DRAFT

ENVIRONMENTAL REPORT

ON

SENEGAL

prepared by the

Arid Lands Information Center
Office of Arid Lands Studies
University of Arizona
Tucson, Arizona
85721

National Park Service Contract No. CX-0001-0-0003
with U.S. Man and the Biosphere Secretariat
Department of State
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THE UNITED STATES NATIONAL COMMITTEE FOR MAN AND THE BIOSPHERE
Department of State, IO/UCS
WASHINGTON, D. C. 20520

An Introductory Note on Draft Environmental Profiles:

The attached draft environmental report has been prepared under a contract between the U.S. Agency for International Development (AID), Office of Forestry, Environment, and Natural Resources (ST/FNR) and the U.S. Man and the Biosphere (MAB) Program. It is a preliminary review of information available in the United States on the status of the environment and the natural resources of the identified country and is one of a series of similar studies now underway on countries which receive U.S. bilateral assistance.

This report is the first step in a process to develop better information for the AID Mission, for host country officials, and others on the environmental situation in specific countries and begins to identify the most critical areas of concern. A more comprehensive study may be undertaken in each country by Regional Bureaus and/or AID Missions. These would involve local scientists in a more detailed examination of the actual situations as well as a better definition of issues, problems and priorities. Such "Phase II" studies would provide substance for the Agency's Country Development Strategy Statements as well as justifications for program initiatives in the areas of environment and natural resources.

Comments on the attached draft report would be welcomed by USMAB and ST/FNR and should be addressed to either:

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OR

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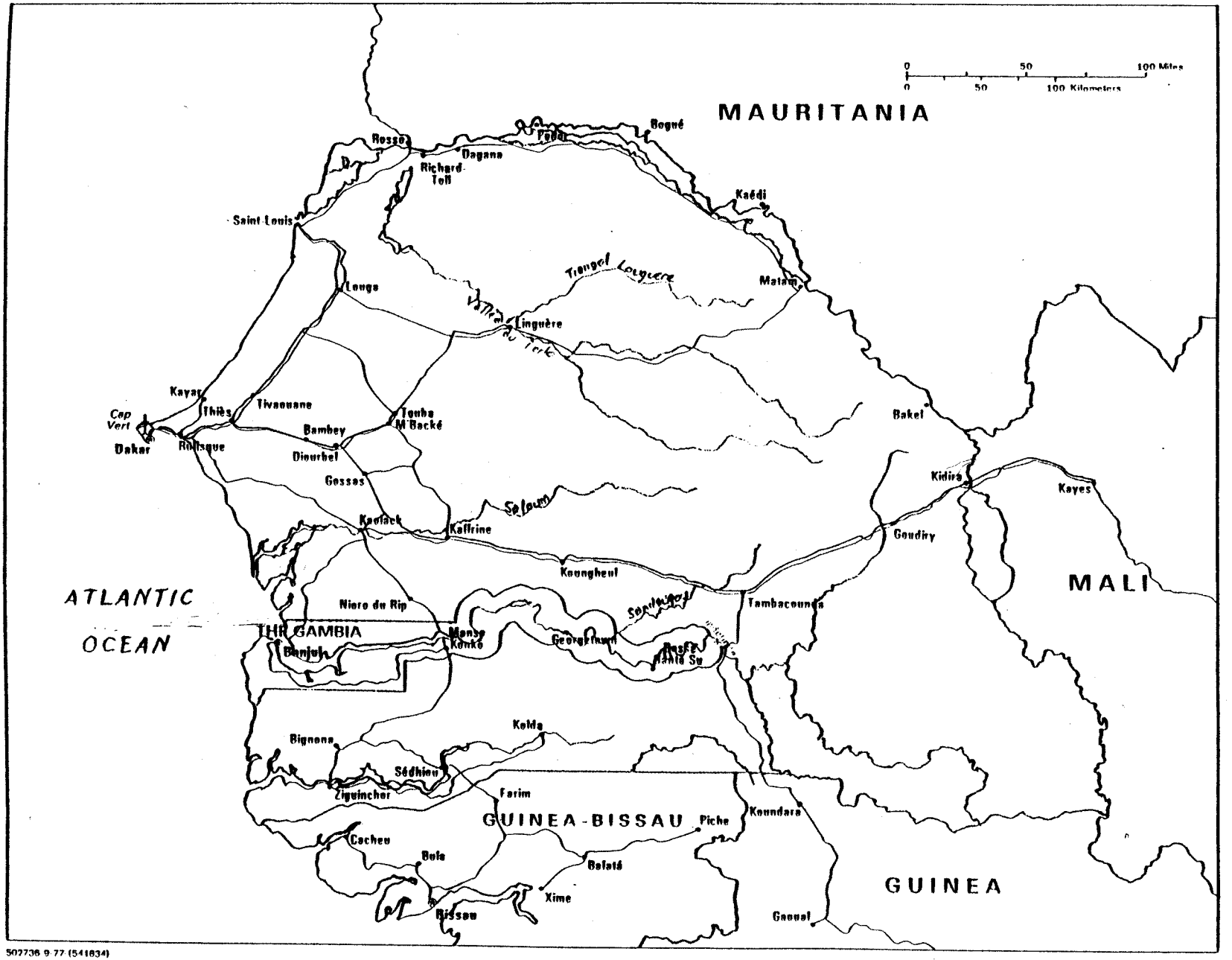
Senegal



502736 9-77 (541834)
Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:3,800,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

DRAFT ENVIRONMENTAL REPORT ON SENEGAL

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Summary

A quarter of the territory of Senegal is arid, and 70 percent is semi-arid. The traditional techniques evolved by the Senegelese to raise cereals and livestock under this climatic regime are inappropriate to meet the demands of its modernizing economy and growing population. Senegal is faced with the following environmental problems, most of which are a result of too slow a response to rapid changes in economic, technological, and/or social conditions:

1) The loss of productive land area, caused by:

   - uncontrolled grazing and negative ramifications of government programs to provide watering places and to reduce diseases of livestock herds.

   - inadequate control of forest exploitation. The woodlands of Senegal are under heavy pressure to provide fuelwood and charcoal, primarily for cook-fires. The majority of Senegalese have no alternative to these traditional fuels, despite the government subsidies of imported butane and butane burners.

   - brushfires, accidental or set to clear land for various purposes, which burn over 40 percent of the country each year, wasting forest and pasture area.

   - abandonment of farmland, due to loss of soil fertility by overcropping or, in those limited areas served by irrigation schemes, by poor irrigation practices; or due to the loss of a crop from drought or ill-timed rains. In either case, the land is left open to erosion and its capacity for revegetation is reduced.

2) Inadequate management of water resources. Runoff harvesting is apparently only practiced at present at the Lac de Guiers, although this problem will soon be addressed for the Senegal River by the Manantali Dam and other schemes planned by the trinational Organization pour la Mise en Valeur du Fleuve Senegal (OMVS). Still, much of the country not reached by the OMVS schemes will continue to suffer from inadequate water supply for domestic uses and irrigation.

3) Water-related disease, including malaria, onchocerciasis (river blindness), trypanosomiasis (sleeping sickness), schistosomiasis, and diseases related to fecal contamination. Onchocerciasis is so serious a problem in Senegal-Oriental that it prevents the establishment of permanent farming communities in the fertile river bottoms.

4) Unbalanced population distribution, caused by the concentration of services and economic and educational opportunities in the Cap Vert region, and the dearth of these in the interior of the country. The result is not only an increase in problems related to overcrowding in Cap Vert, but a loss of rural productivity on which development of the country depends.

5) Problems related to modernization, mostly found in and around Dakar:

- inadequate sanitation facilities. Open sewers encourage rodents and transmit disease, especially when they overflow during the rainy season. They discharge into the ocean, causing pollution of the seawater up to one km. offshore.

- industrial effluents, including hydrocarbon pollution in the Dakar harbor.

- air pollution caused by vehicle exhaust.

These environmental problems are a constraint to the development of Senegal. If they are neglected, progress in the country will be much impaired if not impossible.

A. Paige Grant
Compiler

1.0 Preface

This draft environmental report is the result of an eight-week review of information available in the United States on the natural resources and environment of Senegal. This is the first step in the process of developing an environmental profile for use by the U.S. Agency for International Development and Senegal government officials. The next step in this process should be a field study which would evaluate the information contained herein, obtain additional information, define issues, problems, and priorities, and provide direction for future efforts to deal with the management, conservation, and rehabilitation of the environment and natural resources.

The information and interpretations presented in this report are preliminary in nature and are not intended to attain the detail and accuracy needed for development planning. This study represents a cooperative effort by the entire staff of the Arid Lands Information Center, but the primary focus, research, and writing were done by Paige Grant. The cooperation of personnel at AID, the Library of Congress, the National Park Service, and the University of Arizona is gratefully acknowledged.

2.0 Introduction

2.1 Geography [1/]

Senegal is the most westerly state of West Africa. A flat country, most of it is a Tertiary sedimentary coastal subsidence basin wherein small gullies and termite mounds provide almost the only relief. Its total land area is 196,192 square km. The northern border, which is shared with Mauritania, is delineated by the Senegal River; the Falémé River defines the eastern border with Mali. Guinea and Guinea-Bissau are Senegal's southern neighbours, and the Gambia forms an enclave of 10,000 square km. along the Gambia River in the southern part of Senegal.

The capital city and major population and industrial center of Dakar is located at the tip of the hooked Cap Vert peninsula where the landform creates a great natural harbor. Cap Vert is characterized by Tertiary basalt and pyroclastics overlying marl, marly limestone and lime deposits of uncertain age. The peninsula juts into the path of northerly marine trade winds, causing lower temperatures than would be expected at the latitude (Dakar 14° 49' N). Rainfall and temperature values are also lower than are found inland.

	Average Temperature (°C)				Average Rainfall (mm)
	Cool Season (Dec. - April)		Hot Season (May - Nov.)		
	daily max.	daily min.	daily max.	daily min.	
Dakar (seacoast)	26	17	30	20	569
Tambacounda (interior)	40	15	40	20	942

The coastal belt from Cap Vert north to St. Louis is covered by active sand dunes and by older, stabilized sand dunes. Depressions between the parallel dunes, called "niayes", develop into small lakes or swamps during the rainy season and support luxuriant vegetation through the dry season.

The most striking physiographic feature in western Senegal is the escarpment of lower Eocene formations which rises from the plain about 18 km. northwest of Thiès. These marl deposits have a maximum depth of some 600 meters near the Cretaceous dome at N'Dias, and are about 60 km. wide at their widest point and 100 km. long. The ridge reaches a height of 148 meters at a point about 30 km. south of its origin, before sloping down to the southeast.

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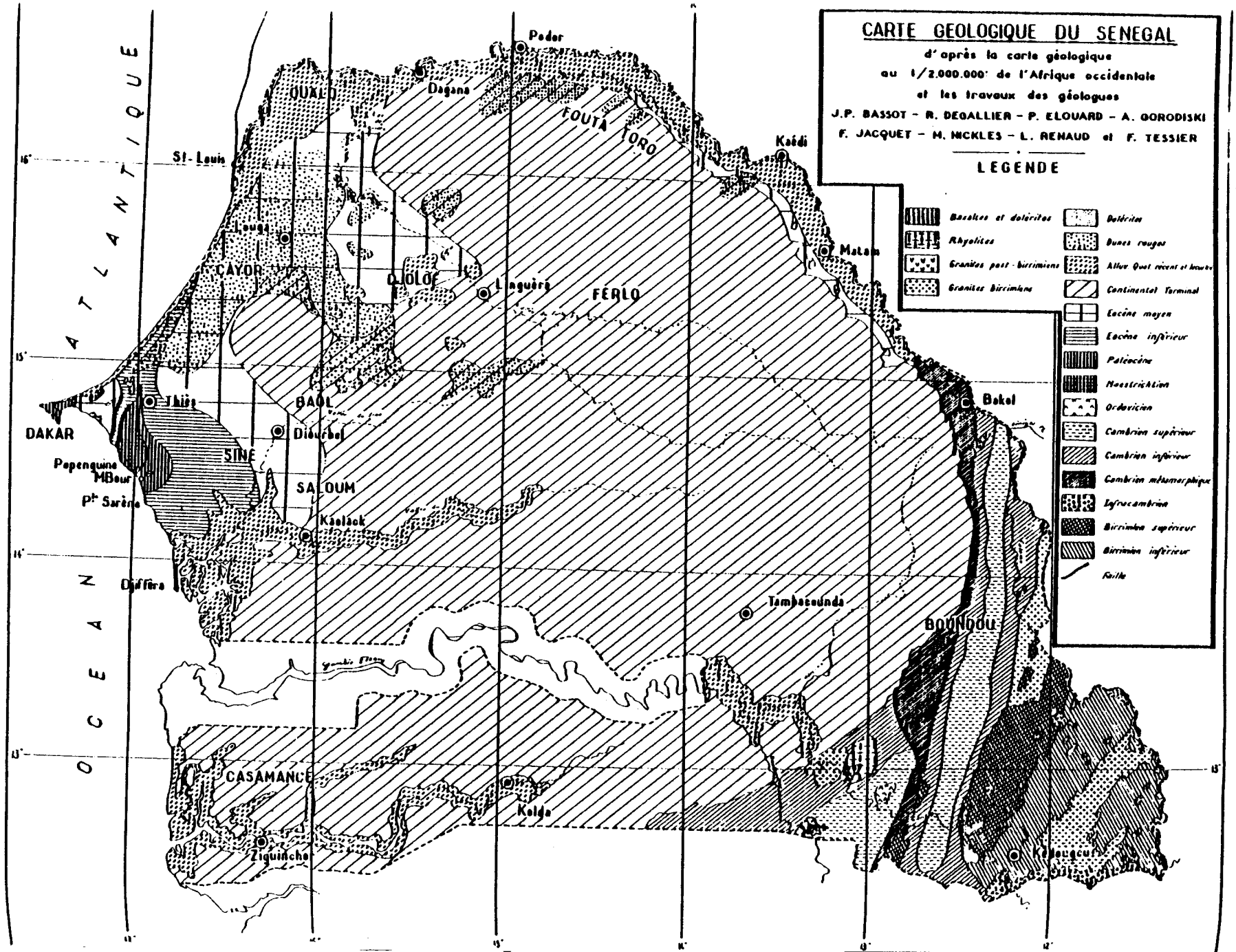
[1] Source: Brigaud. 1960.
Europa. 1979.
Nelson, et al. 1974.
Parsons Co. 1963.
U.S. AID. 1979.

Figure 1: Geologic Map of Senegal



South of the Thiès escarpment are the Sine-Saloum estuary, the delta of the Gambia, and the estuary of the Casamance, all characterized by Quarternary alluvial deposits, swamps and salt flats. North along the Senegal River, Quarternary alluvium overlies the Middle Eocene deposits of marine marls, fossiliferous limestones and quartzite sandstone.

All four of Senegal's major rivers - the Senegal, Saloum, Gambia and Casamance - are wide and meandering for most of their length and have broad estuaries at their mouths where they deliver runoff into the Atlantic. The amount of flow they carry fluctuates widely between wet and dry seasons and between wet and dry years, and the amount to which they are effected by saltwater intrusion upstream varies commensurately.

