Participation in recurring costs of maintenance, including wages, vehicles, and maintenance of spare parts stocks-$500,000/year.

2. A study to determine the extent of a telecommunication network to serve the needs of an agriculture extension service in each country.

Methodology: The network should be based on existing needs but should forecast the future requirements based on the planned expansion of extension services in each country. The forecast should take into account the effects of expanded land agriculture and irrigated farming resulting from the development of water resources.

Time Frame: A study based on the existing agricultural extension services in the Sahel countries could be initiated immediately and could be completed in less than one year. Planning and engineering of the network can be completed in six months.

Estimated Cost: $1,000,000.

3. A similar study to supply the telecommunication needs of an upgraded public health service.

Methodology: There are at present about 1200 rural dispensaries in the Sahel countries. The study should determine which of these should be equipped with communications equipment, the various echelons in the communications hierarchy and the type of equipment required. The network designed should be flexible.to accommodate changes in the number of points served and the type of service required.

Time Frame: One year for the study. Six months for engineering.

Cost estimate: $1,500,000.

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WATER RESOURCES - OMVS

I. Hydrometeorology: to overcome the lack of continuous reliable records of rainfall, run-off, river flows, sedimentation by time units for key stations which are essential for project design, the timing of activities related to flood and low flows, and for constructing dependable mathmatical models for planning purposes.

a. Personnel - senior hydrometeorologist for five years (from NOAA or USGS PASA or an individual contractor); two hydrologists for 3 years each; one communications technician for 2 years.

Estimated cost: $910,000

b. Training - one equipment specialist per country (3) trained in U.S. for 10 months; 10 Senegal, 5 Mauritania, 10 Mali technicians trained at various short courses in gauge maintenance and installation, sediment analysis, evaporation measurement, raingauges, calibration of flow meters, etc., and on-the-job. Two communications specialists per country trained in the region.

Estimated cost: $250,000

c. Equipment - recording gauges and staff gauges at St. Louis, Diama, Richard Toll, Dagana, Matam and Bakel, Senegal; Kaur Massene, Rosso, Bogbe, El Bir and Kaedi, Mauritania; and Kayes, Galougo, Manantali, Bafing-Makana, Gourbassi, Tonkoto and Kali in Mali (18). A network of up to 40 raingauges (some in remote areas teleautomatic). A radio (SSB) network for flood warning and possible computerized forecasting to be used as a safety guide and alert for irrigated and flood recession crop planting, as well as real-time reporting to OMVS on rainfall and river stages.

Estimated cost: $690,000

d. Five year project estimated cost: $1,850,000.

2. Hydrogeologic Analysis - to train riparian staff in groundwater investigation and analysis.

a. Staffing - one expert hydrogeologist (nine months) to analyse all existing data concerning groundwater in the basin and prepare a qualitative report and a map showing where lack of hydrogeologic data could be critical for future water and land management. Also prepare a program hydrogeologic study covering: geologic conditions as they influence ground-water possibilities, including geologic history and characteristics of individual geologic units related to water-bearing properties, individual aguatic characteristics, and boundary conditions; ground water hydrology, including source of recharge, characteristics, fluctuations and natural discharge quantities, general conditions of depth, area, direction of movement, and relationship to streams, lakes or ocean, aguatic conditions of thickness,

transmissivity, permeability, specific yielf, boundary conditions, annual yield, coefficient of storage, quality, both chemical and baterial,salt water intrusion possibilities and prevention, artesian conditions and extent; utilization of groundwater, including present usage, direct irrigation, conjunctive use of groundwater and river water, irrigation and drainage, drainage water disposal; and economic considerations, including availability and cost of drilling equipment and personnel, availability and cost of envelope material, casing, screens, pumps and motors, sources and cost and availability of energy, spare parts, pump lift, efficiency, yield, life of well, and replacement cost of well, and corrosion and encrustation possibilities. Contract with three well-drilling experts to conduct program of investigations and train riparian staff of at least one technician/engineer from each country for three years.

