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

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Technical Background Papers

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DETAILED BACKGROUND PAPERS

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I. GENERAL OVERVIEW

A SOCIO-ECONOMIC FRAMEWORK FOR THE ESTABLISHMENT OF A LONG-TERM DEVELOPMENT STRATEGY IN THE SAHEL

The need for establishing a long-term development strategy in the Sahel is well recognized. This strategy must be collaboratively designed by the external donors and the African countries and organizations. What follows here is a suggested framework which could be used in that design.

The conceptual perspective upon which the framework is based is the view that development action is taken for the purpose of achieving certain objectives in the face of given constraints. The objectives, may at times, be in conflict with one another, so decision-makers must make choices as to the relative weights which should be attached to each. This occurs, for example, if investments which appear most profitable also involve greater risk. In this case, a determination has to be made of the extent to which income is valued at the margin more or less than avoidance of risk. Given the opportunities which are available, taking into account all the constraints, a careful weighting of objectives and an analysis of those opportunities should reveal various feasible courses of action. When taken together, simultaneously or in sequence, these combine together to form a development strategy.

A major factor inhibiting the formulation of such a strategy at any given time is the availability of information upon which to base decisions. Consequently, the strategy must allow for the gathering of data and their incorporation into the decision-making process as they become available. Frequently this will result in a staging of various actions in successive development phases to allow for the time required to obtain data upon which subsequent decisions are to be based. As an example, local agricultural research is essential in expanding knowledge of the potential of the Sahelian countries, and many decisions concerning how best to exploit that potential must await the results of the research.

In the next section, an attempt is made to identify the long-term development objectives of the Sahelian countries and regional organizations. No effort is made to weight these since this can only be done by leaders of the countries concerned, but the present economic situation is assessed to see how it reflects current progress in achieving the objectives. The major constraints limiting attainment of the objectives are also described, followed by an analysis of several alternative, but not mutually exclusive, actions which might be taken in their pursuit. A proposed strategy containing several of these actions is then suggested and some of its social implications are assessed. Finally, an attempt is made to estimate the progress which could be attained by the first years of the twenty-first century, the orders of magnitude of the capital required, and the implications for possible donor assistance.

A. Long-Term Development Objectives

Long-term development objectives 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/

1. The mitigation of consequences of future emergencies.

2. The attainment of self-sufficiency in food stamples.

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 largely to have accepted these objectives.

The first of these, to mitigate the consequences of future emergencies, is an obvious outgrowth of the deprivation and suffering experienced during the recent drought. The Sahelian countries want to ensure, even in the worst years,

1/ United Nations Sahelian Office, An Approach to Recovery and Rehabilitation of the Sudano-Sahelian Region, New York: November 1974, p. 35.

that their populations have adequate food and water, and that their wealth of natural resources and animal herds is over the long run maintained intact.

The second objective is that of attaining self-sufficiency in basic food necessities, especially cereals and meat. This has received increased emphasis not only because of the drought, which necessitated large food imports, but also because per capita food production has been declining generally over a longer period. The objective of self-sufficiency, however, is not yet completely defined with respect to precisely when or to what foods it should apply and at what set of prices. At a minimum, there appears to be general agreement that it must involve the capacity of these countries to use their own resources to meet not only ordinary essential food needs but also the shortfalls which occur over an average one or two decade rainfall cycle. There is less agreement as to whether this capacity should also be sufficient to supply essential foods at reasonable prices during periods of truly catastrophic drought, sustained over several years, such as are likely to occur no more than once or twice in a century.1/

1/ This is the definition assumed in a study done for the French Ministry of Bilateral Cooperation (Societe Centrale pour l'Equipement Territoire Internationale and Societe d'Etudes pour le Developpement Economique et Social, Essai de definition d'une strategie anti-secheresse dans les pays saheliens francophones de l'Afrique de l'ouest, October 1975). The United Nations Sahelian Office, on the other hand, notes 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," (An Approach to Recovery and Rehabilitation of the Sudano-Sahelian Region, November 1974, p. 35). 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 (Sahelian Zone: A survey of the Problem of the Sahelian Zone with a View to Drawing up a Long-Term Strategy and a Programme for Protection, Restoration and Development, Rome: 1974, p. 68). There remains under this approach, of course, the question of where world grain stores should be held and what their size should be. Finally, at the Club de Amis meeting in Dakar in March 1976 it was recognized that the objective of self-sufficiency has yet to be fully defined.

There also appears to be widespread agreement that the concept of self-sufficiency should apply at least to traditional foods, such as millet and sorghum. Less clear is whether it should necessarily apply and at what price level to foods such as wheat and rice which assume greater relative importance in consumption as incomes grow and urbanization takes place. While substitution of local production for imports of these foods may appear privately profitable if domestic prices are maintained at levels higher than world prices, there is some disagreement over the importance of attaining complete self-sufficiency if this involves local production which is economically very inefficient when output is valued at world prices. Finally, there is the question as to whether self-sufficiency in staple foods should be defined for the region 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 this goal as being defined at the national level. Regional organizations and donors, on the other hand, appear to see greater prospects for cooperation between countries, which might not have to be individually self-sufficient as long as this objective would be satisfied for the region as a whole. Thus there could be some specialization of production within the region, though transportation systems would have to be improved to permit more efficient distribution of food among countries.

The third major objective is the acceleration of economic and social development with particular emphasis on the least developed countries. As an economic goal this implies a growth of income, both in the present and in the future, and an increase in the equality of its distribution; as a social objective, it calls for the attainment of at least a minimum standard of nutrition, health, and education for each member of society.

Although these three objectives may sometimes be in conflict, as was suggested earlier, it is most likely to apply in the short run. Over a longer period the best way that the Sahelian countries can protect themselves in time of emergency or fulfill other objectives such as becoming self-sufficient in staple foods is by developing strong, viable economies which provide them with the resources needed to achieve these objectives. This can only occur with the acceleration of economic and social development.

B. The Current Economic Situation

The current economic situation in the Sahelian countries is represented by

their present status in relation to each of these three long-term development objectives.

1. Consequences of Emergency Drought Conditions.

The Sahelian countries are adversely affected in several ways by the periodic drought which affects the region. This was most recently seen following the sharp decline in rainfall in 1972 and 1973 after a relatively dry period from 1968 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 due to the decline in production, increased demand for government expenditures for famine relief, decreased savings as people try to maintain their consumption standards at the same time that their incomes are reduced, 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. These directly affect the welfare of the people concerned and 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 1. The loss of production of about 15 to 20 percent in the agricultural sector was very severe for people who are already very poor and who had already suffered a previous drop in production from 1971 to 1973. This average hides, moreover, important disparities between regions which resulted in some people losing virtually everything. The result was extensive human suffering and some loss of life. 1/

1/ Although information is scanty, that which exists indicates that human mortality related to the drought was much less than was at first feared. This was due not only to relief efforts but also to the tenaciousness and skill which the people of these countries have developed to survive a catastrophe of this magnitude. For an extensive discussion of the methods they used, see John C. Caldwell, The Sahelian Drought and its Demographic Implications, Overseas Liaison Committee, American Council on Education, Paper No. 8, December 1975.

TABLE I

Effects of Drought

	Chad	Mali	Mauritania	Niger	Senegal	Upper Volta
Change in Real Output 172-73 (%)						
GDP	n.a.	-6	+1	n.a.	-19	-9
Agriculture	n.a.	-21	-13	n.a.	-20	-16
Change in Govt. Revenue 1972-73 (%)	-13	+9	+10	-	+9	+11
Change in Current Govt. Expend. 1972-73 (%)	+2	+10	+33	+9	+8	+16
Change in Value of Exports 1972-73 (%)	-6	+11	n.a.	+1	-19	n.a.
Change in Current Account Surplus as a % of Imports						
1972-73	+22	-5	+7	n.a.	-11	+3
1973-74	-22	-35	-5	n.a.	+14	-45

Source: Elliot Berg, The Recent Economic Evolution of the Sahel, Center for Research on Economic Development, University of Michigan, June 1975.

There may also have been significant physiological damage to some children because of malnutrition during this period, which could have an effect on their future productivity. 2/ Finally, declines in the size of livestock herds and changes in their age/sex composition resulting from the drought will affect production of meat and milk for many years.

There were important indirect economic effects as well. Although government revenue actually decreased only in Chad, as seen in Table 1, the rate of increase for the other countries was generally less than it had been in previous years. In addition inflation accelerated to about 10-15 percent per year, and thus the real value of this revenue tended to decline. At the same time, current government expenditures, except for Senegal, grew more rapidly from 1972 to 1973 than did receipts, exacerbating the problem of budget deficits, especially in Chad and Mali. Furthermore, the rise in government salaries was greater than that of materials and supplies, indicating some decline in government effectiveness, a common phenomenon in time of fiscal pressure. With respect to exports, the drought had a decidedly depressing effect, especially considering that quantity declines, due to yield losses in some areas of 30 to 40 percent, were offset by commodity price increases on the world market and that the expansion of 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, 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. The deterioration in this balance was especially severe for Mali and Upper Volta. The effects on current account were offset somewhat, however, by debt cancellation and relief and by external emergency assistance of various sorts.

2/ Elliot Berg, The Recent Economic Evolution of the Sahel, Center for Research on Economic Development, University of Michigan, June 1975, p. 30.

One source of instability in foreign exchange earnings became especially apparent during the drought: concentration of exports on a few primary commodities. Senegal and Mauritania had the advantage of having minerals in addition to agricultural products or livestock as major exports. Though this did not directly benefit people outside the mining sector, it gave the governments additional access to public revenue and foreign exchange to help cope with the emergency. Upper Volta was also aided by substantial remittances from its workers in the coastal countries. 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 as well as weather conditions at home.

In comparison with past droughts of similar magnitude, especially that of 1913-14, the region seemed better able to protect itself in 1972-74. Whereas loss of livestock and shortfalls of crop production were very severe in some areas, this was partially due to the period of abundant rainfall during the 1950s and early 1960s which encouraged people to settle in normally drier areas and which allowed the livestock population to expand to the limits of the carrying capacity of the rangeland, a phenomenon which was also aided by improvements in animal health care and by water development. Human mortality was reduced during the drought, however, because "better roads, greater commercialization of the whole region, more awareness of what was happening assisted by modern communication and administration, national governments, and massive international relief efforts all helped the people's own efforts and reduced a potentially murderous period into a very painful one." 1/

2. Self-sufficiency in Essential Foods.

The situation with regard to self-sufficiency in essential foods differs markedly between countries. All except Senegal are net exporters of meat, primarily in the form of live animals. Each country, as seen in Table 2, imports some cereals, but imports are a much greater proportion of total consumption for Mauritania and Senegal than for the others. In addition, each has become increasingly dependent on cereal imports as measured by decreases in cereal self-sufficiency,

1/ Caldwell, p. 67.

TABLE 2

Indicators Related to the Objective of Self-Sufficiency in Essential Foods

		Chad	Mali	Mauritania	Niger	Senegal	Upper Volta
Self-Sufficiency in Cereals (%) a/							
1961-65		99	99	67	105	70	98
1969-71		98	97	51	99	66	96
Labor Productivity in Food Crops (kg/head) b/							
1961-65		276	228	88	246	211	180
1969-71		184	184	75	216	212	162
Average Yields (kg/ha)							
1961-65		761	750	375	464	573	489
1969-71		742	699	342	582	616	485
Cereal Aid and Imports (thousands of metric tons)							
1970:	Aid	-	-	7	4	2	-
	Imports	6	3	37	12	240	22
1972:	Aid	7	19	25	3	8	4
	Imports	12	26	32	12	424	33
Composition of Imports 1970-72 (%)							
Food/total		17	20	n.a.	n.a.	28	n.a.
Cereals/Food		21	20	n.a.	n.a.	42	n.a.
Wheat & Flour/ Cereals		95	52	28	55	31	93
Rice/Cereals		-	14	56	-	58	7

Notes: a/ Production minus exports divided by total consumption.
b/ Net weight of staple foods produced per head of rural population.

Sources: FAO Yearbooks; World Bank estimates; Food Aid Bulletin, 1971-74; IMF Directions of Trade and International Financial Statistics; UN Statistical Bulletin, July 1973; DAC (74) 27.

defined as production minus exports divided by total consumption, from 1961-65 to 1969-71, years of relatively average rainfall.

Paralleling this decline was an apparently marked decrease in average food production per member of the rural population. Although data on agricultural production and population are not very reliable, the evidence for this conclusion is very pervasive with regard to both the magnitude of the phenomenon and its widespread occurrence. On the average the decline measured about 16 percent throughout the region. The reasons for this are not known. It does not appear to have been due to a fall in yields since they decreased in some countries but increased in others at the same time that the area allocated to food crops was expanded in all countries except Chad. One possibility is that more labor was allocated to cash crops, such as peanuts and cotton. Another is that greater numbers of people of working age may have been away during the growing season, possibly working as wage laborers in the coastal countries. Finally, in some areas such as part of Upper Volta there is a scarcity of good farm land which may have resulted in a decline in labor productivity even if yields did not fall.

Whatever the causes, the implication is clear that urban demand for food was being met only partially by local production, the rest being furnished by purchased imports, or, increasingly, by food aid. From 1970 to 1972, before the effects of the drought were fully apparent, imports of cereal into the region increased by 68 percent, and food aid grew by 5 times. As seen in the Table 2 a large proportion of these imports was wheat and rice, foods which are consumed in relatively greater quantities in urban than in rural areas and for which there is a relatively high income elasticity of demand. Unless this trend can be reversed so that per capita food production in rural areas expands to supply the growing urban market, imports of these as well as other foods can be expected to increase in the future since the urban population is projected to grow at about 4.7 percent per year in comparison with an anticipated annual growth rate of the rural population of 1.7 percent. 1/

1/Caldwell, p. 71.

TABLE 3

Indicators of Current Living Standards, About 1972

	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
Literacy (%)	5-10	5	1-5	5	5-10	5-10
Student Enrollment (%)	14	12	10	6	23	6
Life Expectancy (yrs.)	40	38	42	43	44	35

Source: U.S. Agency for International Development, Development Assistance Program 1976-1980: Central-West African Region, Vol. 1: Overview and Program Conclusions, November 1975, p. 6.

3. Present Living Standards and Recent Economic Growth.

The countries of the Sahel are among the poorest in the world. As shown in Table 3, annual per capita GDP in four of these countries ranged in 1972 from $70 in Mali and Upper Volta to $120 in Niger. Mauritania, with $175, is more favored only because of its rich iron ore deposits. Neglecting revenue from this source, its per capita GDP was only $125 per year. Further more, 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, though most of this is narrowly concentrated in the region of Dakar.

With the exception of Mauritania and Senegal, 89 percent or more of the work force is in agriculture. Even in Senegal agriculture accounts for 76 percent of total employment. Thus more 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, compared with the LDC average of 427 kilograms, in all the countries except Mauritania and Senegal. This indicates a very low level of labor productivity and of the stock of capital.

Table 2 also shows several other indicators of human welfare and productivity. Literacy rates are very low, only 1 to 10 percent of the population being able to read and write. Prospects for improving this situation in the near future are also relatively poor given that only in Senegal are as many as 23 percent of children from 5 to 19 years of age attending school. Finally, as an indicator of the lack of nutrition and health which exists in these countries, estimated life

expectancy at birth varies from 35 to 44 years of age. The data on mortality levels are very weak, however, and only in Senegal is it likely that life expectancy is, in fact, greater than 40. Infant mortality rates are generally very high, perhaps 225 per thousand. Furthermore, mortality appears to be declining only very slowly in these countries.1/

The growth performance of the Sahelian countries during the decade prior to the drought, as shown in Table 4, was very poor. Except for Mauritania with its rapid development of iron ore exports, all the countries experienced little if any increase in per capita GDP. Even Mauritania's growth was largely confined to a small mining enclave and did not improve living standards for a broad segment of the population. The reasons for this poor performance appear to be based primarily on the slow growth of crop production. Groundnut exports increased between 1963 and 1970 by 7 percent per annum in Niger and by 2/ 35 percent in Upper Volta, but they fell in Mali and Senegal. Food production also remained stagnant. The only other bright spots were the success of cotton extension programs 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 improvements in animal health care and water development.

Producer prices remained relatively stagnant, at least until 1970 when the price of livestock began to rise. Since prices of goods purchased by farmers increased throughout the 1960s, there was a decline in rural living standards in most areas, with per capita returns on cash crops decreasing by perhaps 30 to 60 percent. Wage earners in the cities fared somewhat better, though it is doubtful if average earnings kept pace with the increased cost of living. 3/

1/Caldwell, p. 9.
2/Berg, p. 14.
3/Berg, p. 18

TABLE 4

Average Annual (%) Rates of Growth, 1960-70

	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

Source: Elliott Berg, The Recent Economic Evolution of the Sahel Center for Research in Economic Development, University of Michigan June 1975, pp. 11, 12.

C. Constraints on Attainment 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, existing domestic marketing and storage systems, 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, such as infrastructure and levels of health and education, can be altered by the government over time. Others, such as those related to the social and demographic structure, are less amenable to deliberate manipulation. Finally, there are the natural constraints of geography which cannot be changed at all. At any particular moment, however, each of these constraints can limit the pursuit of national objectives and thus determine which strategies are or are not appropriate. Details concerning many of the constraints are given later in this report. Only some central elements are summarized here.

1. Natural Conditions.

The major constraint is the low quantity and high variability of rainfall, each of which becomes more pronounced as one moves from south to north. The region is characterized by cyclical periods of drought, and the short period during which agriculture is possible even in normal years 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 essentially poor, lacking in many cases essential nutrients such as phosphates and nitrogen. Except in a few cases, known mineral deposits are of poor quality. The region is fortunate in having several extensive river basins, but these are not easily exploitable with large-scale development projects. Finally, with the exception of a few crowded areas, population density is generally low, and land is readily available except where restricted by the prevalance of disease in some of the of the richer areas near rivers and in the higher rainfall zones. The low density of population, however, increases the per capita cost of transportation and the provision of public services in rural areas.

The natural environment has not been uninfluenced by man. Population growth has resulted in a shortening of fallow periods and a consequent reduction in soil fertility. Relatively abundant rainfall and the development of new sources of groundwater during the 1950s and early 1960s led to an extension of cultivation into marginal areas with resulting destruction of vegetation and erosion of soil. The expansion of livestock herds during the same period and the breakdown of traditional authority in controlling the use of the rangeland led to overgrazing and the depletion of pasture, making these areas vulnerable to drought and desertification. Finally, increased demand for firewood associated with growing population and urbanization has resulted in considerable loss of bush and tree cover, especially near settled areas.

2. Infrastructure.

The extensive area covered by the Sahelian rural population and long distances to markets combined with limited resources in the past for investment have resulted in a transportation and communications system which is very inadequate for the development of the region. Grain surpluses in one area cannot be moved economically to others where there is a deficit, and the cost of transporting food and other products to and from the coast is very high. 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.

3. Human Resources.

Levels of health, nutrition, and education are generally poor. There is a high incidence of mortality and morbidity. Nomadic populations especially suffer from a lack of available medical services. Malnutrition is common among younger children. 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 large proportions of government budgets are currently going to education, the effort is not sufficient to support the pace of development desired.

4. 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 they can also inhibit individual initiative. Of special relevance is the pastoral tradition of subsistence production which can conflict with the use of herds for their output 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 urgent problem of overgrazing resulting from the breakdown of traditional social authority in controlling the use of the rangeland.

5. Population. Although its density is generally low, population growth is likely to accelerate to about 2.5 percent per year by the end of this century, and this may inhibit development in several ways. First, it limits the capacity of these economies to provide each member of the population with increasing amounts of capital. Second, it creates an age structure in which as much as 50 percent of the population is under 16 years, increasing the demand for food as well as for education, health, and other public services without a commensurate increase in production. Third, it creates growing pressure on the land in some areas, which requires relatively rapid intensification of agriculture or outmigration. The latter will also be accenturated to the extent that the Sahel is unable to support increasing numbers of people, and they choose instead to settle in higher rainfall areas. Finally, an anticipated urban growth rate of close to 5 percent per annum will increase rapidly the demand for marketed goods, public services, and wage employment.

6. Domestic Markets and Storage.

Most food in the Sahelian countries is both produced and consumed on the farm. Except in Senegal, urban demand for food is relatively unimportant in relation to total production. The commercial system for supplying urban markets with domestically produced foods is not well developed, therefore, and costs of distribution are relatively high. Seasonal storage of grain by farmers and traders appears to be reasonably efficient, although seasonal price differentials tend to exceed storage costs somewhat. Interannual storage is clearly inadequate, however, as indicated by large year to year differences in prices. This is because fluctuations in yields are very great, and thus storage capacity would have to be quite large to significantly reduce year to year price fluctuations. Farmers in some areas hold very large stocks, but storage in other areas is much smaller in relation to need. Only exceptionally are there stocks anywhere which would be adequate to sustain consumption at normal levels during periods of prolonged and severe drought, such as that which occurred from 1968 to 1973.

7. Exterior Markets.

The Sahelian countries have opportunities to buy and sell goods and services abroad. They are fortunate in having relatively favorable market prospects for their major exports, especially cotton and livestock. Although the latter may be subject to greater competition from third world meat exporters.[1/] Prices of grains, their major food import, are expected to fall somewhat in relation to those of their agricultural exports. The situation with regard to mineral exports of iron ore, copper, uranium, and phosphates is also promising over the long run. On the import side, they have experienced major price increases in recent years. These should slow, however, as inflation is brought under control in the industrial countries. Finally, most of the Sahelian nations export labor on either a temporary or permanent basis to the coastal countries, where opportunities for employment exist. Their ability to continue doing this in the future will, of course, depend on the host countries' willingness to accept this source of additional labor.

1/ The discussion here is based on World Bank price projections for the next ten years.

8. State of Knowledge. The current state of knowledge varies markedly between sectors. It is probably greatest in cash crop agriculture, where research and development have been going on for many years. It is less extensive for food crops since this area was much neglected in the past. Nevertheless, there exist known profitable technical improvements involving the integrated development of cash and food crops, both for dryland farming and for small-scale irrigation. These include the introduction of improved seed varieties, the use of fertilizers and other current inputs, the development of small scale water control, and the employment of oxen and related equipment. There also is a technical package of pasture improvement and management for the Sudanian zone which is being developed in Upper Volta. No similar package, however, yet exists which could be applied in the Sahel. For fishing, a low-cost chemical preservative has been recently developed which could substantially reduce loss due to insect damage.

Of equal importance, there is being developed at present in these countries institutional structures in the form of semi-autonomous, state-owned, rural development corporations, which serve as a conduit for the exchange of information between farmer and experiment station. As with research and development, this structure is more fully elaborated for cash crops than for food crops and livestock. This is especially true in Senegal where groundnuts have been cultivated as a cash crop since the nineteenth century, but extensive work has also been done in Mali and some of the other countries to promote and to improve the cultivation of groundnuts and cotton.

There is less useable knowledge available at present for rational development of the river basins, though more is known about the Senegal River than about either the Niger River or Lake Chad. In each of the basins there are fundamental studies and surveys yet to be made which are essential

to rational planning for the use of the water in these systems. There is more knowledge of geological conditions, but much remains to be done here as well. In other new technology areas, such as alternative sources of energy, data are even scarcer.

Studies are currently being conducted of the comparative economic cost of various agricultural and industrial activities in two Sahelian countries, Mali and Senegal.1/ These indicate that agriculture and livestock are generally much more economically viable than industry and within agriculture, that production of export crops is more profitable than that of cereals. Including food crops in rotation with groundnuts and cotton, however, is quite efficient, especially if combined with livestock in mixed farming. Industry also tends to use much more capital-intensive techniques than does agriculture, except in the informal small-scale sector. Despite generally high costs, there are certain modern industrial activities, such as textiles and some types of food processing, which appear to be quite profitable and could probably supply exports to the world market.

9. Government Policies.

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 which results from a poor resource endowment and low level of economic development. It also exists because of 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.

A second constraint on agricultural development is related to government influence on the prices received by farmers and herdsmen. For a variety of reasons, including the desire on the part of government for export tax revenue and political

1/ World Bank studies in progress.

pressures to keep food prices low for urban consumers, the prices received by farmers in the past have been generally low in relation both to their levels on world markets and to prices of manufactured goods.1/ One result was lower real income of rural producers, which discouraged investment in agriculture and slowed the expansion of production. Another was to encourage the consumption of imported foods, especially rice and wheat in Senegal and Mauritania. Although producer prices were raised quite substantially during 1973-1975, the effects of these price increases have been eroded somewhat by inflation, and the danger of maintaining too low levels of producer prices remains. At the same time, manufacturing activity is usually protected from competing imports and granted direct incentives such as tax holidays and subsidized credit. 2/ In the case of public enterprises, direct subsidies are often substantial. All this enables industrial activities to exist despite their frequent high economic cost and to draw resources away from agriculture.

One of the effects of low incomes 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, in their most productive years, leaving behind people who are least able to undertake rural development. Second, there frequently are not enough jobs available in the formal sector to employ all of 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 are a source of income and capital. These earnings also help to stabilize family consumption during poor agricultural years. 3/ 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 seems likely, though, that government policies concerning wage legislation, agricultural prices, etc., are important variables.

1/ Berg, pp 101, 02.
2/ World Bank study cited above.
3/ Caldwell, p. 53.

There is a rather unique monetary and fiscal system which exists in most of these countries. 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) both of which are members of the French franc area. In return for access to a common reserve pool (Compte d' Operations) and guaranteed convertability of their common CFA franc, these countries conform to explicit restrictions on their monetary and fiscal policies.
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, tend to favor foreign-owned operations at the expense of African entrepreneurs. 1/ This discourages the creation of financial intermediaries, which could be important for generating domestic savings and their investment in productive activities. Mail 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 in 1973, has the freedom to adjust its credit policies to promote local productive investment. While restrictions on the use of independent monetary and fiscal policy to stimulate economic activity and credit expansion could be detrimental for development, it has also been argued that the Sahelian economics are too small, open, 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.

1/ U.S. Agency for International Development, Development Assistance Program 1976-1980: Central-West African Region, Vol 1: Overview and Program conclusions, November 1975, p. 15.

D. Analysis of Possible Actions

There are a number of alternatives, but not mutually exclusive, actions which might be taken over the next few decades in pursuit of the various economic objections. In general, these actions 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 constraints listed above. Several of these actions are described and analyzed here.

1. **Concentrated development of food crop production on small-scale irrigated and dryland farms by the introduction of improved varieties, fertilizers, ox-drawn equipment, and other farm inputs and by the establishment of a system of support services including credit.**

This action would most effectively work toward achieving the objecti of self-sufficiency in staple foods. To the extent that surpluses were stored and preserved, it would also help to avoid the worst effects of future drought. As an isolated action, however, it has several important disadvantages.

First, except for rice, the technology of foodcrop production is less advanced than that of cash crops. Relatively little work has been done , especially at the local level, n developing and adapting new varieties of millet and sorghum, the major food crops. There is an urgent need, for example, to come up with a short-cycle variety of millet so as to reduce the susceptibility of that crop to shortened periods of rainfall. In addition, **the responsiveness of food crops to fertilizer in drier areas is still questionable. Finally, there is disagreement over the desirability of introducing ox-drawn techniques into foodcrop production in areas of marginal rainfall.**

Second, even if a viable technology package were available, it is questionable how the farmer would pay for his agricultural inputs in the absence of a cash crop. To be sure, he could

sell some surplus millet and sorghum on the local market, but this market is thin, and in good years the price is likely to fall to low levels. 1/ Farmers, in fact, 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 may sell the surplus on the local market. In addition, he could be forced to sell some grain at harvest time for needed cash. In either case, the excess grain sold tends to depress the local price. As a result, there is a disincentive for the farmer to deliberately expand his production of millet and sorghum as a cash crop. If rainfall is good, he receives a low price; if it is bad, he needs 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 for sale to take advantage of high prices in poor years. While this will enable him to pay for purchased inputs under these conditions, he will have trouble in years of abundant harvest if food prices fall to very low levels.

1/ As was true in Mali in early 1976, for example, when the price of millet fell to 13 Malian francs compared with close to 150 francs during the heights of the drought. The figures on self-sufficiency in Table 2 indicate, in fact, that a production increase of less than 5 percent in fairly normal years such as 1969-71 would satisfy excess consumption requirements. This, of course, makes no allowance for caloric deficiencies which exist or for the increase in consumption that mignt occur as prices fell.

As an alternative to storing very large quanitities of grain, the farmer may prefer instead to shift land and labor at the margin between food and cash crops so as to take advantage of changes in their relative prices, keeping always in mind the size of grain stocks he has on hand. If this is his behavior, increases in productivity for food crops will probably not result in a substantial expansion in their output, since this would likely be accompanied by a decline in price. Rather, farmers will respond by reallocating land and labor released by the new technology into cash crop production. While this will help the farmer to pay for purchased inputs, it raises the question of whether development efforts should not be concentrated on introducing techniques which yield the highest return regardless of whether they apply to food or to cash crops.

In some areas it may be difficult or impossible to produce cash crops, either because of poor natural conditions or because of inaccessability to transport. Farmers in these drier, more remote areas are, unfortunately, those most vulnerable to drought. Here the solution seems to be in developing low cost techniques of **conserving water and preserving or improving soil fertility, such as the use of rock phosphate and rotations** involving legumes to fix nitrogen in the soil. The use of rock phosphate already appears to be feasible, and appropriate steps should be initiated to take advantage of this resource.

2. **Extensive development of small-scale irrigated and dryland integrated production of cash and food crops, together with mixed farming, by the introduction of existing and future technical packages and the development of systems for supply-necessary production inputs and credit.**

This is probably the most effective approach currently available to raise rural incomes for a large number of farmers. Because it involves the joint production of food crops and cash crops, often in rotation, it also is an important means of promoting self-sufficiency in staple foods. The fact that food crops

can make use of the residual effect of fertilizers on land previously devoted to cash crops and that ox-drawn equipment purchased for cash crops can also be employed for food crop production implies that payment for these inputs does not have to depend on the proceeds earned from the sale of food crops. With respect to the other objective, mitigating the consequences of future emergencies, 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 when flooding does not occur. Or fertilizers which raise yields in average years may actually decrease net farm income in poor ones because of the additional costs incurred. 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 which preserves moisture.