The southeastern corner of Senegal is marked by outcrops of the Pre-Cambrian rocks of the "African Shield"; these are primarily quartzite, granite, and granitized schists. These grade westward into the Cambrian schists of Falémé and sandstones of Boundou. There is then an abrupt shift from these very old formations to the Cretaceous Continental Terminal formation, which occupies by far the largest part of the country. This former seabed is composed of heterogeneous clay sandstones, 20 meters thick at the "beaches" and hundreds of meters thick in the center near Ferlo. It is masked in many places by late Pliocene sandstone laterites, rich in iron, giving rise to "iron pans" in much of the north. Red dunes, yellow dunes, marine beaches and lacustrine deposits representing various climatic events of the Quarternary Period overlie the Continental Terminal Formation at other points.

Senegal's climate is dominated by a monsoon that moves from southeast to northwest across the country from June to October, retreating along the same path by which it arrived.[2] The southwest of the country receives the most rain: from 1300 to 1500 mm annually over the course of 100 days, on the average. In the north, an average of 350 mm is received in the course of 30 days of the year. The semi-arid region of the "Sahel" (meaning the "coast" of the great arid "ocean" of the Sahara desert) covers most of Senegal north of the 15° parallel. The susceptibility of this region to periodic drought, and the social, economic and environmental disruptions caused by these recurrent phenomena, are becoming increasingly well-documented.

The monsoon coincides with the warm season; cooler temperatures occur from December through March (see Table 1). Temperature variations are clearly much less important than moisture availability in the determination of growing seasons and vegetation type. Evaporation rates are extremely high, estimated at 409.6 mm. per year at Dakar, 441 mm at Thèis, 460.4 mm at M'Bour, and still higher inland.[3] Evaporation is exacerbated by the dry, dusty "harmattan" wind that blows from the northeast out of the central Sahara for most of the year.

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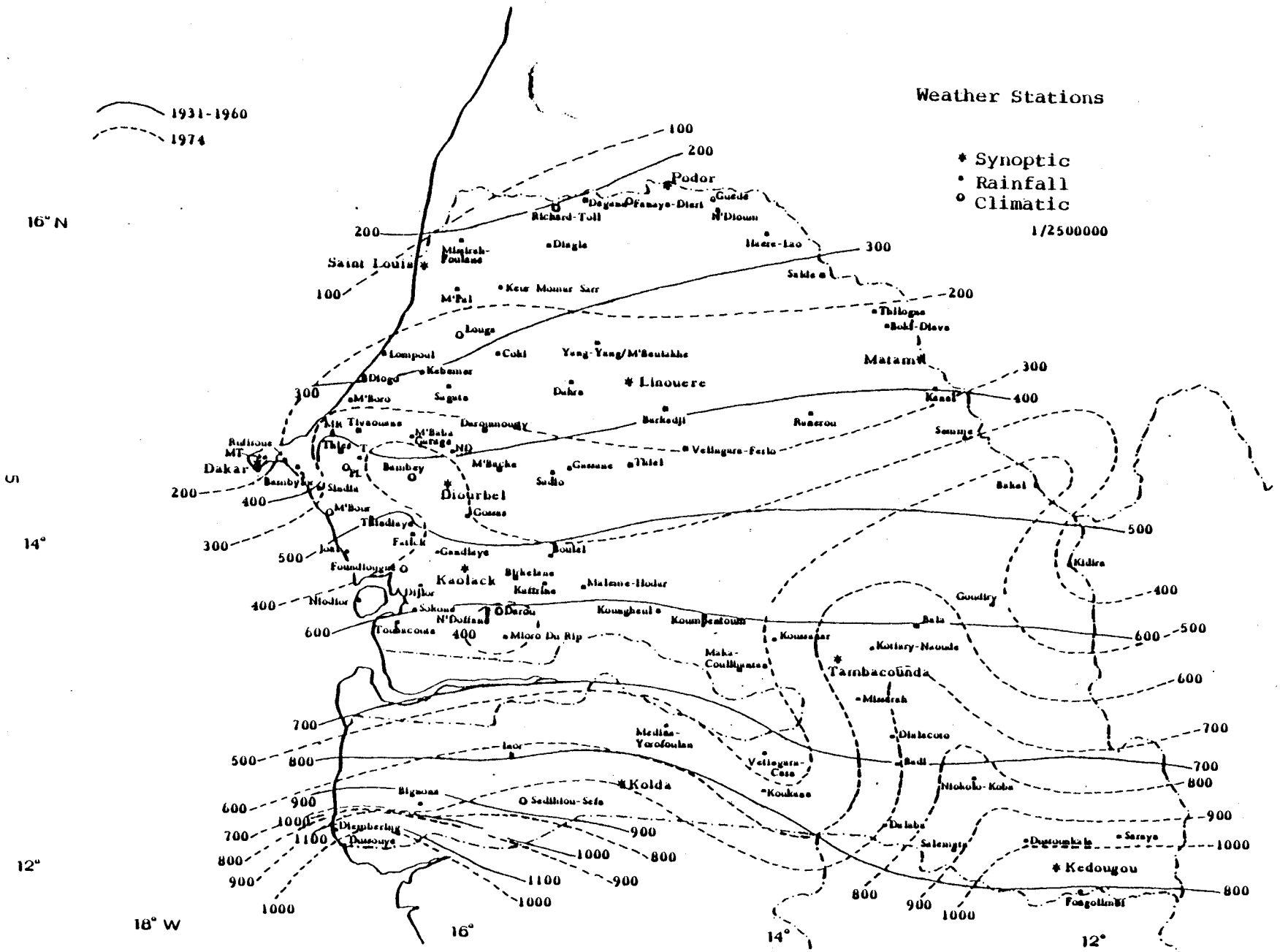
[2] Source: Leroux. 1973.

[3] Source: Parsons Co. 1969.

Figure 2: Average Rainfall Patterns, May 1-August 31.



Source: Parsons Co. 1969.

Table 1: Average Monthly Temperatures, °C

	J	F	M	A	M	J	J	A	S	O	N	D	Year Avg
Dakar*	12	21	21	22	23	25	27	27	28	27	26	23	24.3
Diourbel**	24	25	28	29	30	30	29	28	28	29	27	24	27.5
Kaolack+	25	27	29	30	30	30	29	28	28	29	28	25	28.0
Kedougou++	24	27	30	32	32	28	27	27	27	28	27	25	27.7
Kolda	24	27	29	31	31	30	28	27	27	28	27	24	27.7
Linguere	24	26	28	30	31	31	29	28	28	29	28	24	28.2
Matam	23	26	29	31	34	33	30	29	29	30	28	24	28.7
Podor	23	25	28	30	32	32	31	30	30	30	28	23	28.5
St. Louis+++	22	22	22	22	22	26	28	28	29	28	26	23	28.2
Tambacounda	25	28	30	32	33	30	27	27	27	28	27	25	28.2
Ziguinchor	24	26	27	28	29	28	27	26	27	28	27	25	26.8

* Years 1947-70 ++ Years 1953-65
** Years 1951-70 +++ Years 1931-70
\+ Years 1931-60

Source: U.S. AID. 1979.

Table 2: Average Monthly Rainfall (in mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Year Total
Dakar*	.4	.7	.0	.0	1	9	91	224	175	64	2	3	569
Diourbel**	0	1	.1	.2	6	40	140	260	189	55	5	4	700
Kaolack+	.5	.9	.0	.1	8	61	160	295	201	64	4	3	797
Kedougou++	2	4	5	7	47	171	258	320	307	129	16	2	1267
Kolda	.0	.3	.0	.0	20	150	258	399	303	116	12	.5	1254
Linguere	.1	2	2	.0	4	31	101	209	136	45	4	2	535
Matam	1	1	.3	.1	4	50	129	202	122	22	2	2	537
Podor	1	2	1	.1	3	16	68	133	84	23	3	2	336
St. Louis	1	1	.0	.2	1	7	44	161	97	29	2	3	347
Tambacounda	.1	.6	.1	2	20	131	197	289	231	70	2	.1	942
Ziguinchor	.1	.9	.0	.1	10	125	363	532	361	146	8	10	1547

* Years 1947-70 + Years 1931-60
** Years 1941-70 ++ Years 1961-70

Source: U.S. AID. 1979.

Natural vegetation types follow the climatic zones of the country: Sahel savanna in the north, characterized by thorny shrubs and fibrous grasses; open grasslands with widely spaced shrubs and trees in the central Sudanian savanna zone; and mixed subtropical forests in the Guinean savanna country of the south. The so-called Groundnut Basin, the most intensively cultivated region in Senegal, extends from between Saint Louis and Louga in the north to Koalack in the south.

2.2 Social Characteristics [4]

The population of Senegal reached 5,541,000 in mid-1979, with a growth rate of 2.8 percent overall (4.1 percent in the cities) during the decade ending in 1978. In 1975, 43.5 percent of all Senegalese were children under fifteen years of age. Their life expectancy at birth was about forty years. In 1972, 29 percent of the boys and 19 percent of the girls between the ages of 5 and 14 were enrolled in primary school. The numbers of secondary school students the following year had dropped to 22 percent of the boys and 5.3 percent of the girls aged 15 to 19. Only 3.2 percent of all Senegalese men and 0.7 percent of the women received post-secondary schooling in 1975, and the overall adult literacy rate was ten percent.

There was but one practising physician to every 14,520 people in Senegal in 1973. What health care is available is concentrated in the cities, essentially out of reach to the rural 70 percent of the population. Although the average food intake of Senegalese citizens is slightly better than in many of its neighbouring countries, malnutrition and nutritional diseases are common, especially among young children under five.

Figure 3 shows the distribution of the major ethnic groups of Senegal: Wolof, Serer, Toucouleur, Manding, Diola and Peul. The Wolof make up a considerable majority of the population, more than a third of the total. Eighty percent of all Senegalese now speak Wolof; although French remains the official language, Wolof is the lingua franca of the country. Despite the diversity of Senegalese peoples, there is apparently little conflict between the various ethnic groups. In fact, they share a fairly homogeneous culture, and 90 percent profess Islam. Those traditional patterns that once existed with relation to the way that different ethnic groups made their livelihood, have tended to blur with the process of modernization and especially with urbanization. The several "brotherhoods" of Senegalese Islam draw their membership somewhat along ethnic lives, but this is offset by groups such as the Wolof belonging to different brotherhoods. These brotherhoods, the two largest of which are called the Tidjaniya and the Muridiya, have great political, social and economic influence in the country. The "Saints", the leaders of the brotherhoods, exact labor and/or a percentage of crop sales from the members. The

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[4] Source: Menes. 1976.
Nelson, et al. 1974.
U.S. AID. 1979.
U.S. AID. 1980.

Table 3: Urban Centers

Town	Geographic Location	Population*	% Annual Growth rate
Dakar	west-central coast	798,729	6+
Kaolack	west-central	106,899	4
Thies	west-central	117,333	5
Saint-Louis	northern border	88,404	4
Ziguinchor	southern	72,726	4
Diourbel	west-central	50,618	4
Louga	northwest	35,063	4
Rufisque	west-central coast	54,000 (1973)	4
Tambacounda	inland; southeast	24,500 (1973)	4

* as of April 1976
\+ as of 1973

Source: U.S. AID. 1979.

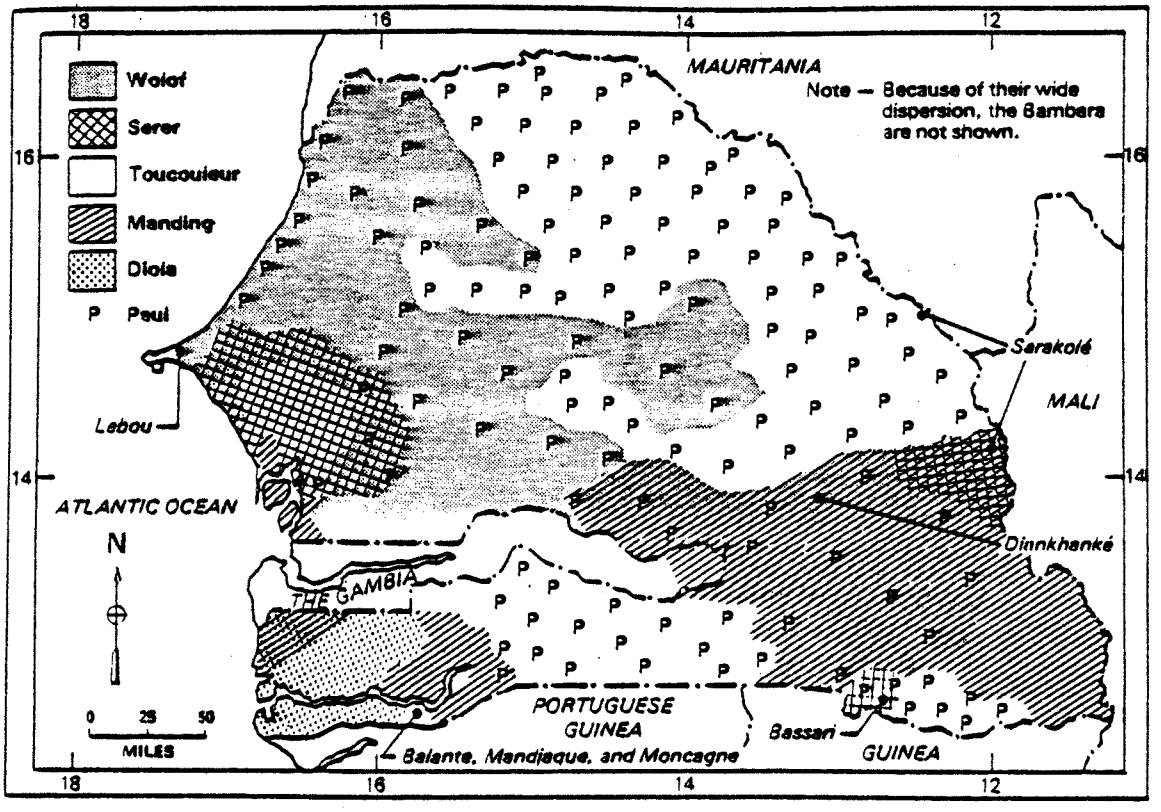
Table 4: Population by Region

Region	Population*	Total Area (sq miles)	People per sq mile
Cap Vert	984,660	212	4,644
Casamance	736,527	10,943	67
Diourbel	425,112	12,949	33
Fleuve	528,473	17,033	31++
Senegal Oriental	286,148	23,006	12
Sine-Saloum	1,007,736	9,243	109
Thies	698,994	2,548	274
Louga	417,737	---	---

* as of April 1976
++misleading considering high-density centers are dispersed over large areas

Source: U.S. AID. 1979.