Estimated cost: $685,000.

b. Training - on-the-job for three technicians/engineers in field drilling, plus 3-week seminar/workshop for up to 20 riparian staff members during second year of contract. One senior hydrogeologist to understudy the consultant and then monitor program.

Estimated cost: $100,000.

c. Equipment - three drilling rigs, with bolts, spares, casings, screeing, retrieving equipment, etc. to drill up to 1,000 deep wells per year for investigative purposes to remain for community water supply, stock points, irrigation, etc.

Estimated cost: $450,000.

d. Four year project cost estimate: $1,135,000.

3. Staff enhancement of OMVS Secretariat - as part of a multilateral effort to provide from U.S. up to five professional staff, selected from fields of civil engineering, agronomy, geology, fishery biology, irrigation engineering, hydro-electric power engineering, system analysis, macro-economics, agricultural economics, transport economics, navigation and inland water transport, and statistics to serve in the Secretariat from 3 to 5 years and to simultaneously train a riparian counterpart as the eventual career replacement. Must be fluent in French.

Estimated cost: $1,750,000.

4. Indicative basin development planning - to provide a specialist in river basin planning to coordinate OMVS Secretariat's preparation of a 40-year Indicative Basin Plan. One consultant for three years.

Estimated cost: $150,000.

5. Preparation of new basin-wide mapping at a scale of 1:20,000.- to use a private land survey firm to install ground control throughout the basin, under direction from Army Topographic Commands; under contract with private firm, fly aerial photograph and prepare 1:20,000 map sheets with one meter contours, where practical, and two meters elsewhere. Also, under supervision of ATC, train at least three riparians in the Management of the full process.

Estimated cost: $12,000,000.

6. Inventory (desk study) of promising tributary projects in Mali and Senegal - to select most promising multi-purpose projects for upstream storage.

a. Personnel - one expert for one year, who is experienced in preliminary desk studies of multi-purpose dam sites from limited mapping scales and with restricted availability of hydrologic data requiring synthesizing stream records, and has little or no access to sites to evaluate geology and soils information; three riparian engineers for on-the-job training in desk studies.

Estimate cost: $70,000

b. Training - on-the-job for three riparian engineers for one year.

Estimated cost: $25,000.

c. Equipment - planimiters, desk calculators, drafting equipment, etc.

Estimated cost: $5,000.

d. Estimated project cost for one year $100,000.

7. Study of low-head, high capacity power houses - to provide a feasibility examination of use of run-of-river, low-herd hydrolpower generation to provide energy for operation of irrigation pumps and power needs of irrigation perimeters.

a. Personnel - contract team of two specialists for 8 months.

Estimated cost: $110,000.

b. Training - on-the-job for one engineer from each country for six months.

Estimated cost: $20,000

c. Cost estimate for 8-month project: $130,000.

8. System Analysis and Water Resource Planning - to set up use of Corps of Engineers river basin models by adapting SSARR (Streamflow Synthesis and Reservoir Regulation) and other river system models from the North Pacific Division (Colombia River, Portland, Oregon) or Sacramento Hydrologic Laboratory to the Senegal system, and to examine and evaluate various combinations of projects to maximize irrigation, power and navigation potential of the river.

a. Personnel - 2-man PASA team from Corps NPD or Hydrologic lab. for 2 years to train riparian engineers and help to modify and test model.
Estimated cost: $175,000.

b. Training - five riparian engineers on-the-job in the basin and for one year in Portland, Oregon, or Sacramento.
Estimated cost: $150,000.

c. Equipment - Hardware and software at the University of Dakar.
Cost estimate: $210,000.

d. Estimated cost for two year project: $538,000.