The major constraint affecting this strategy is the current lack of trained administrators and technicians who will be needed if rural development institutions are going to be developed and extended to most farmers in the Sahelian countries. There is therefore an urgent need to increase the capacity of these countries to train people in relevant skills. Inadequate transportation, health, and rural education are also important constraints, but these can be eased somewhat by integrating projects in these areas into agricultural development programs under a unified administrative and financial authority. It is important, too, that price policies in these countries provide adequate farmer incentives if rural development programs are to succeed.

This approach is applicable primarily to the more accessible, higher rainfall areas where cash crops can be profitably grown. Many people in drier, more remote regions have been relatively unaffected by past efforts to promote the production of crops for export. Some of these are able to earn cash income from the sale of animals and their milk; others would benefit from greater development of the transportation system. But the cost of extending integrated rural development schemes to some such areas would be very high, and in some

cases probably prohibitive, especially if continuing recurrent subsidies are to be avoided. In addition, it may not be desireable to encourage people to live in very marginal areas because of the damage to the environment which they may cause. Consequently, it is likely that some people will continue to remain outside the cash economy unless they resettle in richer, more accessible areas.

3. Develop extensive and semi-intensive livestock production through water development, pasture improvement, range management, and improved animal husbandry and health practices. In the Sudanian zone, a technical package based on pasture improvement and management is soon to be applied in Upper Volta; a similar package has not yet been developed for the Sahel. On the other hand, there is some scope in the Sahel for water development. This must be accompanied, however, by measures to prevent overgrazing. Interventions which develop extensive and semi-intensive forms of livestock production appear generally to have high economic rates of return and to substantially increase earnings of foreign exchange. They also help to assure self-sufficiency in meat production, though this is of greater interest to Senegal than to the other countries, which are all net exporters of livestock. Even these are concerned, however, by the effects on consumers of rising meat prices resulting from the failure of local supply to keep pace with demand in West Africa. The expansion of production and especially the control of overgrazing would also help to mitigate the effects of future emergencies by providing a greater wealth base upon which the herdsman could draw.

Extension of livestock services run into many of the same constraints as agricultural development, such as lack of trained manpower, inadequate infrastructure, and inaccessability of the population. The solutions appear to be similar, including training programs, road construction and implementation of integrated rural development schemes. In addition, there are important problems posed by the large cultural gap which separates herdsmen and government livestock services and by the difficulty of finding ways in which pastoral people can contribute financially and politically to these programs. Finally, there is the crucial problem of finding

ways to persuade people who do not privately own their own land to engage voluntarily in range management programs which may not always seem to be in their immediate self-interest.

4. 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 interventions could be made. Deterioration of fish due to insect damage, which results in losses of 30-50 percent of the catch, may be amenable to solution through the use of a recently developed, low-cost chemical perservative. Substantial gains could also probably be achieved through fishery management, but there is presently a severe lack of trained personnel. There is also a general need for capital and infrastructure to be channeled into this sector. In addition, the establishment of fish ponds appears to be a potentially profitable activity. One advantage of developing the fish industry is that it would help to achieve all three major objectives. Better fishery management and the establishment of fish ponds would provide some protection against drought; expanded production would help to reverse the decline in exports which has characterized much of the region in recent years; increased catches and improved preservation would aid in accelerating economic and social development, especially in some of the poorer areas of the region, where fishing is an important activity.

5. Promote local production of the major imported grains, wheat and rice, as a substitute for imports. As shown earlier in Table 2, wheat and rice account for between 55 and 100 percent of total cereal imports into the Sahelian countries. These imports are already a large proportion of total consumption in Senegal and Mauritania and are projected to grow rapidly in the future for all of the countries. If self-sufficiency is defined to include these grains, the achievement of this objective means that imports will have to be replaced by local production. This might be accomplished using a variety of irrigated and dryfarming techniques. In contrast to millet and sorghum, the governments can regulate domestic prices of these imported grains by applying import duties, subsidies, or restrictions and by using foreign

exchange reserves as a buffer against fluctuations in prices on the world market. Producer prices, plus any direct subsidies or development programs, could therefore be used to encourage increased production as a substitute for imports.1/ In addition, higher domestic prices would also reduce imports by discouraging consumption. This would shift demand in the direction of alternative food staples, such as millet and sorghum, causing prices of these to rise, thus stimulating their local production. Higher domestic prices for food grains would not, however, be welcomed by consumers.

Recent estimates of the real economic cost of producing wheat and rice in two of the Sahelian countries, Mali and Senegal, indicate that it would be more efficient to expand imports of groundnuts, cotton and livestock in order to earn foreign exchange to purchase these cereals on the world market.2/ Thus self-sufficiency in all cereals including rice and wheat would be accompanied by some loss with respect to the third objective of accelerating economic and social development because of higher costs of this form of import substitution. The situation varies between countries, however, since interior countries such as Mali enjoy greater natural protection against imported cereals because of the relatively high cost of transporting them from the coastal ports. This makes import substitution in general a relatively more profitable activity for these countries than for Senegal and Mauritania. In addition, the cost of producing rice varies markedly with the region and type of production technique. There is, in fact, substantial scope for increasing domestic production in ways which are not much less efficient than producing export crops if high cost techniques involving mechanization and other expensive inputs are avoided. In addition, there are some areas, such as parts of the interior delta of Mali which cannot be used to produce export crops but which are suitable for growing wheat or rice.

1/ For the interior countries especially, smuggling might prevent the adoption of a price structure very different from those in neighboring countries.

2/ From a study in progress by the World Bank on the comparative cost and incentives of various agricultural and industrial activities in West Africa.

6. Develop intensive irrigated agriculture, river transport, and hydroelectric power made possible by large-scale river basin development. Water is critical to the survival of the Sahel. Three great river basins, largely untapped, exist within the region, but, despite more than a decade of study and experimentation by the Sahelian states, additional careful planning and detailed information are still required to reduce the risk of mismanagement which could destroy this great natural resource of the area. The gathering of this information should begin immediately to make it available as soon as possible as an input into planning for full development of the region since the economic viability and independence of the Sahelian states depends ultimately on the development of these basins for irrigated agriculture, reliable river transport, and hydroelectric power available for mining and industry.

In the interim, this large water resource can be broadly employed for irrigation in small-scale activities to increase agricultural production. The largest single impact on the lives of the farmer that additional water can provide is by ensuring that the rainy season crop has adequate moisture. Supplemental water provided from the major rivers and lakes, from wells, and from natural and man-made catchments 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-round irrigation.

Although irrigation, especially when combined with upstream storage, will substantially decrease the variability of yields normally associated with fluctuations in rainfall, it does not provide complete security if there is severe drought which lasts for several years in succession. In addition, it will only contribute to self-sufficiency in essential foods to the extent that these are grown on the irrigated land. Since the prices of most food crops are relatively low in these countries, high costs of maintenance and operation of irrigation works may require that cash crops also be grown in these areas. Finally, rates of return on large-scale irrigation and dam construction in the region are currently estimated to be relatively low. These may be expected to improve in the future, however, as the demand for power, transportation, and agricultural production increases. Thus the major contribution that large-scale

river basin development can make to the acceleration of economic growth probably will not be realized for a number of years. In addition, there are questions concerning the pace at which the kind of social change required by a radical transformation in agricultural techniques can and should take place. For all these reasons, major decisions concerning how river basin development is to proceed should probably not be made for some time. Nevertheless, a greatly enlarged program over the next fifteen years is essential to acquire additional data, to experiment with different crop varieties and techniques of irrigated agriculture, and to plan carefully for the ultimate full realization of the region's potential.

7. Invest extensively in mining and new technology activities such as solar energy. Where high quality mineral deposits exist in reasonably accessible area, such as the rich iron ore deposits of Mauritania, they can be an important source of income, government revenue, and foreign exchange. Mining employs relatively few people, and often leads to greater inequality in the distribution of income. One important advantage of mining activity is that it is not affected directly by drought and thus can be an important source of the foreign exchange needed to import food in the event of emergency. The major problem in the Sahelian countries 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, moreover, and further exploration is required. There are substantial reserves of rock phosphate, however, which could be mined at low cost and distributed to farmers to help overcome one of the principal nutrient deficiencies in the soil.

As shown earlier in Table 3, the use of inanimate energy in the Sahelian states is at very low levels. Ninety percent of total energy consumption for power and heat comes from wood. This has resulted in a serious depletion of trees, especially around urban areas. With a growing population, the region will have to find alternative

sources of energy. Yet with the high price of petroleum products on world markets and with limited foreign exchange earnings, these states have difficulty importing what they need. Existing known reserves of oil and gas are meager. One possibility consists of importing natural gas, which is currently being burned off, from Lybia or Algeria. Another is to purchase hydroelectric power from coastal countries which have excess capacity. Ultimately, of course, the regions own rivers can be expected to contribute to their power needs, but, as noted above, time is required to collect necessary data for river basin development. There is also a great potential for solar energy, though the appropriate technology is not yet available. Wind energy is another important possibility, with wider on-farm use an early investment priority. Implementation of new technologies for municipal and industrial power generation should also be undertaken on an experimental scale. In summary, it appears that the region has considerable energy potential, but there is need for a substantial program of research to develop new technologies that can effectively exploit that potential. These could substantially help to accelerate economic and social development and might even contribute to the other two objectives as well.

8. A major effort to industrialize, and thus to diversify the economy, by undertaking large public investments or by offering substantial incentives to private investment. Massive industrialization would do little to mitigate the consequences of future drought emergency or to increase self-sufficiency in staple foods. Furthermore, since it is not currently as economically profitable as investment in agriculture, in most instances forced industrialization would tend to retard rather than to accelerate economic and social development. Because of the limited employment it generates, concentration on industrial growth would also tend to make the distribution of income more uneven. Despite this, government policies in most countries act to artificially stimulate industrial investment by offering import protection, tax holidays, and other incentives.[1] While such policy measures generally are questionable, there are certain industries such as textiles and some food processing which are profitable and should probably be encouraged, even to the extent

1/ World Bank Study in progress cited previously.

of promoting their exports abroad. In this way a cadre of managers and skilled industrial workers can be build up as industrialization emerges.

9. Investment in extensive health and education programs in rural areas. It has frequently been argued that direct provision of welfare services 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 effectively in agricultural development programs. In addition, sustained rural development will require a healthy population with at least the minimum level of education necessary to adapt successfully to a changing environment. At the same time, however, it seems unwise to improve health and education of people without at the same time increasing their opportunity to be productively employed. In addition, the costs of extensive rural health and education programs are high, and some balance must therefore be maintained between these efforts to directly improve the people's welfare and interventions aimed primarily at increasing production.

One solution might involve including some aspects of health improvement and education together with agricultural development in integrated rural development programs. This has some advantages in terms of a simplified and somewhat decentralized administrative structure. In addition, it facilitates the financing of the programs, out of the increments of additional production which are achieved. If agricultural interventions include food crops, it also will help to assure that improved health is accompanied by better nutrition where required. The major disadvantage is that the objective of directly improving human welfare may be lost sight of if the major focus of the program is an agricultural development.

Whether it takes place within the context of integrated rural development schemes or not, there is an urgent need for major reform in the education system as it applies to rural areas. The curriculum of the formal primary system is oriented too much toward the French-speaking urban civil services and away from the preparation of skilled manpower for rural development. Substantial gains could

be made without large additional expenditures through curriculum reforms, applications of new techniques and methods, in service training of teachers and non-formal and adult education. Cost could be kept low, for example, if villagers contribute labor to the construction of buildings and perhaps augment teachers' salaries through food contributions. To the extent that the school and its staff serves the entire community and not just children of school age, the assumption by the village of a substantial portion of the monetary costs should also prove acceptable and help to insure the relevance of the school's program. There are also possibilities for expanding the use of non-formal education programs by radio in the region. This may be in fact, the most cost-effective way of reaching large numbers of people.

In the health sector, there is also a need to more effectively reach people living in rural areas. In addition, too much emphasis now seems to be placed on curative as opposed to preventative medicine. An integrated health system would include material and child health, family planning, nutrition education, communicable disease control, sanitation, potable water supply, and health education as well as curative activities. Effective delivery in rural areas might be achieved using village health workers backstopped by mobile teams operating out of rural dispensaries.

As noted earlier, the major advantage of effective education and health programs is that they contribute directly to the well-being of the people involved, especially if these are the poorest and least able to participate actively in development programs. In addition, they may also contribute indirectly to accelerating economic and social development if they help to increase worker productivity. With respect to the other objectives, a healthy population is certainly better able to resist the effects of food deprivation in time of emergency. Reduction of infant and child mortality combined with the use of family planning also makes more effective use of food in that more of those who only consume during their early years survive to become producers later, thus contributing to the goal of self-sufficiency. Finally, an educated population is better able to successfully adapt to a changing environment, thus helping to avoid some of the worst effects of drought.

10. Expand and improve transportation facilities in order to stimulate agricultural and commercial activity and to allow for the distribution of food in emergencies. Transportation plays a strategic role in rural development because without the possibility of moving goods and services cheaply to and from markets, farmers have little incentive to expand beyond production for their own subsistence needs. Criteria for evaluating transportation projects should therefore be broad and place special emphasis on this important role in accelerating the pace of economic and social development. In addition, the major constraint on achieving self-sufficiency in staple foods is probably the absence of a well developed commercial network to supply urban areas with food from the surrounding countryside. The construction and maintenance of an extensive road network, including feeder roads to villages, is a vital step. **Finally, adequate transportation infra-structure and equipment is an important prerequisite to lessen the effects of drought since it is essential for effective distribution of food in time of emergency.** The major factors inhibiting the development of the transportation sector are the absence of appropriate criteria for evaluating the developmental impact of roads and railroads and the limited capacity and resolve of the governments to provide adequate maintenance given their generally difficult budgetary situations.

11. Encourage migration of people out of areas of limited potential and into regions where the environment is more suitable for agricultural development. One of the important characteristics of the region is that it has areas which are very marginal in their capacity to support an expanding population. This is particularly true of the Sahel which is probably close to its maximinum carrying capacity today. There are, on the other hand, substantial underpopulated areas of higher rainfall to the south which could be used for agriculture and livestock. Disease, especially onchocerciasis and trypanosomiasis, is a problem in some of these areas, and eradication efforts currently underway should be continued and accelerated. Resettlement would contribute in an important way to reducing loss from drought because rainfall in these areas is not only more plentiful but also more regular than in more northerly zones. It would also help to increase food self-sufficiency by permitting greater yields to be obtained and by avoiding the pitfall of declining

soil fertility where population is growing in relation to the limited supply of available land. Finally, the greater potential of these regions implies that economic and social development would be accelerated. A problem in this approach is that where governments do not have the ability to regulate the use of these lands, resettlement may only follow traditional lines, in some cases benefitting mostly first settlers, rather than follow the best use of such lands. For this reason, some persons argue for solving land tenure, range control and major agricultural policy problems on presently settled lands before opening up these last great natural resources of the Sahel-Sudano Zone.

Migration also occurs to the coastal countries where there are profitable economic opportunities. The effect of this on reducing the risk of severe deprivation during drought appears to be beneficial because of the remittances which are returned and which provide an emergency source of income to families left behind. It is less clear, however, whether self-sufficiency in essential foods is enhanced or economic and social development accelerated over the long run. While productivity of the migrants probably increases, and some additional savings are made available to their home villages in the form of remittances, the people left behind are deprived of the services of workers in their most productive years. Finally, there is some question as to whether the coastal countries will allow this migration to continue unabated if it appears that jobs are being taken away from their local citizens.

12. Achieve self-sufficiency in the production of essential foods under all weather conditions by increasing grain reserves stored for emergency use. This approach would be 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.1/ 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

1/ The World Bank has estimated these costs at $2.82 million for capital investment and $435,000 for annual costs, including interest charges, per 10,000 tons of stored grain. During the 1972-73 drought over 1.2 million tons of grain were supplied to the Sahelian states from external sources. With growing population it appears as if at least 2 million tons would have to be stored by the year 2000 to maintain self-sufficiency under similar conditions. This would require a $564 million investment and would cost $87 million annually. If drought of this duration and magnitude occurred twice in each century, this implies that cumulative annual expenditures to avoid importing grain during each drought would average $4.35 billion.

fluctuating supplies, moreover, there is the possibility 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 their on-farm stocks of cereals. Most grain storage is done on the farm, and there appears to be opportunities for offering incentives and improvements which could increase the size of these stocks, though probably not to the levels necessary for truly catastrophic loss in the event of severe and prolonged drought. In addition, governments may wish to experiment with buffer stocks in an attempt to create greater seasonal or interyear stability of food prices. Ideally, this might be attempted at first without making any explicit commitment to support a guaranteed price since if there are large surpluses, such commitments usually prove to be useless and result in a loss of confidence of producers.1/ As experience is gained, the government may find itself capable of playing a more important role in mitigating the effects of drought. But the approach should be gradual rather than attempting to do too much too soon without adequate experience.

13. 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 catastrophic drought.2/ Though at first glance it may appear to be less

1/ The world's experience in managing foreign exchange rates may be relevant here. The system which existed until 1971 in which governments made explicit commitments to defend particular rates broke down when their capacity to do so was clearly insufficient relative to the magnitude of the task. It was replaced by a system in which rates are allowed to fluctuate. Central banks intervene as necessary to preserve orderly exchange market conditions but do not commit themselves to specific rates, thereby avoiding having to counteract the full pressure of speculation. Although perhaps not perfect, the present system has on enormous advantage over the system of fixed exchange rates--it works.

2/ The World Bank has suggested that a reasonable target would be 120,000 tons of grains stored for emergency use. Given the cost per 10,000 tons noted above, this would require $33.84 million in capital investment and $5.22 million to be expended annually.

effective than storage in minimizing risk, 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 limited present capacity for effective administration . But the coincidence, such as occurred during 1972-1974, of very high world prices of grain and catastrophic drought is unlikely to be repeated. Furthermore, to the extent that grain is purchased out of foreign exchange reserves or is obtained as part of an international insurance program, dependency on concessionary food aid is reduced, though of course self-sufficiency in staple foods, if defined to apply to all situations, is not preserved. The major constraint is probably in the transportation sector because of the inadequate facilities which exist for transporting large quantities of food from the coastal ports to when it would be needed in the interior. 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 activities.

E. A Proposed Strategy

The long-term development strategy for the Sahel must be formulated collaboratively by the external donors and the African countries and organizations. A framework for designing that strategy has already been suggested, and several alternative, but not mutually exclusive, actions have been analyzed within the context of that framework. Out of this analysis come certain conclusions regarding the desirability, feasibility, and timing of these approaches, which, when taken together, suggest a strategy offered here as a proposal.

The essence of this strategy is that it calls for a number of actions to be taken in a phased sequence which takes into account both the essential timing of activities required for rational investment and the uncertainty implicit in all long-range planning. For the next fifteen years or so, it is proposed to concentrate productive investment on dryland and small-scale irrigated agriculture, livestock, and fishing. During this period there would also be a heavy investment in experimentation, gathering of information, and the establishment of the human and physical infrastructure necessary for the next stage. Phase Two would center on development of the river basins for multi-purpose use and on the exploitation of new technologies and mineral deposits which have been discovered. Finally, a third phase of development is perceived, beginning early in the

next century, when concessional aid would be first reduced and then eliminated and when full-scale industrialization would be initiated.

1. Phase One

Productive investment during this phase will be most profitable if concentrated on dryland and small-scale irrigated farming, livestock, and fishing. This might be best accomplished using an integrated rural development approach involving investment of both cash and food crops, as well as of livestock and fishing where feasible, and accompanied by complementary investments in transportation health, and education under a unified administrative authority. Experience has indicated that the application of known technology can result in modest increases in production per farm spread over large numbers of people, when viewed from the region as a whole, this implies a substantial overall expansion of output. Although ultimately constrained by the high cost of reaching farmers in drier and more remote regions, the development of small and medium sized farms is today still the most efficient known way 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 would serve as a vehicle for developing the institutions required to link the farmer with the research and development being conducted in this area, thus contributing 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 best strategy in this area would be to experiment with numerous pilot projects in order to develop an effective package for later diffusion throughout the zone. In the higher rainfall Sudanian zone, on the other hand, a suitable package consisting of pasture improvement and management is already being developed and introduced. Assuming this effort succeeds, it should be duplicated elsewhere in the zone. 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 government livestock services and of allowing the former to participate in the conception, financing, and implementation of these programs. As an alternative source of protein, fishing, also offers attractive investment opportunities during this phase of development.

In particular, the introduction of a recently discovered low-cost chemical preservative could avoid substantial deterioration of the catch due to insect damage, and the establishment of fish ponds appears also to be worthwhile.

As far as river basins development through large-scale multi-purpose projects is concerned, the first priority is for an urgent program of basic data gathering. This would include the establishment of networks of rainfall and river gauge stations, the undertaking of extensive ground-water studies, the assessment of environmental factors, a detailed mapping of the basins, and a full survey of fishing resources and mineral deposits in the area. In addition, there should be a series of pilot projects which would experiment with and evaluate alternative methods of irrigation, crop varieties, and organizational systems. Some progress already has been made in this direction, especially in the Senegal River basin, but there is much more to be done.

While this information is being gathered and experiments conducted, the large water resources of the basins can be employed for irrigation in small-scale activities on hundreds of thousands of hectares. Supplemental water, which can be critical for the rainy-season crop, is available from wells, natural and man-made ponds, and the diversion of unregulated river flows. In addition, it is possible in some areas to plant two crops using water which is pumped or otherwise diverted during the dry season. All this would provide experience vital to the development of large-scale irrigation once upstream regulation is available.

Phase One would also be a period of massive investment to train people in all skills, since lack of trained manpower capable of conceiving, elaborating, and implementing projects, policies, and programs is perhaps the major constraint inhibiting development of every sector in the Sahel. An important effort would be made to involve farmers and herdsmen directly in programs of agricultural and livestock development, and extension workers, veterinary assistants, and cooperative managers would be drawn directly from their ranks so that training would take place in the community and among the people who are to be reached. In addition, basic education systems would be reformed and made more directly relevant to the tasks of development. Health services would also be developed and improved so that major debilitating diseases could be controlled, increasing the productivity of the population and improving levels of well-being. Current efforts to rid the high rainfall areas of diseases such as onchocerciasis and trypanosomiaisis would also be continued. Finally, there would be a major effort to gather demographic, nutritional, and health data on the population as a prelude to future economic and social planning.

The first development phase would also see substantial investments made in the construction and maintenance of transportation infrastructure, especially roads and railroads. This would open up new markets and services of supply, reduce the cost of marketing food crops, and increase communications necessary to develop all sectors of the economy. In addition, it would facilitate the distribution of food to remote regions in the event of emergency.

Major investments would also be made during this phase in research and development related to livestock, fishing, mining, and industry, in addition to that described earlier which is necessary for rational development of the river basins. This would create a sustained flow of technological innovation and would contribute to the solution of specific problems, such as finding a technical package for livestock in the Sahel or developing a short-cycle variety of millet. It might also lead to revolutionary advances associated with new technology, as in the field of solar energy. Only if a substantial, broad, and sustained effort is made in all these directions will the potential of these countries be fully revealed.

Actions taken during this phase would offer increased protection against the effects of moderate fluctuations in rainfall and would even improve the ability of people to avoid severe deprivation due to prolonged drought. This would occur because of improved techniques and seed varieties introduced into dryland and irrigated agriculture and because of the expansion of land under small-scale irrigation. It would also occur if incentives and improvements were offered to increase on-farm storage. There is at present, however, probably 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. Consequently, as part of the strategy, grain reserves would be stored in the country at levels sufficient to sustain the population until imported foods could arrive and be distributed. Foreign exchange reserves would also be accumulated or other arrangements worked out with donors for the purpose of importing food from the rest of the world in the event of need, and studies would be initiated to examine the costs and benefits of holding and distributing emergency reserves of foreign exchange, cereals, water, and animal feed in alternative ways.

2. Phase Two. Depending on the outcome of the research and experimentation of the first phase, development during Phase Two would be concentrated on efficiently exploiting the major natural resources of the region. Foremost among these are

the river basins, but profitable opportunities for mining and the use of solar energy or other new technologies might also be discovered during the earlier phase. It has been estimated that close to 4 million hectures in the region might be eventually be brought under irrigation. This could be started on a large scale once the first upstream storage dams have been constructed towards the end of this century, but full development of the irrigation potential would not take place until the twenty-first century.

Phase Two would also see a continuation of efforts to develop dryland agriculture and livestock, but it is likely that interventions in this sector would be subject to diminishing returns as programs are extended to increasingly marginal and inaccessible areas. A major effort would thus be devoted to encouraging resettlement in higher rainfall areas cleared of disease or on the land being brought under irrigation. Development of human resources, infrastructure, and research capacity would also be continued suring this phase.

3. Phase Three. By the early part of the twenty-first century, the Sahelian states should have the level of resources, both human and material, which would enable them to begin decreasing the concessionary element of foreign assistance until they reach the point at which they no longer would be dependent on donor foreign countries for aid. This would mark the end of the special "club" relationship between donors and countries. It would also mark the beginning of an era in which African regional planning and cooperation would play an increasingly important role. This would be the phase, too, when industrial growth would be initiated on a large scale. While some industry could effectively complement agricultural development during Phases One and Two, the more important contribution during this period would be in laying the basis for later industrialization. This would occur through the skills created in existing and some new industry, through the expansion of the market for manufactured goods, and through laying the groundwork for the development of new sources of power. By this third phase, moreover, the Sahelian countries should be in a position to concentrate on the development of industry within the framework of an integrated regional and international economic system.

F. Sociological Considerations

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 strategy 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 population;

-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 AID strategy emphasizes "development from below" which is based on existing strengths and capacities of the population. It ecourages complimentarity rather than competition through an natural specialization and, efficient exchange of goods and services. To see the full importance of this we should examine further the complex societies.

1. <u>The Sahelian Farmers</u>

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.

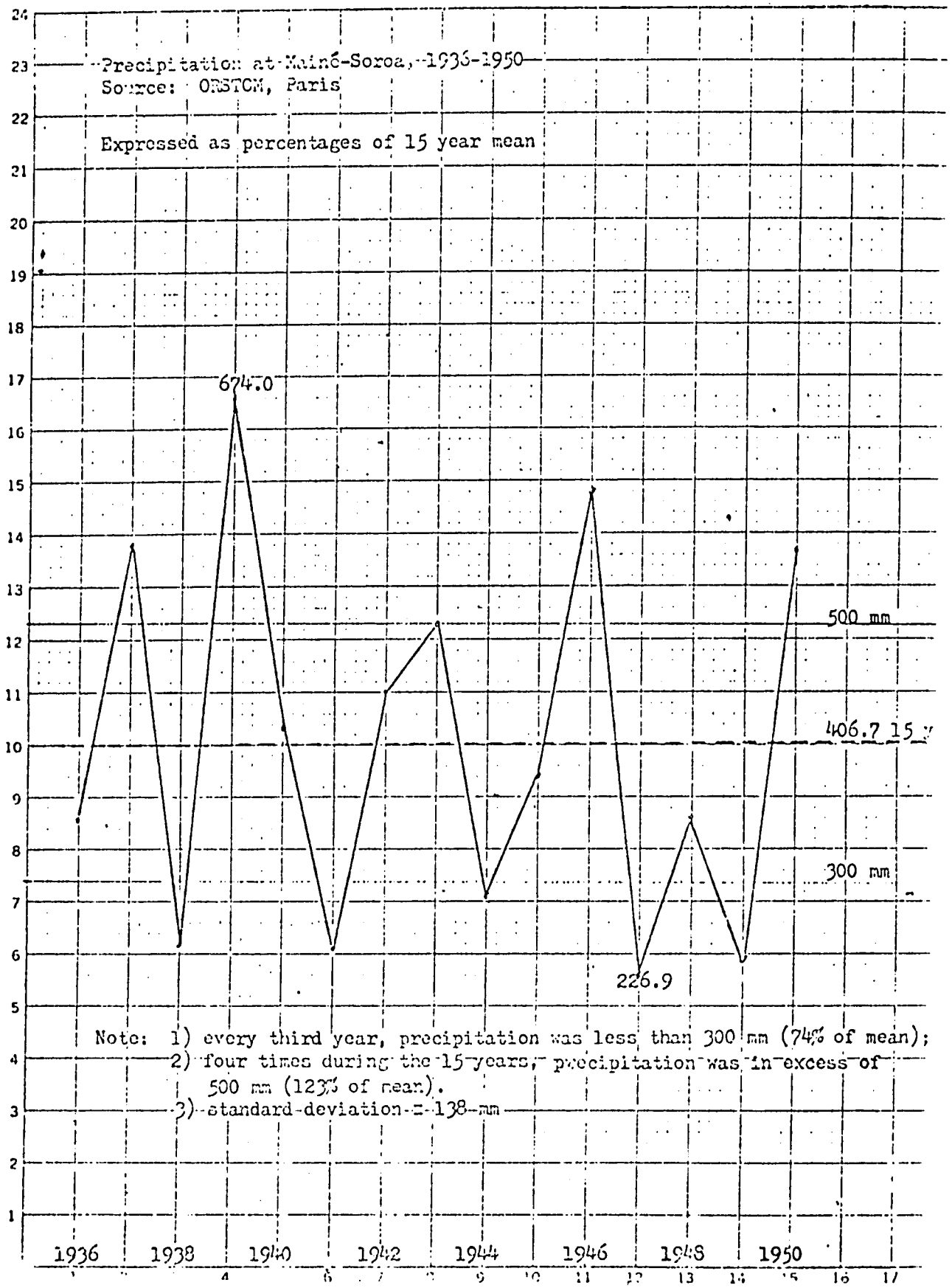
The farmer's task is to allocate his resources (labor, land, tools) to assure himself and his household of having sufficient food for home consumption and sufficient cash to pay taxes and provide items which cannot be locally produced. In the more arid parts of the region, harvests are unlikely to be 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 granaries in which the surplus production of a good year are stored.