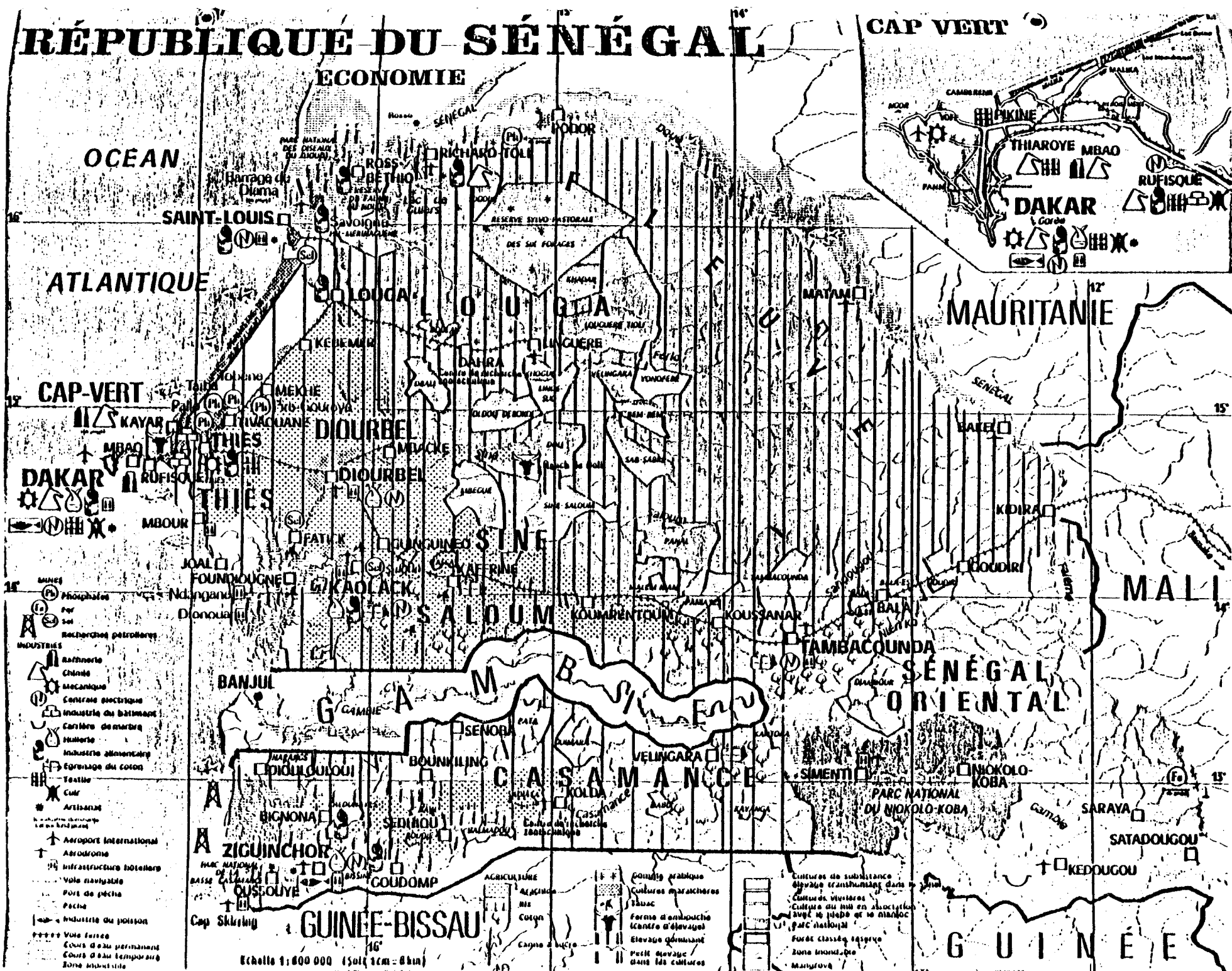
Figure 3
Ethnic Groups by Geographic Location



Source: Menes. 1976.

brotherhoods engage in such enterprises and groundnut cultivation and transport, and the development of cooperatives.

Ever since the French began to develop urban centers in the colony of Senegal, there has been migration from the rural areas of Senegal and from neighboring countries to these centers of commerce and employment. These movements are amplified by periodic agricultural failures, due to drought or a drop in the price for the groundnut cash crop. The long revolution in Guinea-Bissau resulted in emigration of thousands of war refugees to Senegal. Sixty percent of the population in Senegal now lives within 330 km. of Dakar. This concentration of population in the West, in the Groundnut Basin and the Cap Vert Peninsula, is a hindrance to development of the country. Unemployment and underemployment is chronic. As one response to the lack of work opportunity in Senegal, some 20,000 Senegalese have continued their migration to work in France.


RÉPUBLIQUE DU SÉNÉGAL
ÉCONOMIE
CAP VERT
OCEAN
ATLANTIQUE
SAINT-LOUIS
Barrage de Diama
ROSS-BÉTHIO
RICHARD-TOLL
PODOR
LOUGA
KEBEMER
LINGUÈRE
MATAM
MAURITANIE
CAP-VERT
KAYAR
MBAO
DAKAR
RUFISQUE
THIÈS
MBOUR
DIOURBEL
MBACKÉ
FATICK
KAOLACK
SINE-SALOUM
KOUNGHEUL
KOUSSANAR
TAMBACOUNDA
KÉDIRA
GOUDIRI
BAKEL
MALI
SÉNÉGAL ORIENTAL
BANJUL
GAMBIE
SENOBA
BOUNKILING
VELINGARA
CASAMANCE
DIOULOULOU
BIGNONA
SÉDHIOU
KOLDA
ZIGUINCHOR
OUSSOUYE
GOUDOMP
Cap Skirring
GUINEE-BISSAU
SIMENTI
NIOKOLO-KOBA
PARC NATIONAL DU NIOKOLO-KOBA
SARAYA
SATADOUGOU
KÉDOUGOU
GUINÉE
Echelle 1:600 000 (1cm = 6km)
MINES
Phosphates
Fer
Sel
Recherches pétrolières
INDUSTRIES
Raffinerie
Chimie
Mécanique
Centrale électrique
Industrie du bâtiment
Carrière de marbre
Huilerie
Industrie alimentaire
Egrenage du coton
Textile
Cuir
Artisanat
Aéroport international
Aérodrome
Infrastructure hôtelière
Voie navigable
Port de pêche
Pêche
Industrie du poisson
Voie ferrée
Cours d'eau permanent
Cours d'eau temporaire
AGRICULTURE
Arachide
Riz
Coton
Canne à sucre
Cultures maraîchères
Elevage dominant
Petit élevage dans les cultures
Cultures de subsistance
Cultures vivrières
Parc national
Forêt classée réserve
Zone inondable
Mangrove

2.3 Economy and Administration [5]

Senegal is divided into eight administrative regions, listed below with their capital cities:

Region	Capital
Cap Vert	Dakar
Casamance	Ziguinchor
Diourbel	Diourbel
Fleuve	Saint-Louis
Senegal Oriental	Tambacounda
Sine-Saloum	Kaolack
Thiès	Thiès
Louga	Touga

There is a governor for each region, appointed by the President. The regions are subdivided into "departments", 28 in all, of which the chief officer is the Prefect. The departments are further divided into a total of 90 districts, each headed by a Subprefect. The basic administrative unit in rural areas is the Communauté Rurale (rural community), usually made up of a group of villages with a total population of 10,000. The Communaute Rurale is led by a Rural Council, and has budgetary autonomy. Several Communautés Rurales can band together into a Groupement Rurale in order to engage in larger projects than could be managed by a single Communauté. The Rural Councils send representatives to departmental and regional councils and are under the overall jurisdiction of the Minister of Interior. The Communauté Rurale system was mandated in 1972 but is not yet in place in all parts of Senegal.

Government programs are administered by a large bureaucracy. Bureaus whose activities affect the environment are listed in Appendix I . Of note are the government development societies, whose missions are to focus on a particular, often regional, problem. Frequently, due to the regional "nature of these programs," the societies will take on activities normally carried out by the more vertically-organized national bureaus. The development societies are listed with government organizations in Appendix I.

Since independence from France in 1960, President Leopold Senghor has piloted the country with a policy of "African socialism". This has allowed considerable reliance on foreign private enterprise and foreign aid, particularly from France. As an example, nearly all industry in the country is foreign-owned and 80 percent of industrial capital is in the hands of French firms. In 1973, Senghor called for "Senegalization" of the economy, entailing the replacement of foreign business personnel by Senegalese workers, and, as far as possible, the turnover of capital to Senegalese ownership.

[5] Source: Europa. 1979.
Menes. 1976.
U.N. Sudano-Sahelian Office (UNSO). 1979.
U.S. AID. 1979.

Agriculture is the dominant activity in the Senegalese economy, providing employment for 70 percent of the labor force and contributing 35 percent of the GDP. The status of the economy is virtually dependent on the cash crop of groundnuts, grown almost exclusively for export. Climatic conditions and the world price for groundnuts determine Senegal's balance of trade. There is a chronic shortage of foodstuffs in the country. The staple of the diet is millet, and rice, sorghum, wheat and maize are also important. Annual cereals production is on the order of 700,000 tons, but an additional 300,000 tons must be imported to cover domestic food requirements.

Agriculture suffered serious losses during the drought of 1968-1973, in 1977, and again in 1979. The resultant exodus of population from rural areas has caused a great reduction of farmland area, to the point that only about twelve percent of the land area of the country is currently under cultivation. Agriculture is concentrated in the Groundnut Basin, where there is a surplus of economically active population. Population density is so great in the Thiès region and in northern Sine-Saloum that the soils of the region are being used at nearly the maximum possible rate (estimated at half the total area). Furthermore, the practice of fallowing is being abandoned in favor of continuous cropping, sapping the productivity of the fields.

The government is attempting to address the problem of the exhaustion and abandonment of farmland by opening up new areas for cultivation in eastern Sine-Saloum and western Senegal-Oriental and resettling farmers into these areas. The new lands will be used primarily for expansion of groundnut cultivation. However, there are simultaneous efforts underway to reduce Senegal's overdependence on groundnuts by diversifying both cash and food crops. Cotton, rice, sugar, and vegetable production are receiving particular emphasis.

Table 5. Principal Crops
('000 metric tons)

	1975	1976	1977*
Rice (paddy)	116	112	62
Maize	49	47	46
Millet and sorghum	621	555	432
Potatoes	5	5*	5
Sweet potatoes	4	4*	5
Cassava (manioc)	109	114	125
Pulses	21	16	21
Groundnuts (in shell)	1,476	1,192	700
Cottonseed	20	28†	28
Cotton (lint)	12	16	16
Palm kernels	5*	5*	5
Tomatoes	18	30	30
Dry onions	23	25*	26
Other vegetables	27	27	28
Mangoes	25	27*	29
Oranges	16	17	18
Bananas	5	5*	5
Other fruit	13	13	14
Coconuts	4*	4*	4
Sugar cane	150*	200*	260

*FAO estimates.
† Unofficial figures.

Source: Europa. 1979.

Livestock is a less important sector of the economy in Senegal than in other Sahel countries, contributing about seven percent of the GNP. In contrast, the amount that pastoral activities have contributed to environmental deterioration in the Sahel, and the amount that the pastoralists suffered in the great drought of the early seventies, are disproportionately large. The trend is now to a shift away from strictly livestock-raising as a livelihood, and to greater integration of livestock with farming activities. Rough figures of livestock numbers are given in the following table:

Table 6: Livestock

('000 head)

	1975	1976	1977
Cattle	2,318	2,380	2,440
Sheep	1,689	1,740	1,760
Goats	844	875	895
Pigs	196	160	166
Horses	204	210	216
Asses	190	196	200
Camels	6	6	6
Poultry	6,200	6,572	6,817*

* FAO estimate.

Source: Europa. 1979.

Marine and continental fisheries make an important contribution to the diet in Senegal, where annual consumption of fish averages 35 kilograms per person. In addition, fish and fish products amounted to 6.7 percent of exports in 1976. The government places great emphasis on development of this sector, especially in maritime fishing. The target is to have all seagoing fishing vessels motorized by 1981, and to develop industries to process fish, with the objective of increasing both local consumption and exports of fish.

There has been steady growth of the industry and mining sector since independence. Some 30,000 industrial workers were employed year-round in 1978, with another 70,000 people working in industry for about four months of the year. Industry is concentrated in the Cap Vert region. It is closely tied to the agricultural sector; more than half of industrial exports come from the groundnut processing industry. The most dynamic are the extractive industries, the chemical industries, and the canning factories. Moderate growth characterizes groundnut processing and the wood, paper and energy industries. Flour mills, sugar refineries, and the various food processing industries are undergoing only limited growth.

Mining is presently dominated by phosphate production in the Thiès region. With the rise in price for phosphates between 1962 and 1974, the value of mineral exports rose sharply during that period and in 1976 represented 16.5 percent of all exports. Geologically speaking, the mineral center of the country is Senegal-Oriental. Research there has turned up some 410 million tons of iron reserves, 350,000 tons of marble (enough to make Senegal second in the world in marble production), and deposits of uranium, serpentine, and other minerals. Exploitation of these materials is dependent on development of transportation facilities.

Production of electricity by thermal generation is at a high level and has been rising steadily, reflecting the needs of the industrial sector. Hydroelectric power from the Manantali Dam, when it is completed, will raise total electric production to 760 million kilowatt-hours.

The government's goal for the industrial/mining sector is to achieve a mean annual growth rate of eight percent, while developing industries that will process products of the Senegalese primary sector and meet national needs, as well as continuing to develop exports to improve the balance of trade.

Table 7: Industry

(Selected Products)

	units	1973	1974	1975	1976
Groundnut oil	'000 metric tons	128.6	142.1	250.0	307.0
Palm oil	"	n.a.	1*	5.4*	5.6*
Wheat flour	"	81	81	87	n.a.
Tobacco products	metric tons	1,570	2,041	2,189	2,216.5
Beer	'000 hectolitres	117.5	113.4	191.4	223.5
Aerated beverages	"	170.7	222.9	268.7	290.3
Canned tuna	metric tons	8,739	14,410	14,225	16,044
Refined sugar	'000 metric tons	29.6	22.3	32.8	33.3
Cotton yarn	metric tons	326.0	269.7	235.2	326.0
Woven cotton fabrics	"	6,287	7,780	7,792	2,358
Sisal manufactures	"	1,956	1,470	1,653	1,723
Shoes	'000 pairs	3,588	4,640	5,172	6,151
Dry batteries	number	10,323	10,261	16,348	20,183
Paints	metric tons	3,605	3,605	3,545	3,807
Matches	boxes	24,450	21,558	18,198	15,448
Soap	metric tons	18,880	17,385	21,144	24,324
Oxygen	'000 cubic metres	360.0	380.0	403.2	378.0
Acetylene	"	82.0	84.0	85.3	88.9
Cement	'000 metric tons	295.6	331.9	352.0	387.4
De-hydrated phosphates	"	69.8	96.8	86.0	67.0
Jet fuel	"	88	96	95	98*
Motor-spirit (petrol)	"	103	101	107	115*
Kerosene	"	12	12	17	22*
Distaillate fuel oils	"	239	132	133	158*
Residual fuel oils	"	203	269	288	303*
Liquified petroleum gas	"	4	3	5	5*
Electric energy	million kWh.	353	407	433	450*

1977: Palm oil 5,700 metric tons; Raw sugar 25,000 metric tons (FAO estimates).

* Estimated production

Source: Europa. 1979.

Tourism is worthy of note as a developing industry. First-class hotel accommodation increased from 300 beds in 1970 to 6500 in 1977.

Transportation facilities are better developed in Senegal than elsewhere in the region. Dakar has a first-class port with 8,000 meters of sheltered quay and 46 berths. A fishing port is under development at Dakar and there are proposals for the construction of a naval repair yard to service bulk oil carriers. There are 14,500 km. of roads in Senegal of which 3,000 km. are paved. Further, 1,186 km. of railroad track links Senegal with Niger, Mali and Mauritania.