9. Power and energy study for basin service area - to determine the appropriate role of the basin's hydroelectric potential in establishing a regional electric power grid.

a. Personnel - 6 man contract team to make study for 6 months. Cost estimate: $500,000.

b. Training - 2 specialists from each member country to take part in the full study effort, including any portion in the U.S. Cost estimate: $100,000.

c. Estimated cost of 8 months project: $600,000.

10. Feasibility study of first priority project selected from desk studies. (AID to fund 25-50 percent) - Time estimated for study, 2 years.

a. Personnel - up to 15 expatriate technicians in various specialities from a consulting firm. AID estimated cost: $1,500,000 and $200,000 in local costs.

11. 25 percent of construction and final design costs of first priority project selected from desk studies - grant or lowest-term loan, estimated time for design and construction, 5 years. AID estimated costs: $80,000,000 in foreign exchange and $25,000,000 in local currencies.

12. Design and construction of river ports: St. Louis to Kayes - AID to fund 50 percent of 12 small river ports (6 in Senegal, 4 in Mauritania, and 2 in Mali, plus a terminal in St. Louis. Each port to have cross-river ferry landings on both sides of the river and, if needed, marigots.

a. Personnel - contract team of four experts for design and construction supervision for 3 years. Construction by local contracts. Engineering cost estimate: $380,000.

b. Training - national riparian staff of one per port (13) for on-the-job training. Estimated cost: $60,000.

c. Construction cost estimates: $350,000 foreign exchange and $650,000 in local costs.

d. Estimated cost of 3 year project: $1,440,000.

13. Coordination and dissemination of agricultural research information - to establish an information system to acquire and evaluate results from various experimental firms, pilot irrigated perimeters, range management and other agriculture research activities in the basin and elsewhere to determine soil-plant relationships in irrigated agriculture, including yields, water requirements, costs of production, balance of inputs, as well as farmers' reactions. To meet immediate and long-term needs for efficient planning and operation of irrigation projects.

a. Personnel - one expert for 3 years. Estimated cost: $210,000.

b. Training - three (one from each country) technicians to ass assemble and publish an annual OMVS bulletin on agricultural research and assist basis irrigation projects and experimental firms in drawing up their programs.
Estimated cost: $90,000.

c. Equipment - publication of annual bulletin for five years
Estimated cost: $45,000.

d. Project cost estimate for five years: $345,000.

14. Basin-wide fishery study -- to develop a program to enhance the yield of a greater volume and higher protein from basin fisheries.

a. Personnel - four-man team of experts from a U.S. university for 2-year field study and to recommend basin-wide plan for increased fresh-water and brackish water fishery yields; one full-time expert in Secretariat to establish fisheries section - 3 years (study to include fish biology, river, estuaries, lake and on-farm pond fisheries, fishing technique, marketing). Cost estimate: $900,000.

b. Training - three technicians for training abroad for one year each (at Auburn University or similar institution) and to work with team for final year prior to assuming staff positions in Secretariat. Cost estimate: $170,000.

c. Equipment - three fibre-glass boats with outboard motors, trawling nets, other nets, vehicles and lab equipment. Cost estimate: $150,000.

d. Cost estimate for 3 year project: $1,220,000.

15. Establishment of pilot on-farm fishing areas - to create one pilot area in each country and operate for five years as cooperative fishery project with farmers in irrigation perimeter. Fish pond or ponds will be created on non-irrigable portion of perimeter land.

a. Personnel - one expert for each project (3) plus necessary local support staff. Cost estimate: $1,050,000.

b. Training - three riparian technicians on-the-job cost estimate: $50,000.

c. Equipment and construction - to design, build and operate pilot on-farm fishery projects. Cost estimate: $3,500,000.

d. Five year project cost estimate: $4,600,000.

16. Experimental program for kenaf production - to experiment in kenaf production as an additional cash crop and to use the fibre for grain bags. Three year experiment with one technician on one of the AID-funded perimeters. Cost estimate: $350,000.