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 harvest is plentiful, providing the cushion for the deficit years.

Where rainfall is sufficient, and where marketing facilities 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, 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 judgment. In other cases prices have 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 technical 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.



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

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 homogenous 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 the 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 transhumant pastoralists.

Farmers recognize the nitrogen fixing contribution of certain trees, notably the <u>acacia albida</u>, or "<u>gao</u>." 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 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 likely 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 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 peoples. 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 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.

2. 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 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 almost 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 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 water, and different capacities to cover distance on the ground. Some of them are resistant to diseases to which others readily succumb. 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 socioeconomic activity of the 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 combined 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 methods. 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 "subsistence 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 supporting 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 a 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.

G. The Role of External Assistance.

A framework for the design of a long-term development strategy in the Sahel has been suggested and a possible strategy proposed. What are the implications for the amount and type of external assistance required if such a strategy were to be implemented?

The answer to this question depends in part on the pace at which the strategy could be implemented if capital and foreign exchange were not a constraint. This pace would likely be determined principally by five limiting factors: (1) technical constraints with respect to the required 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 more of them; (3) the degree to which the countries are willing to allow expatriate personnel to fill this human resource gap; (4) their ability to amass the domestic resources required for investment and essential recurrent public expenditures; (5) the speed at which people are desirous of or willing to have their lives altered by development efforts. Although it is impossible to predict accurately

just how rapidly these constraints would permit the strategy to be implemented, for purposes of estimation we have assumed that by the early part of the next century more than 3 million farms, involving a total of 14 million hectares of dry farming and 500,000 hectares of irrigated agriculture, as well as 6 million pastoralists would be covered by some form of functioning rural development scheme, though this coverage would probably be very rudimentary for the more remote farms and for many of the pastoralists.[1] In addition, all the major hydrometeorological and hydrogeologicical studies would have been completed, and river basin and mining development would be well underway. Both the physical resources and the transportation, health and education infrastructure would exist, furthermore, which would permit the Sahelian countries to move into a period of sustained growth and industrialization during Phase Three. Finally, though there would still be a need for foreign assistance, 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 could be eliminated altogether.

The proposed strategy designed to achieve this goal has implicit in it a requirement for substantial amounts of external assistance during Phases One and Two. Any projection of the total value of that assistance is bound to be very approximate, but there is sufficient information and experience available to forecast at least the orders 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 each of these countries to introduce technology packages and to establish systems for supplying necessary production inputs and support services, including credit. These costs were extrapolated

1. This compares with 800,000 farms which are currently covered by one of the existing programs; with a density of at least one extension agent per 200 farms (FAO estimate).

over the total acreage and numbers of pastoral families projected to be covered by the programs.[1] Experience with river basin development in other countries also provided us with cost estimates. Although less information is available on what might be done in mining and transportation, for the sake of completeness, we forecast approximate values of investments which could be made in these areas. Finally, we estimated very roughly the manpower requirements for most of these activities, especially agriculture and livestock which are the most important, and projected the cost of necessary training. The results shown in Table 5 yield a gross estimated total investment cost of $15 billion over the next three or so decades.

1/ The assumption here is that the cost of these development schemes remain constant over the entire area and population covered. Clearly this is inaccurate since costs can be expected to rise in more remote areas. There is, however, little information on the extent of this increase.

TABLE 5

ESTIMATED TOTAL COST OF INVESTMENT, PHASES ONE AND TWO

(million US $ in 1975 prices)

Agriculture a/	
Dry Farming b/	$2,500
Land Resettlement c/	1,000
Irrigated Agriculture	4,000
Research and Development	750
Livestock	
Semi-intensive Range Development	500
Other Livestock, Fisheries, Research and Development	150
Health	1,000
Education and Human Resources Development	500
Minerals d/	500
Transportation e/	2,000
Telecommunication	100
River Basin Development f/	1,500
Power and Energy	500
TOTAL	$15,000

a/ 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.

b/ 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.

c/ Per hectare cost of irrigation projects ($8000 per hectare) multiplied by a projected acreage in the year 2000 of .5 million hectares

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

e/ Assuming new criteria are accepted.

f/ Includes studies and pilot projects in addition to construction of one upstream storage dam in each major basin.

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 expand this contribution or to purchase capital equipment and otherwise to pay for investment is extremely 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, these projects will contribute to increased production, 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 will not be achieved for some time to come. The timing of project related current and capital expenditures is such, therefore, that these expenditures 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 to services provided and which therefore channel newly created resources directly back into productive activities. This is already done in most of the agricultural development programs which involve export crops.

Although these payment systems help to cover recurrent operating expenditures in the programs concerned and even permit some repayment of capital, they cannot provide the initial financing for much capital 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 the financing of most investment and even a substantial part of initial recurrent expenditures, which are not included in Table 5, 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 the Sahelian countries were $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 Lome' 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 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 excessively 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. The ratio is very high for Mali 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, though they should start to expand as rural development pro0 grams gather momentum. Donors currently 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 strategy succeeds, the ability to repay debt should increase. Therefore, the Sahelian countries ought to be in a position by the early part of the next century to begin to pay interest on their borrowings, albeit initially at relatively low rates. It is suggested, then, that economic assistance should be highly concessional for the first few decades or so, but that as production increases as a result of these development efforts, the terms of aid be made increasingly stronger. The timeing of this change in 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.

II. SECTORAL DISCUSSIONS

II. A. Geography and Climate*

1. Geographic Setting

The Sahel-Sudan region consists of six nations, Chad, Mali, Mauritania, Niger, Senegal, and Upper Volta. Until their independence in 1960 all were French colonies. Chad was administratively a part of French Equatorial Africa, the others were part of French West Africa. All six are contiguous and encompass part of the southern Saharan Desert and adjacent sub-Saharan semi-arid savannas.

The terms Sahel and Sudan have been variously used as pertaining to this and other regions. Both are Arabic words. Sahel means shore or coast and is used in connection with coastal zones in Morocco, Tunisia and elsewhere. Sudan means black.

2. Extent and Area

The Sahel-Sudan countries of west Africa range from 27° 30'N latitude (northern Mauritania) to 7° 30'N latitude (southern Chad), a distance of some 1,950 km, and from 17° 30'W longitude (western Senegal) to 24° E longitude (eastern Chad), a distance of about 4,400 km. The total area is about 1.7 times that of western Europe and about equal to 67 percent of the area of the United States (Table 1.1). Areas of the individual countries also are given in Table 1.1 and geographic relations are shown in Figure 1.1.

The region is sparsely populated in comparison with most temperate regions of the world. Countries in the more moist southern zones (Senegal and Upper Volta) have denser populations than the countries with greater areas of desert. Note the extremely low density in Mauritania. The State of Arizona in the arid southwestern part of the United States also has a low population density, intermediate between the highest and lowest densities in the Sahel-Sudan region.

Topography and Drainage

The Sahel-Sudan region ranges in elevation from sea level on the Atlantic coast of Senegal and Mauritania to 3,417 m on top of the volcano,

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* Massachusetts Institute of Technology, "A Framework of Agricultural Development Planning," in A Framework for Evaluating Long-Term Strategies for the Development of the Sahel-Sudan Region, V.II, Cambridge, Mass.: MIT, 1974.

Emi Koussi, in the Tibesti mountains of northern Chad. There is an east-west oriented trough running through the central part of the region with higher elevations to the north, east and south.

Little rain falls in the north so no perennial streams arise there. Four major river systems traverse part of the region. The Senegal flows into southwestern Mali and then northwestward to the Atlantic Ocean. It forms the boundary between Mauritania and Senegal. The Niger River enters southern Mali and flows northeastward to "The Bend of the Niger" where it flows eastward and then southeastward into Nigeria and then southward into the Atlantic Ocean. Most of Upper Volta is drained to the south by the Volta River complex (White Volta and Black Volta).

The Logone-Chari system originates in the moist areas to the south and the southeast of Chad and flows northwestward to Lake Chad. Lake Chad is a fresh water lake with no continuous surface outflow although occasional large floods pass through to adjacent desert areas.

Arable Land

The characteristic of the arid and semi-arid climates of the region combine to make little of the land arable. As shown in Table 1.2 only 7.9 percent of the total land area of the region is classified as arable. In contrast 24.3 percent of all of Africa and 24.1 percent of all of the continents are classified as potentially arable. Twenty-six percent of the arable lands of the region are cultivated. This points to the very poor quality of land currently used in Sahelian agriculture.

TABLE 6

Arable and Cultivated Lands of the World in the Mid 1960s

Continent	Area 10^9 hectares Total	Potentially Arable	Percent of Total	Cultivated (mid 1960's)	Percent of Arable
Africa	3.02	0.733	24.3	0.158	21.6
Sahel-Sudan region	(0.53)	(0.042)	(7.9)	(0.011)	(26.0)
Asia (except USSR)	2.74	0.627	22.9	0.518	82.6
Australia and New Zealand	0.82	0.154	18.8	0.016	10.4
Europe (except USSR)	0.48	0.174	36.3	0.154	88.5
North America	2.11	0.465	22.0	0.239	51.4
South America	1.75	0.680	38.9	0.079	11.6
USSR	2.23	0.356	16.0	0.227	63.8
Total	13.15	3.168	24.1	1.388	43.8

Source: President's Science Advisory Committee, 1967

Soils of the Sahel

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

a) Hydromorphic

These are widespread in the region and characteristic of land subject to submergency 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, and are found in depressions and along river banks. They are good for rainy season sorghum and millet, groundnuts, cowpeas, maize and cotton. The last two crops, though, require control of the phreatic groundwater.

b) Vertisols

This soil type includes poorly draining solid 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 phosporus. 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 lacustrine sediments and are suitable for rice, sorghum planted after the receding flood, fodder crops, and where properly drained, wheat and cotton.

c) Halormorphic

Halomorphic soil types are found on small, exposed elevations in the hydromorphic plains. They are also found in themerging zones between natural levees and sandy banks. In practice, these are bare soils whose leached horizons have been carried away by erosion and have 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 soil types 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, serving as dry season grazing land for transhumant cattle herds.

e) Ferruginous

Tropical ferruginous soil types 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, phosporus, organic matter and nitrogen. Rainy season red and white millet, cotton, and groundnuts are grown on these soils.

3. Climate

The climate of the Sahel-Sudan region varies from that of a hot desert to that of a dry subtropical woodland. Rainfall ranges from less than 100 mm/yr in the north to more than 1250 mm/yr in the south. Throughout the region, rainfall is essentially unimodal, falling in a single season. In the northern Sahel the wet season is in July and August. Farther south the wet season becomes progressively longer, lasting from May to September. A general "rule of the thumb" is that as one goes northward from the southern coastal forests (with a rainfall of about 2400 mm/yr) toward the Sahara, the average annual precipitation decreases 1 mm per kilometer traveled.

Temperatures range from warm to hot, with only stations in the highest mountains of northern Chad ever recording temperatures below 0 C. Stations in the northern areas have recorded maximum temperatures in excess of 50 C (122 F), usually in the months of April, May and June. Frost is unknown in most of the region. Most stations have a bimodal distribution of lower temperatures, generally in December-January and again during the wet season of June to September.

Winds in the region are seasonally variable. During the dry season, the region is under the influence of dry northeasterly trade winds, called the harmatten. At the beginning of the wet season violent winds associated with thunderstorms are common. Later in the wet season, southerly monsoon winds dominate.

The level of solar radiation is high, with few cloudy days recorded other than during the wet season. Relative humidity is generally low. Evaporation rates are high, with annual potential evapotranspiration values in excess of 2400 mm common in the north.

Weather Patterns

Intertropical convergence zone: On a world-wide scale a series of discrete tropical anticyclones forms belts on each side of the equator. In these zones, descending air north of the equator results in hot dry air at the surface, moving southward as the northeast trade winds. Where the northern and southern belts converge near the equator, the air rises and cools, resulting in rainfall. The area of convergence is known as the Intertropical Convergence Zone (I.T.C.Z.).

Monsoon Rainfall

Most of the region receives its rainfall from a monsoon system, a seasonal north-south oscillation of the I.T.C.Z. Mitchell (1973) gave a concise summary of the operation of this system in west Africa. An annual cycle of a northward penetration and a southward withdrawal of a warm, humid air controls the rainy season and the rainfall. In cross section, this airmass is wedge shaped, of limited vertical extent in the north and deeper to the south. At the leading edge is a sharp discontinuity in ground level relative humidity with extremely low humidities existing to the north and higher values to the south.

Generally, the discontinuity is at its farthest south position in January, a few degrees north of the Guinea Coast at about 7° N latitude. Progressively the front moves northward until August when it reaches approximately 23° N latitude. A more rapid southward retreat restores the January position.

The weather associated with this system has been subdivided into five types, as follows:

Zone A. North of the relative humidity discontinuity: (a) very low atmospheric humidity; (b) few clouds; (c) possible dusty haze; and northeast trade winds.

Zone B. Humid, No-Rain Zone: (a) much higher relative humidities; (b) continued syrong easterly components in winds; (c) little (limited diurnal) cloud formation and (d) no rain.

Zone C. Thunderstorm-Shower Zone: (a) more frequent cloud development; (b) occasional showers and thunderstorms; (c) in the southern part of the zone, large scale organized thunderstorms moving with strong squalls from east to west; (d) the result is a scattered rainfall pattern with bright sunlight days between showers (often torrential rains) of short duration.

Zone D. Overcast-Steady Rain Zone: (a) clouds stratiform rather than cumulus type; (b) frequent, prolonged steady rains.

Zone E. Overcast-Drizzle Zone: (a) overcast skies; (b) light rains and drizzle but extended, heavy rainfall rare.

A number of other factors interact with the moist air wedge to influence both (a) the extent of its northward movement during a given year and (b) the amount of moisture actually precipitated. At least in Zone C, which provides most of the rainfall to the Sahel-Sudan region, high level easterly air flows stimulate the disturbance line phenomena. Any reduction of these high level easterly winds decreases the rainfall of the zone. At times the northern parts of the subdesert and Sahel are influenced by westerly winds, resulting in unseasonal extensive cloudiness and occasional dry season precipitation. Such "heugs" as they are called, appear to be extreme southerly extensions of winter rainfall of the Mediterranean region. For practical purposes, such aberrant dry season rainfall is of no use for crop production.

Variability

Significant variation of the weather often occurs. Such variations are generally most extreme in the arid and semiarid zones, and include geographic and temporal (daily, seasonal and annual) components.

Especially in the desert and to a lesser extent throughout the thunderstorm shower zone (Zone C) a given storm may deposit a significant amount of rainfall in one area, while only a few hundred meters away, no rainfall occurs! In the subdesert and Sahel, these widely spread storms (which often result in excellent forage conditions, especially of ephemeral plants) provide the basis for nomadic grazing. Some areas simply may not receive adequate rainfall for one or more years, while others may have enough to produce relatively favorable grazing conditions.

The rainfall at Niamey, Niger, and its airport only a few kilometers away were compared for the year 1953 (Cocheme and Franquin 1967). The results showed that the average difference amounted to 62 percent of their combined daily means, yet the annual totals differed by only 11 percent.

In the wet season, especially in the zones of low average annual rainfall, rains do not occur every day but as "wet spells." Cocheme and Franquin (1967) examined the distirbution of wet spells at Zinder, Niger, a station with a mean annual precipitation of 540 mm. They found that most rainy days occur singly (63-70 percent), or in groups of two days (17-18 percent), with single wet days being most numerous both at the beginning and at the end of the wet season. The monthly mean occurrence of three-day wet spells is less than one and has been recorded only in July, August, and September. As a general rule, in the area here considered, there is one day in the growing period (wet season) for each 5 mm of annual precipitation (Figure 3.1).

Climatic Zones

The weather patterns permit the designation of five east-west oriented climatic zones based primarily upon average rainfall and associated vegetation characgeristics (Figure 3.2). From north to south, these zones are:

> Desert. The desert has an average rainfall below 100 mm/yr; annual deviations from the mean are ± 60 percent. Generally fewer than 10 rainy days/yr. occur. Evapotranspiration rates are generally more than 2100 mm; no marked rainy season exists, and winds are generally light, averaging 3-5 km per hour. Parts of the desert may not have rainfall for several successive years.
>
> Much of the area is a barren, sandy subtrate that quickly absorbs any rainfall. In local situations, groundwater is trapped near the surface, supporting isolated oases. In others, surface conditions are such that long dormant seeds of quick maturing ephemerals sprout, grow and mature rapidly, producing another crop of seeds that await the next rain, one, two, or ten years in the future.

Under average conditions, 36 percent of the region is desert.

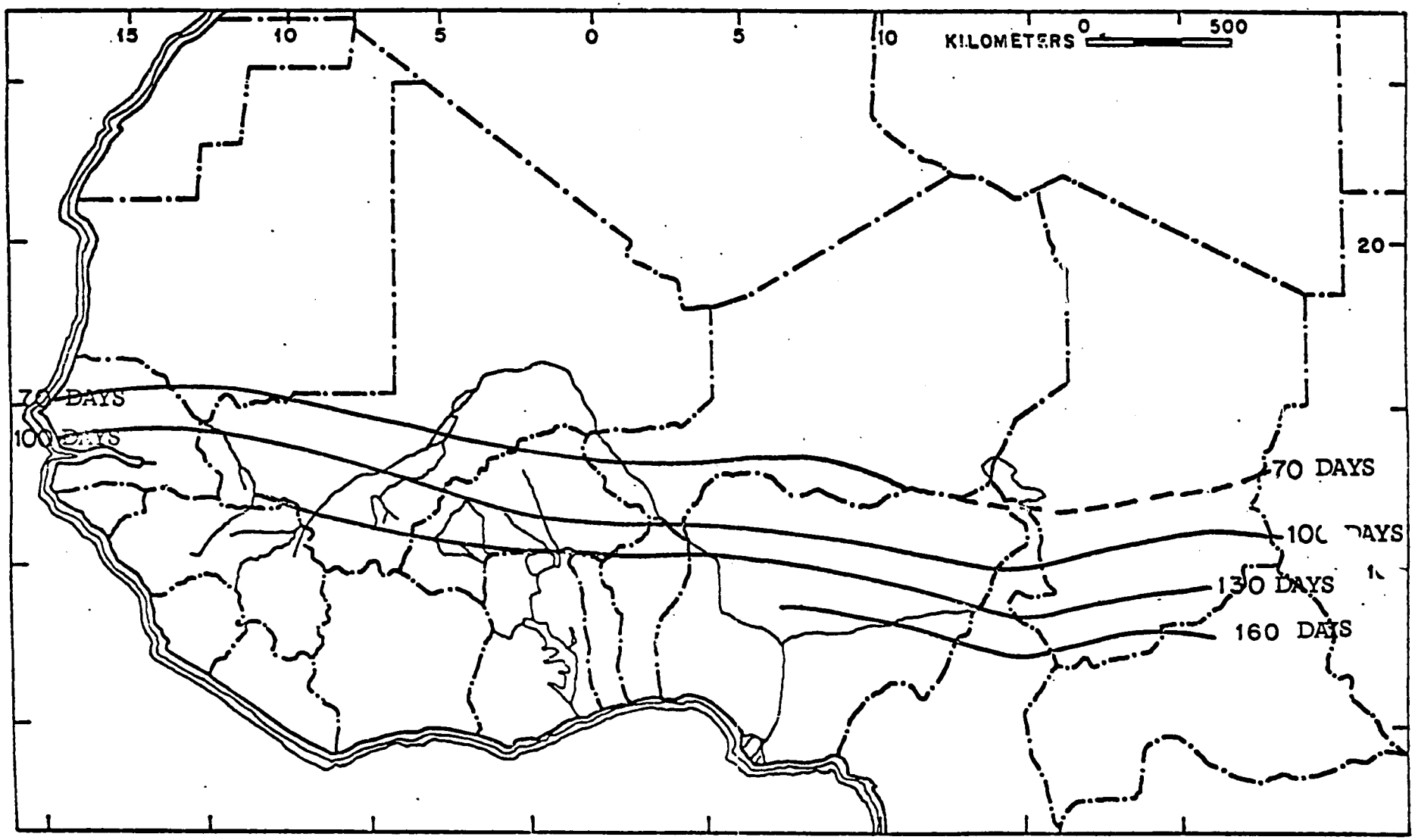

TABLE 7 Average Number of Days in the Wet Season

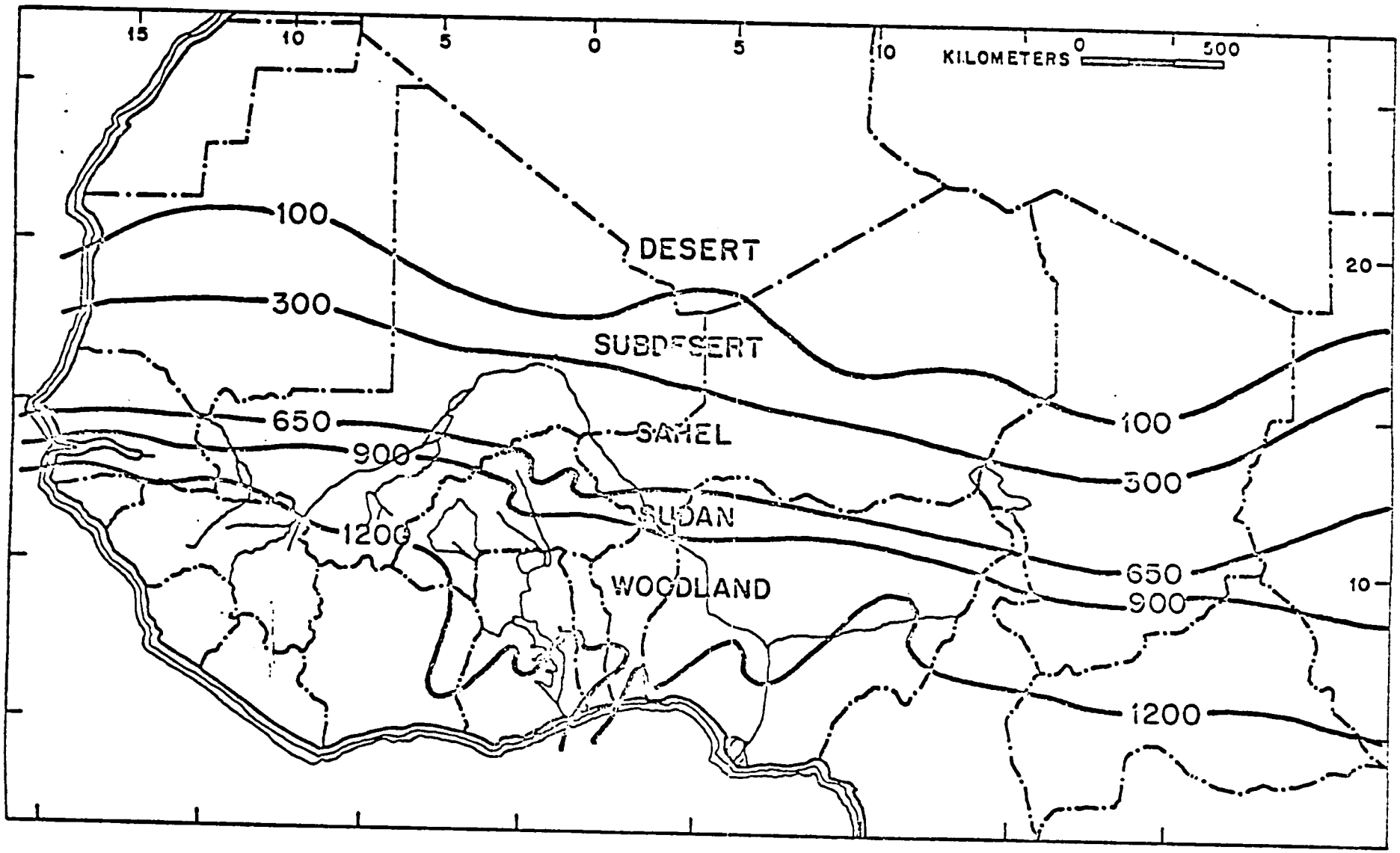

TABLE 8 Climatic Zones of the Sahel-Sudan Region

Subdesert. Average rainfall is between 100 and 300 mm/yr; annual deviations from the mean are ± 40-75 percent; 28 percent of the region is subdesert. Generally there are 10 to 25 rainy days per year, more or less concentrated in the months of July and August. Evapotranspiration rates generally range from 1800 to 2300 mm/yr. Winds are stronger, averaging 6-13 km/hour.

Sahel. Average rainfall is between 300 and 650 mm/yr; annual deviations from the mean are ± 30-45 percent. This zone makes up 17 percent of the region. Generally there are 26 to 46 rainy days per year, concentrated in a rainy season during the months of June, July, August, and September. Evapotranspiration ranges from 1700 to 1900 mm/yr. Winds are often strong, averaging 5-16 km/hour.

Sudan. Average rainfall is between 650 and 900 mm/yr; annual deviations from the mean are ± 25-30 percent. Generally there are 50 to 65 rainy days per year, concentrated in a rainy season during the months of May through October. Ten percent of the region is in this zone. Evapotranspiration rates range from 1600 to 1800 mm/yr. Winds are less strong, averaging 6-7 km/hour.

Woodland. Average rainfall is over 900 mm/yr; annual deviations from the mean are low, ranging ± 20-25 percent. Generally there are 65 to 80 rainy days per year, concentrated in a rainy season between May and October in the nine percent of the region which is in the woodland zone. Evapotranspiration ranges from 1600 to 1750 mm/yr. Winds are low, averaging 3-8 km/hour.

The statements made here were derived from detailed rainfall data and climatic parameters from weather stations in the Sahel-Sudan region as provided by a variety of sources.*

Climatic Trends

Some knowledge of past climatic conditions of a region is necessary to evaluate possible future climatic trends. Three types of evidence of past climatic conditions exist: weather station records, historical writings and paleoclimatological studies.

Weather Station Records

Instrumental measurements of climatic variables have been taken only during the past 300 years. Enough stations to determine global or hemispherical averages have been available only since about 1880. Few weather stations

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* U.S. Department Commerce, Monthly Climatic Data for the World;
U.S. National Climatic Center, World Climatic Data-Africa, 1952-1973;
Senegal A.S.E.C.N.A. Service Meteorologique, Normales Climatologiques du Senegal (1963);
U.N., F.A.)., Nouakchott, Mauritania, Pluviometric (1974); and
Chad Service Hydrologique, Precipitations Journalieres (1965).

with continuous records covering more than 30 years exist in sub-Saharan west Africa. One of the longest records is from Dakar, Senegal for the period from 1887 to date.

The records for west Africa, like weather station data throughout the world, exhibit typical patterns of alternating ups and downs, especially in rainfall. As pointed out by Landsberg (1974) this "has always been an incentive to the periodicity hunters. Yet in data universes so beset by irregularities, where it may take five decades to obtain a reasonably stable mean value, this has--by and large--been a disappointing enterprise."

Becker (1974) correlated rainfall with cereal production in Niger and Upper Volta in forecasting future yields in the region. He tested two hypotheses: "Rainfall over the Sahelian region during the past several years has not decreased in a significant manner with time," and "Relative changes in rainfall trends have not been significantly different between the north and south extremes of the sahel." Becker, for various reasons, included only rainfall data for the years between 1955 and 1972. He assumed that the average rainfall for this period was normal for the regions and made projections therefrom. However, as shown later, the base used by Becker was apparently too high.

When Landsberg (1973a, 1973b) and associates analyzed rainfall records from three stations in Senegal, they found the annual variations to be great. Their analysis of wet and dry years led "to the simple statistical conclusion that one would at least once in a century except a sequential series of six or seven years with rainfall deficiencies, but there is an equal chance for that many years wetter than the median."

Various reports indicate that the years immediately preceding the current drought were much wetter than normal (a "little pluvial" period) throughout sub-Saharan west Africa. One indicator was the high level of Lake Chad. Lake Chad receives most of its recharge from river systems that arise in the more moist zones to the south. Because of the seasonal nature of rainfall in the area, the lake has an annual variation of about one meter in level, reaching its lowest point at the end of the dry season.

Variations in Lake Chad levels for the period 1907-1972 were indicated on a graph published by the UNDP (1972). Their graph was based in part on actua records of lake levels and in part on reconstructed points derived from other information. Figure 3.3 is redrawn from their data.

An examination of the graph reveals that the level of Lake Chad was higher in 1955-1965 than at any period since 1907. In order to determine whether these levels were indicative of widespread conditions, a set of isohyets (lines of equal rainfall) for all of the region was constructed, based on data for 1962, 1963 and 1964, the years in which Lake Chad reached its highes levels. Lack of data points in northern areas, especially in northern Mali, Niger and Chad, made the drawing of isohyets very tentative. In spite of the limitations of the basic data on which the "little" pluvial" isohyets

are based, it is clearly evident that increased precipitation occurred throughout the area and not just in the Lake Chad basin.

An examination of the Lake Chad data also reveals that the levels during the current drought are no lower than they were during 1913-1915 and 1941-1943. This is true even though the current upstream use of water is probably greater than earlier. To determine the extent of the drought, isohyets were constructed for the years 1970-1972. Again the absence of weather stations in northern areas made the drawing of the 100 mm isohyet very tentative, but the widespread nature of the drought became apparent.

To help quantify the magnitude of the effects of the contrasting wet and dry periods, the areas of each of the six countries lying between various isohyets were calculated and compared with the areas under average conditions. Several significant observations can be made. Refinement of the isohyets probably would not change significantly the conclusions but would certainly add more precision to them. The conclusions are:

Isohyet shifts. The north-south shifting of isohyets during wet and dry periods is more pronounced in the northern, drier zones than in the southern Sahel and Woodland zones.

Geographic variations. At least during 1970-72, the drought was markedly more severe in the western (Mauritania, Senegal) part of the region. The effects of the wet period appear to have been relatively uniform throughout the region.

"Little pluvial" results. The wet period resulted in relative changes of area from average conditions in rainfall zones as follows: below 100 mm zone, 9 percent decrease; 100-300 mm zone, 9 percent decrease; 300-650 mm zone, 13 percent increase; 650-900 mm zone, 1 percent increase; over 900 mm zone, 25 percent increase.