The general health of the economy of Senegal fluctuates from year to year depending on the size of the trade deficit, which is dependent in turn on the size of the groundnut and cereals harvest. Even in the best years, however, Senegal relies on large-scale assistance from foreign sources to finance development. Nearly two-thirds of the capital expenditure in the 1977-81 development plan will be provided by foreign bilateral and multilateral agencies, chiefly France, the U.S., the Federal Republic of Germany, World Bank and the European Development Fund. Much of this assistance is in concessionary form, so that Senegal has a relatively low debt service burden, representing 6.1 percent of its foreign earnings in 1976.

3.0 Natural Resources

3.1 Water

3.1.1 Description of the Resource [6]

The availability of water to a great extent governs land use and conditions of health or famine among populations living at the subsistence level, and also affects the condition of the Senegalese economy. Water supply in the country is highly erratic, dependent largely on rainfall which varies greatly in amount and timing from year to year. Even where surface water supplies are adequate to support cultivation, the problem is not always solved; in Senegal-Oriental, exploitation of the fertile river bottoms is limited by the prevalence of onchocerciasis, a water-borne disease of the region.

The disastrous drought of 1967 to 1973 prompted speculation that a climatic shift toward drier conditions was in progress. However, on examination of the record has shown "rather convincingly that there has been no major change in climate, only fluctuations that are to be expected by the geographic position of the Sahel and the random variations one can expect in precipitation patterns. Major droughts are a part of the climate there." (Landsberg, 1973 [7]). Planning is in progress to reduce the damaging effects of wet year/dry year variations by storing surface waters during their periods of abundance and releasing them slowly for irrigation and other purposes over dry periods.

3.1.1.1 Surface Water [8]

Four major river systems channel the runoff from Senegal and the highlands of its neighbouring countries.

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[6] Source: Menes. 1976.

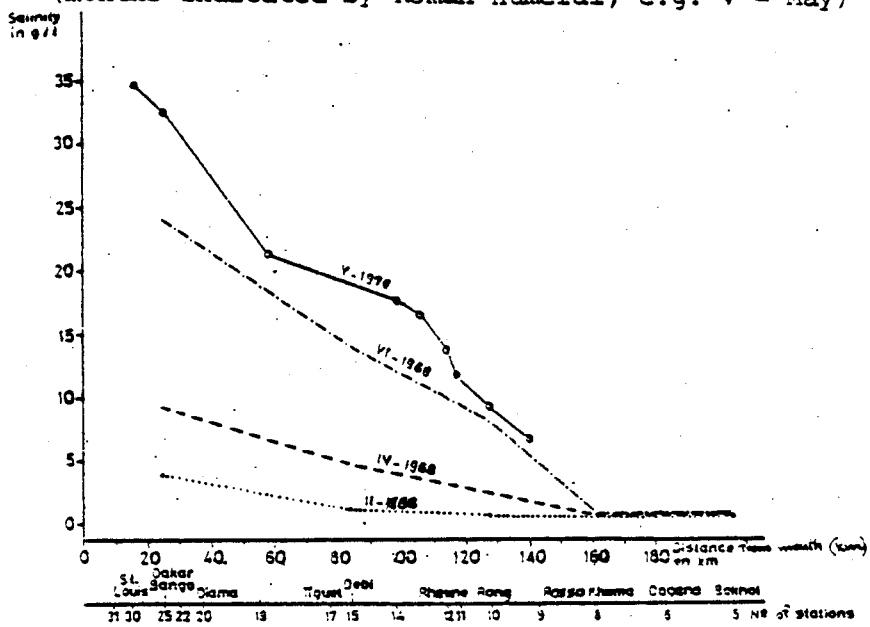
[7] Source: Major, et al. 1974. p. 7.

[8] Source: CIEH. 1979.
Major, et al. 1974.
Nelson, et al. 1974.

The Senegal River rises in Guinea and flows 4000 km. along Senegal's northern border to its mouth at Saint-Louis. Its 330,800 km^2 watershed falls in four countries: 30,800 km^2 in Guinea; 155,000 km^2 in Mali; 75,600 km^2 in Mauritania; and 72,400 km^2 in Senegal. Its main tributaries are the Bafing, Bakoye and Faleme Rivers which have their source in Guinea's Fouta Djallon region, where annual rainfall is at least 1200 mm. Beginning in April, these heavy rains do not produce floods on the Senegal until September. Thereafter it takes about six weeks for the flood crest to reach the sea. Average flow in the Senegal River, measured at Bakel, has varied from 310 cubic meters per second (m^3/sec.) in the 1944-45 flood season to 1300 m^3/sec. in 1924-25. Flood height at Bakel measures eleven meters on the average, but is subject to the same fluctuations as the flow regime. Downstream of Bakel, the flood height decreases due to storage in the flood plain and in branches of the old riverbed. By the time the floodwaters flow into the sea below Saint-Louis, the crest is imperceptible.

Owing to the very flat gradient of the Senegal River, at low water ocean tides are felt as much as 480 km upstream, and the river water becomes saline for nearly half that distance (see figure 4). A flow of at least 100 m^3/sec is necessary to prevent seawater intrusion. Although the brackish water intrusion has the advantage of bringing in anadramous fish which are exploited by local fishermen, it is disadvantageous to agriculture, and for that reason a number of structures have been built on the river to prevent saltwater intrusion. The most important of these are the gates on the channel through which the Lac de Guiers corresponds with the Senegal River. The gates allow the lake to fill with fresh water carried downstream on the flood crest, but close to prevent intrusion of brackish water into the lake. This system allows the lake to provide part of the water supply of Dakar. [9]

Figure 4: Salinity of Senegal River as Function of Distance from the Mouth and Month of Measurement (months indicated by Roman numeral, e.g. V = May)



Source: Monteillet and Rosso. 1977

[9] Source: Menes. 1976.

The next major river system south of the Senegal is the Saloum and its affluent, the Sine River. These are sluggish, brackish streams that flow in numerous channels through an extensive tidal swamp just north of The Gambia. Only the lower reaches are perennial streams.

The Gambia River flows through Senegal from the southeastern border with Guinea to the eastern border of the Gambia. Rising in the Fouta Djallon highlands of Guinea, where the Senegal and Niger also have their headwaters, the Gambia falls from an elevation of 1500 meters at its source to 75 meters at Mako, Senegal, in a distance of 300 km. It then meanders slowly for another 300 km through the plains to Gouloumbo, which is nearly at sea level. In the final 500 km of its course, the river is subject to tidal influences. Roughly 250 km of the lower reaches are saline at low flow. Although only about a quarter of the 1,184 kilometer river flows through Senegal, 77 percent of its 77,850 km^2 watershed lies within that country. Average annual flow of the Gambia, estimated from less than ten years of record, is roughly 305 m^3/sec., and 95 percent of the annual flow measured at Gouloumbo occurs between July and November.

The fourth major stream in Senegal is the Casamance, flowing in the narrow drainage of the same name between The Gambia and Guinea-Bissau. It is a slow, swampy river for most of its 300 kilometers, tidal for half of that distance, and a broad estuary in the lower third of its course. Salinity in the lower reaches limits its usefulness for agriculture, but high rainfall in the region makes it suitable for rice-growing.

Another major category of surface water in Senegal are the "marigots", which are shallow lakes filled by seasonal runoff. The city of Saint-Louis obtains its water supply of 3600 m^3/day from marigots, as do many smaller villages. These bodies of water are likely to be particularly prone to infection by polluted floodwaters and hence provide habitat for disease vectors such as the malarial mosquito and schistosoma cercariae-bearing snails.

3.1.1.2 Groundwater [10]

The municipal water supply for Dakar is drawn in part from three aquifers underlying the Cap Vert Peninsula. These are:

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[10] Source: Menes. 1976.
Parsons Co. 1963.
United Nations. 1973.

1) a semi-confined sandy Eocene aquifer covered in the west by a basaltic formation. This aquifer is located north of Dakar. It is 50 to 80 meters thick and capable of delivering some 30,000 cubic meters of water per day. The water contains 400 ppm of total dissolved solids (TDS), and leaves iron deposits.

2) an unconfined sandy aquifer near Tiaroye.

3) Paleocene limestones at Sebikotane in the west of Cap Vert and Pont in the east. Water quality registers 400 ppm of TDS. In 1973, 7 boreholes were providing Dakar with 50,000 cubic meters of water per day.

All three of these aquifers are replenished by rainfall and are subject to seawater intrusion when pumped below sea level. Data obtained from piezometer records over many years have established a safe level for pumping to avoid salinization of the wells. These aquifers cannot supply all of Dakar's water requirements. An aqueduct from the Lac de Guiers provides the remainder, but the combined capacity of these two water supply systems is less than the anticipated need for water in Dakar by the year 2000, estimated at 350,000 cubic meters per day. This consumption rate is predicated on the average daily per capita consumption in 1968 of 76 liters per day. That average value masks the fact that 75 percent of the urban population has to fetch its water from public taps and consequently uses only about 15 liters per person per day, far too little to contribute effectively to improving hygiene and health. In other words, the figure of 350,000 cubic meters per day should be taken as the minimum requirement for the city of Dakar in twenty years.

Central Senegal has groundwater reserves both in a number of shallow phreatic aquifers and in the deep Maestrichtian formation which underlies most of the country. The phreatic aquifers are often adequate to serve local needs. In 1963 it was noted that water levels in irrigation wells sunk in shallow aquifers at Bambey had not declined during ten years of operation. These aquifers are made up of sands, marly sandstones, marls, limestones and interbedded marly limestones, lower Eocene to Pliocene in age. The more permeable formations are found west of Diourbel, with yields up to 50 cubic meters per hour per well. Other productive formations include the Continental Terminal sands and Eocene limestones around the Ferlo region, and the area between Niors du Rip and the Gambian border. Depths to a water table vary from five to sixty meters, generally being shallower in the west and deeper in the northeast of the region. Groundwater flow is primarily eastward from the Thies escarpment. The aquifers are recharged largely by rainfall. Chemical water quality is fairly high west of Diourbel, from 300 to 600 ppm TDS. The shallow aquifers in the east of the region contain more saline water, with TDS between 500 and 1200 ppm. As a rule, wells in the shallow aquifers are polluted by direct contamination with excreta and dejecta, making them a focus for the spread of disease. This problem apparently is negligible in the deep Maestrichtian aquifer.

The Maestrichtian (Cretaceous) aquifer is composed of 200 to 250 meters of sand and sandstone under clayey marls and argillic sandstones of the Eocene Continental Terminal formation, which makes the Maestrichtian an artesian aquifer with its piezometric surface higher in the south. The water it contains varies in quality from 500 ppm TDS in the interior to as high as 2500 ppm TDS in the northwest of the country. The capacity of the aquifer is tremendous, indicated by the fact that in nine years of pumping some 23 million cubic meters of water from 50 wells in an area of 50,000 square km., the water table in the region dropped barely 50 centimeters.

The Pre-Cambrian and Paleozoic formations in the far east of the country are not favorable for the occurrence of groundwater. In the Pre-Cambrian rocks, the only place that water might occur would be in the joint systems of the formations. Paleozoic sandstones and shales do store some water and yield it at the very slow rate of some five cubic meters per hour. Laterite deposits covering most of the southeast often will yield some groundwater. The best aquifers in the region are isolated alluvial deposits near stream channels. These are mainly sands, clays and beds of lateritic gravel, occurring at the inside curve of meanders, at tributary junctions, and where laterite deposits have been deeply incised. Villages in this region have a very problematic water supply.

3.1.2 Legislation [11]

Water law in Senegal is determined in part by custom, in part by colonial legislation retained by the present administration, and in part by laws elaborated after independence. Customary law applies especially in rural areas and principally in matters of personal status and land ownership, except where the land is registered or where its acquisition or transfer has been done according to written law.

Colonial water laws still in force are the following:

- Civil Code, Articles 640-645. Regulates those waters which may be considered in the private domain, such as rain water, wells, watering places, springs, irrigation and drainage canals and intermittent surface runoff on private land. These waters may be acquired by gift, sale, inheritance or by way of fulfilling any lawful contract.

- Decree of 14 April, 1904. Provides that a community which owns a drinking water supply should protect it against sources of pollution.

- Decree of 5 March, 1921. States that public waters may not be appropriated, and that the right to their use will be granted by the government on approval of an application for a water-

[11] Source: Caponera. 1978.
Johnson and Johnson. 1977.

use concession. Concessions will be granted to a specific individual for a specified period not to exceed 25 years, and for a particular use. The concession authorization may be cancelled by the government for breach of contract or in the interest of the general public.

- Decree of 29 September 1928. Articles 1 and 2 amended by Decree No. 52-679, 3 June 1952, later supplemented by Decree No. 55-490, 5 May 1955. Declares all surface and ground waters to be in the Public Domain, with the exception of those private waters covered by the Civil Code, above.

  · Provides that any works undertaken in, over or across a watercourse, and all water diversion projects, are subject to prior authorization by the Administration.

  · Allows a landowner to acquire a right-of-way for water conveyance through adjacent land when the water is to be used for irrigation or mining activities, providing that fair compensation is paid to the owners of land crossed by the conveyance.

  · Directs that flood control measures may be undertaken by the government partially or totally at the expense of the beneficiaries.

  · Prohibits the discharge or disposal of refuse or harmful effluents in or around Public Domain waters.

  · States that drainage of ponds or marshes may be ordered for public health purposes and that improvement and extension of agricultural land may be provided for.

  · Requires that drainage waters must be disposed of by conveying them across adjacent lands, so long as proper compensation is arranged. If neighbouring landowners avail themselves of the drainage facilities installed by the upstream landowner, they must share in the costs of construction.

- Order No. 9929TP, 15 December 1955. Establishes protection zones around sources of drinking water. Regulates use of groundwater. The only exploitation of groundwater <u>not</u> subject to governmental approval is a well to an unconfined aquifer from which water is withdrawn by hand, and which was built prior to the 1955 Order. Any well fitted with a mechanical pump and producing more than ten cubic meters per day must be approved prior to construction.

Post-Independence Water Law:

- Decree No. 61-205, 13 May 1961. Article 2. The National Water Committee (under the Ministry of Public Works, Housing and Town Planning) is charged with defining general policy, drawing up programs, and coordinating resources in water development.

- Decree No. 64-474, 26 June 1964. Amended by Decree No. 65-574, 6 September 1975. Establishes the Directorate of Water in the Ministry of Planning and Industry, responsible for (1) regulation of the study of water installations in rural and grazing areas and (2) general management of river basins, for such activities as hydropower, agricultural water works, and flood control. Drilling of boreholes is overseen by a local caretaker under orders from a representative of the Water Section of the Public Works Service. Establishes the Ministry of Energy and Water and outlines its responsibilities.

- Law No. 65-59, 19 July 1965. Article 1: Tapping water sources, water supply and distribution by non-government entities is permitted only by concession, sub-contract or special authorization from the State. Article 2: The State has nationalized all existing community services for water production and supply.

- Ministerial Order No. 30-65, 6 March 1968. Established the Directorate of Water and Forestry under the Ministry of Rural Development, including:
  - Office of Soil Conservation and Land Management
  - Office of Rural Engineering
  - Office of Inland Fisheries and Fishbreeding, responsible not only for pisciculture but also for development of inland waters for agricultural water-supply schemes.