17. Basin-wide minerals survey. USGS PASA team of four experts for a four year air reconnaissance and surface drilling to determine the nature, extent and commercial viability of mineral deposits on the basin.

a. Personnel - 16 man years of American experts.
Cost estimate - $1,120,000.

b. Training - on-the-job for 2 years each of 3 technicians. or geologists from each country.
Cost estimate: $90,000.

c. Equipment - two core drills with spares and an aerial magnetometer survey, test digging equipment, etc.
Cost estimate: $400,000.

d. Estimated cost for four year project: $1,610,000.

18. Non-formal education program for farmers in irrigated perimeters - pilot project to determine how pre-extension education can help farmers with limited or no formal schooling to absorb extension education in agriculture, small-scale and cottage industries, organization and participation in cooperatives, and hygiene. Perhaps, in association with UNESCO? Functional literacy and rural youth training may also be incorporated.

a. Personnel - non-formal education team from U.S. university or private firm such as A.I.R. of four professionals plus up to 10 graduate students or sub-professionals for 3 years to initiate pilot project and develop experienced riparians for modifying and replicating through new irrigated perimeters.
Cost estimate: $1,250,000.

b. Training - 9 Senegal, 6 Mauritania, and 3 Mali educationists for one year each and then support for two years as employees of Secretariat.
Cost estimate: $210,000.

c. Equipment: film, projectors, charts, etc.
Cost estimate: $250,000.

d. Estimated cost for three year project: $1,710,000.

19. Control of Malaria and other vectorborne diseases - to control or eradicate malaria, schistosomiasis, trypanosomiasis, filariasis, etc wherever they are in the basin. Cost estimate for five years: $5,000,000.

20. Development of water filtration system using local materials - to provide improved potability to community and individual household water supplies in order to reduce intestinal parasites and other waterborne diseases in the irrigated perimeters. Starting with low-cost units developed by the Asian Institute of Technology and Mekong Committee (two stage units using cocoanut husk fibre and burnt rice husks) develop a system of low-cost, high and acceptable reliability, easy maintenance without chemical additives, and acceptable to users.

a. Personnel - one sanitary engineer, one chemist technician for three years, plus local staff for necessary research and field trials in various sizes and other various qualities of input water. Cost estimate: $300,000.

b. Training - two technicians from each country on-the-job. Cost estimate: $100,000.

c. Equipment: lab equipment and field testing materials. Cost estimate:$50,000.

d. Estimated cost for three year project: $450,000.

Annex IV.2.f.(ii)

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WATER RESOURCES - NIGER RIVER BASIN

1. Hydrometeorologic Network and Operation: to coordinate with the Agrometeorology Project of WMO/UNDP and establish a basic network of daily real-time reporting of rainfall and river stage/discharge

stations in order to provide flood warning, flood recession planting schedules, water availability information and improvement of both basin and project planning capability.

a. Personnel - senior hydrometeorologist, 5 years; two hydrologist for 3 years each; one communications technician for two years; and one system analysis engineer for 3 years.

Estimated cost: $1,120,000.

b. Training - one equipment specialist per country (9) trained in U.S. for 10 months; 10 Nigerian, 6 Nigerien, one Cameroonian, one Chadian, 5 Beninese, 2 Voltans, 9 Malians, and 7 Guineans trained at various short courses in the basin in gauge maintenance, sediment measurements and analysis, evaporation, raingauges, calibration of flow meters, etc. and on-the-job, 2 communications specialists per country trained at Agromet center.