Drought results. The drought periods resulted in relative changes in area from the wet period as follows: below 100 mm zone, 28 percent increase; 100-300 mm zone, 16 percent decrease; 300-650 mm zone, 20 percent decrease; 650-900 mm zone, 51 percent decrease; over 900 mm zone, 73 percent decrease.

Historical Writings

Prior to the development of instrumentation and the establishment of weather stations, some indications of short term variations and longer trends in climate can be inferred from various historical records. In some parts of the world written records are available for periods as early as 2000 years ago. However, the earliest written records for the Sahel-Sudan region apparently date from the Sixteenth Century.

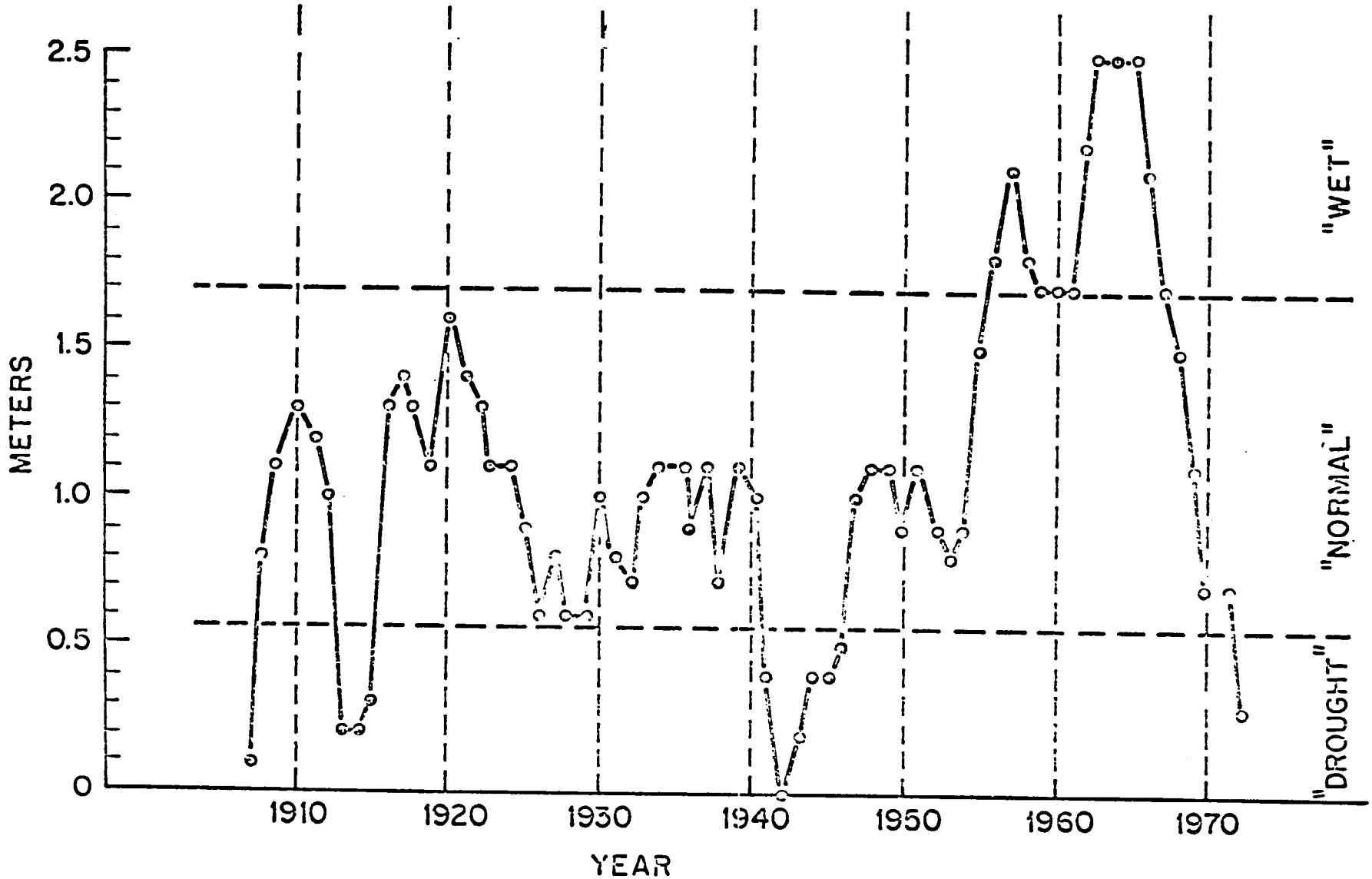

TABLE 9 Variations in Maximum Levels of Lake Chad

An analysis of part of these records reveals that 21 droughts of varying lengths have been reported, with reports based on epidemics which resulted from drought caused famines. It is probably unwise to make any generalizations concerning the lengths of past drought periods, especially the earlier ones where only a year or two is listed as a famine or epidemic. Most of these were probably preceded by two or more years of little or no productivity. Of the 21 droughts epidemics listed, 6 lasted 1 year; 7 lasted 2 years; 1 lasted 3 years; 1 lasted 4 years; 1 lasted 5 years; three lasted 6 years and 1 lasted 18 years. The records demonstrate that droughts are a part of the normal climate of the region.

Paleoclimatology Studies

A number of techniques have been developed to evaluate, at varying levels of temporal precision, past climatic conditions. Especially in the past two decades considerable knowledge concerning prehistoric climatic conditions has been accumulated. Paleoclimatology bases its conclusions on data from many sources including physical geography, paleontology, chemistry, ice cores, deep sea cores, pollen studies, tree ring analysis and others (Butzer 1971).

Paleoclimatology studies in the Sahel-Sudan region have barely begun. However, some general conclusions concerning past climates are indicated in the following summary:

> The mean temperature of the middle latitudes decreased gradually throughout the Cenozoic era, with virtually no change in the tropics. During the Pleistocene a series of glacial and interglacial periods occurred. Current geochronological techniques place the last of these glacial periods as having reached its maximum about 20,000 years B.P. (before present). Although the Sahara and its southern semiarid belts have not been studied as intensively as some other parts of the world, considerable is known about major climatic variations there. Figures 3.4 and 3.5 compiled from several different sources, summarize major happenings.
>
> It is evident that during the past 200,000 years the Sahel-Sudan has varied from much wetter than present to drier than present conditions. Some researchers consider past wetter periods as being more the result of decreased evaporation associated with lower temperatures than the result of actual increases in rainfall.

4. Interpretations

Various people have postulated that mankind's modifications of the world environment can result in major climatic shifts. That such impacts are evident in microgeographic areas (such as cities) cannot be argued. That such modifications as slight increases in CO_2 and particulate pollution in the atmosphere can cause any major climatic shift in the area as large as the Sahel in 10 or even 50 to 100 years is not at all evident.

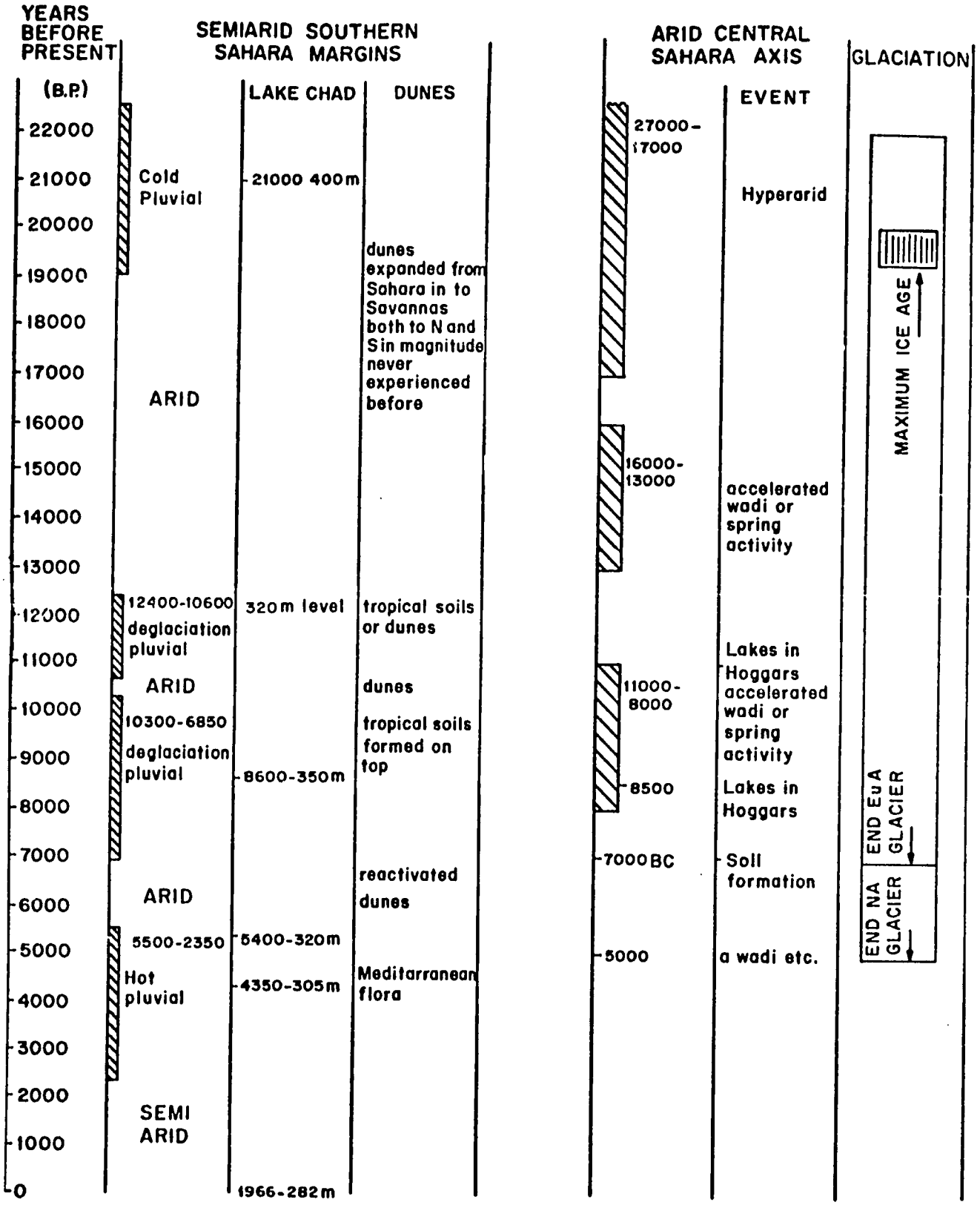

TABLE 10 Summary of Past Bioclimatic Conditions

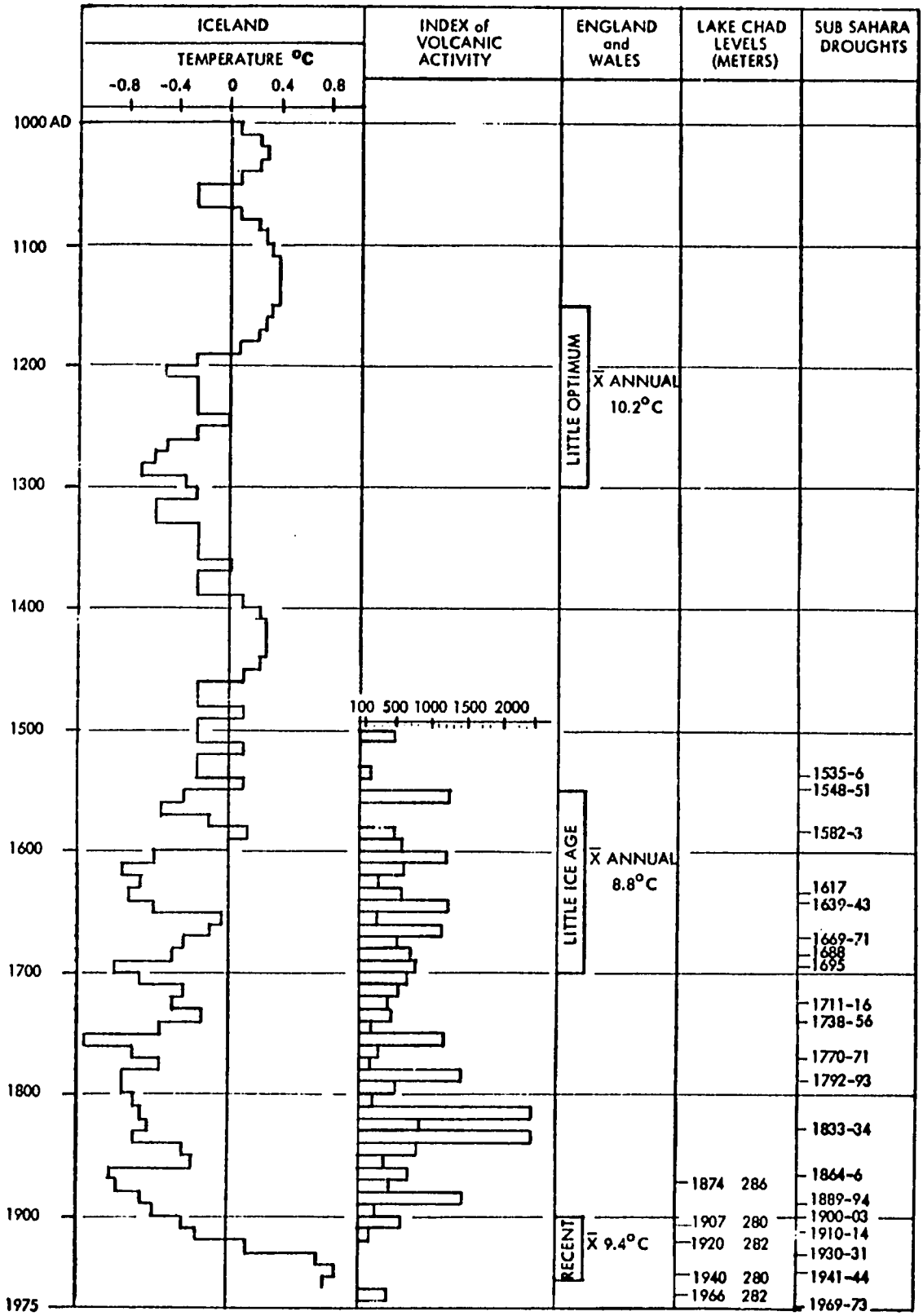

TABLE 11 Climatic Indications of the Past 1,000 Years

Some have suggested that massive, long-term climatic changes have already resulted from such factors as air pollution (Bryson 1973). Others take the view that variability is one of the characteristics of climate in most parts of the world and that no clear indications of long-term climatic shifts are yet evident.

Several interdisciplinary seminars have been conducted in recent years concerning various aspects of mankind's effect on the environment. One was "Inadvertent climatic modifications--Report of the study of man's impact on climate," sponsored by the Massachusetts Institute of Technology in 1970 (Anon. 1971). The following statement was included in their conclusions.

> In relation to the earth's history our recent climatic fluctuations, covering less than 300 years, are only small-scale noise, are seemingly random, and are certainly not well understood...In fact, as has been frequently pointed out, it will be difficult to identify any man-made effect because, first, with our present state of knowledge, we do not know how to relate cause and effect in such a complex system, and, second, man-made effects will be obscured by the natural changes that we know must be occurring.

This same symposium attempted to put into perspective any effect of industrial activities of the past one or two centuries by pointing out that long before the Industrial Revolution, agriculture and animal grazing had denuded about 20 percent of the continental landmasses. This drastically changed the heat and water budget of the earth and may well have had effects on climate.

Little direct evidence relating to the Sahel-Sudan region exists. At the Symposium on Drought in Africa, held in July 1973 by the Center for African Studies at the University of London, various views about the future of the region were expressed (Dalby and Harrison Church 1973). Some predicted continued, ong-term drought; others saw the current drought as only another in a continuing series of drought-moist periods characteristic of the region.

El-Sayed and Landsberg (1973) analyzed rainfall records from Dakar, Senegal (1887-1972) and found that rainfall decreased by one-third mm/yr during the period of record. Similar analyses performed by Landsberg (1972) on rainfall data from two other stations in Senegal (Bambey, 1923-1972 and Ziguinchor, 1920-1972) revealed no significant persistent departure from median values.

Dr. James McQuigg, Professor, Department of Atmospheric Physics, University of Missouri, Columbia, recently (1974) stated in part:

> While it is true that there are important differences in topography, soil and in societal and governmental structure from one part of the Sahel-Sudano region to another, there is a climatic feature that is common to the entire area. This feature is the <u>variability</u> in

> precipitation from year to year. The periods when precipitation is below some threshold value of economic importance may not always be coincident over the entire region, but the fact that there will be periods when there is not enough rain is one aspect of the climate that is dependable.
>
> Whether one views the current prolonged drought as just the sort of event one expects from time to time through random chance, or a manifestation of a shift to some different climate, the implications for modelling climatic impact on economic/ecological/societal events are almost the same.

5. Weather Control

Studies of attempted weather control in other areas, especially cloud seeding to increase precipitation, were examined. Some attempts appear to have been locally successful, under special conditions, in increasing rainfall. However, the technology for inducing increased rainfall over such wide expanses as the Sahel-Sudan region apparently does not exist; even if it did it would probably be economically unfeasible. When the moisture bearing monsoon air masses do not move far enough northward, early enough in the season, current cloud seeding techniques could not possibly produce rainfall, especially on the timetable needed for crop production.

6. Climatic Projections

> Throughout his history, and in spite of his technology, man has remained impotent before the task of predicting with certainty--let alone controlling--the fluctuations of the climate on which he depends.

This quote, from Dalby and Harrison Church (1973), represents the view of many, if not most, modern climatologists. From the previously referred to Symposium on Drought in Africa, J.A. Allan (1973) concluded, concerning the question of climatic change in west Africa:

> Those competent to appraise the evidence had to conclude that the causes of such changes are numerous and still not well understood. Climate is always changing and there is no such thing, for example, as 'normal rainfall,' only an average rainfall over a specific period.

7. Plant Ecology

West Africa has a series of vegetation zones that more or less correspond with the previously defined climatic zones. The exact north-south extent of these, and even their average rainfalls, are not clearly defined (Whyte 1967, Holdridge et al. 1971, McGinnies et al. 1968, Rosevear 1965, and others). Generally, three belts are recognized: the northern desert

belt with annual rainfall less than 300 mm, the savanna belt with rainfall less than 900 mm, and the southern woodland belt with rainfall more than 900 mm. Each of these belts is further subdivided into vegetation zones (Figure 3.6).

Desert belt. Desert zone (below 100 mm rainfall per year). In a few places today, and formerly more extensively, the vegetation consists of scattered areas of small perennial trees, shrubs, and grasses. These occur wherever physical conditions combine to concentrate and retain run-off water from the scattered rainfall. Under certain conditions these plants survive, even though no rain falls locally for several years. In areas where scattered violent desert rainstorms saturate the surface, seeds of ephemeral plants (grasses and herbs) that have been dormant for years, sprout, grow, and result in large expanses of green vegetation. Even after such an area dries out and the plants die, their roots and stems remain for years to help prevent wind and water erosion.

In the Sahara area, wide areas on and around the higher elevations of the Tibesti (northern Chad) and Ahaggar (southern Algeria between northern Mali and northern Niger) have more rainfall and formerly had more vegetation. The Ahaggar had extensive tree cover even within historic times. Total precipitation minus potential evapotranspiration generally exceeds - 2200 mm/yr and may reach - 2400 mm/yr.

Subdesert zone (100 to 300 mm rainfall per year). This is a more moist version of the desert, with wider expanses of scattered perennial woody vegetation. Grasses and herbs are more widespread and little dune activity exists. Total precipitation minus potential evapotranspiration generally ranges between - 1300 and 1650 mm/yr.

Savanna belt. Sahel zone (300 to 650 mm rainfall per year). This part of the savanna belt has vegetation consisting of scattered acacias and other thorny, narrow-leaved trees and bushes. Between the bushes and trees is an almost uniform cover of short grasses that are generally below 40cm in height. Because of the low height of these grasses, fires are rarely widespread and have little impact on the ecosystem. The total precipitation minus potential evapotranspiration generally ranges between 1300 and 1650 mm/yr.

Sudan zone (650 to 900 mm per year). This zone has scattered, taller trees, often broad-leaved and deciduous. Between the trees are tall (to 80 cm) perennial grasses. Fires, especially in the southern part, are partially responsible for the maintenance of the savanna. Locally, where conditions combine to contain fires, the trees become quite dense and forests develop. The total precipitation minus potential evapotranspiration generally ranges between 800 and 1300 mm/yr.

Woodland belt. Doka woodland zone (950 to 1400 mm rainfall). This zone is part of the woodland that formerly extended south to the coast. The Doka woodland is characterized by large numbers of Isoberlinia trees (I. doka and I. Dazielli) that are deciduous, losing their leaves during the dry season. During this four to six mont period, widespread fires occur in the woodland and associated grasslands. Total precipitation minus potential evapotranspiration generally ranges from 400 to 800 mm/yr.

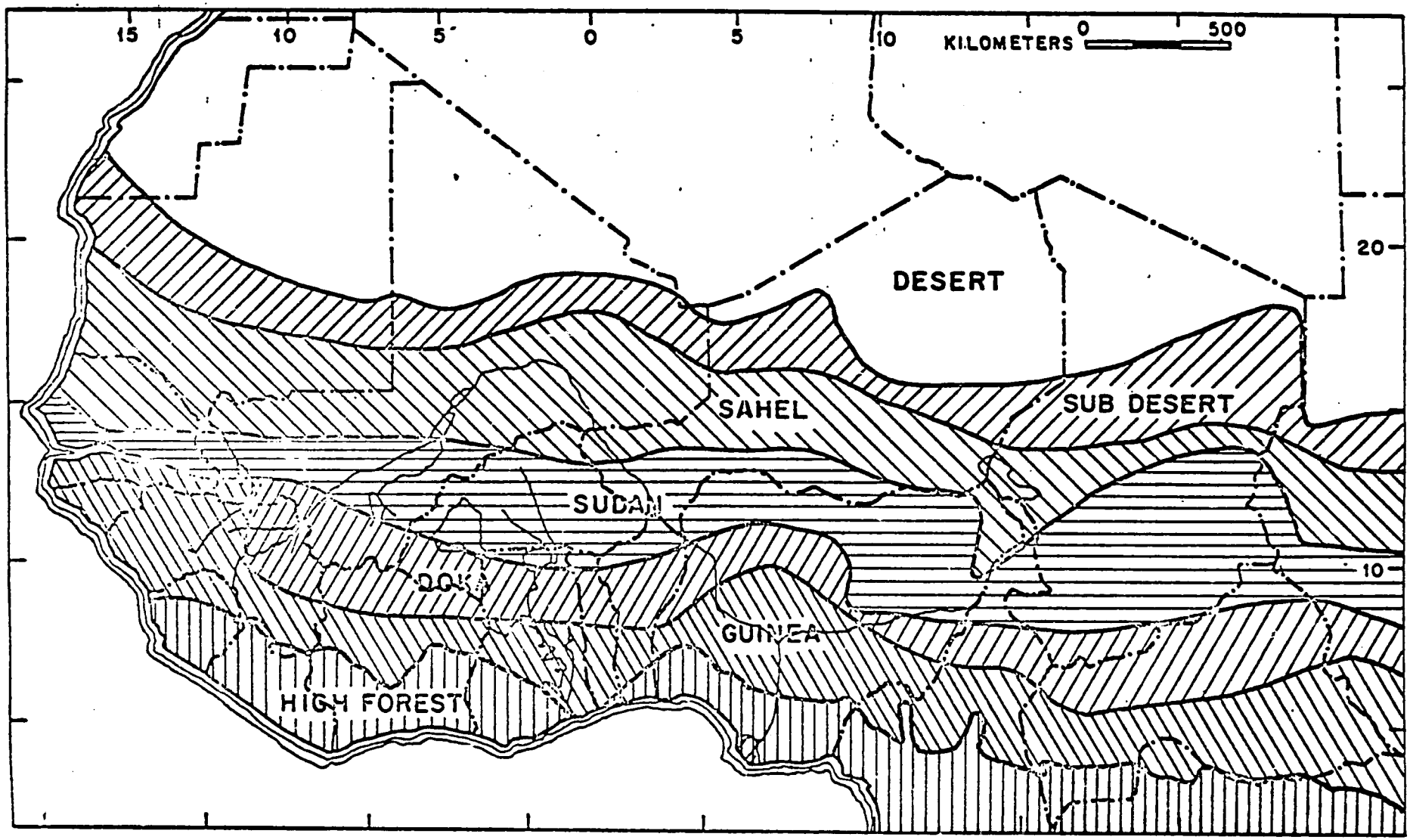

TABLE 12 Vegetation Zones of West Africa

Guinea woodland zone (1400 to 1800 mm rainfall). This zone is characterized by several kinds of trees that tend to include fewer seasonally deciduous species and are classified as "relatively moist" types. The dry season in this zone lasts only three to four months. Total precipitation minus potential evapotranspiration generally ranges between 0 and 400 mm/yr.

High forest zone (over 1800 mm rainfall). This is a closed rain forest, with a great diversity of kinds of trees including many broad-leaved evergreens. The dry season is quite short, often only a few weeks in length. Even during this period, the relative humidity remains high. Total precipitation generally exceeds the potential evapotranspiration.

II. B AGRICULTURAL SECTOR

FARMING

Concentration of the development effort in the Sahel must be directed to the agricultural sector which comprises almost 90 percent of the population. Further, since most all the crop farmers practice rainfed agriculture, development must first focus on improving rainfed agricultural techniques so that production can parallel a growing population. In the meantime, over the next ten to fifteen year, it will be necessary to gather data on the major river basins and ground water resources and to support broad small-scale irrigation programs as these countries come to rely more heavily on irrigation to ensure a sufficient food supply for a steadily rising demand. When more reliable data are gathered on the extent of both surface and ground water availability, large-scale irrigation through major upstream storage should be considered.

General

The population in the Sahel sedentary zone is made up of farmers growing millet, sorghum and peanuts and some migratory or semi-migratory herders. The rainy season in this zone is irregular both in the quantity and distribution. The variability in crop yield is high because the crops are not well adapted to the low rainfall and short growing seasons are experienced all too frequently. In the Sudano-Sahelian zone, with its 6-1/2 million sedentary farmers, the growing season is longer in average years and the variability in crop yields is less.

The Sudanian zone generally has the best agricultural potential with its greater rainfall, but parts are infested with vectors of onchocerciasis and trypanosomiasis. In sections of the zone, onchocerciasis is being eradicated and will be opened for settlement. The biggest area to be cleared is in the south of Upper Volta, an area equal to almost 20 percent of the cultivated area of Upper Volta.

River valleys are presently used for flood recession agriculture, for flooded rice production, and to a lesser extent, for irrigation. The yields in flood recession and flood agriculture are quite variable depending on the flood. Variability can be reduced by introducing better adapted varieties.

TABLE 11

CHARACTERISTICS OF ECOLOGICAL ZONES

Ecological Zone	Area 000 km2	Population 000	Population km2	Percent of optimal yield probability level 98%	50%	2%	Drought Resistance*
Desert	2155	330	0.16	-	-	-	
Sahel, pastoral	1400	1590	1.10	-	-	-	
sedentary	655	5780	8.8	20	74	100	27
Sudan sahelian	473	6520	13.8	65	86.5	100	75
Sudanian	423	2930	6.9	80	93.5	100	85
River Valley	144	1960	13.7	65	86.5	100	
Oncho Zone	5	-	-	80	93.5	100	85
Capital Cities	5	1040	20.8				

* 1970 basis

* Drought resistance equals ratio of yield in the 50 year drought to the average yield x 100

Source: FAO and MIT

Under irrigation, the yields would not be subject to rainfall variability assuming that there is sufficient water supply for the area to be irrigated.

Table 1 illustrates the characteristics of each zone and the probability of yield and drought resistance.

1. Dryland Agricultural Strategy

The objectives of a dryland agricultural strategy over the next ten to fiteen years could be to:

a) increase the capability of the Sahelian countries to provide enough food and cash crops to withstand short cyclical periods of drought.

This increased capacity can be accomplished within the next 15-20 years through five simultaneous actions:

i) inputs of improved technology -- tools, fertilizers, seed, pesticides -- supplied at a rate that will allow farmers to assimilate them into their existing farming operations. The establishment of some type of agricultural credit is imperative;

ii) accelerated training of professional and intermediate level agriculturalists and extension workers;

iii) upgrading governmental agriculture institutions, particularly the agricultural ministries and related agencies (i.e. livestock services);

iv) accelerated research on essential food and feed crops as well as commercial export crops. Priority should be given to formulation of improved production packages for food crops; and

v) a concerted effort to improve health conditions in the dryland farming area. The countries should also consider future policies on child spacing consistent with their ability to feed their people.

The increased capacity in the agricultural sector will tend to reduce the high variability of crop yields. Better production decisions can be made because of this, but continued growth is intrinsically linked to wise policies on pricing which can make agriculture profitable for the farmer.

b) assure an equitable distribution of income among farmers as the capacity of the agricultural sector increases.

Modification of existing policies on pricing, marketing, taxes and duties is needed so that they can provide more incentive to the farmer to produce more. A balanced food/cash crop development program is needed in order to:

i) increase farm incomes as a means to increase the nutritional level of the rural population and their consumption of non-agricultural commodities;

ii) provide capital for investment in agriculture and in future non-agricultural production;

iii) provide additional foreign exchange for importing needed commercial and consumer goods, and

iv) supply the food needs of an expanding urban population.

The basic assumption behind these objectives is that Sahelian agricultural producers are responsive to market forces and the opportunity to improve earnings. To increase agricultural production one should increase the profitability of agriculture. Since labor is the principal input in Sahelian agricultural production, increasing the profitability of agriculture means essentially increasing the returns to labor and later to capital since any sustained rise in returns to labor will result in greater use of off-farm inputs.