- Decree No. 66-393, 31 May 1966. Article 2: Set up the National Committee for River Basin Development under the Ministry for Industrial Development.

- Convention of 11 March 1972 on the Status of the Senegal River. Article 4: No project which would alter the agricultural, industrial or navigational use of the river may be implemented without the unanimous approval of OMVS member states. Article 6: Navigation on the Senegal River is free and open for OMVS member states. Article 7: Member states will cooperate to maintain the river in navigable condition.

- Although an order of priority for water use is not legally specified, in practice it is generally:

  (1) drinking water supply (with first preference given to the most populous zones);

  (2) livestock and agricultural needs; and

  (3) industrial and recreational requirements. The latter is scarcely afforded any consideration.

3.2 Soils [12]

3.2.1 Description of the Resource

The soils of Senegal are a product of climate, parent materials, and drainage, interacting over geologic time. Thus the Sahel is characterized by Subarid soils, the central Sudanian region by Tropical ferruginous soils, and Guinean areas by Ferralitic soils, as a function of their principal climatic regimes in recent times. Variations within these soil types are produced by differences in parent material, drainage, or geologic history. For instance, pockets of Brown subarid soils in the Tropical ferruginous soil region are produced by limestone formations that come close to the surface. Topography, which more or less governs drainage, plays an important role in soil formation. Where rainwater runoff collects, it encourages the breakdown of organic matter, the oxidation or reduction of iron, and the leaching of iron, manganese, or clays. Most of the soils of Senegal bear hydromorphic traits.

A number of ancient influences have left their mark on Senegalese soils. The iron pans which occur in the east and over the Continental Terminal formation were formed in a Tertiary climate comparable to the present one or perhaps more humid. The sandy expanses in the northwest of the country testify to a more arid regime. The red, weakly ferralitic soils around Kaolack, where annual rainfall now averages 900 mm, can only be explained as the product of a moister climate of about 2000 years ago.

The Centre Interafricain d'Etudes Hydrauliques (CIEH) has classified the soils of the savanna region of West and Central Africa on the basis of their productive potential for range or agriculture. The five classes in the system are defined as follows:[13]

Class 1: Generally good soils. These soils do not have any serious limitations, and are able to produce good yields of suitable, climatically adapted crops.

Class 2: Generally moderate to good soils which have slight to moderate limitations which may restrict their use. Yields of climatically adapted crops are moderately good.

Class 3: Generally poor to moderate soils. These soils have one or more limitations of moderate intensity, are usually of fairly low natural fertility, and generally give low to moderate yields of climatically adapted crops under traditional systems of management.

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[12] Source: Centre Interafricain d'Etudes Hydrauliques (CIEH). 1978. Maignien. 1965.

[13] Source: CIEH. 1978.

Class 4: Generally poor soils. These soils have moderately severe to severe limitations and under traditional systems of management, give generally poor yields.

Class 5: Soils generally unsuited to cultivation, though sometimes locally suitable for rough grazing or other extensive uses. They suffer from limitations which are generally severe enough to exclude cultivation, such as shallow depth, steep slope or very unfavorable soil reaction (extreme acidity of salinity/alkalinity) virtually preventing crop growth unless improved.

It should be noted that the capability classification of the soils assumes traditional cultivation practices.

Class 1 soils are hydromorphic. Formed under damp conditions, they occur in Senegal primarily along the Senegal River and in a large pocket south of Dakar. In addition, there are numerous minor occurrences too local to appear in the large-scale CIEH study.

Soils in Class 2 include certain hydromorphic soils that are not as productive as those in Class 1. Also in Class 2 are some Brown subarid soils and some immature soils developing over sandy alluvium. Class 2 soils have a very limited distribution in coastal regions of Senegal.

The soils of the southwestern and central part of the country fall into Class 3. They include Tropical ferruginous soils and Ferralitic soils which have been desaturated to a greater or lesser degree. Some vertic Brown subarid soils, Vertisols, and Immature soils are also included in Class 3, but they occupy a much smaller area than the Tropical ferruginous and Ferralitic soils. The former are the most common soils of dry savanna areas; the latter are found in the more humid savanna regions.

Class 4 soils cover most of the north and east of Senegal. Class 4 covers two groups of soils whose only common characteristic is their lack of suitability for agriculture. In the north of Senegal Class 4 soils are comprised of Immature soils, Reddish-brown subarid soils, and Tropical ferruginous soils over aeolian sands. These soils are generally light-textured and sandy, with little profile development. At the opposite end of the scale are the Vertisols, which are clay soils of very heavy texture and occur in the east of the country.

Class 5 soils in Senegal are the loose, shifting dune sands of the ergs and some pockets of shallow lithosols which occur in the center of the country.

3.2.2 Legislation [14]

Decree of 4 July 1935, Title III, Article 30: Provides that owners of woods and forests may not engage in clearing operations which would be likely to cause soil erosion and/or flooding.

[14] Source: Caponera. 1978.

3.3 Vegetation [15]

3.3.1 Description of the Resource

The native vegetation of Senegal grades from the Sahelian grasslands of the north with their widely-spaced bushes and trees, to rainforest in the southern lowlands and mangrove swamps in the lower Casamance region. (Refer to Figure 5, which details vegetation types in the Senegambia, throughout the following discussion.)

The northern third of the country (indicated by map unit #17) is characterized by a climatic grassland dotted with trees and bushes. This is a zone of sharp contrast between the dry and rainy seasons. The rains cause a flush of grass cover and bring on the new growth of woody species. Both the grasses and the leaves of many tree and bush species are consumed by wild and domestic grazing animals. The annual species produce seed by the end of the rainy season; the vegetative portion of the plant then dies, but the seed is prepared to survive the dry period and germinate with the next rains. The woody species use various techniques to survive the dry season. Some lose their leaves soon after the rains end, thus eliminating an important source of moisture loss. Among these deciduous species are Commiphora africana, Grewia spp., Zizyphus, Cordia rothii, and Combretum aculeatum. Acacia raddiana and certain other species retain their leaves for part of the dry season before dropping them. Finally, there are evergreen species, of which the most important are Balanites aegyptiaca and Maerua crassifolia. Late in the dry season, these trees often provide the only green fodder and proteins for livestock and wild herbivores, particularly gazelles.

Many trees in the Sahel have become casualties of the long drought. Their regeneration is impaired by the practice of lopping limbs for fuel and fodder. The loss of trees accelerates desertification. Plants which grow in their shade lose their habitat and are no longer present to extend their root mat through the upper layers of soil, so that the soil is subject to wind and water erosion.

Grass communities in the Senegalese Sahel generally fall into the following groups:

1) Aristida mutabilis and Eragrostis tremula pastures. These grasslands cover large areas of the Sudan region of West and Central Africa, from Senegal to Chad.

2) Schoenefeldia gracilis pastures. These occur on loamy sand soils and are excellent for livestock, but are sensitive to drought.

3) Aristida pallida grasslands. A perennial plant with a hard stubble, this grass makes poor pasturage for livestock.

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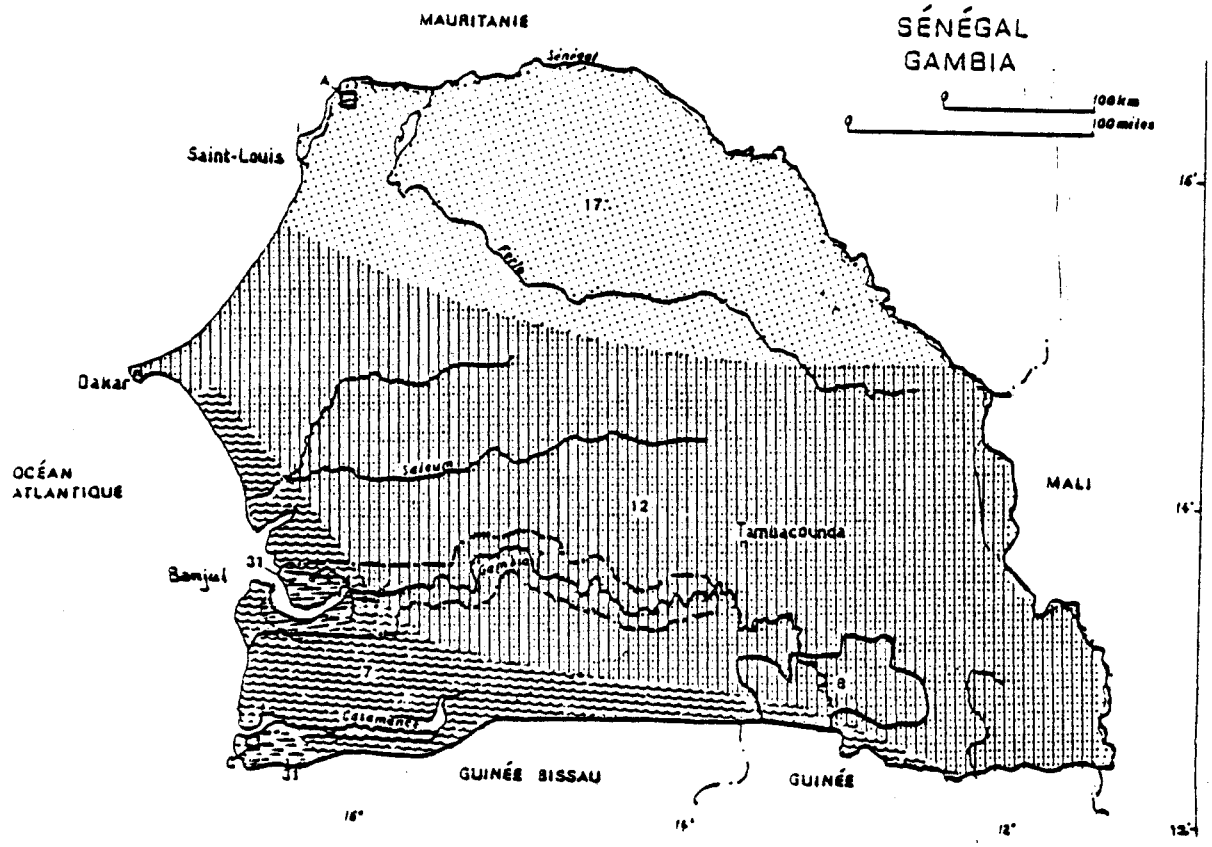
[15] Source: Cornet and Poupon. 1977.
IUCN. 1979.

Figure 5. Vegetation Types in the Senegambia



7 Guineo-Congolian Lowland Rain Forest-Secondary Grassland Mosaic

12 Undifferentiated Sudanian Woodland

17 Sahelian Acacia Deciduous Bushland and Wooded Grassland

31 Mangrove

A. Parc national du Djoudj 12.000 ha

B. Parc national du Niokolo Koba 826.000 ha

C. Parc national de Basse-Casamance 4.000 ha

Source: IUCN. 1979.

4) Panicum turgidum and Stipagrostis (Aristida) pungens: perennial bunchgrasses that occur on sands under very arid conditions. Woody species that occur in this community include Acacia senegal, Balanites aegyptiaea, and Commiphora africana, with Acacia tortilis dominant in the north.

Most of the central and western part of Senegal is covered by Sudanian woodland (map unit #12). This area has had its native vegetation deeply modified by cultivation, cutting, grass fires and grazing. The remaining woodland is relegated to rocky hills and plateaus. The most common of the larger trees (8 to 12 meters tall) are Anogeissus leiocarpus, Balanites aegyptiaca, Lannea microcarpa, Prosopis africana, and Sclerocarya birrea. The shorter trees (about 6 meters tall) include Combretum glutinosum, Strychnos spinosa, and Terminalia avicennioides.

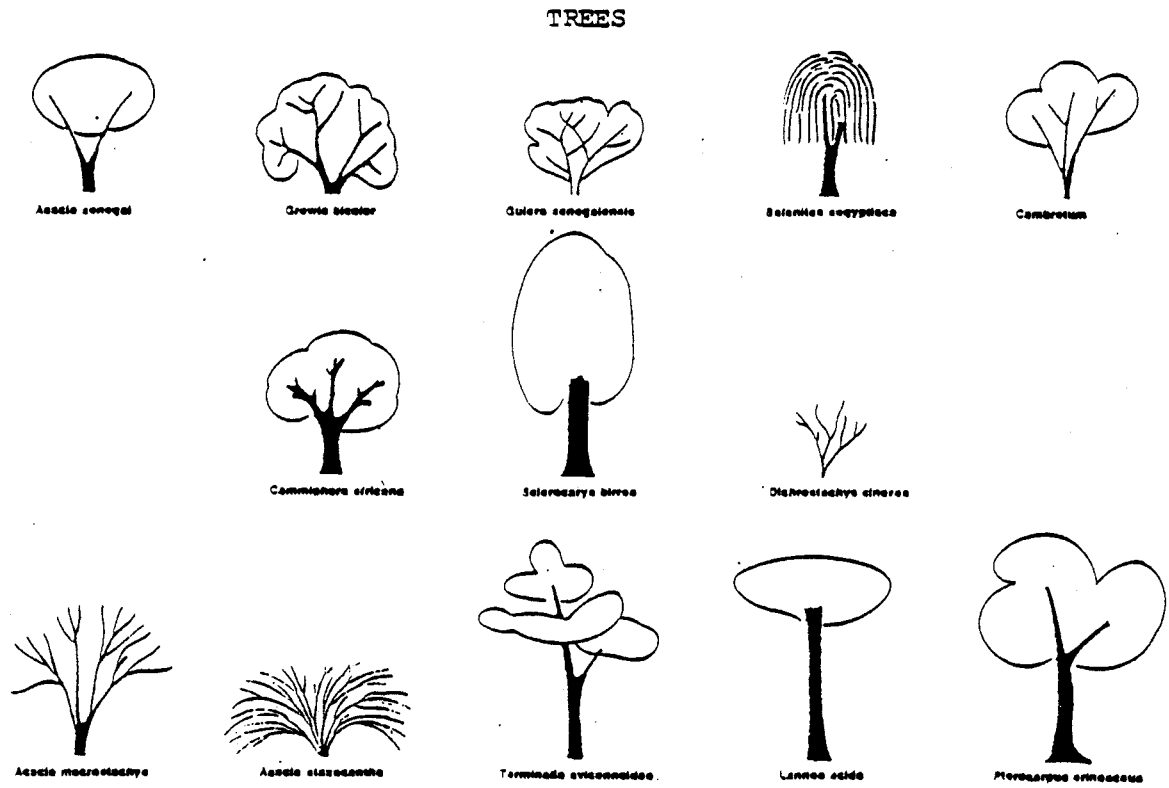
A gradient of vegetation in the center of the country from the Sahel into Sudanian woodland is shown in Figure 6. The transition from arid to more humid climate vegetation occurs at roughly the 750 mm isohyet. On both sides of that line, however, the presence of woody species is governed in large part by the existence or absence of depressions where water can accumulate, the depth to a hardpan, and the amount of grazing activity.