Estimated cost: $690,000.

c. Equipment - Recording gauges (limnometers) for key stations, and staff gauges for remainder[1/] network of 100 tele-automatic

1/ (Proposed hydrolic network in Niger Basin:
Guinea: Mainstream-Siguiri, Kouroussa, Faranah; tributaries-Mandiana, Fiffa, Kankau, Kerouane
Mali: Mainstream - Bamako, Segou, Mopti, Timbuctou,Gao; tributaries-Niono (Office du Niger), D'nzarra, Bougouni, Kangara.
Niger: Mainstream-Ayorou, Niamey, W,Gaya; tributaries-Maradi, Yatakala, Bessebangou
Dahomey: mainstream-Malanville; tributaries-Malanville, Bensakou, Sinaongourou, Keremon
Nigeria: mainstream-Onitsha, Shintaku, Kainji Dam, Yelwa; tributaries-Lokoja, Makurdi, Yola, Kaduna, Ka, Sokoto
Cameroon: tributaries-Garoua
Chad: tributaries - Lere
Upper Volta: tributaries - Bilanga, Liptougou
Ivory Coast: tributaries-Krimbirila Sud, Sanhala, Zaguinoso.)

raingauges (use Agromet network, where applicable), use of Agromet communications for reporting daily readings, forecast and warning dissemination. Train up to 20 riparians in system analysis and computer utilization (at Agromet Center in Niamey or at NPD of Corps of Engineers in Portland, Ore.).

Estimated cost: $790,000.

d. Five year project estimated cost: $2,600,000.

2. Hydrogeologic (groundwater)survey - provide a team to pull together existing knowledge and conduct field training of riparian technicians in groundwater investigation and analysis and the preparation of basin groundwater maps showing extent, depth, quality and quantity of groundwater and pertinent drawdown and recharge information.

a. Personnel - consultant for one year to analyze all existing information and prepare a qualitative report; prepare map indicating where lack of adequate hydrogeologic investigations; contract team of five well-drillers experts to conduct program and train riparian staff of at least one technician from each country (3 years, 120 man-month)

Estimated cost: $1,120,000.

b. Training - on-the-job for 9 technicians/engineers, plus two 3-week seminar/workshops for up to 20 riparians each during 2nd and 3rd year of contract.

Estimated cost: $270,000.

c. Equipment - 5 drilling rigs with bolts, spares, casing, etc. to drill up to 2000 deep well per year for community water supply, irrigation, stock watering points and provide necessary data on groundwater.

Estimated cost: $660,000.

d. Four-year project cost estimate: $2,050,000

3. Land Classification and Soils Studies - to prepare basinwide land capability maps and train personnel in soils studies.

a. Personnel - consultant for 6 months to analyze existing information and prepare program of obtaining additional data to prepare basin-wide land use and land capability maps; team of two experts to obtain missing data and supervise preparation of maps, while training riparian staff - 2 years.

Estimated cost: $315,000.

b. Training - one chief soils specialist for service as counterpart to consultant and on-the-job training to continue Secretariat program of soils studies and analysis; 9 technicians for two years to work with contract team in on-the-job training and up to 20 technicians each as participants in two 2-week seminar/workshops.

Estimated cost: $230,000.

c. Equipment: maps, aerial photographs, satellite photos and tapes planimeters and other drafting equipment and supplies,

Estimated cost: $30,000.

d. Three year project estimated cost: $575,000.

4. Basin-wide mapping project - same as project No. 5 under Senegal basin.

Estimated cost: $19,000,000.

5. Inventory (desk studies) of promising mainstream and tributary dams and diversions - similar in purpose, scope and implementation to project No. 6 for Senegal basin.

a. Personnel - one expert for 2 years and five riparian engineers for on-the-job training. Estimate cost: $200,000.

b. Training - on-the-job for five riparian engineers for two years. Estimated cost: $50,000.

c. Equipment - $10,000.

d. Estimated cost for two year project: $260,000.

6. River Niger Commission staff enhancement of Secretariat - identical to project No. 3 for Senegal basin.

Estimated cost: $1,750,000.

7. System Analysis and Water Resources Planning - the same project as project No. 8 for Senegal basin. Also see project No. 1.

Estimated cost: $538,000.

8. Power and energy study for basin area - same scope as project No. 9 for Senegal basin, except team to take one year for study.

a. Personnel - 6 man contract team for one year.