2. Future Food Consumption and Needs.

The six Sahelian countries plus Gambia and the Cape Verde Islands have a total population of about 25 million, with an annual average growth rate of 2.7 percent. By 1990 the population is estimated to be about 40 million. The urban population is increasing faster than the total, leaving the lower rate of increase in the farm population and thus a decreasing agricultural labor force. A major problem in the region is how to increase the productivity of the farm labor force, growing at the rate of 1.5 percent a year, to provide the food for the 2.7 percent increase in the total population. By 1990 the agricultural population will be only 80 percent of the total, down from the current 90 percent, and the agricultural labor force will have diminished even more as a percentage of the whole.

TABLE 12

Potential Production of Millet, Sahel-Sudan Region

Climatic Zone	Sahel	Sudan	Woodland	Irrigated	Total
Area in zone (km^2)	887,270	502,568	493,122	12,550	1,855,510
Allocation to crops	.06	.30	.30	.90	-
Cultivable area (km^2)	53,236	150,769	135,937	11,295	351,237
Cultivated fraction	.07	11	.38	1.0	-
Allocation to this crop	.45	.20	.10	-	-
Area in crop (km^2)	1,677	3,317	4,486		9,480
Productivity (kg/h)	75	375	1,200		-
Production ($kg/10^6$)	13	124	538		675
Cal/kg	3,410	3,410	3,410		-
gm protein/kg	95	95	95		-
Calories x 10^9	43	424	1,836		2,303
grams protein x 10^6	1,195	11,817	51,140		64,152

Source: MIT, A Framework for Agricultural Development Planning, December 31, 1974

In calculating both current and future consumption by the Sahelian population, the question still remains whether the total supply of cereal grains is sufficient for adequate nutrition of the population.

It is possible to divide the supply as estimated from FAO data by the estimated population and to get a figure of the supply per head. The absolute value of the FAO data is only approximate*. FAO data are from diet studies made in 1964-1966. These indicate that there is generally a near sufficiency if judged by the dietary standards, except in Upper Volta (82 percent). However, this also is only approximate since there is a lack of data on precisely what are the human nutritional needs in this region.

In the rural areas, farmers produced enough food grains for themselves. In urban areas, where income plays a substantial role in a family's ability to meet its dietary needs, judgment of dietary adequacy is more difficult and indeed the adequacy will vary with changes in prices and income. A mitigating factor is that a substantial proportion of the urban population maintains some rainy season farming activity. However, for lack of recent data there is no objective way of judging the adequacy of urban diets in the regions and only subjective observations on which to build a judgment. It can be assumed that the regional food supply is sufficient to meet minimal caloric requirements, although low in certain aminoacides (components of protein) and certainly low by developed country standards in animal protein.

FAO, in its March 1976 report presented to the meeting of the Club des Amis du Sahel, projected food consumption for the region in 1990. (See Table 3). A projection of the potential supply was also presented. The French SEDES-SCET International study (Essai de Definition d'une Strategie Antisecheresse dans les pays Sahelian Francophone 1976) provides an independent set of estimates of supply and consumption up to the year 2000.

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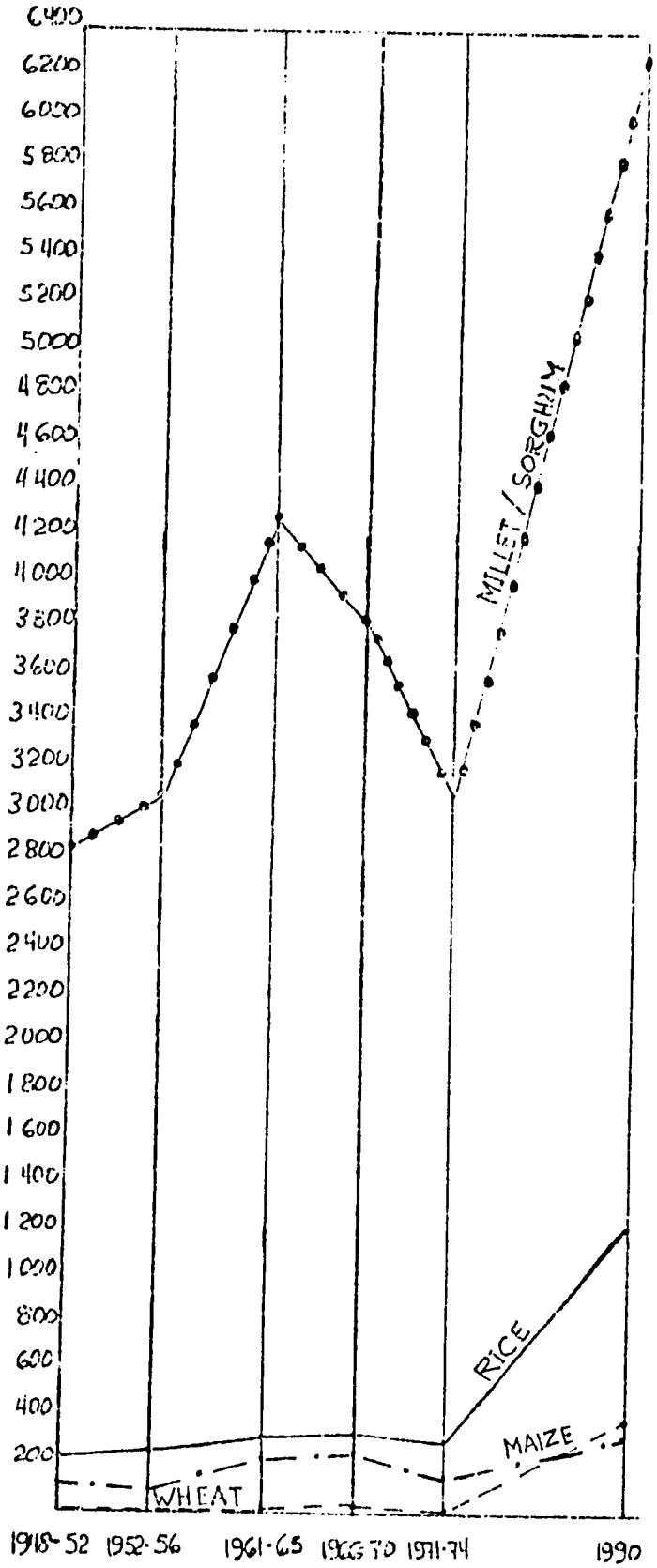
*Furthermore, the FAO data do not include food gathered from wild plants and trees which is a significant source of foods for rural population.

TABLE 13



Source: FAO, 1976

(,000 TONS)

CONSUMPTION

The increase in consumption of food grains proposed in the FAO study amounts to about 3.2 percent a year. With an increase in the farm labor force in the region of about 1.5 percent a year, this leaves about 2.2 percent a year to be obtained by increased productivity. In the aggregate, this is quite attainable for all cereals during average years and for the region as a whole. This assumes a market structure between producing and consuming countries, a pricing policy that encourages the production of the food grains, and a series of profitable, technical innovations developed, demonstrated and extended.

In order to avoid all imports at present consumption levels (except wheat), an increase of 2.2 percent in production is attainable. What does this imply for individual commodities and for individual countries? For commodities, except for wheat, the necessary increases in supply over the next 15 years appear attainable in "average" years. Rice, with a required production increase of 6.1 percent a year, may not be in sufficient supply and other grains may have to be substituted. Technology is also available to lower the risk on yields. However, in a way, this is "buying time." There already are over-populated rural areas, where the density of population is so high that outmigration is taking place and settlement is occurring in the less densely populated areas and in areas being cleared of disease vectors (such as that of river blindness). While it is expected that rainfed agriculture supplemented by small irrigation systems can meet the needed supply up to 1990, thereafter, however, it is expected that more intensive means of production, probably through river basin development, will be needed to meet the domestic food demands.

On a country basis the question of increased supply is complicated by differences in the percentage of the population engaged in agriculture and in its rate of change, the productive potential of the soils, the rainfall, the population density on the land, the potential availability of fertilizer and its costs, and local government policy.

Thus, while the aggregate regional production of cereals (excluding wheat) may be sufficient, individual country productions will not be. National shortfalls will vary from year to year. Trade thus becomes essential and the SEDES-SCET International study estimates the need for interregional trade of up to 1.5 million tons of grain a year, an annual quantity far greater than all regular plus the drought assistance imports. For this trade volume to be possible, there is a need for revised pricing policies that encourage the production

of surplus in one country and its exports to another, an infrastructure of storage facilities, roads and railroads that can carry a greater volume of trade, and commercial institutions capable of handling this volume of trade and transporting it.

3. A Program to Develop Dryland Agricultural Production

The high variability of rainfall and the declining soil fertility in the Sahel are probably two of the most serious physical constraints to agricultural development in the future. Broad recommendations can be made as to how these constraints could be eliminated or reduced, but more resources must be devoted to the entire question of dryland agricultural research and the development of an adaptive technical package. In addition, there are marketing constraints which are due in part to the pricing policies of the countries.

The variability of the quantity and the distribution of rainfall as well as of the effective length of the rainy season cause a dangerously large variability in the crop yields. These fluctuations in crop yield could be reduced and some suggested programs to effect this follow:

a) 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) Breeding Plants Adapted to Shorter Season

Plant breeding programs in the Sahelian states need to be accelerated by setting up more teams to improve the liaison with international research networks and national research centers (e.g., sorghum/millet breeding programs in the U.S.). There is an active millet breeding program in Bembey, Senegal (FED, FAC, UNDP) which needs to play more of a regional role. It could be strengthened in its focus. Similar programs are needed first in sorghum and then in maize.

c) Improving Water Management Practices

This includes tillage practices to increase the amount of rainfall that runs into the soil to reduce run off. It includes practices to reduce run off such as building small levees and ridging land. Plastic covers (mulches) can be used that permit the rain to run into the soil, but reduce evaporation and thus lengthen the period for which the crop has an adequate water supply. However, they may be too costly for field crops.

These and other practices are outlined in the National Academy of Science study, "More Water for Arid Lands," and also in the report from the Institute for Desert Research, Sede Boker, of the Ben Gurion University of Negev, Israel.

There are also areas of low lying lands (bas fonds) and areas from which flood waters recede,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. Strengthening of the research program on flood recession agriculture is important.

There are also areas downstream from existing dams which could be used for irrigation, with a minimum of engineering work. The principles of this are well understood, but in some cases financing of small downstream irrigation projects is needed. This is a suitable activity in development projects.

There are several relatively simple ways to construct small plastic reservoirs for storage of irrigation water for use outside the growing season. While technology has been developed at the Institute for Desert Research in the Negev, Israel, the economics need to be studied in the Sahel. Three simple storage systems are:

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 demand;

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

iii) medium and large sized irrigation perimeters (over 100 hectares) which may or may not comprise all the land farmed by the families involved, and may be for one crop a year, for two crops or for year-round production.

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

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. Industrial type irrigation 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.

d. Improving Soil Fertility

There is a generally low level of phosphate in the soils of the Sahelian states combined with low levels of nitrogen. After a few years of cultivation with phosphate and nitrogen fertilization, a response is obtained from 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 if the social benefit is less than the social cost.

i) 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 ground rock phosphate. Such plants could be used in Niger, Mali and Upper Volta. A German proposal exists for Mali and a USAID proposal for Niger. 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 of phosphates for export. There have been many years of agronomic 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 also usuable in 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.

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

-- 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 quantity fixed is variable. There are food legumes adapted to the region which can be grown in rotation, e.g., cowpeas and peanuts. There are also forage legumes which have been accepted by farmers in the past and which might be profitable at a higher level of fertility. This needs further study. Improved cowpeas and peanut varieties are available and there may be other tropical food legumes acceptable in the area that would be profitable.

-- improving nitrogen fixation. It is believed 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 NAS on World Food and Nutrition Study and by 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 partly under FAC

sponsorship, but with more funds and international collaboration in this, progress should be more rapid.

-- 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 and in response to fertilizers. For example, rice is more effective in the use of nitrogen than most other crops. Traditional (grasslike) 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 from the atmosphere.

-- 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. A promising area is the large lacustrine salt deposits of Chad and Niger.

-- 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, will help to build up soil fertility and maintain the soil organic matter to improve the mineral retention capacity of the soil (the ion exchange capacity).

e. Improved Resistance to Crop Pests.

Pests of all types from fungi and insects to birds 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 of the sector. In the absence of control, the long-term response will be a shifting of agricultural resources into industrial or export crop production. The following crop protection controls are offered:

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 buildup of insect populations. The study of means and cost of control of major insect pests should be intensified. A diagnostic service should be provided. 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 like sorghum (but not millet) 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 grain distasteful only until maturity. Then, with prompt harvesting, bird damage would be minimal.

Damage to cereals is even worse when they mature out of the usual dryland growing 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 research and the extension of its results need to be intensified. The reduction of bird damage is of high priority.

iv) weed pests. It is probable that competition with weeds is one of the major causes of losses in food 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.

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

v) fungal and bacterial diseases. Plant breeding and crop residue management are the means used to reduce the buildup and effect of these diseases. Research is already underway in plant breeding programs.

f. Improve Farming Equipment

Farming has been carried on for centuries with traditional hand tools and with traditional means of management and fertility. The introduction of animal traction and fertilizer and the increase in the quantity of produce sold off the farm disturb the equilibrium of the existing systems. Their equilibrium is also upset in some parts of the region by the increasing density of population, i.e., 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 technology; i.e., the machinery workshops at Ouagadougou and Bobo Dioulasso. This provides employment as well as training for 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 feedback from the farmers) of the real problems. These linkages need to be further developed within and between the countries. The linkage between the experimental units and the development organization is particularly important.

ICRISAT has a very substantial program on dryland farming systems, and a different but equally valid approach has been taken at Sede Boker 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 system 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.

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 a more complex one of changing the whole agricultural system and the social calendar.

g. Improve on-Farm Storage

Traditionally farmers hold the vast majority of grains stored. Farm grain storage needs to be studied along with methods to reduce losses, price policies that encourage storage, credit and timing of repayment to encourage storage and to reduce the need to sell grain at harvest time.

Storage by 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. However, grain losses in government storage have been quite high and costs greater than in the private sector.
sector.

District and national storage is necessary. The new anaerobic storage of fumigated grain in sacks in 550 ton capacity containers (FAO, ODI, German and AID funded) seems to offer a potential low cost solution. 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 further study. FAO has developed a methodology for this purpose and has started national studies outside the Sahel.

In the Sahel region traditional storage is 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 probably have to be subsidized.

There is little knowledge of the extent of losses which occur between harvesting and domestic consumption or export 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, and losses from insect damage are particularly high in storage of cowpeas.

Levels of losses should 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 for district and national storage. In certain parts of the region threshing machines are being introduced; however, since there are known losses in threshing, its utilization needs to be evaluated. There are also losses in traditional methods of milling and grinding grain and in food preparation.

The FAO has proposed 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.

4. Agricultural Research

The results of research on eliminating constraints on agricultural production are only of value if they are put to use. There are 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) the international center responsible for sorghum research. Seeds of this variety are supplied to the national research centers of the Sahelian states by ICRISAT through AID Joint Project 26 in Zaria, 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, Senegal on 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 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, 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 a lesser extent, with peanuts.

A further contracted responsibility of the research institution is the multiplication of mother seeds to supply to the development organization, which may, in its turn, 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 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 research has been generally neglected, and more can be done. At present it is being built up but, to date, the program has delivered little in rainfed crops except new maize and rice varieties. The system needs a thorough check to increase food production and farm income.

Recommendations on research are:

(a) ensure that the research linkages (from the institutions to the farmer beneficiaries), internationally and regionally, are effective;

(b) intensify efforts of research in plant breeding to overcome physical constraints; test the varieties selected in practical farming systems and at practical levels of fertility; and subject the selected varieties to processing, cooking, and taste tests before attempting to promote them. This has co be done on a national basis. It requires not only strengthening the facilities and developing contractual relationships between research and development organizations, but also training of African workers;

(c) research mother seed multiplication by existing research institutions. This is, institutionally, the simplest and most efficient method of obtaining the mother seed rather than setting up a new organization exclusively for the job; and

(d) multiply 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 can buy it. It is not recommended that inputs such as improved seed by subsidized except, if necessary, when the variety is first introduced.

5. Training

In the past the agricultural program has been short of funds which has curtailed the training of staffs at all levels. 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 a 5-6 year post-BAC (Baccalaureat equivalent to bachelor of arts degree) program for "Ingenieur de Conception" and "Docteur 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 an American M.S. degree or the Doctorate du 3^{e} cycle (French). These facilities then could be more fully used.

There is a lack of a higher agricultural school to provide this training in the Savannah 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" - rural engineering
- administration at 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.

Any increase in development programs will need cadres at these levels and may suffer serious delays while waiting for them to be trained.

At the "ingenieur de travaux" level, 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 de-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 be exhausted if a sustained development thrust were to be launched.

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

6. Farm Prices and Farm Income

In the 1960's the Sahelian states, with the exception of Chad, showed a general decline in the real level of per capita income in the farm sector and a real increase in per capita income in the non-farm sector. The indices of farm prices, corrected for the rise in the cost of living, showed stagnation or decline. The disparity between per capita farm and non-farm income grew considerably.

Increases in the world prices of export crops were, in general, not passed on to the farmers. To a large extent this was caused by the governments increasing the export taxes as a source of public revenue. During 1973-1975, prices to the farmers were substantially raised by the relationship between these prices and the long-term world market prices. Given inflationary conditions, it is not yet clear if this trend will continue.

TABLE 14

Comparison of Per Capita Income in Constant 1970 U.S. $ in 1960 and 1970, and Cost of Living and Farm Price Indices (1965 basis=100) FAO

	National Income		Agricultural Sector Income		Non Agri-cultural Sector Income		Index of Cost of Living	Index of Farm Prices
	1960	1970	1960	1970	1960	1970	1970	1970
Senegal	217	189	101	73	583	602	122	71
Mauritania	90	152	60	58	364	830	-	-
Mali	55	46	34	22	241	300	-	-
Upper Volta	38	56	27	28	131	374	113	97
Niger	78	86	56	54	378	422	121	95
Chad	84	66	48	36	274	373	-	-

Source: FAO

TABLE 15

Change in Farm Price Indices (basis 1965=100) for Food and Export Crops
Sahelian States and World Market

	Peanuts			Cotton		Millet/Sorghum			Rice		
	1970	1974	1975	1970	1974	1970	1974	1975	1970	1974	1975
Senegal	82	113	159	100	106	112	150	170	117	139	194
Mali	230	na		132		164			200		
Upper Volta	94	100		94	103	100	150		100		
Niger	87	127	250	87	113	95	208				
Chad	na	116		100	123	100	100		100	128	
World Market	111	208		97	218	102	194		136	132	397
Export Price (U.S. or other large exporter)				88	215	105	225		99	308	

Note: Mauritania data not available

Source: FAO

The declining rate of return to farm labor has a number of important consequences: (a) farm incomes are kept low, (b) employment of non-family labor to meet peak seasonal labor demands has been discouraged resulting in the maintenance of large families and under-employment of family labor for the rest of the year; (c) there has been premature exodus of labor from the rural areas to the urban, and (d) agriculture remains a low status "way of life."

The mass of Sahelian subsistence farmers produce food crops primarily for subsistence (including on-farm storage to tide them over during periods of short drought). They sell only a small surplus because of the combination of limited markets for their products and the low return to labor for any additional output. The farmer gains most of his cash income from the cultivation of cash crops.

It is generally accepted that food crop production is and must be limited by the price formed in the market place. If more food production is desired, it can best be accomplished by improving the marketing and pricing systems.

Regulations of cash crop prices for export is a function of government policy and cannot be altered without the substantial institutional changes which would be needed in order to alter prices of locally consumed commodities. In addition, governments can influence the price of locally produced grains through their import policies of grains such as rice and wheat and perhaps through price stabilization programs.

In the past, not enough attention has been given to pricing policies of food and cash crops and their interrelationship since the majority of the Sahelian farmers engage in both types of crop production.

Low export crop prices have a depressing effect on food crop prices. Low export prices tend to cause farmers to shift their resources to food crop production, thus increasing the general food supply and decreasing food prices. These actions weaken the ability of agriculture to produce a surplus for investment in its own development and to pay for modern inputs without subsidization.

During the drought the high prices of cereal crops, due to market forces, drew extra resources into food crop production. With good weather conditions, some places, i.e. western Upper Volta, recognized that the return per man day, was greater in sorghum production than in cotton, and farmers reacted accordingly producing a surplus sorghum crop during the year 1975-1976.

In the past governments have attempted to influence the price of food grains in at least two major ways: (a) by subsidizing imported cereals such as rice and wheat and (b) by government price stabilization programs.

a) Cereals Import

There are two striking factors in the cereal imports of the region. First, only Mauritania and Senegal import a substantial part of their total cereal supply. Second, however, in every country in the region, as bread consumption grows, wheat imports are increasing at an alarming rate. Between the 1961-1965 and 1966-1970 period Mauritania increased wheat import 7.0 percent and Senegal 5.1 percent, while the rest of the region increased cereals imports an average of 13.5 percent.

The total supply of domestically produced grains of the four interior countries declined slightly in the decade of the 1960's, but still amounted to 96-99 percent of the supply in 1969-1971. During the height of the drought this figure declined greatly.

With the possible exception of Senegal and Mauritania the region has the capability of producing sufficient rice and wheat during normal years to satisfy domestic demand. Whether this would be a sound investment and whether the cost would be greater than that of imported rice and wheat needs to be established.

b) Grain Price Stabilization

The objective of seasonal grain price stabilization programs is to provide sufficient price incentive to producers. In general, price stabilizing programs are not designed to replace the grain dealers because the government does not have the means or structure to do so.

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 occasional surplus cereals need to be exported (the EEC model).

When a government grain board sets cereal prices too high, it runs the risk of accumulating stocks in excess of what it can store and 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 grain price stabilization:

--where only 10-20 percent of the production is marketed, a small like percentage increase in production can double the quantity available to be marketed. Curves of probable production indicate a 50 percent probability of getting a yield 80 percent of the average in the Sahel and 86.5 percent of the average in the Sudano-Sahelian zone. So the fluctuations in a country like Niger (about one million tons a year supply) may be on the order of 150,000 tons in 50 percent 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 would have 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 would all expect the government to buy their whole market surplus at harvest time thus avoiding storage cost and tying up their 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 sell part of his family food reserve expecting to buy more from the government later at a lower price;

--governments have problems in buying good quality grain where no official grading system exists. Poor quality grain is difficult to store for any prolonged period of time;

--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 speculating with other commodities;

--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 storage facilities 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 demand, and
. when governments that have tried to displace the grain dealers have found themselves unable to maintain the market supply; and

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

It is very doubtful that the Sahelian governments can stabilize the price of grain by a buy/sell operation, considering the size of the countries, the transportation problems, and the limited financial and technical means at their disposal.

Given the substantial problems involved in the pricing system, there is a need to study the interrelationship between the price of food and cash crops and the production decision of the farmer. Studies of costs of production of different crops produced in different ways and in different regions are basic. There is also a need to study the effect of government pricing policy of imported and concessionary foods on the price of domestically produced grain.

7. Transport Constraints

Another factor affecting the marketing structure in the Sahel is the lack of roads. Roads permit the movement of people and grain into and out of the region. Projections of food grain supplies indicate that there will need to be an increase in the traditional movement of grain between countries to overcome long-term deficits.

Intra-regional price differentials in food grains are largely a reflection of high transport costs between countries in the region. The part of the price differential due to lack of information on local prices can be overcome by market information services, but that due to transportation itself can only be reduced by improvements in the road system.

It cannot be assumed that road transport is the least cost method under all circumstances. No area is completely cut off from the outside, even if it has no road. There are good examples of widespread use of animal powered transport where no road system exists. For example, firewood - a bulky commodity - is hauled into Ouagadougou within a radius of 50-60 km by donkey carts and into Niamey by camels. The economics of these intermediate levels of transport technology should be studied in relation to the cost of road transport.

LIVESTOCK

General

Traditional methods of ruminant production were aimed primarily at producing enough milk for the subsistence of the herder with meat as a byproduct. Livestock production also represents an effective means of harvesting the extensive Sahelian rangeland, of converting agricultural residues and byproducts into forms for human consumption, and of adding to soil fertility through manure.

As part of the emphasis on dryland agriculture production, more efficient production of livestock should be encouraged because:

1. Livestock is one of the main sources of foreign exchange for the interior Sahelian countries and income for the nomadic population.

2. There is a rising demand in West African coastal meat markets, and Sahelian herders must now compete with other meat exporters (Argentina, Australia); otherwise, Sahelian livestock industry is threatened.

3. Meat is an available food supply and a valuable source of protein for the increased nutritional level of the population. There is considerable potential to expand non-ruminant (pigs and poultry) production to meet local needs.

4. Through mixed farming livestock manure is a valuable means to improve soil fertility.

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. The number of cattle exported to the coastal countries also increased over this period. 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 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. As a result, production has stagnated since 1968. 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. Indeed the last drought reduced considerably the ruminant livestock herd.

TABLE 16

Ruminant Livestock Herd and Its Production
1970 and 1975 (FAO 1976)

	Cattle Head 000		Sheep and Goats Head 000	
	1970	1975	1970	1975
Senegal	2600	2350	3000	2750
Mauritania	2560	1500	6850	6200
Mali	5350	3700	11250	9200
Upper Volta	2500	2300	4000	3750
Niger	4100	2500	8500	7600
Chad	2500	3000	5500	5000
Total	21,600	15,350	39,100	34,500

The drought had an effect of accelerating marketing 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 the purchasing of meat. Meanwhile, meat prices in the coastal countries rose very rapidly as the consumers sought to increase their meat consumption. These factors brought about substantial price increases in and more export from the interior.

The response 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 Sahelian supply for the mass African market supplemented by imported frozen meat. As the world market price was equal to or less than the price of meat in the interior countries, they ran into serious price competition.

Future Demand:

The level of dietary intake of animal protein in the Sahelian States is, on the average, low. Mauritania has an average of 37.1 gm head/day; however, the farmers in the Senegal river basin will have a much lower intake. The Upper Volta level of 4 gm/head/day is almost negligible. Any increase in income will be accompanied by an increase in the demand for meat. According to FAO (1976), the coefficient of elasticity is higher for sheep and goat meat than for beef.

TABLE 17

Animal Protein Supply for 1970 (FAO 1976)

	Animal Protein Meat Milk gm/ Day	Eggs gm/ Day	Fish Poultry Head/ Day	Total	Percent Protein in Animal Form	Percent Caloric Intakes Protein
Senegal	10.3	0.9	12.8	24.0	30	9
Mauritania	31.5	1.0	4.6	37.1	47	23
Mail	10.3	0.8	3.6	14.7	21	8
Upper Volta	2.8	0.6	0.6	4.0	6	4
Niger	12.6	1.1	0.5	14.2	19	9
Chad	7.9	0.3	5.7	13.9	16	7

However, if the increase in income is accompanied by an increase in the price of cereals, purchase of cereals will have a higher priority over the purchase of meat. The consumption of meat may not increase and may even decline. The coefficient of elasticity for milk is only about half or less than for meat, showing that the consumption of milk will not increase as much with income as the consumption of meat.

The ruminant livestock herds amount to about 15 million cattle and 35 million sheep and goats, with the cattle providing over 60 percent of the ruminant meat. The cattle herd, which is more susceptible to drought losses, was reduced by 29 percent between 1970 and 1975 and the sheep and goat herds by 12 percent.

The cattle herd also supplied the 450,000 work oxen used in 1970 and will be called upon to supply almost 1,500,000 in 1990. This will require about 7-1/2 percent of the available supply of oxen of suitable age. However, there may be local shortages.

The increase of supply for meat demands projected by the FAO for 1990 will be difficult to achieve if efforts to develop the sector are delayed. An increase of seven percent a year in cattle and five percent a year in sheep and goat production will be required. The increased demand for meat (as well as for draft animals) on the domestic market will be incompatible with maintenance of the levels of exports in the early 1970's; that is there will be a conflict between the domestic and export markets for the limited supply. The outcome in terms of the partition of the supply will depend upon the political and economic decisions taken on the import of meat from the world market and the import duties imposed on it.

The projected increase in demand for milk is also unlikely to be met, in part due to lack of production and in part due to difficulties in assembling the small quanitities of milk from large numbers of dispersed producers.

TABLE 18

Demand for Ruminant Meat, 1990 (FAO 1976)
(000 tons)

	Beef Domestic	Total	*Annual % Increase in 1975	Sheep/Goat Domestic	Total	Annual % Increase	Milk Domestic	Annual % Increase
Senegal	76.1	76.1	8.2	12.5	12.5	3.0	425	7.3
Mauritania	32.2	63.7	9.7	16.8	26.8	4.4	360	5.6
Mali	80.0	80.0	4.7	72.0	72.0	6.0	303	6.7
Upper Volta	42.8	42.8	4.2	27.0	27.0	5.0	174	4.8
Niger	63.4	94.0	8.6	53.4	53.4	5.2	467	5.6
Chad	43.5	96.0	7.0	22.7	25.0	3.9	349	4.9
Total	343.0	452.6	6.9	203.8	216.7	5.0	2168	5.8

*Includes export at 1970 levels

Recommended Program of Livestock Development

To meet the projected increase in domestic and export market demands within the limitations of the Sahelian economy, increased production and the market of surplus meat and milk can be accomplished through the various techniques proposed below:

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

2. Improve the yields of pastureland 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 systems for 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.

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.

1. Water supply development

Water development on rangeland has usually led 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 to administer.

Recommendations:

a. 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.

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

c. 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.

d. 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.

2. 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:

(a) by improved range management practices, e.g., controlled grazing, burning, brush control, reseeding;

(b) by construction of small levees (of stones) to hold the water on the land and increase the water supply for the pasture;

(c) by improving nitrogen fixation which may increase yields; and

(d) by using 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).

3. 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 for nomadic herders. The projects include the UNDP/AID center at Dilly, Mali, the UNDP/AID/FAC Assale - Serbewal project in Chad, AID Chad livestock project, and the IBRD Mopti regional livestock project.