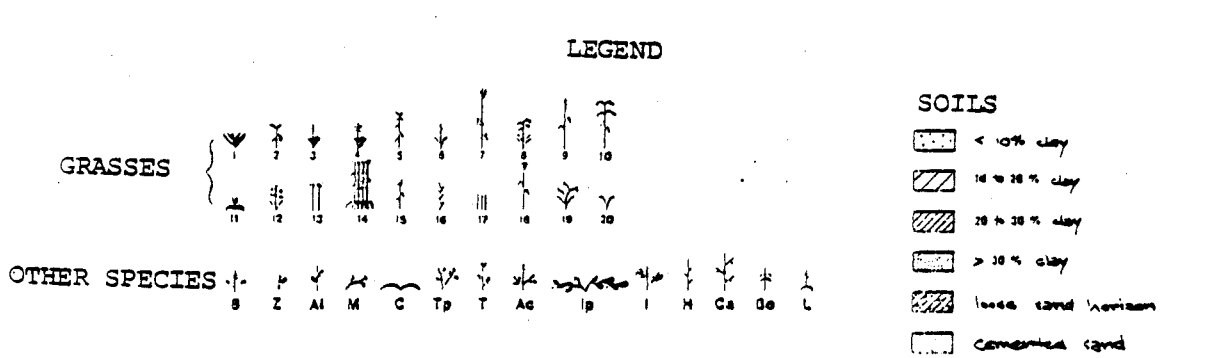
Map unit #7 in Figure 5 demonstrates the extent of the Guineo-Congolian lowland rainforest and the tall grasslands which occur with an abrupt transition at the forest edge.

The grasslands, more extensive than the rainforest, are believed to have developed as a result of shifting agriculture. Generally, when a plot is left fallow under the shifting agriculture regime, it is recolonized by the orginal forest species by natural coppicing, suckers and the seedlings. However, where this "brush fallow" is short and/or the soil is poor, grasses may invade the area. Grasses are especially well adapted to move onto sandy soils and are more tolerant to dry conditions than the rainforest species. When brush fires occur, the grasses and fire-resistant species survive whereas the original rainforest trees are killed. The result is the establishment of extensive grasslands in the Guineo-Congolian region, dominated by Panicum maximum, Pennisetum purpureum, and Imperata cylindrica.

Mangrove communities (map unit #31 Figure 5) occur in Senegal only at the mouth of the Casamance. They depend on periodic flooding with salty or brackish water. The principal trees in this community are Rhyzophora racemosa, R. harrisonii, R. mangle and Avicennia nitida. The estuary zone where the mangroves grow is an important feeding and breeding ground for many brackish-water crustaceans and fish.

Figure 6. Vegetation Transect from North to South in Central Senegal (Fete-Ole to Ndoli)





GRASSES

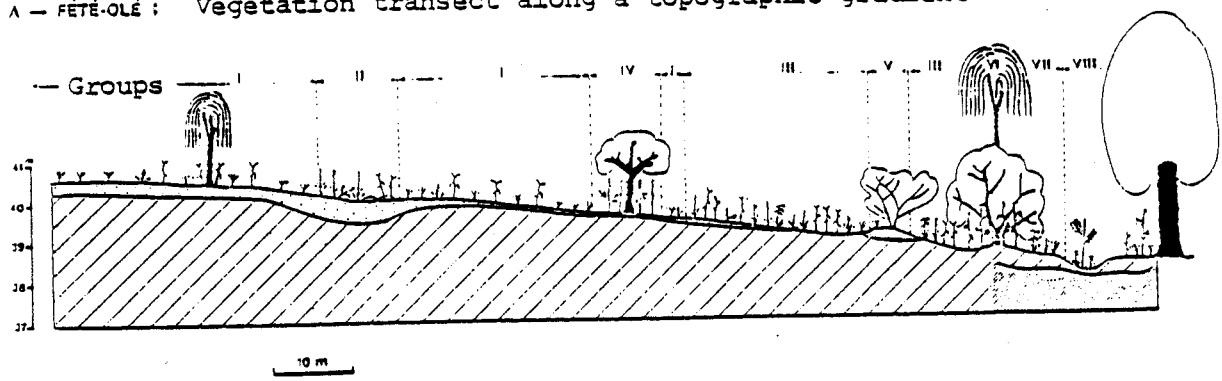
1 — Aristida
2 — Schoenfeldia gracilis
3 — Cenchrus
4 — Dactyloctenium aegyptium
5 — Digitaria
6 — Brachiaria
7 — Otheteropogon hagerupii
8 — Panicum
9 — Pennisetum
10 — Aristida stipoides
11 — Echinochloa colona
12 — Eragrostis
13 — Chloris
14 — Andropogon gayanus
15 — Cienium elegans
16 — Schizachyrium exile
17 — Elionurus elegans
18 — Andropogon
19 — Aristida kerstingii
20 — Loudetia togoensis

OTHER SPECIES

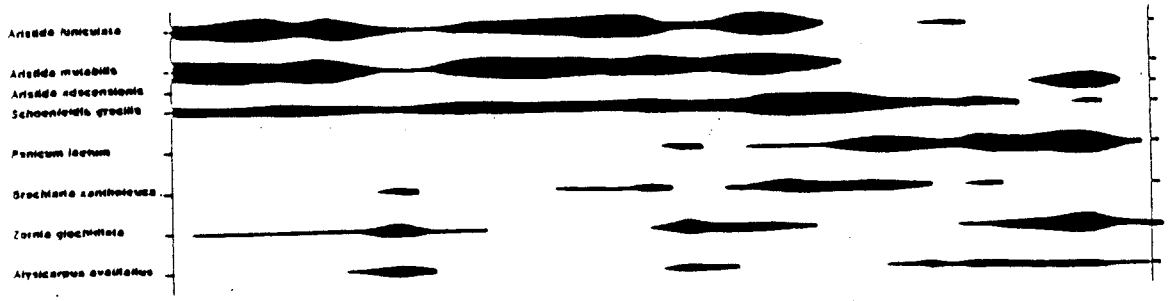
B — Blepharis linariifolia
Z — Zornia glochidiata
Al — Alysicarpus ovalifolius
M — Merremia
C — Commelina forskaolei
Tp — Tephrosia purpurea
T — Tephrosia
Ag — Achyranthes argentea
Ip — Ipomoea
I — Indigofera
H — Hibiscus
Ca — Cassia
Ge — Borreria
L — Lepidagathis anobrya

Source: Cornet and Poupon. 1977.

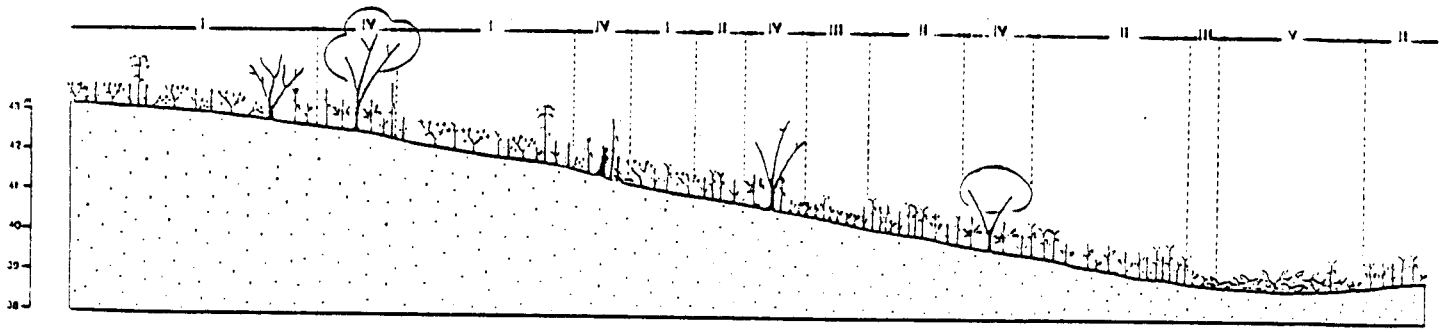
A — FÉTÉ-OLÉ : Vegetation transect along a topographic gradient



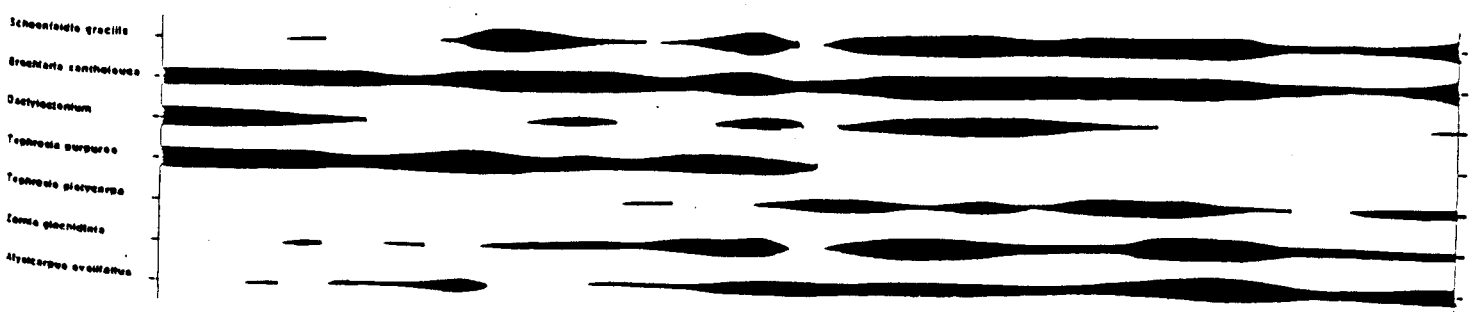
Breakdown of principal species



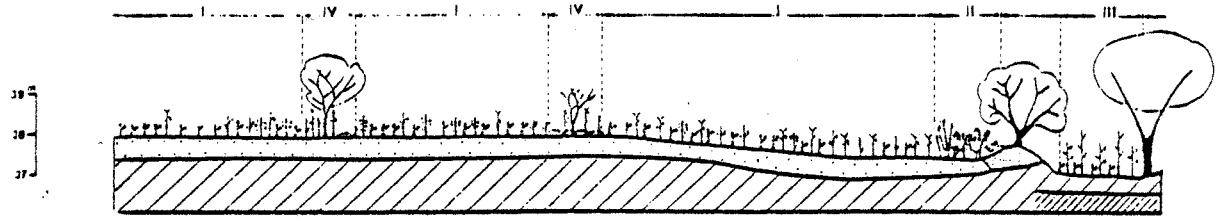
B — OAHRA-NORD : Vegetation transect along a topographic gradient.



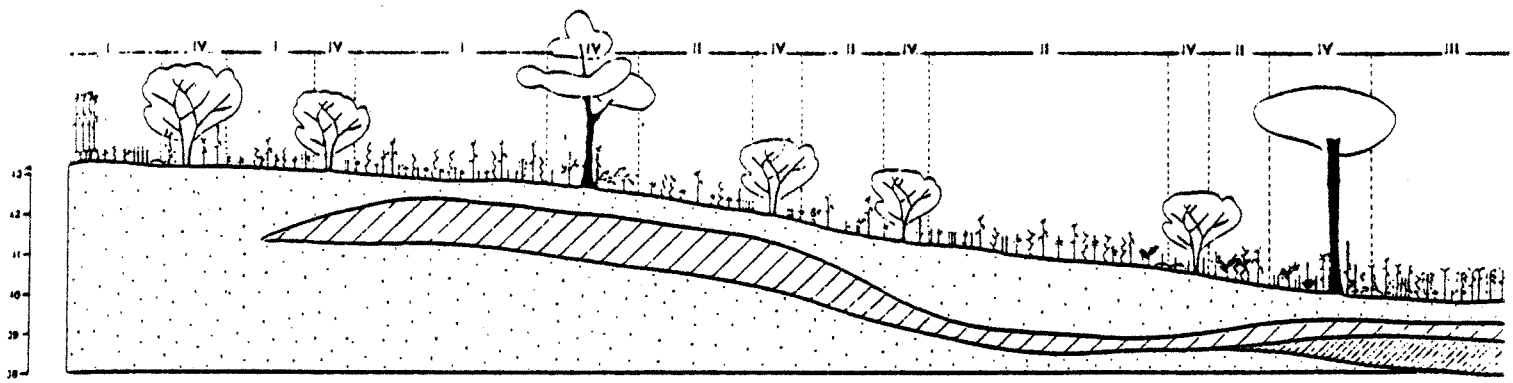
Breakdown of principal species



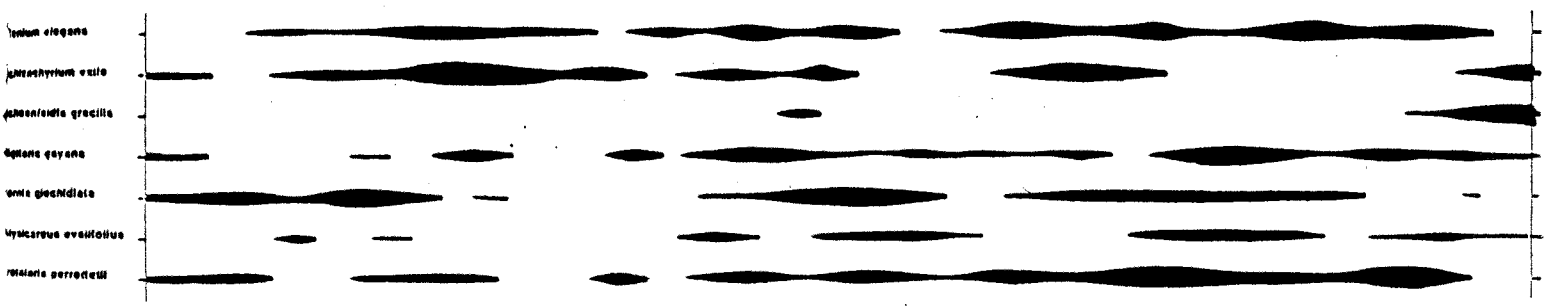
C — DAHRA-SUD : Vegetation transect



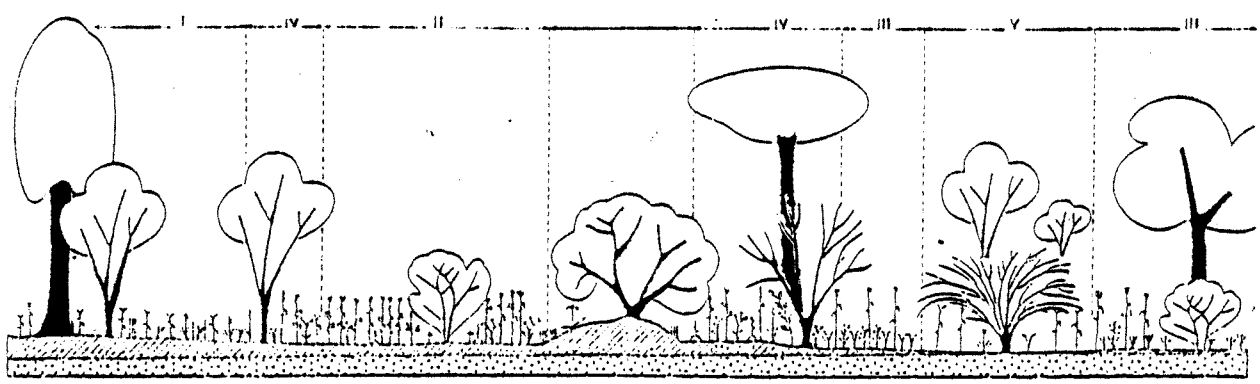
D — NOOLI-NORD : Vegetation transect along a topographic gradient



Breakdown of principal species



E — NOOLI-SUD: Vegetation transect



3.3.2 Legislation [16]

- Forest Code, 1965: lists protected plant species which may only be exploited with special authorization from the Directorate of Water and Forests.