Estimated cost: $900,000.

b. Training - 2 specialists from each country.

Cost estimate: $250,000.

c. Estimated cost for 15 month project: $1,150,000.

9. Basin-wide Fishery study - same as project No. 14 for Senegal basin, except time of study to be 3 years and six technicians to be trained in U.S.

a. Personnel - four=man team for 3 years; one full-time riparian expert in Secretariat to establish fisheries section for 4 years.

Estimated cost: $1,200,000.

b. Training - six technicians for training in U.S. or Canada for one year each and to work with team for balance of study, prior to assuming full-time position in Secretariat or Government agency.

Estimated cost: $240,000

c. Equipment: three fibre glass boats with outboard motors, trawling nets, etc., other nets, vehicles, and laboratory equipment. Cost estimate: $180,000.

d. Cost estimate for four year study: $1,620,000.

10. Pilot irrigated agriculture projects - one each in Niger, Mali, Nigeria, Guinea, Benin and Upper Volta. Up to 500 ha. each using a variety of water sources and irrigation types at $4,000/ha development costs and $200/ha/yr o & m costs.

Estimated cost for 5 year project: $15,000,000.

11. Feasibility study of first priority project selected from desk studies - identical to project No. 10 for Senegal basin.

Estimated cost: $1,700,000.

12. 25 percent of construction and final design costs of first priority project from desk studies - identical to project 11 for Senegal basin. Estimated cost: $100,000,000.

13. Basinwide minerals survey - similar to project 17 for Senegal basin.

a. Personnel - 24 man years of American experts. Cost estimate: $1,680,000.

b. Training - on-the-job for 2 years for 3 technicians or geologists from Guinea, Mali, Niger, Nigeria and 1 each from Ivory Coast, Upper Volta, Benin, Cameroons. Estimated cost: $240,000.

c. Equipment - two core drills with spares and an aerial magnetometer survey, test digging equipment and satellite photography, etc. Cost estimate: $600,000.

d. Five year project cost estimate: $2,520,000.

14. Support for Secretariat Cadre Development - to train riparian technicians for selected permanent positions in RNC secretariat. 20 riparians for up to Ms. level at U.S. and regional institutions. Estimated cost: $650,000.

15. Non-formal education program for farmers on pilot irrigation projects - identical with project No. 18 for Senegal basin. Estimated cost: $1,710,000.

16. Coordination and dissemination of agricultural research information - identical with project No. 13 for Senegal basin, except limit to Mali, Niger, Upper Volta, and Nigeria.

Estimated cost: $400,000.

17. Aquatic weed study - to examine the kinds of aquatic weeks existing in the basin and determine magnitude of water and other losses attributable to them, then devise a control and/or eradication program using most modern and economic biological chemical and mechanical control techniques consistent with ecological safety, while training a riparian staff member to carry on the program.

a. Personnel - three experts for two and a half years. Estimated cost: $615,000.

b. Training: one riparian biologist/weed specialist on-the-job for Secretariat position and eight riparians for on-the-job training in field sampling and laboratory testing and field trials. Estimated cost: $35,000.

c. Equipment: Fibre glass boat with outboard motor, vehicle field and laboratory scientific equipment. Estimated cost $100,000.

d. Three year project estimated cost: $750,000.

18. Basin-wide resettlement study - to determine economic and socially acceptable schemes for resettlement of populations from reservoirs and other capital project sites and for bringing new

populations into large-scale agricultural projects. Urban resettlement and rural agriculture and non-agriculture resettlement will be considered. BEfore recommending any specific schemes, small-scale pilot projects will be tried out in the field.

a. Personnel - six man interdisciplinary team from an American University or consulting organization for four years. One riparian sociologist for on-the-job training as a permanent Secretariat staff member. Estimated cost: $1,680,000.

b. Training - one riparian Secretariat staff member on-the-job; up to 25 riparians on-the-job and with short seminars to return to national agencies. Estimated cost: $100,000.

c. Equipment: vehicles, radios, computer time, office supplies and equipment. Estimated cost: $100,000.

d. Four year project cost estimate: $1,880,000.