The packages might be based upon gaining the participation of herders by a program of reducing calf mortality by parasite and disease control, 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 range management, grazing control, and water development programs, 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, and dry season cattle finishing are all potential components of such a package. When productive activities have been launches the herders may elect to participate in social service activities, education, training, improved domestic water supply, and improved health services.

4. Increasing ruminant livestock production in higher rainfall zones

With the higher rainfall the number of options open for developing livestock production increases. 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, and removing trees for use and sale as firewood. This necessitates rural planning for land use and trying to preserve the traditional relationship between farmers and herders. Frequently, the best areas with vacant land are those recently cleared of disease vectors - tsetse 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 such might be installed at a feasible cost.

In the Sahel, pasture improvement with brush control, range management, reseeding and other means is often feasible, provided it can be controlled by water or land being allocated to a certain group.

There has been experience with grazing associations which have been viable and continued after the expatriate project management left. However, it has always been difficult to control the grazing by 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.

Mixed farming is generally close to some large city with a road network in which milk assembly and processing schemes are feasible.

5. Mixed farming systems

So far there are few, if any, examples of 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 means a cropping system designed to support the livestock enterprise and vice versa. This integration, used to build soil fertility, was recognized by the Romans and, until the advent of the 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 rotation to maintain fertility; the hay and forages are gazed or fed to the ruminants, together with other crop residues. The animal manure is applied to the land, preferably by a means that does not lose the available nitrogen. The ruminants may be draft animals, cows, finishing steers, sheeps or goats. Other agricultural byproducts and even crops may be fed to pigs and poultry, again using the manure on the land.

This type of development is extremely important as a means of maintaining and improving soil fertility without the use of chemical fertilizers.

In setting up a development program for sedentarised herders, the following steps are recommended:

a. Identify sparsely populated areas where potentially good grazing grounds and farm lands are found. If not contiguous, the grazing and farmlands should be linked by cattle tracks.

b. Select areas where the potentials for grazing and cropping can be maximized at low cost.

c. Specify rules regarding the use of grazing and farmland.

d. Execute projects directed towards removal of major factors limiting grazing land in order to enhance the potential animal carrying capacity. Since the shortage of protein in the dry season and flyborn 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 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.

e. Select interested Fulani pastoralists who can be accommodated in areas where the environmental base has been improved. The choice of prospective candidates will not be difficult. Many semi-nomadic Fulani are keen on increased opportunities to engage in farming. Notably, units that are short of cattle to an extent that their self-sufficiency and independent 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 units with less than ten head of cattle per household member.

f. Group units according to their affiliation to wider kinship groups in order to facilitate social interaction and cooperative arrangements.

g. Define grazing grounds and farmlands and subsequently divide them into feasible operating groups adjusted to the labor force and herd size of the units.

h. Grant secure farmland titles to individual units. Although communal grazing rights have a strong tradition, it seems that the use of land and responsibility for grazing grounds have individualized.

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 not make it 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.

6. Modern ruminant production systems

In the higher rainfall zones, if suitable land can be found and water supply is available, there is a possibility that small ranches can be developed.

Some available areas may be infested with tsetse flies, but it may be possible to produce either zebu cattle with careful management and prophylaxis, 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 does not provide milk for the substence of the herders.

Care will be needed to ensure that these ranches are limited to the target populations lest investors outside the livestock sector take ranches in their own names or in the names of nominees.

7. Poultry production

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

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

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.

8. Pig Production

Pig production is popular among the animist population in Upper Volta where it is even an export product. The "European" butchers shop 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 few local sources of improved breeding stock. Little is known of the health status of the pigs or the economics of production.

9. 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 from the interior countries. 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, a third for taxes and other expenses (assuming taxes are all paid), and a third for interest on investment and profit. 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 francs ($13.40), but some of the regional governors recently applied a new tax of 10,000 francs ($22.30) a head to discourage export.

This situation needs to be revised in the light of the new competitive state of the market on the coast. The cost of getting 1 kg of meat from Australia to Abidjan is about equal to the cost of moving meat from Bamako to Abidjan by the least cost method plus taxes, with no allowance for interest or profit.

The principles of development on 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.

10. 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 poorly 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 organization - the Livestock and Meat Board - which is responsible for coordinating development projects, and Upper Volta has its Regional Development Organization which integrates 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 organizations 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 infrasturcture for delivering the package, with shortages of adequately trained personnel, with payment of salaries for more officials in the services, and for their logistical support.

11. Personnel Training

Personnel are needed in various disciplines for production, marketing and processing phases, as well as for veterinary services and administration. People are also 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 preferably should be satisfied in a regional institution in one of the Sahelian states and be acceptable 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 agricultural) 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.

12. 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 model 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.

Recommended Studies

a. Study the effect of improved range management practices, such as controlled grazing, burning, brush control and reseeding, on rangeland productivity and livestock production, including the seasonal change in digestability of the forage and its ability to support livestock. This applies to the different climatic zones.

b. Select improved forage species for rangeland and forage production.

c. Determine the feasibility of constructing various types of simple structures to decrease the run off of water from rangeland.

d. Review the "experimental" Sahelian livestock production interventions to propose a future course of action leading to an integrated development plan.

e. Review Sudanian zone livestock interventions to identify a set of viable activities including land use planning, control of grazing, pasture improvement, tsetse clearance, and water supply. This includes the organization of an extension system.

f. Evaluate the interventions and spontaneous development in mixed farming systems, including the supply and use of byproducts, the effects on soil fertility and rotations, integration of forage conservation into the farming calendar, veterinary services delivery, animal finishing and marketing. This includes the provision of extension for farmers in livestock production.

g. Develop viable poultry production activities as a component of integrated development programs.

h. Evaluate the pig production systems in the higher rainfall area including limitations in feed supply, health status, and markets, and the economics of parasite control, intensified production, improved breeds and alternative sources of feed.

i. Evaluate the effectiveness of the existing vaccines and the strengthening research program to develop new vaccines. This might involve protection against hoof and mouth disease and against other diseases which are not currently in the region.

FISH

With a production that has reached about 300,000 tons a year and has the potential to 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 product

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

Considering the small amount of resources invested in the sector by governments, the output is amazing. The industry consists of full-time and part-time fishermen using different systems for catching fish according to the conditions, type of water (lake, river, flood plain, etc.) and season. Additionally, there is 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 and the volume was greatly reduced by the drought.

1. Constraints

a) First, there are losses due to insect damage when the treated fish are 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 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.

b) Apart from losses in storage and marketing, the next most important constraint is inadequate fishery management at all levels in the sector. There is also a severe lack of trained personnel. Training of higher cadres has been proposed for a regional school to be set up at Mopti. A pilot program was submitted by the UNDP in December 1974 under CILSS, and the proposal for preparing a project for five 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 capability of higher cadres, who could then train medium and lower level cadres within individual states.

c) 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 and 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.

2. Some Current Activities

Mali: Fish production of about 100,000 tons a year, exported (dried or smoked) to Ivory Coast, Ghana and, to a lesser extent, Upper Volta. A FED project since 1971 covers

-- 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, and

-- extension and professional training of middle level personnel.

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* Occasional Paper No. 4 of CIFA, the Committee for Inland Fisheries of Africa, FAO, Rome 1975.

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.

Chad: The fish catch in the Lake Chad Basin is about equal to that of the Niger River in Mali, and the problems are generally similar. 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 is modest--on the order of 10,000 tons a year.

There was a one and a half year FAO/UNDP fishing development project in Niger to train people from Niger and Benin 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.

FOA/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 an early developmental 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.

3. Recommendations:

a) The fisheries sector provides a potential for increased tax revenues by Sahelian governments if production

is increased and management improved. The sector is a large employer of part-time labor. Therefore, training schools and research should be further expanded and supported.

b) Fisheries cooperatives should be organized so that new techniques for lessening the rate of spoilage can be disseminated.

c) Credit should be provided for new equipment purchase and transport systems for getting fish to the markets should be developed.

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 Eaux et Forets are responsible for combatting desertification as well as the programs for providing wood for heating, fish smoking and structural uses.

A CILSS/FAO Conference held recently in Dakar had as its objectives:

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

1. Problems

a) 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:

i) there is no massive advancing form of desertification caused by man,

ii) 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,

iii) localized desertification is occurring due to man's activities, and may be caused by:

- removal of the vegetative cover for cultivation and subsequently abandoning the land as unsuitable for cropping,
- overgrazing, particularly around permanent water points, and
- denuding the area of forage.

b) Deforestation is a serious problem caused by:

i) 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,

ii) careless cutting of trees for livestock to browse, and

iii) farmers cutting down trees which serve as bird roosts.

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

2. Interventions:

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

i) it is difficult and costly to plan and establish, and no one species would cover the whole region,

ii) it would only serve as a windbreak for a few hundred meters, and

iii) 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.

b) Feasible Interventions: Certain activities can be identified, such as:

i) the need to define the role of the forestry service,

ii) 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 Bodo Dioulasso (Upper Volta) and in the Cameroons.

iii) reforestation, which 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 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.

iv) use of the forest service in a program of conservation of the vegetative cover, land use classification, and management. This would include a soil conservation service role for planning conservation practices as part of agricultural development programs.

3. Delivery System:

A forestry activity or a series of activities are rarely self-supporting or feasible 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.

II. C. HUMAN RESOURCES DEVELOPMENT

Among the approximately 25 million people in the eight Sahelian countries, there are roughly 37 distinct linguistic/tribal groups. As a result, 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 development will not take place 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 by assisting, regionally and nationally, with these primary education reform goals.

Given the present circumstances, the schools, especially the primary schools, tend to impede rather than contribute to rural development. Fundamentally, the system in each of these countries is still patterned after the French model developed in the colonial period rather than having 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 enlitist and urban i.e., They are geared to the needs of those few who will rise through the entire system to take professional positions, rather than to the vast majority who will receive only a few years of schooling. 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 of 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 the following table, 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 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 system 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 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 educational/human resources development include:

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 educational/human resources development sectors can be significantly increased in spite of human resources needs. Financial contributions are being made for education/human resources development purposes, but 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 experimentation on greater utilization of educational television capability; (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 (1) and (2) are essentially at the basic and functional levels, category (3) 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, where in 1970 42% of the age cohort group was in primary school and 8% in secondary 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 language. The question of choice of language is a controversial one, and has relivance to national goals, functions of education, availability of basic and of technical material, social custom and other matters. Clearly this a matter for national deliberation and choice. Many educators do feel, however, that more attention could be focused on the advantages of the local languages than heretofore. 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 the 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 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 centers 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 thos 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. If primary systems were taught in African languages, 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. The importance of learning an internationally used language such as French should not be underestimated, however. Many African nations feel strongly that such ability is essential to having access to advanced knowledge and technology in the developed work as well as inter-African and other international cooperation.

However, 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 in order to lighten the construction and recurrent costs which the Sahelian countries and donors will need to cover. The fact that the school and its staff will be serving the entire community may well make the assumption by the villages of a portion of school costs acceptable and thus make the expansion of the system viable and help to insure its relevance.

Efforts to "Ruralize" the Primary School System. Constraints for pilot project efforts attempting to make the rural primary schools serve rural needs have been (1) lack of pre-planning studies of socioeconomic 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 processess 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 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.

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 development 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 revision to

illiteracy after leaving an incomplete 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 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 and health, 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 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 enrollment 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 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 the distribution of 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.

The development of radio capabilities and the production of necessary materials for enrolled listeners, 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 per country, 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, "partial" capability installations would each 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, and health. 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. 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 approached such as basic literacy newspaper, transportable and inexpensive records and record players which can be incorporated into radio education activities, can 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. 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 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 manpower for the agricultural sector for all Sahelian countries. In addition, 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 FNSA'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 upgrading 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 upwards of 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)

<u>The estimate for Irrigated Agriculture</u>:

Based on 100,000 farms it would require

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

Assuming that there will be 200,000 irrigated 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 levels of staffing now exist for land already under irrigation.

Information related to the number 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
Engineering	A1	15	108	88
Engineer	A2	5		
Counselor	B1	59	410	284
Director	B2	67		
Technical Agency	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 (Societe d'Etudes pour le Developpement Economique et Social) made the following recommendations related to manpower needs in agriculture:

There should be made available immediately 230 agriculturla 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 200 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 levestock; (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

agricultural, rural engineering and livestock should be doubled within 5 to 6 years (Ph.D. level)

In terms of institutional needs in each state, SEDES

one school to 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 technicians 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 agricultural based on the U.S. estimate of Niger's dryland agriculture needs for the year 20000, 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 req-ires 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 makes 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 adequately prepare qualified managers and administrators to serve at all levels throughout the government structures of the Sahelian countries. Unless this basic manpower requirement is addressed at the provincial and local government levels, as well as in the capital cities, it will be difficult to improve substantially the existing development efforts and it will be impossible to carry out with any degree of effectiveness expanded development 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 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 for their respective countries. Unfortunately, however, these institute and university programs rarely concern themselves with middle and lower level administrative manpower reqirements 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 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 government 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 si 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.

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 government 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.

II.D.MINERALS

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.

1. Fertilizer Minerals

a. 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 fluorine 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, 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.

b. 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 could become a supplier of ammonia to the region.

2. 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 presently 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 focused 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 regionwide 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 progresses, those sites identified in preliminary surveys close to access arteries could become attractive enough to encourage the expenditure of private funds for more detailed exploration.

II.E. INFRASTRUCTURE

1. Transporation

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 extention 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 market 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 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 2,000 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. Additionally, there are 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 Nguigmi. 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 Nouadhibu 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 1,300 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 groundnuts 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 parts of Lagos and Port Harcourt relieved. An extension of the Conakry-Kawkaw 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, 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 analysis 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 and humanistic method of analysis which differs from the traditional economic evaluation. This method would seek to assess the intangible benefits of opening up communication to relatively isolated populations such as the benefits of better health services and educational opportunities and the cultural impact of closer and more frequent contact with more developed regions and the outside world. 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 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. The Improvement of Highway Maintenance

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 and 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.

c. 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 be 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.

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 government 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 cargoes. 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 cannot 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 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 upriver 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 may not be 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 five 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 future 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 highway network.
Estimated Cost: Undetermined.

(4) Studies in each Sahelian country to determine recurring maintenance costs in highway department.
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

II.E.2 TELECOMMUNICATIONS

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 ad 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 progressively as the future demand arises due to the long-term development program, 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, 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.

Proposed Projects

Some projects which should be initiated as soon as funds are available include:

a. Set up a telecommunications network to tie in with the gathering of hydrologic data.

   Estimated Cost: $7,750,000

b. Study needs of agricultural extension services for a telecommunication network.

   Estimated Cost: $1,000,000.

c. Study the public health services' needs for a telecommunication network.

   Estimated Cost: $1,500,000

II.E.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 region (1975). (See Annex I) An FAO report on Sahel agricultural development, presented at the recent Club Des Amis meeting in Dakar, is also available, as is a French report on water resources presented at the same meeting.

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 Tillabery 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. 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 (FOA 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 stablize 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 évapotranspiration 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 wherever 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 effects

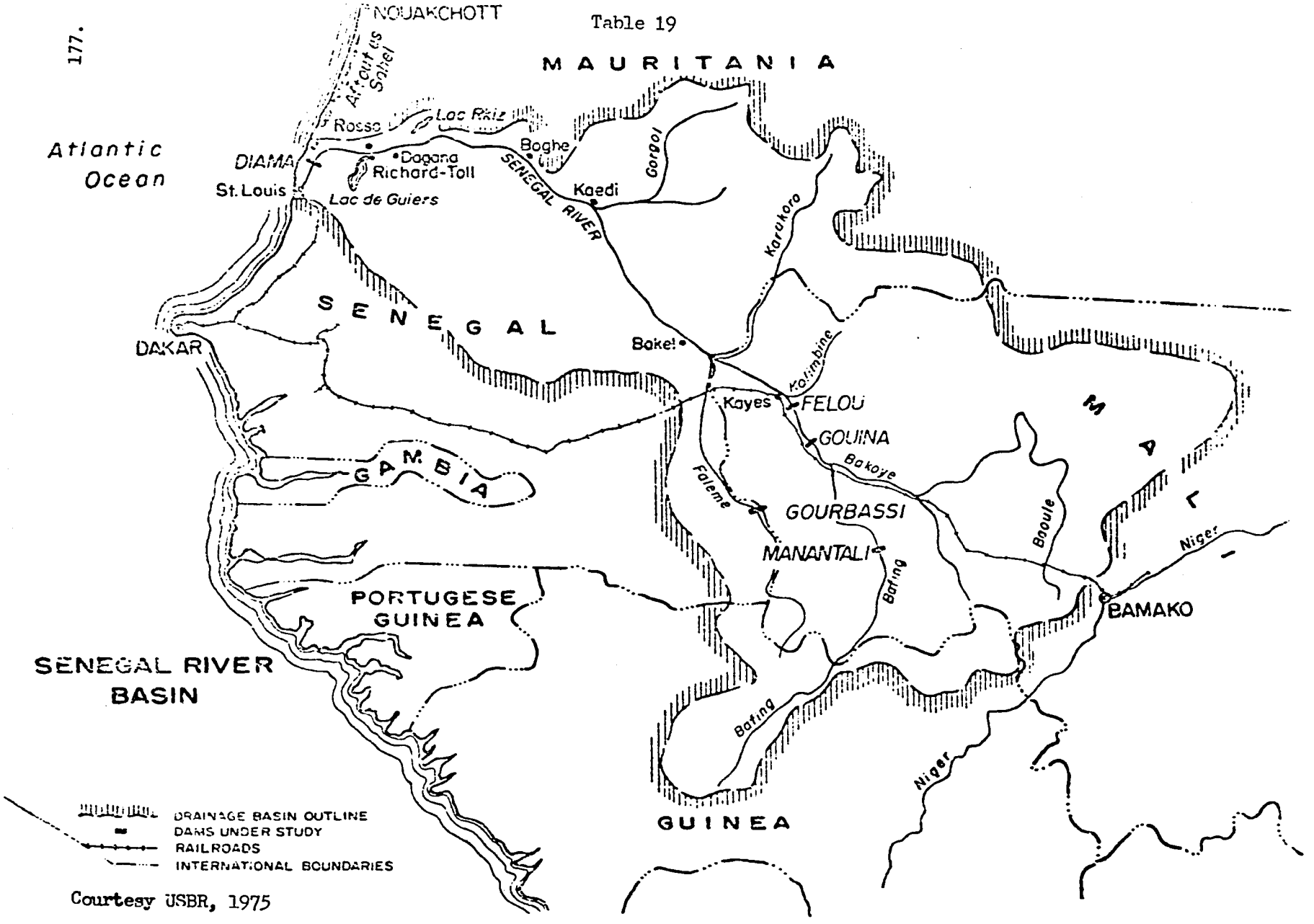
on disease vectors and other environmental impacts of both changes in the river regime and the introduction of large-scale year-around irrigation.

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 live-stock.

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 satisfactory 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

Table 19



Courtesy USBR, 1975

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 basins? How much water and electric power are needed to exploit them? Where are the mineral 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 susidized 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 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, Gambia, and Volta basins, international basin authorities have been established with membership by all or most countries riparian to the surface water system.

b. The Senegal River Basin

The Organization 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, and Kaedi Mauritania; Richard Toll, Dagena, Podor, Matam and 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 Manantali, there has been no clear concensus in definitive technical studies 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 Manantali, the People's Republic of China submitted its technical conclusions on Manantali dam in March 1975. However, the report could not be studied as it is in Chinese, apparently not available, and the principal basis for summarizing it is an oral report to OMVS with accompanying drawings and maps. The Chinese are not interested in participating in funding investigations, final design, or construction, but have estimated project costs at $250 million and state that the dam would provide 771 million KWH per year 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 Manantali 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 Manantali 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, and that other alternative sites may be more economical and should be investigated.

There are a number of unresolved technical problems connected with Manantali, 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 Manantali are unknown, making design of a dam extremely risky; (b) the estimated 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 quesswork 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 Manantali - since minimum flow of 100^3 M/sec at Bakel is needed for salinity repulsion, Manantali's 300^3 M/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 salt-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 some of the problems in utilizing the OMVS as an implementing agency for investigations and project implementation. Under pressure from its member govern-

ments, 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, hydroelectric 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 large-scale 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, agronomic, soils classification, topographic, 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 over-built or under-built (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 (which means several days of virtually no flow).

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, there is the vast hydrologic records on file in the OMVS 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. 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, while 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 generations. 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 might 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, archelogical 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 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 must undertake this program. It will require secondment of up to 25 professionals in such fields as civil engineering, economics, agronomy, livestock, sociology, public health, 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 illstrative listing of projects to strengthen the OMVS Secretariat and MOVS planning capability follows.

<u>Hydrometeorology Study</u>

<u>Estimated Cost</u>: $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

Construction and final design costs of first priority project selected from desk study.
Estimated Cost: $ 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

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, Benin, and Nigeria.

Less than a million years ago the upper Niger entered a vast inland lake in the Timbuctou-Arouane 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 hydrometerologic 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 mouth.

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. 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 the Southwestern Chad. From the confluence with the Benue, the Niger flows another 500 km southward, terminating in a complex delta system of islands and divergent channels 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 it source, the Niger flow 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 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 artifical 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, the monthly mean outflow rates, as often measured at Dire (about 50 miles upstream from Timbuctou) 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 about 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 evaportation 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 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 seven months or more and is below 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 and 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 peak exceeding that of the later February flood, and thus dominates the regime from there to the sea.

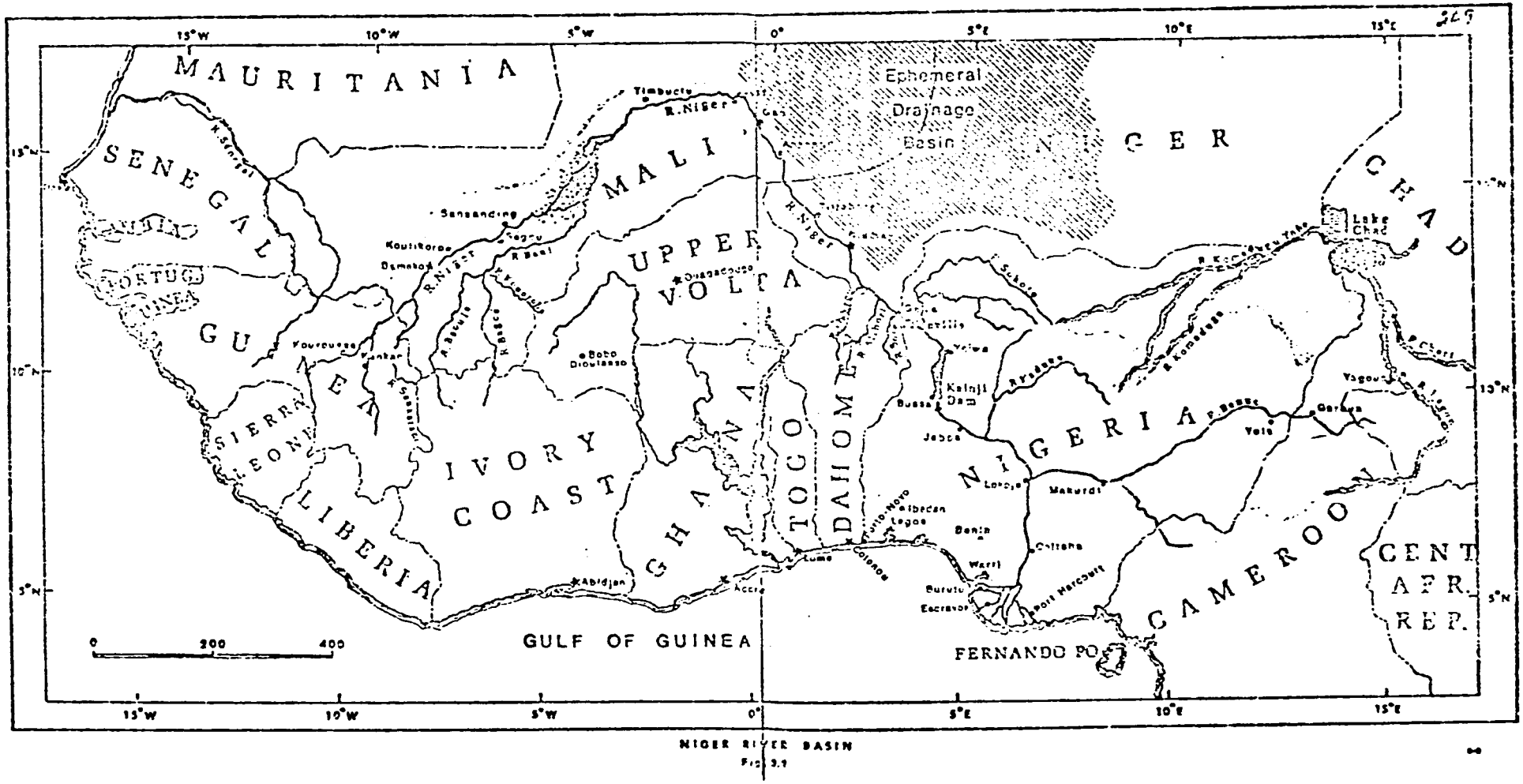
The average annual rainfall in the basin varies from 2500 mm in the highest part of the catchment in the parts of Zone I and shades down to 750 mm at the entrance to the interior delta. In the interior delta there is rainfall of 250-750 mm, while through Zone III the variation is from 250 mm near the 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 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).

Table 20

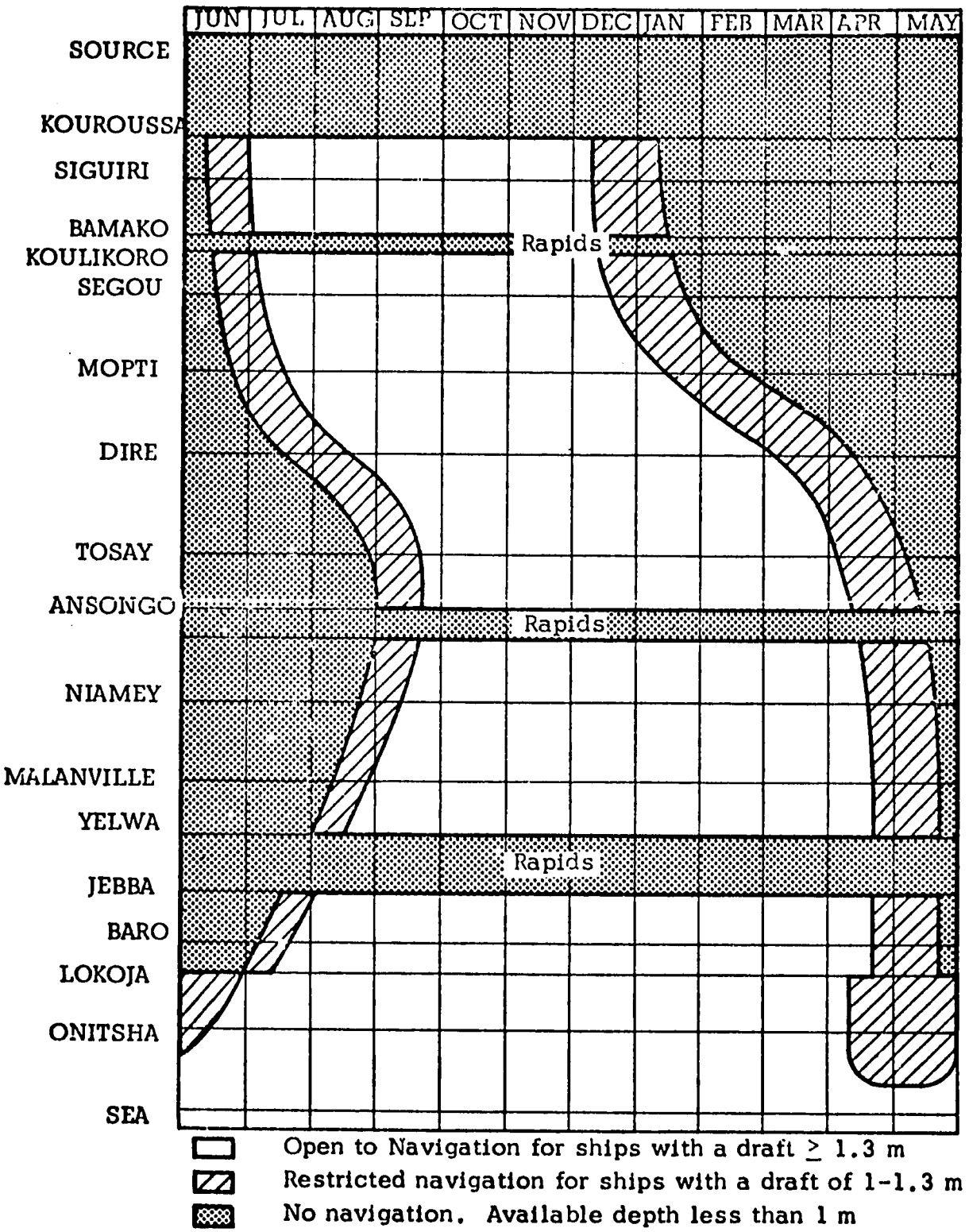
NIGER RIVER BASIN



NIGER RIVER BASIN
Fig. 3.1

Courtesy of Helmen and Narven, Inc. 1968

Table 21



Navigability of the Niger

Source: Holmes and Narver 1968.

Much of the interest to date in using Niger water has been for inland water transport in various reaches of the mainstreams from Kouroussa to Bamako, from Koulikoro to Amsongo through the interior delta, from Tillabery, Niger, to Yelwa, Nigeria. The other reaches are not open to navigation because of rapids and the Niamey to Yelwa reach is obstructed by the Malanville-Gaya bridge which has only a 0.6 m clearance at normal high water.

The Niger River 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 to 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 capabilities 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 would 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 Niger River 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 Niger River 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.