- Decree No. 67-610, 1967 and Law No. 67-28, 1967: establishes a code for the protection of forests and game.

- Law No. 74-46, 18 July 1974: an expansion of the Forest Code, containing dispositions against harmful cutting practices and for the prevention of brush fires.

3.4 Wildlife and Protected Areas [17]

3.4.1 Description of the Resource

Senegal possesses a rich and varied fauna. Within its boundaries are a number of species at the northern limit of their geographic range, such as the chimpanzee, elephant, hippo and buffalo. Other species present are at their most southerly point of occurrence, including some palearctic migrant birds, among them the gull-billed tern and little tern. Senegal is an important staging and wintering area for huge numbers of western European bird migrants, as well. All of these points make the country a place of particular zoological interest.

Wildlife is confined mainly to the national parks, which occupy some four percent of the area of the country. However, wild animals are also known to occur in hunting reserves and in some unprotected areas. Piscivorous birds, for example, occur in such large numbers along the lower Senegal River thay they are perceived as a nuisance. In the rainy season, elephants migrate from the flooded Niokolo-Koba Park to the Matam area on the Senegal River and to an area on the Guinea-Bissau border. Hippos are still found in small numbers in the upper reaches of the Faleme River. Buffalo occurs throughout eastern Senegal. Eland*, roan antelope and hartebeest still survive on the southeastern plateaus, but the more sedentary ungulates such as oribi and bush duiker are being hunted to extinction. The large predators are also being killed off, especially as they prey increasingly on domestic stock as their wild prey becomes more scarce.

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[16] Source: Johnson and Johnson. 1977

[17] Source: Dupuy and Verschuren. 1977.
IUCN. 1973.
IUCN. 1976.

* Species indicated with an asterisk are endangered.

The government of Senegal has often repeated its commitment to nature conservation in the country. Their goals in this area are protection of complete ecological units of as many Senegalese ecosystems as possible, providing adequate refuges for migratory birds, research, and controlled tourism. The National Parks are the foci for these activities.

Niokolo-Koba National Park was created in 1925, although effective protection was not established until 1960 and its present size was not attained until 1969. The park encompasses 900,000 hectares of Sudanian grasslands and savanna woodland on the Gambia River and its tributaries, with Guinean gallery forest fringing the riverbanks. Elevations vary from 16 to 311 meters above sea level, with the high point at the summit of the Assirik Mountains. Nearly the entire area is flooded during the rainy season of June to October. Even during the dry season, surface water and forage supplies are always adequate for the wildlife population.

Animals are abundant and readily seen. Aerial censuses have been carried out since 1968. These surveys have provided the following tally:

elephants Loxodonta africana	350
buffalo Syncerus nanus savanensis	2500
hippopotamus Hippopotamus amphibius	1000
antelopes (nine species, principally:)	
Buffon's kob Kobus kob	20-25,000
Defassa waterbuck Kobus defassa unctuosus	
bushbuck Tragelaphus scriptus	
warthog Phacochoerus aethiopicus	10,000
lion Panthera leo	120
baboon Papio papio	10,000

Species present in unknown numbers include:

leopard* Panthera pandus
lynx Felix caracal
palm civit Nandinia binotata
side-stripe jackal Canis adustus
wild dog Lycaon pictus
ratel Mellivora capensis
aardvark Orycteropus afer
giant pangolin Manis [Smutsia] gigantea
bush pig Potamochoerus porcus

Other primates besides the overabundant baboons are:

chimpanzee* Pan troglodytes
western red colobus Colobus badius temmincki
vervet Cercopithecus aethiops
patas Erythrocebus patas
lesser galago Galago senegalensis

Even this substantial list of the mammals in the park is not exhaustive. In addition, 329 bird species have been recorded, 36 reptile species, 20 species of amphibian and 60 species of fish.

Poaching has been on the increase since 1973-74. Due to this factor, the elephant herd has dwindled from the size it had attained after management of the herd began in 1967. Niokolo-Koba could support as many as 1500 head of elephant, and the age structure of the herd favors growth of the population, if poaching could be controlled. Crocodiles in the Gambia River and its tributaries are also heavily poached.

Buffalo herds in the park are prospering, although they may be susceptible to the livestock diseases imported by domestic animals passing through the territory from neighbouring countries. The hippo population is at an optimal level. The roan antelope Hippotragus equinus koba, which is disappearing elsewhere in Africa, is thriving at Niokolo-Koba. So is the rare Lord Derby's eland* Taurotragus derbianus, of which the population numbered some 400 in 1977. The large bubal hartebeest Alcelaphus bucephalus major, which survives at Niokolo-Koba, is the subject of a cooperative project to reintroduce it into Morocco, where it became extinct in 1925.

Niokolo-Koba is threatened by the planned construction of dams on the Gambia River upstream of the park. If these dams are constructed, most of the park would be permanently inundated.

The Djoudj National Park, a 16,000-hectare area in the Senegal River delta 100 km. northeast of Saint Louis, was established in 1971 primarily as a bird reserve. One of the first places south of the Sahara with fresh water supplies, the park is a haven for some three million migratory birds from western Europe each year, as well as many year-round residents. Altogether more than a hundred species have been recorded of which 90 percent are waterfowl and 60 percent palearctic migrants.

The thorny Sahelian brush vegetation of the park, chiefly Acacia nilotica and Tamarix, also provides habitat for a number of mammals:

patas Erythrocebus patas
zorilla Ictonyx striatus
Libyan striped weasel Poecilictus libyca
ratel Mellivora capensis
African civet Viberra civetta
striped hyena Hyaena hyaena
serval Felis serval
African wildcat Felis libyca
Bohor reedbuck Redunca redunca
red-fronted gazelle Gazella rufifrons
cheetah Acinomyx jubatus

The West African manatee* Trichechus senegalensis has been introduced into the Djoudj.

Research has been conducted in the area since 1955, before it was designated as a park. There is a bird-banding station at the Djoudj, which is under the sponsorship of "Afring".

There have been reports of problems with feral pigs and donkeys in the park.

This reserve is also threatened by the construction of dams on the Senegal River as planned by the OMVS. There is concern that the use of herbicides, pesticides and fertilizers to intensify cultivation in connection with OMVS projects will upset the balance of the ecosystem in the Djoudj and damage its bird and animal populations.

The environment of the National Park of Basse-Casamance is more reminiscent of Zaire than of Senegal. Located in the extreme south of the country, the park incorporates mangroves at its west end and Guinean woodland, savanna and secondary forest through the rest of its area. Animals in the park include the endemic mona monkey Cercopithecus mona campbelli, sitatunga Tragelaphus spekis and yellow-backed duiker Cephalophus sylvicultor. Among its more than thirty other mammal species are:

patas Erythrocebus patas
red colobus Colobus badius
chimpanzee* Pan troglodytes
Beecroft's scaly-tailed squirrel Anomalurops beecrofti
crested procupine Hystrix cristata
great cane rat Thryonomys swynderianus
Cape clawless otter Aonyx capensis
genet Genetta spp.
Gambian kusimanse Mungos gambianus
spotted hyena Crocuta crocuta
serval Felis serval
leopard* Panthera pardus
bush pig Potamochoerus porcus
hippopotamus Hippopotamus amphibius
bushbuck Tragelaphus scriptus
buffalo Syncerus caffer and S. nanus
duiker Cephalophus maxwelli
Buffon's kob Kobus kob
aardvark Orycteropus afer
West African manatee* Trichechus senegalensis

More than 120 species of birds have been recorded in Basse-Casamance. Among them are the yellow-casqued hornbill Ceratogymna elata, the Senegal tourado Turacus persa, and the blue-billed weaver Malimbus nitens.

Research has been conducted at the site of the park since 1940 and more intensively since 1969, under the direction of l'Institut Fondamental d'Afrique Noire (IFAN).

The Madeleine Islands National Park protects one of the few rocky habitats of continental west Africa. Situated opposite Dakar, this marine park was established after 1976. About thirty pairs of red-billed tropic birds Phaethon aethercus nest at this park.

Another marine park, primarily a bird refuge and recently established, the Langue de Barbarie National Park near Saint-Louis represents the southern breeding limit in Africa of such species as the gull-billed tern Gelochelidon nilotica and the little tern Sterna albifrons. At the same time it is the northernmost African nesting site of certain species, such as the royal tern Sterna maxima.

Finally, the Saloum Delta National Park, some 200 km. south of Dakar, is a 60,000 ha. reserve encompassing sandy islands, lagoons, and the most northerly mangrove swamps in Africa. Located in the delta of the seasonal Sine and Saloum Rivers, it also incorporates 600 ha. of the dry forest of Fathala. Water birds abound in the park, including flocks of flamingos. There are also reedbuck, manatees and marine turtles. It has been reported that there are problems with local people raiding nests in the park.

In order to complete the protection of sample units of all of Senegal's ecosystems, it would be ideal to establish a reserve in the northeastern Sahel, in the salt flats of Sine-Saloum, and on some bird islands between the Gambia and the Guinea-Bissau border.

3.4.2 Legislation [18]

- Decree No. 072, 1966: created an interstate public entity to control certain pest species of birds.
- Decree No. 67-610, 1967: Hunting and Protection of Fauna Code. Established classified forest reserves and game under partial or total protection.
- Decree No. 69-858, 1969: provided for the creation of a National Parks Bureau.

3.5 Minerals [19]

3.5.1 Description of the Resource

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[18] Source: Johnson and Johnson. 1977.

[19] Source: Europa. 1979.
Ministry of Industrial Development and the Environment (MDIE). 1976.
Schreiber and Matlock. 1978.
U.S. Bureau of Mines. 1976.
U.S. Bureau of Mines, personal communication.

At present, Senegal's mineral extraction activities include the mining of phosphates, attapulgite (fuller's earth, used in drilling mud), salt, gypsum, and gold, and the quarrying of basalt, marble, brick clay, and cement materials. Explorations are in progress for other mineral reserves, including iron, copper, petroleum, limestone, and additional sources of phosphates.

Phosphates are mined at Taiba, 40 km. north of Thiès, and at the Pallo Mine near Lam-Lam. Both deposits are in Middle Eocene sedimentary rocks and are extracted using open-pit techniques. The reserves at Taiba are of pelletal phosphate rock and are exploited jointly by private companies and the government. At the Pallo Mine the phosphate beds have been laterized into calcium aluminum phosphate, and the government has a fifty percent interest in the mining operation there. The P_2O_5 content of both reserves is over 35 percent. The 1979 production figures were 275,000 metric tons of aluminum phosphate and 1,651,000 metric tons of calcium phosphate fertilizers. Railroad lines connect the sites of production with the port at Dakar. Transportation is an important consideration in development of Senegal's mineral industry.

All known reserves of phosphate rock in North and West Africa occur in marine sedimentary rocks of Late Cretaceous to Early Tertiary age. This fact has facilitated the location of additional phosphate deposits in Senegal in the region east of the Lac de Guiers and at Tobene. The combined capacity of these reserves is estimated at 350 million metric tons. Senegal has processing facilities to produce superphosphates, and a triple superphosphate plant is planned to commence production in 1981.

Attapulgite production levels in 1979 were double the previous year's, at an estimated 13,000 metric tons. The demand for this rare earth has risen sharply with increased drilling activities, especially in petroleum exploration.

About 381,000 metric tons of cement were produced in 1979. A limestone deposit has been located at Pout, of which some 100 million cubic meters are suited for cement manufacture. This reserve could supply a cement factory with an output of one to two million metric tons per year.

Some 1979 production levels of other minerals were:

salt	140,000 metric tons
basalt	850,000 metric tons
gypsum	12,000 metric tons
brick clay	(amount unknown)
gold (1978)	78 troy ounces (2.42 kg)

Marble production in 1979 was 8,000 cubic meters. A new, high-grade deposit of marble has been located which is expected to increase production to 30,000 tons per year.

Senegal is pursuing an aggressive minerals exploration program. Evidence of copper has been found in a sedimentary formation composed of old volcanics at Alingheul, Bandaffass, Kouroudiako and at other sites in Senegal Oriental. A substantial iron deposit, estimated at 900 million metric tons, is under study at Faleme. The ore at this site contains 45 to 48 percent iron, which could be enriched locally with a simple treatment to an iron content of 68 percent. The Faleme iron deposit could be exploited at the rate of ten million tons of 68 percent iron per year. However, the lack of adequate transportation facilities at Faleme to move the iron to processing and marketing centers has prevented exploitation of these reserves to date.

A number of Senegalese, foreign, and multinational oil companies have carried out explorations for petroleum in Senegal. Shell Senrex has studied the Casamance region and, with Esso, along the Mauritanian border; Permis de Thiès drilled exploratory wells in Cayas and Bargny to a depth of more than 4000 meters. There have been negative results thus far. Should petroleum be located in the country, Senegal could refine up to 800,000 tons per year in its processing plant. At present, the refinery processes imported crude oil. In 1977 its output was 765,000 tons.

3.5.2 Legislation [20]

- Act No. 76-66, 2 July 1976. Established the State Domain Code. Book I - general provisions. Book II - the public domain. Book III - the private domain. Book IV - miscellaneous provisions.

- Decree No. 67-1006, 1967. Regulates the ad valorem duties on most minerals.

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[20] Source: FAO. 1977.
Johnson and Johnson. 1977.

4.0 Resource Utilization

4.1 Agriculture [21]

Agriculture in Senegal is divided about equally between production of groundnuts for export and production of millet and sorghum for domestic consumption. Programs for crop diversification have been underway since 1969, and the future of cotton, vegetable and rice production looks promising; however, in 1976, only about five percent of all Senegalese farmers were raising these alternative crops.

The history of how Senegal's economy became so intricately linked to the groundnut makes interesting reading. Formal experimentation with African tropical agriculture dates back to 1819 in Senegal, when France obtained a concession of land on the Senegal River and set up a model farm under the direction of the agronomist Richard Toll. The farm was a failure. During the same period, however, the local farmers were successfully adapting an American import, the groundnut, into their cultivation systems. A Frenchman seeking a means to exploit the crops grown in the region sent a batch of groundnuts to Marseille in 1840 to test their acceptability on the French market. They were instantly popular, and once the political climate of France allowed it, Senegal was colonized, the necessary transportation facilities installed, and the exploitation of groundnuts began in earnest. Harvests rose from about 45 thousand tons in 1885 to 200 thousand tons in 1914 and on to 600 thousand tons by the beginning of World War II.

During the first few decades of the development of this cash crop economy, the effect on the local people was largely positive. They were able to cultivate their own food crops as well as the groundnut cash crop. In 1925, however, the world price for groundnuts began a sharp decline, forcing the colony to put more land into groundnut production to maintain the level of earnings from the cash crop on which France had become dependent. Food crop production was reduced, and rice had to be imported in large quantities to meet the needs of a growing population.