19. Design and construction of river ports and fleet - AID to fund up to 50 percent of design costs and 25 percent of construction costs of river port facilities at Kouroussa, Siguiri, Bamako, Segou, Mopti, Dire, Tosey, Ansougo-Mali; Tillabery, Niamey, Gaya - Niger; Malanville-Benin; Yelwa-Nigeria. Also modest fleets of tugs and barges and cross-river ferries and landings at a few key points.

a. Personnel - three-man team of experts for one year study, one year design, and 2-year supervision of construction. Estimated cost: $630,000.

b. Training: one riparian on=the-job to assume Secretariat post of Chief of Navigation Division. Five riparians for on-the-job training with team. Estimated cost: $110,000.

c. Equipment: vehicles, drafting, etc. Estimated cost: $150,000 .

d. Four year estimated project costs: $890,000.

c. 25 percent construction costs: $1,500,000.

Annex IV.2.f.(iii)

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WATER RESOURCES - LCBC

1. Hydrometeorologic Network

To provide a basic network of daily real-time reporting of rainfall and river stage/discharge stations in order to have fundamental hydrologic data for input to project studies and provide flood warning, flood recession planting schedules, and water availability information.

a. Personnel - senior hydrometeorologist, 3 years; to hydrologists for 2 years each; one communications technician for two years; and one system analysis engineer for 3 years. Estimated cost: $840,000.

b. Training - one equipment specialist per country (4) trained in U.S. for 10 months; 16 Chadians, 3 Cameroonians, 2 Nigerians, and 2 Nigerians trained at various short-courses in hydrology and meteorology and on-the-job; 2 communications specialists per country for training in the region; and up to 10 riparians trained in systems analysis and computerization of hydrologic data at NPD of Corps of Engineers in Portland, Ore., or the Engineer Hydrologic Center at Sacramento. Estimated Cost: $510,000.

c. Equipment - recording gauges (meters) for key stations and staff gauges for remainder (Cameroon - Mussuk, Logone Basin, Dana; Chad-Bol, Massakori, AmRaya, Douguia, N'Djemena, Guelengoeng, Dik, Sarh, logone Gana, Bongor, Lai, Baibokaum, Gore, Boumkabir, Kyabe, Yao, Missenya; Niger-Nguigml, Difta; Nigeria - Baga, Dikwa, Geridam) and network of rainfall gauges. SSB radio network for real-time reporting. Estimated cost: $580,000.

d. Three-year project estimated cost: $1,930,000

2. Hydrogeology (groundwater) survey

Provide a team to perform functions described in project no. 2 for River Niger Commission.

a. Personnel - consultant for 8 months to analyze all existing information and prepare a qualitative report, prepare map indicating gaps; contract team of three well-driller experts to conduct program and train operation staff of one technician per country for 3 years. Estimated cost: $685,000.

b. Training - on-the-job for 6 technician/geologists, plus two 3-week seminar/workshop for up to 10 riparians each during second and third year of contract. Estimated cost: $200,000.

c. Equipment - 3 drillings with bits, spares, casing, etc. to drill up to 1000 deep wells per year for community water. Supply, irrigation, stock watering points and provide accessary data on groundwater. Estimated cost: $450,000.

d. Four-year project cost estimate: $1,335,000.

3. Study of Water Balance of Basin and Explanation of Fresh-Water Lake.

To model the basin water balance, posit a plausible theory to explain fresh water in Lakes Chad and Fitri, and have

a riparian water scientist with experience on the LCBC staff.

a. Personnel - senior water scientists for 2 years. Estimated cost: $140,000.

b. Training - on-the-job for riparian scientists as counter-part to senior scientist and to take over permanent position in Secretariat. Estimated cost: $15,000.

d. Two year project estimated cost: $205,000.