An 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 interests 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, for 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 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 for resettlement, 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

Niger River 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

Construction and final design costs of first priority project from desk studies.
Estimated Cost: $400,000,000

Basin-wide minerals survey
Estimated Cost: $ 2,520,000

Support for Secretariat Cadre Development
Estimated Cost: $ 650,000

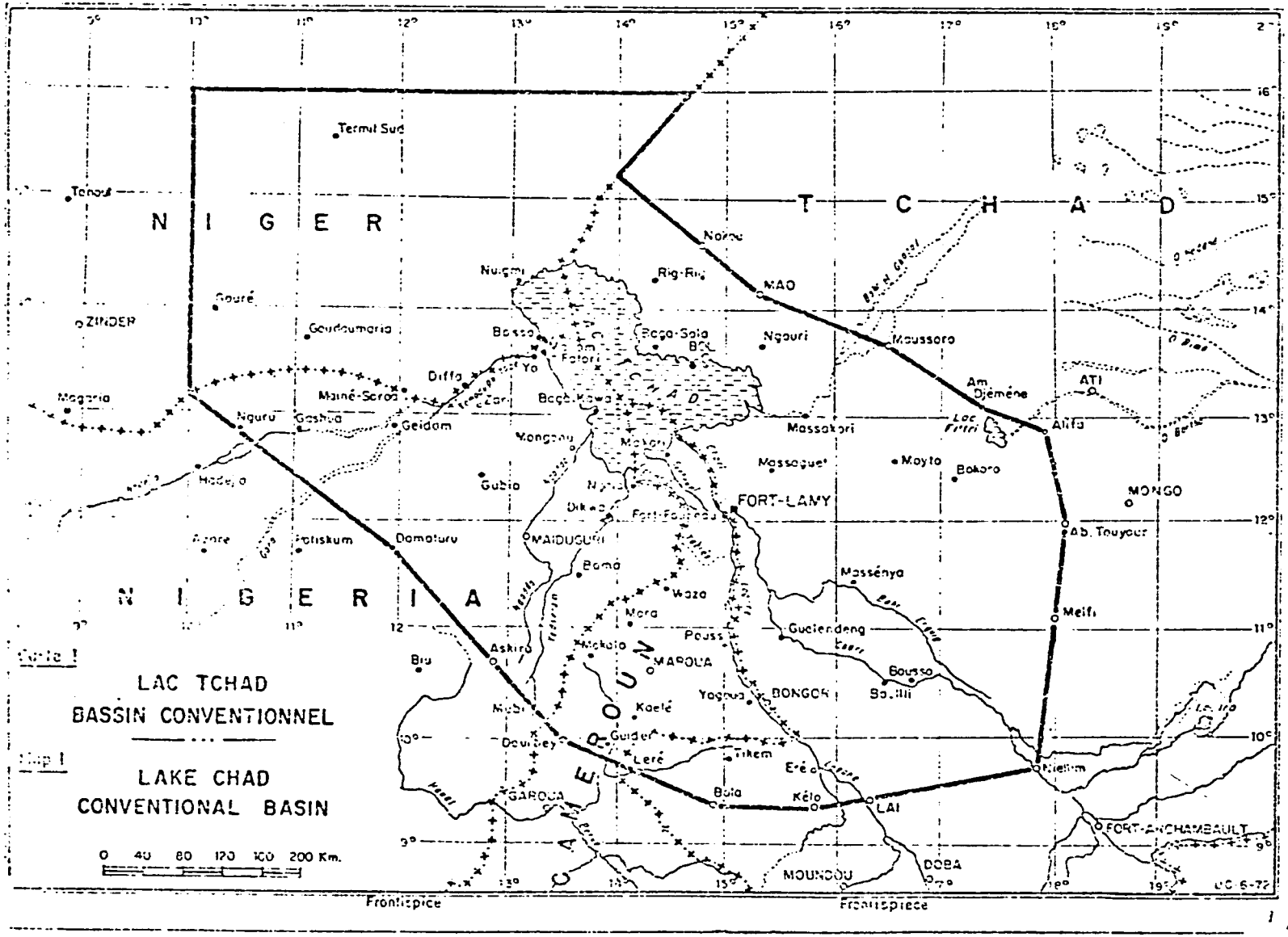
Non-formal education for farmers on pilot irrigation projects
Estimated Cost: $ 1,710,000

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: $ 6,630,000



Source: Lake Chad Basin Commission 1973

Table 22

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 in 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 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 Chad is an extensive, almost circular region, covering some 2.5 million km^2 and located between latitudes 6° and 24^oN 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 Benue, a major tributary 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 basin 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 en-route. 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, Libya 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. 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 (LCBC) 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 channelization and controlled flooding, or from goundwater.

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 drains 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 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 recent drought and events of the two normal rainfall seasons 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 continue 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 Liro(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 -- the 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 320m 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 headwaters of the Benue tributary of the Niger make a large indent in the shape of the Lake Chad basin. The Mayo Kebi appears to have progressively captured and directed flood flow of the Logone basin. A more permanent channel could capture and divert much of the mainstream 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 with 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 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 Secretariat 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 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 experimental irrigated agriculture farms in the Sahel. The Director of Engineering is a capable technical administrator and 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 and 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.

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 in 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.

Diversions 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 the months after the rainy season. A small diversion dam on the Komadugu Yobe is under construction to expand the Diffa experimental irrigation farm.

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 estimated 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 $7.8 \times 10^9 m^3$ and this would lower the lake level by 76 cm which -- assuming a return to predrought 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. without lowering the lake during overage years below the critical level. 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 listing 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: $ 538,000

Power and Energy study for basin area
Estimated Cost: $ 600,000

Basin-wide fishery study
Estimated Cost: $ 1,220,000

Establishment of pilot on-farm fisheries areas
Estimated Cost: $ 3,135,000

Basin-wide minerals survey
Estimated Cost: $ 1,610,000

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

Final design and construction cost for first priority project
Estimated Cost: $ 50,000,000

Aquatic weed study
Estimated Cost: $ 750,000

Basin-wide transportation study
Estimated Cost: $ 400,000

Legal advice for preparing a statement of principles of water utilization in the Lake Chad Basin
Estimated Cost: $ 115,000

II, E.4. POWER AND ENERGY

The present utilization of energy in the Sahelian countries is representative of their United Nations catagorization 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.

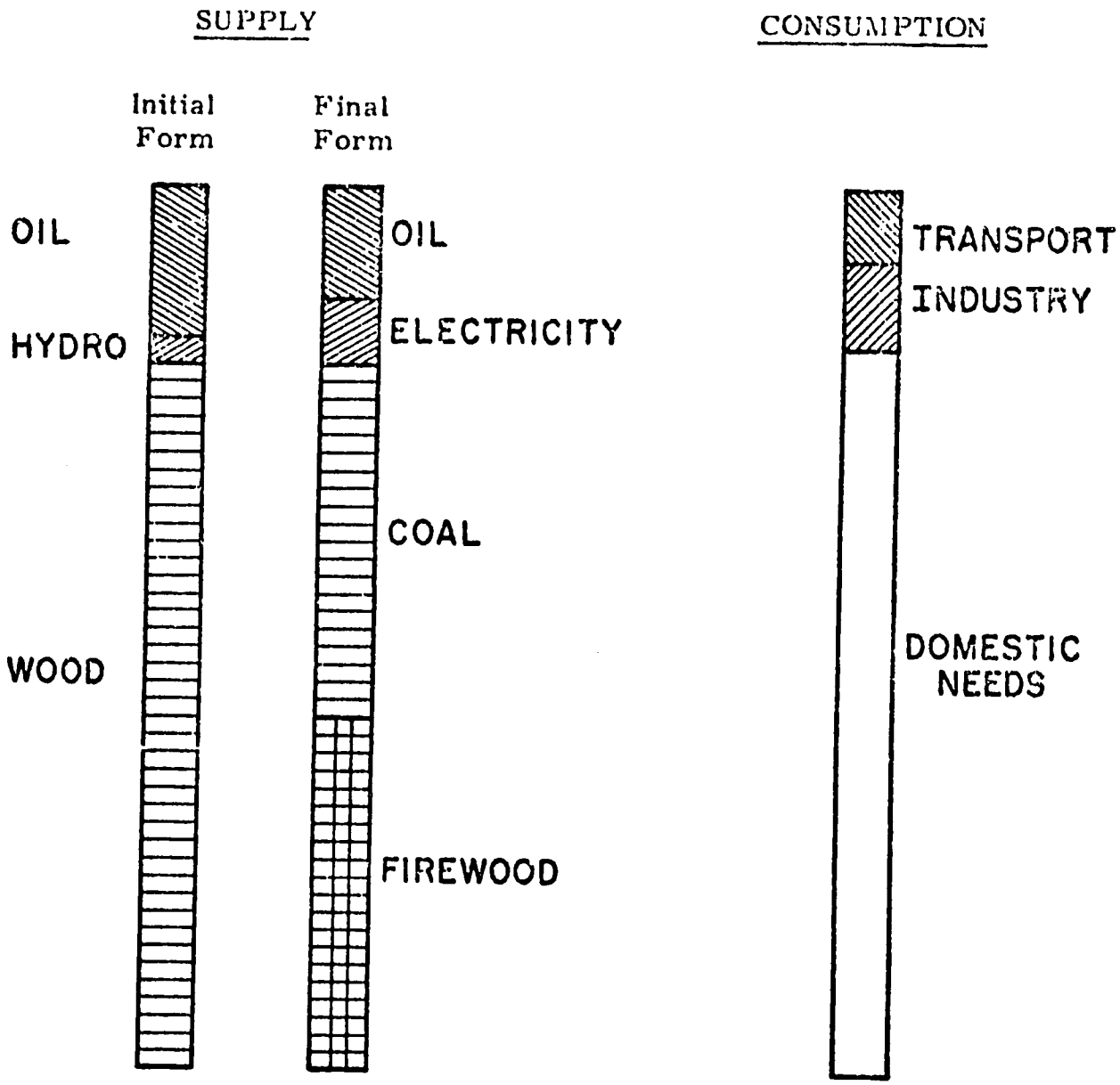
Insofar as energy from fuel for power and heat is concerned, wood represents 90 percent of total energy consumption in the region. Use of wood as a fuel is beginning to have detrimental effects on forest and tree resources. Upper Volta and, to a lesser degree, Mali, may be on the verge of significant 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 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

Table 23



Present Pattern of Energy Consumption and Supply

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 delemma 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 appears 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 Tennesco, 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 a low-cost solution to energy needs would be realizable 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 liquefaction 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 goodwill 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 consortium, and there are important known uranium 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 Senegal and Niger rivers is substantial, but not impressive when compared to other 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 feasible medium-term solution to the region's energy needs, 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 hydrometerologic data and the 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 prioirty 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 agriclutural 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 isolation is between 8 and 10 hrs. a day in most of the region. Under these conditions, the average solar energy available in the region is about 560 calories/cm^2/day. Although solar energy institutes exists in both Naimey and Bamako, most research and development will take place in the developed countries. Sahelain research 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 governmetns and regional institutions to obtain knowledge of the techniques of making and implementing energy policy and training their own technicians in these concpets is the power ane 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.

II. F. HEALTH SECTOR

I. INTRODUCTION

In formulating recommendations to improve the health of people in the Sahel, a number of elements can be identified for careful consideration. These elements will necessarily be a part of any proposed approaches to raise health levels, and they will play a key role in the eventual outcome.

The first such element is the identification of the health problems which currently exist and the diagnosis and eventual elimination of their causes. Recommendations therefore must seek to develop the capability for rendering not only therapeutic but more importantly, preventive services for long-term improvement of health conditions in the region. This approach emphasizes an integrated program of health, nutrition and population services.

The second important element is the identification of those constraints on the provision of services which are not inherent components of the health problems themselves, but, rather, are a reflection of inadequacies in human and material resources, or of deficiencies in the design and implementation of approaches to health problems. The identification of these kinds of constraints is important because they can potentially be modified or removed by better utilization of resources or by infusion of additional ones.

The third element of importance is the recognition of the fact that states of health can affect and be affected by activities in other, non-health sectors. This recognition is important because it necessarily brings with it a broader view of the nature of health problems, and therefore a broader delineation of the area of responsibility of health workers which is more accurately tailored to the problems.

For example, from the health sector point of view, the recognition of the interaction of health with other sectors leads to an awareness that accomplishments in the non-health sectors can enhance states of health, such as when improvements are made in the quality and quantity of food. It can also lead to an awareness of potentially negative influences on health levels, such as when environmental changes made for development purposes brings about uncontrolled dissemination of insect vectors of disease.

Obviously, then, to maximize health achievements with positive inputs from non-health sectors, as well as to protect health levels from being eroded by activities in other sectors, certain kinds of general recommendations are required. They would seek to establish mechanisms to engage health workers in a broad and comprehensive variety of health-promoting activities not restricted to treating existing illnesses, but also including educational, nutritional, and sanitation sector activities that can prevent disease and illness. Family planning should be included in their services whenever possible. Also, the approaches suggested would seek to establish mechanisms by

promoting activities not restricted to treating existing illnesses, but also including educational, nutritional, and sanitation sector activities that can prevent disease and illness. Family planning should be included in their services. Also, the approaches suggested would seek to establish mechanisms by which health workers can have a role in the design and implementation of projects in non-health sectors which have a potential impact on health levels, be it positive or negative.

From the point of view of non-health sectors, the recognition of interaction with the health sector leads to the realization that achievements in the health sector can enhance their gains, such as when reductions in absenteeism or disability permit a fuller participation in labor, education, or other pursuits. However, not all positive gains in the health sector add to the achievements in non-health sectors. Thus, reductions in mortality which increase population growth rates or alter the age structure of the population can slow or cancel the gains being made by increasing the demand for goods and services.

These consequences of health achievements, although relevant from the point of view of workers in non-health sectors, must also be reflected in any health sector recommendations to improve health. Specifically, the positive consequences of health achievements need to be noted in every domain because this would help health planners to determine more precisely the role of health interventions in an overall socio-economic development scheme. Also, the potentially negative consequences of health gains on population growth rates need to be counteracted, and health workers can accomplish this in part by working to control fertility. Recommendations on integrating family planning into maternal child health programs and devising additional means of providing family planning to rural populations outside the scope of established health services.

The fourth and final element deserving of careful consideration is the priority attached to health in the overall social and economic development strategy. The long term objectives articulated by the Sahelian countries as a group, rather than as individual countries, appear to be responsive to both social welfare (including health) and economic needs, according the highest priority to neither one. In the absence of any clear cut theoretical reasons for focusing most heavily or exclusively on either social or economic goals, and in the light of pressing social needs, the mixed emphasis of the objectives which have been put forth appears to represent the most satisfying course of action for both host countries and donors to pursue.

The recognition of these dual priorities gives direction to any approaches we may recommend for improving health levels. That is, by being responsive to health problems and humanitarian concerns, we shall attempt to make recommendations that pertain to populations which evidence the greatest needs, and by being cognizant of economic objectives, we shall attempt to make recommendations which promote these goals by directing services to the groups which figure to play a prominent role in achieving the economic objectives.

II. CURRENT HEALTH PROBLEMS

Estimates by Caldwell for the Sahel suggest a birth rate close to 50 per thousand, a life expectancy under 40 years, an infant mortality rate still over 200 per thousand, and a crude death rate no lower than 30 per thousand. Estimated rates for the nomads reflect even worse conditions. These are among the most unfavorable measures of general health levels, and among the worst in Africa which has the lowest life expectancy of any major world area.

The burden placed on children is particularly staggering. Rates of forty to fifty percent mortality before the age of five are often quoted. Fournier in rural Niger has reported infant mortality rates of 250-300 per thousand live births, and the fact that only four of ten live births live to be five years of age. From the strict point of view of health needs, it is clear that children are in desperate need of intensive efforts to protect their states of health.

Infectious diseases are repeatedly referred to by all observers as the major category of disease morbidity and mortality in the Sahelian countries. This is not surprising, for it appears to be true not only in the rest of Africa, but throughout the developing world. It was also true in the more developed countries prior to the twentieth century.

Recognition of this generalization leads to the important conclusion that certain host and environmental factors, which are shared in common by the poor people of developing countries, are the key determinants of infectious disease morbidity and mortality. From what is known about the living conditions in the Sahel, we can list the chronic state of malnutrition which exists particularly among the young as a determinant host factor. Evidence of the existence of the problem is seen in a survey from Senegal which has estimated that 9-14% of children under five suffer from grade III malnutrition. Evidence for the importance of the problem is seen in the effect of measles on mortality of children in the Sahel contrasted to its usual benign effect on United States children.

Among the environmental factors which contribute importantly to the incidence of disease are the lack of clean, safe supplies of food and water, inadequate disposal of human and animal wastes, prevalence of insect vectors of disease, and conditions of crowding where they exist.

The relative importance of various infectious diseases is not well known because of a lack of reliable incidence and prevalence rates. This is a major constraint in planning rationally for disease control efforts. Certain diseases are thought to be more important in some countries or areas than others, and this is undoubtedly true for diseases which are vector-borne, but it has not been reliably established for others which spread person to person. Non-infectious diseases such as cancer, diabetes, and cardio-vascular disease are even less well characterized. They receive scant mention from most observers, so that the extent of the problem which they pose for Sahelian peoples remains unknown.

On the basis of existing reports, however inadequate for comparative purposes, we can list the following diseases as being responsible for significant morbidity and/or mortality: malaria, tuberculosis, diarrheal diseases, measles, menigitis, parasitic infections by protozoa and helminths, syphilis, gonorrhea, leprosy, and trachoma. Of limited geographic distribution but having serious economic impact where they prohibit productive utilization of land areas, are onchocerciasis, trypanosomiasis, and schistosomiasis.

These assessments of the nature of health problems in the Sahel, and of the factors which promote their occurrence have not come to novel conclusions. The situation has been apparent to many observers for some time. What would be novel is a more precise and accurate descriptio of the relative importance of various diseases, not only by disease category, but by age group and other epidemiologic variables. However, even lacking this more suitable data for precise interventions, there are many recommendations which can be made. The challenge of the health problems is not a theoretical one in which the causes of disease are unknown and must be researched. Rather, the challenge is one of commitment to apply existing knowledge and resources to problems which we recognize and understand in specific enough terms to be useful. This indeed would also be a novel and welcome development in the Sahel.

III. CURRENT CONSTRAINTS IN MEETING HEALTH NEEDS

A. Health Budgets

The percentages of the total national budgets of the Sahelian countries which are allocated to health are usually under ten percent, and reach levels as low as five percent in Chad. These allocations reflect health investments of about one dollar per capita, and operationally of only 30 cents per capita in Chad. With such scant financial resources, it seems clear that only minimal kinds of services of a very rudimentary nature can be provided, and/or that only a very few people can be served. Reflecting on these figures for a moment, one can imagine what must be the enormous dimension of the health problems. Most of the constraints that remain to be described are in large measure a direct consequence of this financial one, and thus its importance cannot be overstressed. The Sahelian countries are among the poorest in the world, and this economic fact of life conditions many essential features of the health sector.

Within the limited financial resources allocated to health in each individual country, it is nevertheless instructive to examine how these limited funds are spent. Certain patterns in allocating funds appear to repeat themselves. For example, a large share of the Sahelian health budgets is allocated to supporting hospitals, and this results in an unbalanced support of therapeutic services. In Mali, for example, three-fourths of the health budget goes to support ten hospitals, while the division of socio-preventive medicine receives only sixteen percent. The same is true elsewhere.

Also, a large share of the budgets goes towards recurrent personnel costs, and this leaves only limited funds for drugs, equipment, and supplies. Therefore, even the basic curative services that might be provided by a system weighted in that direction, are hampered by inadequate resources in providing these services. As an example of how serious this problem can become,an astounding estimate of 85% has been made for the percentage of the budget devoted to personnel costs in Upper Volta.

Since hospitals and personnel receive most of the available funds, and since these are located almost exclusively in the largest population centers, then it is not surprising that there is great disparity in the services provided to urban and rural residents. If measured in terms of per capita health expenditures in Mali, it is estimated that Bamako city residents receive $8.40 per capita compared to only $1.10 for rural residents.

These observations concerning the inadequacies of total resources available for health, and of the unbalanced nature of even the few resources that are available in favor of therapeutic services among urban residents, contain very clear cut implications for recommendations when viewed from a number of perspectives which we believe have been or should be adopted. First is the perspective which emphasizes the importance of preventive public health services, second is the perspective of seeking to help populations which evidence the greatest need, and third is the perspective of seeking to help populations targeted to participate in economic development schemes. Since the logic of the first perspective, the preventive approach, is self-evident and agreed upon by many health officials in the Sahelian countries, it is clear that recommendations must be made to establish a more balanced delivery of both curative and preventive services. Since the second and third perspectives are already reflected in articulated Sahelian long term objectives, and since rural populations appear to have the greatest needs, as well as the largest roles in agricultural development, it is clear that approaches to improving their health levels must receive the highest priority. Also, from the magnitude of the inadequacies in total resources, large infusions of funds will have to be invested.

B. Personnel

Observers are unanimous in reporting a lack of personnel, and this applies to most if not all categories of health workers. Furthermore, as alluded to earlier, this lack of personnel is particularly serious in rural areas.

The training of many of the health professionals is considered to be inadequate because of the kind of in-service training often given, and the lack of programs for retraining, and to be inappropriate because it does not include more public health studies.

Recommendations which seek to overcome current constraints in the category of personnel must seek to increase their numbers, and to improve their quality and distribution.

C. Health Facilities and Delivery Systems

Data from Senegal illustrate the point that there is an uneven distribution of facilities in terms of beds available per 1,000 residents. In the urban area of Cap Vert, there is one bed per 257 residents compared to one bed per approximately 2,000 residents of the less populated areas of Senegal Oriental.

Estimates of the population covered by existing medical care facilities give an indication of the adequacy of the number of facilities. Most estimates of coverage are very low, indicating a real lack of any effective ability to reach the majority of the populations. An estimate from Senegal gives a coverage of only 15% and if the quality of the coverage is further considered, then the coverage becomes incredibly low. Most of the nomadic populations remain outside the reach of any existing mechanisms for delivering services.

The services available at many rural dispensaries are minimal, involving simple first aid measures and dispensing of basic drugs. Many rural dispensaries are reported to be in very poor physical condition, and drugs and equipment are often missing.

From these assessments, the alternatives appear to be recommendations which seek to construct new facilities or to develop new mechanisms for delivering services to rural populations. The need to renovate existing facilities is also great in certain areas such as Chad.

D. Health and Demographic Data

We have already mentioned the lack of very precise data on incidence and prevalence rates. However, the lack of reliable information inhibits a wide variety of undertakings in the health sector, as well as other sectors. Data collection and analysis systems must be developed so that good data are available for effective planning and implementation.

E. Health Administration

Among the administrative weaknesses which appear to exist now to some extent in each country, and which could be expected to constrain the effective utilization of any additional resources, are the lack of health planning capability at the national levels, the lack of a unified authority for all health matters within the ministries, the lack of mechanisms for evaluating programs and personnel, and the lack of coordination of donor assistance. These deficiencies may in part have political causes, but appear due also to a lack of trained skills in health administration.

IV. SOME ASPECTS OF PROJECTED HEALTH PROBLEMS

Without the introduction of considerable efforts to control infectious diseases, one would anticipate that the list of major disease problems in the Sahel would not be changed considerably in the immediate or long term future. Since there is currently a major effort to control onchocerciasis in selected areas, one could project that this disease would be of diminished importance in the next twenty years.

As for reducing the toll exerted by the other disease problems of the area, one can hope that current plans for improving rural agricultural, livestock, and fisheries production will result in improvements in per capita income. This in turn could provide a means for reversing some of the poverty, its attendant living conditions and malnutrition which contribute so importantly to promoting the incidence and impact of infectious diseases. Thus, if these economic objectives are pursued in conjunction with a series of health goals designed to reduce the burden of infectious dieseas, and to remove the constraints in the areas of personnel and others, there is reason to expect improvement in the overall measures of health levels. However, the commitment required and the magnitude of the tasks remain particularly great in the Sahel, and counteracting a potentially positive trend may be certain of the health and economic achievements themselves.

For example, gains in the reduction of mortality may well alter the size and structure of the population burden to the already growing numbers of people in the Sahel. This health sector related contribution to the population could offset or diminish economic gains, so that health sector workers must increase the magnitude and scope of their task to include efforts at limiting population growth.

Also, achievements in large scale environmental changes, or large scale resettlements may create new opportunities for the spread of disease and insect vectors of disease. This economic sector contribution could cancel health gains, so that additional effects will have to be made to include health considerations in the design and implementation of a variety of non-health projects.

V. CONCLUSIONS

From these assessments of the nature of the health problems facing the Sahelian peoples, of the constraints imposed by and within the health sector, and of projected problems which remain to be addressed, the picture which emerges in broad outline is a very unfortunate one. It depicts for the most part very rudimentary medical care services, and even these minimal services are restricted in availability to a small percentage of the total population of the area. And as if this were not enough, the convinction is that even if curative medical care services could be upgraded and extended to an even wider segment of the population, then health problems would persist because therapeutic services are not well suited or adequate in dealing with the causes of infectious diseases. What appears to be needed is the addition of a new variety of preventive public health measures.

To bring about the necessary changes in the kind, quality, and coverage of health services in the face of such an imposing list of problems and constraints represents a formidable challenge to the commitment of donors and of the Sahelian countries. As an initial step in alleviating these health conditions, the following recommendations have been conceived. It is assumed that the health changes sought will be pursued in the context of accelerating social and economic development, to which they may contribute, and from which they will derive additional support.

VI. RECOMMENDATIONS

1. To obtain acceptance of health goals which dictate a high priority to expanding preventive public health services, and to extending both curative and preventive services to a majority of the rural populations.

This recommendation is made first because its adoption by the Sahelian countries and donors is a prerequisite to the acceptance of many of the recommendations which follow. It embodies conclusions which are not new. In fact, the priorities are already mentioned in the health plans of some countries, and in the reports of most analysts of the health situation in the Sahel. However, despite this apparently encouraging state of affairs, there is really little evidence that the priorities are being put into practice. This discouraging fact signals to us that there undoubtedly are complex and continuingly valid reasons for why the existing systems have evolved to their current state, and that the implementation of the priorities would produce such fundamental changes in the medical establishments and certain populations that it is meeting a considerable resistance which is not often mentioned. In short, these priorities appear to have been accepted only on paper. This recommendation, therefore, testifies to the importance which must be given to these priorities, and urges a more knowledgeable and committed adoption of them.

2. To make operational the existing systems for delivering medical care services.

This is a priority recommendation for short term implementation. It recognizes and endorses, as evidenced by the current design of existing services, that the need for basic medical care services occupies a primary place in health priorities. This has not been adequately supported by many health analysts in their zeal to recommend preventive services. Our view is that until the Sahelian countries can accomplish what they are already committed to doing in the area of basic medical care, there is no point in trying to upgrade or expand services focusing on the less than immediate needs.

2a. To define the minimum kinds of medical care services that the Sahelian countries are truly committed to providing at each level of the health delivery systems.

This will be the first step which can be taken immediately and which may already have been taken by some countries. The listing which this proposal is intended to bring about should represent what the governments are capable of providing under current conditions from existing facilities.

2b. To identify existing gaps between what services the governments have deemed themselves capable of providing, and what services are actually being provided.

These gaps would be identified through a careful survey and evaluation of the existing facilities. The deficiencies will thus become a primary focus of efforts to make existing systems operational.

2c. To correct the identified deficiencies immediately through the use of all available internal resources, and secondarily by means of external assistance.

It is anticipated that the most urgent deficiencies, such as unstaffed dispersaries, or dispensaries operating without drugs, could be corrected by a redistribution of personnel, and reallocations of drug supplies, and other resources. If these measures prove inadequate to bring existing facilities to the minimum level of service, then external assistance should be sought to complete the process.

This may well constitute the least ambitious of all the recommendations we shall propose, yet the anticipated difficulties are great. This is because of the reorientation of priorities which is reflected in these recommendations. It may involve reassigning medical personnel from urban areas, and redistributing drugs, from hospitals which have little, to dispensaries which have less. However, unless these recommendations can be carried out, it will reveal an inadequate commitment to the welfare of the rural majority, which commitment many of our recommendations depend on.

3. To expand the kinds of medical services that can be provided from facilities that are operational, but are only providing the minimum level of basic medical services.

Since the medical care services being provided from the rural dispensaries would be the least comprehensive, it would seem most important to begin upgrading the medical care system from the bottom up. The goal is not to make each medical facility completely autonomous, since some centralization of services will always be required for the most specialized surgical and other services. However, there are a number of medical care services that one would not expect to have been included in the minimum level of services, and some of these could now be included in a strengthened system. Also, of special importance would be the addition of preventive public health measures. The following recommendations are made to achieve the expansion.

3a. To identify the additional medical care and public health services that are to be provided in an upgraded system.

Obviously each country may wish to define these services for itself. Identification of the public health measures is considered to be expecially important since this will represent a new orientation for existing facilities. Among the basic medical care services that might be added at the most peripheral levels are more highly trained nurses, a new construction to allow for a few beds, a small maternity service, an expanded supply of drugs, pure water supplies, refrigerators, vehicles to allow for medical evacuations, and facilities for minor surgery. The list of potential public health measures could be even longer. There are a number of demonstration health posts now being supported in parts of the Sahel such as in Senegal, Chad, and Mali which include a variety of public health measures, and the most promising ones from these models might be considered for wider application. Among the public health measures that we would deem

feasible and desirable are a variety of educational efforts aimed at improving pre and post natal care, infant nutrition, disposal of human wastes, provision of clean supplies of water and food, and personal hygiene. There are a number of public health measures more direct than health education which could be engaged in to prevent health problems. These include the actual provision of food to rehabilitate those who are malnourished, the construction and maintenance of latrines and wells, the provision of fertility control devices, and immunization. All these services could not be provided within the confines of the health post walls. Since some of these measures require an application to groups of people to be truly effective, this orientation to public health also singals the need for health personnel to be responsible for entire population groups surrounding their facilities, and not only for the population of patients who present themselves. Health workers must become more mobile.

3b. To provide the additional personnel, drugs, equipment, and supplies required to expand the basic medical care services and to include the public health services.

To what extent external assistance will be required is not known, but it is expected to be great. It is anticipated that as certain rural development projects begin to pay economic benefits to their participants, and as the demand for health services grows, then these participants could be expected to absorb some of the costs of their health services. Existing attempts to tie in economic and health projects such as those in Mali and Senegal should also be studied for possible funding mechanisms. However, this would not apply to everyone but primarily to rural producers. In the meantime, the provision of the necessary material resources for implementing this recommendation represents an area in which external donors have already stepped in, and an area in which they can make major contributions.

3c. To provide additional training in public health to existing personnel.

This could form the basis for the beginning of a regular program of retraining of health personnel which we expect to recommend elsewhere in this report. It is expected that existing personnel do not have the necessary appreciation for the importance of environmental factors in disease causation, and that they need to acquire

skills and attitudes that will be necessary to deal effectively with problems at the population level.

4. To extend basic medical care and public health services beyond the reach of existing facilities to the village level through the use of volunteer village health workers.

This recommendation seeks to implant a new mechanism for reaching the majority of the rural Sahelian population, or rather, seeks to develop a framework within which rural populations can help themselves to promote their own health with a minimal dependence on the limited existing health systems. The services which rural populations could provide for themselves are far from ideal and comprehensive, however; the choice is really between the limited services, or continued lack of any services. The potential of this approach has been demonstrated in parts of the developing world, including rural Niger. The following recommendations are made.

4a. To establish pilot projects on as wide a scale as feasible in the immediate future in each of the Sahelian countries.

Essentially these projects should provide short term training to village volunteers nominated by their villages. They would be taught to recognize common disease problems, to administer simple drugs and first aid, to recognize conditions requiring evacuation, to report disease outbreaks, to maintain simple records, and to engage in the promotion of village public health through efforts in the areas of family planning, nutrition, sanitation, personal hygiene, and water supply. Traditional midwives could similarly be nominated and receive formal short term training to improve many aspects of pre and post natal care of children and mothers. Models in Niger and elsewhere should be evaluated for any generalization which might help smooth the implementation of village workers in the Sahel. The Niger project should receive additional support and extension. The important features of the projects developed so far include retraining, supervision, and community involvement, and all these elements should be allowed for in the design of pilot projects in the Sahel.

4b. To investigate the feasibility of including traditional health workers from the villages as members of the new village health team.

Traditional health workers have several important characteristics which might be used to promote this program. They live in the villages, and are trusted and known by the people.

4c. To extend the program of volunteer village health workers as the best ways of doing so are evolved from pilot projects.

The major problems are expected to be in the areas of supervision.

5. To develop fully mobile health teams as an additional mechanism of delivering a variety of health services.

Mobile health teams have already been created in the Sahelian countries in response to the major endemic infectious diseases. By being available to respond to disease outbreaks, and to provide immunizations on a mass scale, these mobile teams provide a valuable service not within the capability of the static health facilities. If these teams could be made fully operational, they could achieve their goals of infectious disease control more effectively. Also, if they could be increased in numbers, and if the services they render could be expanded, they could make even more substantial contributions to improving states of health. In order to achieve these goals, the following recommendations are made.

5a. To make operational the existing mobile health teams.

Mobile teams are continually plagued by shortages of vehicles, fuel, spare parts, drugs, vaccines, refrigeration equipment, jet injectors, and funds for travel expenses. In order to maintain these teams in the state of prepared alert necessary to control...funds to keep the teams operational.

5b. To define the immunization goals of mobile health teams.

Over and above their function as disease "fire fighters", the mobile teams can, as a matter of more routine and regular service carry out mass immunizations. However, these programs need careful planning to assess which vaccines are feasible to provide, to which target populations, and with what frequency. This proposal seeks to recommend studies which will develop realistic immunization goals for the existing mobile teams. After these have been identified, support will have to be provided in terms of vaccines and commodities.

5c. To increase the number of mobile health teams, and to expand the kinds of services they deliver.

This recommendation would be for implementation after the fire fighting and immunization functions of the existing teams are being fulfilled. By increasing the number of teams, smaller geographic areas could be assigned to each team. This would permit the teams to spend more time in each village, and to make more frequent visits. In such a situation, the teams could provide certain basic medical care services to villages which have not yet developed village health workers, and/or could lend support to existing village workers. Also, they could carry out a number

of preventive public health measure ranging from health education to inspection of water supplies. Ideally, one can conceptualize a system where a mobile team would be assigned to a static health facility. It would constitute the mechanism by which this facility could extend its reach over an entire population in a specified geographic area on a regular enough basis to satisfy the needs of this population for basic medical care and public health services. The costs of providing such comprehensive coverage would of course be enormous. It would be of interest to develop this model on a pilot basis, however, at some static health facilities. We might then include a mobile health team as part of recommendation 3a. In a model area, a mobile health team could serve as the link between an upgraded rural health facility and a large number of volunteer village health workers. This would result in an integrated and relatively antonomous three faceted health delivery system serving the needs of a defined geographic area.

5d. To develop mobile health teams capable of delivering basic medical care and preventive public health services to nomadic populations.

Movement patterns of nomads by season should be studied, collection points at watering and other locations identified, and teams assigned to visit the most suitable locations for reaching large numbers of nomads at regular intervals. A number of basic health services could be provided, including such things as vaccination, health education, and treatment of common problems.

6. To develop and support training opportunities for all categories of medical workers.

In order to meet wide spread shortages of personnel, additional training opportunities in a wide variety of health fields will have to be developed and/or supported. More precise assessments of manpower needs consistent with specific health sector goals should be made, and plans made to train those numbers which can be effectively absorbed.

Improvements in the quality of the training received appear to be needed to provide more public health training and more relevant experiences during in-service training.

Many observers have echoed the needs which existing personnel have expressed for retraining periodically to provide new information and professional stimulation. Recommendations have been made for achieving this through the development of a traveling faculty, and the feasibility of this approach should be experimented with. Such a program might also provide a badly needed mechanism for evaluating personnel performance.

7. To develop more accurate and reliable data gathering capability on health and vital statistics.

The Sahelian countries can not afford to waste any resources on programs which are vitiated by incomplete or inaccurate data. Almost everyone is unanimous in bemoaning the lack of data on the Sahel, and in expressing the need to rectify this situation, yet there is little evidence that any real progress is being made in the area of data collection. Our belief is that donors who recognize the fundamental importance of good data for effective planning and implementation of all health programs can make a significant contribution to the Sahel people by making the commitment now to develop data collection mechanisms. The following recommendations are proposed.

7a. To analyze existing or forthcoming census and survey data

Most of the countries are carrying out or have just completed censuses, and numerous special surveys of the populations have been conducted. It is important that this data be centralized and analyzed for the population and health factors crucial to health planning; and that the results be tabulated and available for planning in all sectors.

7b. Promote censuses and additional surveys to fill data gaps

In those instances where professional analyses of incomplete data cannot provide the missing information or demographic and health planning, additional data collection should be undertaken. Continuing support of census programs in each country is necessary for tracking and understanding of events and for formulating future plans.

7c. To develop a system for recording vital events.

Studies should be undertaken to develop and implement the most feasible ways of achieving this continuing record of health and population statistics. As village health workers are implanted, perhaps this responsibility could be given to them.

7d. To upgrade existing systems for reporting communicable disease

The disease notification system which exists in some countries is basically sound. However, it was not designed to provide reliable incidence and prevalance rates as much as to provide a means of alerting health authorities to potential outbreaks. This

important but limited function could be expanded upon to provide more reliable epidemiologic information. Pilot projects to develop such upgraded reporting systems could be started in selected areas. Several elements of a well designed reporting system can be described. They are the following:

1- A listing of reportable conditions
2- A listing of diagnostic criteria for the reportable conditions.
3- A mechanism for channeling the reports to the proper authorities such as telephone, telegraph, or messenger.
4- A mechanism for carrying out surveillance of reports received.
5- A mechanism for reacting to reports with appropriate interventions.
6- A mechanism for feeding back summary reports to the providers of the routine reports.
7- A mechanism for enforcing penalities for delinquent reports.

If developed, such reporting systems could incorporate additional features' such as reporting on nutritional deficiencies, and thereby provide a nutrition surveillance system.

7d. To obtain data by sampling methods in areas where information on a total population is not deemed feasible to collect.

8. To carry out special studies to determine the magnitude of certain infectious disease problems, and to determine the feasibility of implementing control or eradication programs.

This recommendation is similar to, but broader than our previous recommendation for mobile health teams, 5b. It seeks to identify those infectious disease problems which can be tackled with existing technology and proven control methods, and suggests that those diseases which are amenable to control should become the targets of specific projects. The recommendation is broader than that focusing on immunization as a technique, because it recognizes the existence of other control measures such as chemprophylaxis and vector control which might be applied effectively in the Sahel.

Mechanisms for implementing these control programs could make use of existing, operational, mobile health teams if immunization or chemoprophylaxis are selected as preventive measures, or they may require a regional approach with specially trained personnel if insect vectors become the targets. The programs could be restricted to relatively specific populations when the goals are to control disease which are restricting the productivity of adult agricultural workers, inflicting excess mortality on children, or hindering the development of certain land areas.

9. To improve the administrative capability of the Sahelian health ministries.

In order to overcome existing contraints the following specific suggestions are made:

9a. To develop a national health planning capability where this does not exist.

This will require the training of health planners. Until they have been trained in adequate numbers, external technical assistance may help to satisfy present needs for planning.

9b. To unify the authority for all health related programs within the Ministries of Health

This is designed to overcome the fragmentation of responsibility for various components of the delivery system, and to unify the authority for technical and budgetary matters under one office. Only when such conditions exist can the overall approach of the national governments be an integrated one. To bring these changes about, ministries could be asked to undergo a thorough review of administrative practices in each country. The more effective procedures could then be recommended for implementation, and the ineffective ones abandoned.

9c. To develop offices to coordinate donor assistance in terms of identified health priorities and objectives.

This office could serve a valuable function in locating donors to support specific components of the health plans where necessary, and to try to rechannel any offers of assistance which are not consistent with health goals into programs that are consistent.

9d. To develop mechanisms for supervising and evaluating personnel, and for evaluating programs.

10. To develop a population program

The drought has brought increasing recognition of the delicate balance between material and human resources. Any benefits of increased food production and infrastructure development threaten to be offset by continuing rapid population growth. It then becomes even more important to anticipate the population effects of the health program so that potential gains in increased infant survival, life expectancy, and health levels are not damped through their added demands on forthcoming agricultural and other programs. Specific recommendations are as follows:

10a. To promote recognition of the need for considering the population effects of health and other development programs

There is a long outstanding need in the development of the Sahel assistance strategy to establish a consistent demographic perspective for the period of the program. Initial baseline demographic information for the development programs could then provide a point of reference for the interactions of health and other sectors with the populations they attempt to effect. The anticipated changes could then be fed back to provide more consistent information between programs and for better program planning. Efforts should thus be made to 1) formalize demographic and health data and baseline projections for the programs (using the resources suggested in 7a, b, and c) and to 2) identify and anticipate the effects and interactions of the programs on these demographic factors.

10b. To offer fertility control information and services to all countries

Information and education programs should be undertaken to inform couples of the advantages of family planning and the methods of regulating fertility. Family planning services should be integrated into maternal child health programs, with an emphasis on child spacing and on developing alternative strategies to bring these to those rural populations beyond the scope of existing services.

10c. To promote appropriate development policies and programs which encourage lower fertility.

Development policies and programs should be supported which would change the socio-economic milieu to encourage smaller families. This could include increased female education and employment which compete with continuous child bearing and rearing, laws and regulations easing access to family planning services, opinion leaders' publicized support for family planning, and economic incentives for smaller families.

11. To develop mechanisms whereby health workers can have input into the design and implementation of projects origninating in non-health sectors which have a potential positive or negative impact on health

It is clear that a number of activities in other sectors such as education, agriculture, and others can influence health levels, and this proposal is designed to maximize potential positive health effects, and to minimize negative one. In addition, the recommendation seeks to promote the concept that the approach to improving overall measures of health must be pursued in a broad way outside the Ministries of Health by harnessing as many of the activities of other sectors as possible to bring to bear their positive influences on health levels.

Exactly what mechanisms should be used by health workers to involve themselves in the activities of non-health sectors are not clear, and many well depend on the specific nature of the activities themselves. As a bare minimum, health workers should be lobbying for their point of view in several other ministries. Beyond this, a number of areas should receive special attention from health workers. We therefore would make the following recommendations.

11a. To involve health professionals in large scale irrigation and resettlement projects to assess their impact on health levels, and to design measures that will promote health as much as possible

11b. To involve health workers in the design of educational curricula and school health programs.

11c. To involve health workers in the communications sector to maximize the potential of radio and newspaper to promote health education goals.

11d. To involve health workers in collaborative projects with rural development workers seeking to promote village education and organization.

11e. To involve health workers in agricultural development of food supplies with the most nutrition potential

12. To identify health problems which affect predominantly the working age population, and to determine the feasibility of control programs.

This could be undertaken in areas where there are special projects aimed at increasing the productivity of farmers, fishermen, or herdsmen. The goal would be to identify the predominant causes of absenteeism,

could be in the form of treatment or preventive measures where applicable. Rehabilitation measures could also be included.

13. To obtain more accurate information on the magniture of non-infectious disease problems.

Since information on cancer, diabetes, and other chronic diseases is not available, this recommendation seeks to begin compiling this data. Certain problems may prove to be of sufficient magnitude that programs designed to treat or control them could have important health effects. These programs might be expected to benefit adults primarily, and to take on growing importance as infectious disease problems begin to recede.

14. To upgrade and extend diagnostic laboratory services throughout the Sahel.

15. To expand veterinary public health services.

There are a number of diseases transmitted from animals to man in the Sahel which are deserving or more study to determine the size of the problem and what control efforts could be made. Rabies is in this category.

16. To create nutrition offices within the Ministries of Health to help achieve stated goals in the nutrition sector.

The creation of a special section within the Ministry of Health can be expected to focus attention on the nutrition related activities which are already a part of the health services, and thereby better insure that they will be carried out. Among the specific recommendations which can be made for such an office are the following:

16a. To develop a system for identifying malnutrition problems as they arise.

This could be developed in connection with the infectious disease surveillance and reporting system.

16b. To provide health education in child nutrition.

Attempts to achieve this could be made through an upgraded set of medical facilities which are providing more public health services. (See recommendation 3a).

16c. <u>To provide food supplements to children with existing or potential nutrition problems</u>.

These supplements could also be provided from upgraded medical facilities which are involved in a wider array of basic therapeutic and preventive services. (See recommendation 3a).

A SUMMARY OF RECOMMENDATIONS ON RIVER BASIN DEVELOPMENT IN THE SAHEL BY OTHER STUDIES

1. Ed Fei Report: Economics of the Sahel, 1974 (AID)

"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 technicals 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 wehre 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, 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. <u>UNSO: An Approach to Recovery and Rehabilitation of the Sudano-Sahelian Region. 1975</u> (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 buildup 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 in 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, J. 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 according 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

9. Senate Subcommittee to Investigate Problems Connected with Refugees and Escapees (Judiciary Committee) and Subcommittee on Health (Labor and Public Welfare Committee) Study Mission to the Sahel, 10 and 11 June 1975 Hearings

"Following are the recommendations of the Study Mission:....
12. Assistance needs to be given to development of water resources but special attention should be given to schemes that are likely not to have negative secondary effects. Simple irrigation projects deserve a higher priority than more elaborate schemes such as massive donor projects." p. 69

10. SEDES/SCET International: Schema de Mise en Oeuvre des Resources en Eau du Sahel de l'Afrique de l'Ouest (Plan for Development of the Water Resources of the Sahel in West Africa), prepared for presentation to the Club des Amis du Sahel at Dakar, March 1976 (Govt. of France)

"Conclusion. Even given the imperfections and the approximations that lack of data necessitates, the rational utilization of the West African Sahelian countries' water resource potential can assure satisfaction of the water needs for humans and livestock, as well as irrigation. However, the realization of this potential will take a very long time, extending beyond 2050.

While the implementation of these programs represents a considerable amount of work over several generations, its urgency demands that the work be initiated as soon as possible....

The costs will be high and the implementation will require complex complementary actions in management, training and extention to the peasants, marketing of production, etc., all of which constitute, in the final analysis, the major constraint for the success of the envisioned objectives. Finally, it would be desirable to institute more precise programs of indicative basin plans....and national plans for water resource use encompassing all sectors of water users, such as cities, rural populations, livestock, agriculture and industry." p. 98

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 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 issue, 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 desirable to have an interaction between donors and the African countries which results in a mutual exchange of information and experience over a farily 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 African 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. <u>The alternative costs and benefits of reducing the risk of severe deprivation for these countries by holding reserves in various forms</u>.

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.

Estimated Cost: $300,000.

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.

Estimated cost: $600,000.

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 tax 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.

Estimated cost: $600,000

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 production and marketing techniques and of 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.

Estimated cost: $1,500,000.

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 problems 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.

Estimated cost: $1,500,000.

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.

Estimated cost: $300,000.

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.

Estimated cost: $300,000.

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 interventions which might otherwise be obscured because of the absence of modern indicators of trade flows, such as highway traffic counts.

Estimated cost: $1,500,000.

9. Alternative economic policies to encourage the commercial production of subsistence foods.

Special attention would be paid to the influence of price fluctuations on food production and on the role which various methods and policies of storage might play. The relationship between food and cash crops would be considered as would be the special problems of remote and marginal areas.

Estimated cost: $1,000,000.

10. Analysis of self-sufficiency 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.

Estimated cost: $100,000.

11. Study of transport policies and how they effect economic development.

This would examine rate structures and their effects on 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.

Estimated cost: $600,000.

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 when they contribute nothing to the output of goods and services. This would aid in comparing projects in this area with those in more directly productive activities.

Estimated cost: $300,000.

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, if available.

1. Pre-project studies. In the report, there is 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-base 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 identify the characteristics of those individuals who regularly appear unsuccessful. Once the analysis has been done, a number of actions relating to the possibility of raising the overall capacity of the group to produce or to invest more effectively may be recommended.

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-deficit years. Why are the Dogon so markedly more productive than their neighbors? What can be learned 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:

-- microhydraulic agriculture

-- the ideology of farming--i.e., motivations for what appears to be "conspicuous display" of harvests in huge granaries

-- labor mobilization in production.

(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 or mobility 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 health services to the bush at a low cost. Various proposals for the training of paramedical or medical auxiliary personnel have been put forth; many of them have shortcomings or are too costly to make a real improvement in access to health services 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 phychiatric 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. One needs to know a good deal more about political, economic, and social exchanges among these peoples. These understandings will alert them to proposals that might disrupt the system and cause a reduction in the amount of useful energy which may be generated by it. One needs 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, there is need to know a great deal more about the nature of the herd, distinctions between ownership rights and usufructuary rights.

f. Finally, listed are 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 of central place theory, to identify the relationships between marketing and settlement patterns.

2. 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 Benin.

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 elites?

e. where one is dealing with "new lands"--i.e., associated with onchocerciasis programs, tsetse clearance, there is need to know who will have access to these lands, what will happen to traditional movements of peoples and how will they affect relations among farmers and herdsmen.

f. where dams are contemplated, there is need to know what the implications of population relocation will be and what provisions are made for drawdown cultivation in the reservoirs.

D. MORE DETAIL ON SPECIFIC PROJECT SUGGESTIONS

MINERALS

Several preliminary projects which should be undertaken and which could lead to further development activities:

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 plants 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.

TRANSPORTATION

Studies and other activities which deserve priority consideration include:

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 method, 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 the more modern routes.

   Objective: To determine whether the reopening and improving of these routes would react to the advantage of Sahelian development.

   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. The 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.

   Time Frame: Two years.

   Estimated Cost: $1.5 million

3. A series of feasibility studies should be undertaken to identify roads in a proposed network. The series of studies should utilize the new methodology 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, await the results of the study on a new methodology 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. This 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 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 the above study begin to take effect. Full feasibility studies of the indicated improvement and expansions would follow with the object of obtaining external financing.

Time Frame: Two years, beginning with year two of Phase II of above study, i.e., at year three of the long range development program. The 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 - $650,000. 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 foreign exchange 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 the study to develop "new methodology" should be applied to the analysis of river navigation projects. /This may point to feasible projects./ This may point to feasible projects which would have been judged non-viable under the traditional analyses.

TELECOMMUNICATIONS

Several activities in this sector should be undertaken in conjunction with the development of projects in other sectors, including:

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 and 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.

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 - $650,000. 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 foreign exchange 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 the study to develop "new methodology" should be applied to the analysis of river navigation projects. /This may point to feasible projects./ This may point to feasible projects which would have been judged non-viable under the traditional analyses.

3. A similar study to supply the telecommunication needs of an upgraded health delivery system.

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 and six months for engineering.

Cost Estimate: $1,500,000.

ANNEX III.D.4 (i)

WATER RESOURCES

A. Senegal - OMVS

Projects under the water resources sector are presented by river basin, i.e., OMVS, Niger River Basin and Lake Chad Basin Commission.

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 mathematical 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, rainguages, 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, Boghe, El Bir and Kaedi, Mauritania; and Kayes, Galougo, Manantali, Bafing-Makana, Gourbassi, Tonkoto and Kali in Mali. A network of up to 40 raingauges in some 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.

Estimatec 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 of 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 aquatic 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, aquatic conditions of thickness, transmissivity, permeability, specific yield, boundary conditions, annual yield, coefficient of storage, quality, both chemical and bacterial, 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 consideration, 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 bits, spares, casings, screening, retrieving equipment, etc. to drill up to 1,000 deep wells per year for investigative purposes to remain for community water supply, stock points and irrigation.

Estimated cost: $450,000.

d. Four year project cost estimate: $1,135,000.

3. Staff enhancement of OMVS Secretariat - as part of a multi-lateral 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 of the Defense Mapping Agency; 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 DMA, 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 Senagal - 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.

Estimated cost: $70,000.

b. Training - on-the-job for three riparian engineers for one year.

Estimated cost: $25,000.

c. Equipment - planimeters, desk calculators, drafting equipment, etc.

Estimated cost: $5,000.

d. Estimated project 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-head hydropower 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 (Columbia River, Portland, Oregon) or Sacramento Hydrologic Engineering Center 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 Center 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 proejct selected from desk studies. Time estimated for study, 2 years.

Personnel - up to 15 expatriate technicians in various specialities from a consulting firm. Estimated cost: $1,500,000 in foreign exchange and $200,000 in local costs.

11. 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: $320,000,000 in foreign exchange and $100,000,000 in local currencies.

12. Design and construction of river ports: St. Louis to Kayes - Twelve 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: $310,000 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 assemble and publish annual OMVS bulletin on agricultural research and assist basic irrigation projects and experimental farms 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: $1,200,000.

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 in the basin.

a. Personnel - 16 man years of USGS experts.

Cost estimate: $1,120,000.

b. Training - on-the-job for 2 years each of 3 technicians.

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. Functional literacy and rural youth training may also be incorporated.

a. Personnel - non-formal education team from U.S. university or private firm 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 irrigated perimeters.

Cost estimate: $1,250,000.

b. Training - 9 Senegal, 6 Mauritania, and 2 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, for example, (two state 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.

B. 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 Nigerion, 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, rain gauges, calibration of flow meters. On-the-job training for 2 communications specialists per country at the Agrometeorology center.

Estimated Cost: $690,000

c. Equipment - Recording gauges (limnometers) for key stations, and staff gauges for remainder 1/ network of 100 teleautomatic rain guages,(use Agromet network, where applicable), use of Agromet communications for

1/ Proposed hydrologic 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-Ayerou, 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

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 basic 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; prepare program of groundwater 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 bits, spares, casing, etc. to drill up to 2000 deep wells 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 basin-wide 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.

Estimated 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.

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 - A team of 4 men 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 a government agency.

Estimated Cost: $240,000.

c. Equipment: three fibre glass boats with outboard motors, trawling nets, 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. Construction and final design costs of first priority project from desk studies - identical to project 11 for Senegal basin.

Estimated Cost: $400,000,000.

13. Basin wide minerals survey - similar to project 17 for Senegal basin.

a. Personnel - 24 man years of USGR experts.

Cost Estimate: $1,680,000.

b. Training - on-the-job for 2 years for 3 technicians from Guinea, Mali, Niger, Nigeria and 1 each from Ivory Coast, Upper Volta, Benin, Cameroon.

Estimated Cost: $240,000.

c. Equipment - two core drills with spares and an aerial magnetometer survey, test digging equipment and satellite photography.

Estimated Cost: $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 Niger River Commission Secretariat. 20 riparians for up to M.S. 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 weeds 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 specialists 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 - Construction 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 naviation 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 services costs: $890,000.

e. Construction costs: $6,000,000.

C. LAKE CHAD BASIN COMMISSION

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; two 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 Corps of Engineers in Portland, Ore., or the Hydrologic Engineering Center at Sacramento.

Estimated Cost: $510,000

c. Equipment - recording gauges (limnometers) for key stations and staff gauges for remainder (Cameroon - Mussuk, Logone Basin, Dana; Chao Bol, Massakori, AmRaya, Douguia, N'Djemena, Guelengoeng, Dik, Sarh, logone Gana, Bongor, Lai,Baibokaum, Gore, Boumkabir, Kyabe, Yao, Missenya; Niger Nguigmi, 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; outline field investigation program; 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/workshops for up to 10 riparians each during second and third year of contract.

Estimated cost: $200,000.

c. Equipment: 3 drill rigs 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 scientist for 2 years.

Estimated Cost: $140,000.

b. Training - on-the-job for riparian scientist as counterpart to senior scientist and to take over permanent position in Secretariat.

Estimated Cost: $15,000.

c. Two year project estimated cost: $205,000.

4. Land Classification and Soils Studies - Identical to project No. 3 for Niger basin.

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 month 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: $538,000.

10. Power and Energy Study for Basin Area - Same as project No. 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: $1,220,000.

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 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: $1,610,000.

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.

Two year project estimated cost: $1,700,000.

17. Final Design and Construction Cost for First Priority Project - Same as project No. 11 for Senegal basin.

Estimated Cost: $50,000,000

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: $30,000.

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 Advice 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 in the interim attend special seminars and short courses on international water law in preparation 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.

IV. ACRONYMS USED IN THIS REPORT

ADB	African Development Bank (Abidjan)
ASECNA	Agence pour la Sécurité de la Navigation Aérienne (Dakar)
AVV	Volta Valley Authority (Ouagadougou)
BRGM	Bureau de Recherches Géologiques et Minières (Paris)
CCCE	Caisse Centrale de Coopération Economique (Paris)
CEAO	Communauté Economique de l'Afrique de l'Ouest (Ouagadougou)
CEEMAT	Centre d'Etudes et d'Experimentation de Mechanisme Agricole Tropicale (Dakar)
CERFER	Regional Road Maintenance and Training Center (Lome)
CGIAR	Consultative Group on International Agricultural Research
CIEH	Comite Inter-African d'Etudes Hydrauliques (Ouagadougou)
CILSS	Permanent Inter-State Committee for Drought Control in the Sahel (Ougadougou)
CUSS	University Center for Health Sciences (Yaoundé)
CVL	Central Veterinary Laboratory (Bamako)
DAC	Development Assistance Committee (OECD) Paris)
EEC	European Economic Community (Brussels)
EF	Entente Fund (Abidjan)
ELC	Entente Livestock Community (Ouagadougou)
FAC	Fonds d'Aide et de Coopération (French Government, Paris)
FAO	Food and Agriculture Organization - U.N. (Rome)
FED	Fonds Europeen de Développement - EEC (Brussels)
IBRD	International Bank for Reconstruction & Development - World Bank (Washington)
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics (Hyderabad, India)
IDA	International Development Association, the concessional loan window of the World Bank
IFAN	Institut Fondamental d'Afrique Noire (Dakar)
IITA	International Institute of Tropical Agriculture (Ibadan)
INSEE	Institut National des Statistiques et des Etudes Economiques (Paris)
IRRI	International Rice Research Institute (Los Banos, PI)
LCBC	Lake Chad Basin Commission (N'Djamena)
MIT	Massachusetts Institute of Technology (Cambridge,Mass)
NAS	National Academy of Sciences (Washington)
NASA	National Aeronautics and Space Agency (Washington)
NOAA	National Oceanic and Atmospheric Administration (Washington)
NORAD	Norwegian Development Loan Agency (Oslo)

NRC or RNC	- Niger River Commission (Niamey)
NPD of Corps of Engineers	- Columbia River Flood Forecast Center (Portland, Oregon)
OAU	Organization of African Unity (Addis Ababa)
OCCGE	Organization for Cooperation and Control of Endemic Diseases in West Africa (Bobo-Diaukuso)
OCLALAV	Organization for Control of Locusts & Birds (Dakar)
OECD	Organization for Economic Cooperation & Development (Paris)
OGEAC	Organization for Control of Endemic Diseases in Central Africa (Yaounde)
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal (Dakar)
ORD	Regional Development Organization (Ouagadougou)
ORSTOM	Office de Recherche Scientifiques et Techniques Outre-Mer (Paris)
OSRO	Office for Sahelian Relief Operations - FAO (Rome)
REDSO/WA	Regional Economic Development Service Office/West Africa-A.I.D. (Abidjan)
SAED	Société d'Etudes pour le Développement Economique (Ouagadougou*
SCET	French Consulting Firm (Paris)
SEDES	Société d'Etudes pour le Développement Economique et Social (Paris)
UNDP	United Nations Development Program (New York)
UNEP	United Nations Environmental Program (Nairobi)
UNESCO	United Nations Economic and Social Council Organization (Paris)
UNFPA	United Nations Family Planning Association (New York)
UNICEF	United Nations Children's Fund (New York)
UNIDO	United Nations Industrial Development Organization (Vienna)
UNSO	United Nations Special Sahelian Office (New York, Ouagadougou)
USBR	United States Bureau of Reclamation, Department of the Interior (Washington)
USGS	United States Geologic Survey, Department of the Interior (Washington)
WARDA	West African Rice Development Association (Monrovia)
WFP	World Health Organization - United Nations (Geneva)
WMO	World Meteorological Organization - United Nations (Geneva)

*Also, Societe d'Amenagement et d'Exploitation des Terres du Delta (St. Louis, Dakar)

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