4. Land Classification and Soils Studies - Identical to project no. 3 for Niger basin.

Three year project estimated cost - $575,000.

5. Basin-wide Mapping Project - Same as project No. 5 for Senegal Basin.

Estimated cost: $13,000,000.

6. Inventory (desk studies) of Promising Dams and Diversions - Same as project No. 6 for Senegal Basin.

One-year project estimated cost: $100,000.

7. Study of Low-head, High Capacity Power Houses - Same as project No. 7 for Senegal basin.

Eight-months project estimated cost: $150,000.

8. LCBC Secretariat Staff Enhancement - Identical to project No. 3 for Senegal basin.

Estimated cost: $1,750,000.

9. System Analysis and Water Resources Planning - The same as project No. 8 for Senegal basin. Also see project No. 1.

Estimated cost: $540,000.

10. Power and Energy Study for Basin Area - Same as project Nol 9 for the Senegal basin.

Estimated cost for 8 months project: $600,000.

11. Basin-wide Fishery Study - Same as project No. 14 for Senegal basin.

Three year project estimated cost: $1,250,000.

12. Establishment of Pilot on-Farm Fisheries Areas - To create one pilot area in Chad and one in Cameroon and operate for 5 years as cooperative fishery project with farmers in irrigation projects. Fish pond or ponds to be created on non-irrigable portions of project land.

a. Personnel - one expert for each project (2) plus necessary local support staff. Estimated cost: $700,000.

b. Training - Two riparian technicians on-the-job and to assume Secretariat posts. Estimated cost: $35,000.

c. Equipment and construction - to design, build and operate pilot on-farm fishery projects. Estimated cost: $2,400,000.

d. Five year project estimated costs: $3,135,000.

13. Basin-Wide Minerals Survey - Same as project No. 17 for Senegal basin.

Four year project estimated cost: $1,640,000.

14. Non-formal Education Program for Farmers - Same as project No. 18 for Senegal basin.

Three year project estimated costs: $1,710,000.

15. Pilot Irrigated Agriculture Projects - One in each country. Up to 500 ha each using a variety of water sources and irrigation types at $400/ha development costs and $200/ha/yr o&m costs.

Five year project estimated costs: $10,000,000

16. Feasibility Study of First Priority Project Selected From Desk Studies -

Same as project No. 10 for Senegal basin. $1,700,000

17. 25 Percent of Final Design and Construction Cost for First Priority Project - Same as project No. 11 for Senegal basin.

Estimated cost: $12,000,000

18. Aquatic Weed Study - Same as project No. 17 for Niger basin.

Three year project estimated cost: $750,000.

19. Basin-wide Transportation Study - To examine the transport needs of the basin and recommend a program of international and national transportation and communication to upgrade the basin's facilities to meet the needs.

a. Personnel - team of five experts for one year to cover road, rail, river and air transport and telecommunications. Estimated cost: $350,000

b. Training - five riparian counterparts for on-the-job training. Estimated cost: $30,000.

c. Equipment - miscellaneous. Estimated cost: $20,000.

d. One year estimated project cost: $400,000.

20. Legal Advise for Preparing a Statement of Principles of Water Utilization in the Lake Chad Basin - To work with the LCBC secretariat, the LCBC, and the Member, Countries to agree upon and publish principles of using basin water resources, and train LCBC Secretariat staff in water law and precedent.

a. Personnel - one legal advisor on retainer for two visits per year for ten days each over three years. Estimated cost: $45,000.

b. Training - one riparian legal advisor to serve as a counterpart for the foreign specialist and on the interim attend special seminars and short courses on international water law to become Secretariat staff advisor. Also, panel of one water law specialist from each member to serve as drafting committee for

statement of principles. Estimated cost: $70,000.

c. Three year project estimated cost: $115,000.