In order to eliminate this debit in foreign trade, the French launched an experiment in mechanized rice production at Richard Toll in 1946. Beset by problems of soil salinization, dust storms and plagues of Quelea quelea grain-eating birds, the area was never able to satisfy Senegal's needs for food grains. In 1960 the project's total rice production amounted to only ten percent of domestic rice consumption. The balance had to be imported and paid for with the proceeds from groundnut sales. Given these unsatisfactory returns on a very heavy investment

[21] Source: Chasin. 1980.
Duke. 1974.
Menes. 1976.
Pelissier. 1977.
U. S. AID. 1979.
United Nations. 1974.

in the project, it was also a serious drawback that the mechanized mode of production employed at Richard Toll did nothing for Senegal's unemployment problem.

By the time of independence, Senegal was apparently locked into virtually a monocrop agriculture. France helped to support this pattern in its former colony by providing price subsidies on Senegalese groundnuts. In 1967, however the subsidies were withdrawn. In the words of a UN Secretariat report, 22/ "The peasants -- objecting to having to buy millet and rice in order to have enough food to grow peanuts [groundnuts] whose price had been declining -- stepped back, re-evaluated their position, and stopped producing peanuts." Rather than being an example of conservatism on the part of the farmers, as it has been interpreted in some circles, this response has proved their capacity to change their behaviour according to logic and experience. The result has been a slow reduction in the predominance of groundnuts in the economy, with expansion of the minerals sector to take up some of the slack. Nonetheless food grain production is far from adequate to meet the needs of domestic consumption, and cropland area has actually been declining due to abandonment during drought. The agricultural sector operates at considerably less than its potential.

Family farms are the rule in Senegal. They average about 2.4 hectares in size in the groundnut basin and 1.5 hectares in outlying areas. They are farmed by five to ten family members. Some 360 thousand of these farm units exist in the country, of which 215 thousand are located in the groundnut basin.

The government is promoting agricultural cooperatives as a means of improving production and simplifying the problem of providing government services to farmers. Such an approach seems to be acceptable in Senegal, since property is traditionally owned by the tribe, with the chief assigning land to a family or group of families depending on their needs and ability. There are now about 2200 cooperatives in operation, of which 1700 are engaged in groundnut production.

By far the largest fraction of cropland is in rain-fed agriculture, located in the section of the country where the rains are the most erratic. Soils are generally low in the basic nutrients of nitrogen, phosphorus and potassium, requiring more fertilization per hectare than in any other country in tropical Africa. Soils in the groundnut basin are overcropped, but the population is reluctant to move elsewhere because of the limited transportation and other facilities in the interior of the country.

Senegalese farmers have learned to adjust to some extent to the constraints of their land. They practice agroforestry in parts of the Sahelo-Sudanian zone, protecting such trees as the locust (Parkia biglobosa), shea-nut (Butyrosperma parkii), and tamarind (Tamarindus indica) when fields are cleared for new cultivation. Acacia albida will even be purposely inter-

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22 United Nations. 1974.

planted, for its benefits are well-recognized. It sheds its leaves with the first rains, supplying organic matter for the improvement of the soil as the dead leaves are turned under with cultivation. When new leaves sprout at the beginning of the dry season, they provide forage for livestock. Found in the Serer country in Senegal, cultivation with Acacia albida appears to be a response to the increasing density of the human population, which makes fallowing land impossible and fertilization critical to keep land in production.

4.2 Fisheries

4.2.1 Description of the Enterprise [23]

Fish accounts for some 80 percent of all animal products in the Senegalese diet. Fish are harvested both from coastal waters and from the four major river systems, particularly the Senegal River. Saltwater species are marketed fresh as far as 100 km inland from the coast, where good road systems allow for rapid transport. What cannot be sold fresh (generally about 15 percent of the catch) is dry-salted, grilled, smoked, sun-dried, or fermented and marketed inland. The same procedure applies to fish caught in the rivers during periods of abundance.

Of Senegal's continental fishery, that on the Senegal River has been the most carefully studied. There the fish harvest is characterized by the flow regime of the river. The occurrence of saltwater and brackish-water species increases with the seawater intrusion which takes place when the rainy season high flows abate, roughly from November to July/August. The distribution of these saltwater species corresponds with that zone of the river which maintains a salinity of 0.5 to 30 parts per hundred. Fresh water species migrate upstream ahead of the wave of salt water intrusion, and expand their range during the floods of late summer, when the area covered by fresh water in the central valley alone increases by 300,000 hectares.

Saltwater genera found in the Senegal River include Elops, Liza, Mugil, Tilapia, Ethmalosa, Ilisha, Cynoglossus, Polydactylus, and Pellonula. The major freshwater genera are Hydrocynus, Alestes, Distichodus, Citharinus and Labco. Freshwater species are apparently more numerous, despite the fact that the fresh water in the river is intrinsically less productive than the brackish water, since sea water has a richer mineral content. Water temperatures and the pH of the river water are generally conducive to high productivity,

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[23] Source: Menes. 1976.
Monteillet and Rosse. 1977.
Reizer and Lessent. 1972.

however. Plankton levels on which the fishing depends are relatively high due to calm water, high water temperatures and low turbidity in the river for most of the year. Saltwater, brackish-water, and freshwater crustaceans are also found in the Senegal River in distribution patterns tied to the amount of saltwater intrusion in the river.

Fishermen along the Senegal are mostly Wolof. Some operate in teams of 20 to 40 in the lower delta and 5 to 10 in the upper delta, led by a captain who holds a permit from the Water and Forest Service. These teams fish with a cotton seine thrown from the shore. Other professional fishermen work individually from canoes, using nets or a line with unbaited hooks. In 1972 there was only one fishing cooperative, located at Débi.

4.2.2 Legislation [24/]

- Act No. 76-89, 2 July 1976. Established the Marine Fishing Code. Consolidates and revises existing legislation dealing separately with different aspects of marine fisheries.
  - Territorial waters are claimed to extend 150 miles offshore and an exclusive fishing zone is claimed, extending an additional 50 miles.
  - Licensing regulations are detailed, including the conditions under which fishing by foreign vessels is allowed.
  - Permissible fishing techniques are specified.
  - The capture, sale or possession of all sea turtles and of bongo, yellow-fin, skipjack, green lobster, shrimp, and oysters under specified sizes is prohibited.
  - A modification of Article 60 of the Fishing Code, made on 13 July, 1978, establishes a fund to allow for policing Senegalese waters to prevent exploitation of its fisheries by foreign concerns.
- Senegal is party to the 1958 Geneva Convention on Law of the Sea, including the Conventions of the High Seas and of the Continental Shelf.

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[24] Source: Anonymous. 1978.
FAO. 1977.

4.3 Pastoralism [25]

For centuries, the Sahel and part of the Sudanian zone has been the domain of nomadic herders of sheep, goats, cattle and camels. Transhumance was a logical response to the seasons and regional patterns of fodder production in this zone. When the rainy season produced a brief flush of grasses in the most arid regions, the nomads were there to benefit from it. This strategy also had the advantage of removing the herds from the river basins during the period when the tsetse fly population was at its most dense, while the flood waters were highest. As the floods receded, local sedentary farmers raised crops in the flooded fields. By the time the crops were harvested, the nomads had moved their herds back to the river basins to graze on the crop stubble and native vegetation of these zones. Then the annual cycle would be repeated.

This pattern was interrupted when West Africa entered the colonial period. The authorities were interested in the development of agriculture and in the management of stable populations, and the transnational migrations of the nomads did not fit this scheme. In an effort to reduce the scale of the pastoralists' movements and to keep them to predictable paths, the colonial governments entered into a program of drilling deep wells to provide permanent watering points for the herds. This program had two unexpected effects. In some places, the pastoralists became semi-sedentary and concentrated their herds around the watering points, causing the vegetation in the area to be virtually decimated and the soil to be seriously damaged by trampling. In other cases, the deep wells were commandeered by farmers for irrigation purposes; their fields were then cropped continuously and the pastoralists forced into more marginal areas to graze their flocks.

This latter process is cited by Delwaulle [26] as an important cause of greatly increased numbers of animals grazing in the Sahel between 1945 and 1967. Other factors were the relatively high rainfall of that period, and government livestock programs run by veterinarians, who tended to focus on reduction of disease without introducing concepts of safe stocking levels and other aspects of scientific animal husbandry. The conventional wisdom of the pastoralists dictates that the larger the herd, the better; a large number of animals is the herder's only insurance against drought, disease or some other disaster when some animals must be sold to maintain oneself. Consequently the herds in the Sahel from the mid-1940's to the mid-1960's were allowed to increase unchecked. The carrying capacity of the range was overreached, and when drought hit in the late 1960's, hundreds of thousands of animals in the Sahel zone died and many others were slaughtered and sold so as to derive some benefit from their inevitable death.

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[25] Source: Delwaulle. 1977.
United Nations. 1974.
Van Dyne. 1974.

[26] Source: Delwaulle. 1977.

Various approaches have been recommended to prevent the repetition of such an event:

1) developing areas for livestock-raising in the Sudanian zone, to reduce the grazing load in the Sahel.

2) developing water for optional distribution of grazing within the Sahel. This must be coupled with control of grazing intensity.

3) fire control to protect forage.

4) mineral supplements to the animals' diet, to increase fertility.

5) controlled grazing, keeping stocking rates within limits that the range can support.

6) selective culling of herds, emphasizing productive efficiency.

All of these programs must be managed with attention to the range of responses they may set in motion. The development of watering places is a case in point. It has been suggested that all wells should be shut down at the beginning of the rainy season, so that herders would disperse the animals over a large area to take advantage of the seasonal ponds that develop, thus reducing grazing intensity around permanent water points.

Many of these programs will be politically sensitive, and will more likely be accomplished by providing incentives such as exclusive grazing rights, or "grazing centers" offering veterinary and social services, than through coercion.

4.4 Forestry [27]

There are 197 sections of "classified" forest in Senegal covering an area of 3.9 million hectares, or 20 percent of the country. The area in small patches of unclassified woods is unknown, but probably contributes significantly to fuelwood supplies of smaller villages. All forests are under increasing pressure to provide fuelwood for a growing population and construction materials for a developing economy. They also are subject to the ravages of brushfires (see Section 5.2). The rate at which the forests are shrinking is a matter of guesswork, but it is recognized that they are being consumed more rapidly than they can be naturally or artificially replaced. Some 18,000 people made their living cutting

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[27] Source: Bertrand. 1977.
Delwaulle. 1977a.
Delwaulle. 1977b.
Kane, Abdoulaye (Chief of Division of Reforestation and Silviculture), personal communication, 23 May 1980.
UNSO. 1979.

fuelwood and construction wood or making charcoal in 1974. The government forestry program has five thrusts:

1) Forest protection and management:
   - brushfire control
   - protection of reserves
   - creation of a botanical garden
   - management of existing forests

2) Restructuring agrarian and pastoral lands:[28]
   - reforestation in the Senegal Delta
   - management of grazing in forest areas and reforestation with fodder trees around watering places
   - restructuring agricultural lands in Diourbel, Louga, Sénégal-Oriental, Siné-Saloum and Thiès.

3) Reforestation for production:
   - plantation of teak, Melina, and cashews
   - Project Mbiddi: plantation of gum trees (Acacia senegal)

4) Reforestation for environmental protection and fuelwood production:
   - sand dune fixation and protection
   - large fuelwood plantations, including one irrigated plantation below Diama Dam
   - reforestation around cities and towns
   - village woodlots
   - plantations along roads

5) Wildlife program: providing equipment for national parks and hunting zones.

[28] This terminology is from UNSO, 1979. It is unclear what "restructuring" involves.

5.0 Environmental Problems and Projects to Address Them

5.1 Desertification [29]

A quarter of Senegal's territory is arid, and 70 percent is semi-arid. Thus nearly all of the country is threatened by desertification, defined as the conversion of marginal dry lands to absolute desert by a combination of drought conditions and overly intensive land use. The most critical areas are the northern part of the Fleuve region, Senegal-Oriental, the eastern central zone of Casamance and the Cap-Vert region.

Desertification is always set in motion by the loss of vegetation cover. Devegetation on a large scale probably began in Senegal with the arrival of steamboats and trains. Forests were cut to fuel the engines and market towns sprang up, using increasing amounts of wood in their cookfires. Wood and charcoal are still the principal sources of energy for the Senegalese. Urban wood consumption continues to rise, placing great pressure on the forests within reasonable transport distance of the cities (up to 350 km from Dakar). The average city dweller uses 2 steres (2.62 cubic yards) of wood annually.

Rural wood consumption is more difficult to estimate, since it is collected daily by individual families and is not brought to a central marketing point where its volume can be assessed. FAO offers a figure for total fuelwood and charcoal consumption in Senegal of 2.22×10^6 cubic meters of stacked wood equivalents in 1973. [30] If fuel consumption is directly related to population, then it can be assumed that consumption of charcoal and firewood has increased at the same rate as population growth (2.8 percent), to 269,336,000 cubic meters of stacked wood equivalents in 1980. There are reports that during the drought peasants who had lost their crops were forced to turn to cutting and selling firewood, thus further reducing the vegetation cover at a time when the land most required that protection.

Grazing activities are another cause of devegetation. As described in Section 4.3, the tendency of the herders is to allow their flocks to multiply as much as possible, thus overtaxing the regenerative capacity of the range. When forage becomes scarce, the herders try to help their animals to survive by stripping leaves and bark from the widely-spaced trees in the Sahel to use as a last-ditch fodder. Many trees have died of this treatment. The removal of grasses and trees from the drylands leaves the soil bare and prone to erosion. The scene is most bleak at the watering places, where the concentration of animals causes compaction of the soil, reducing its infiltration capacity and thus its potential for restoration of the vegetation cover.

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[29] Source: Delwaulle. 1977a and b.
Kane, A., personal communication, 23 May 1980.
United Nations Sudano-Sahelian Office. 1979.
Ulinski. 1978.

[30] Source: Bertrand. 1977.
A stacked wood equivalent is roughly equal to a two-meter (six-foot) cube of wood as it is stacked in the field (including interstices). Personal communication, Mylo Cox, University of Arizona, 9/5/80.

Agriculture has also contributed to the problem. The demand for increased food and export crop production has forced the extension of agriculture into fragile marginal lands, as well as the intensification of cultivation of lands which are made susceptible to erosion by poorly adapted new techniques of cultivation. As one example, irrigation projects which are introduced without adequate training of the farmers who make use of this unfamiliar technology have resulted in salinization, alkalinization, or waterlogging of the soils. Under traditional cultivation, soil fertility is diminishing because fallowing time has been reduced or dispensed with altogether. Under either regime, abandonment of the fields in times of serious drought leaves these unprotected soils open to devestating erosion.

Brushfires cause much damage. Approximately 40 percent of the country is burned each year, provoking the destruction of pasturage, crops, forests and sometimes habitations. Fires are set for a number of reasons: to clear land; to clear the brush around a village, which the people fear will harbor snakes and other pests; to drive game; while smoking wild bees from a hive to collect honey; or simply by accident. The harm done by brushfires is immeasurable, but fire is one of the principal causes of deforestation in Senegal.

The Government of Senegal has had a longer commitment to combatting desertification than any other country in the region. A list of ongoing and proposed anti-desertification projects are listed in Appendices II and III. The activities include:

1) livestock development and improvement of range management techniques;

2) forest protection and management;

3) forest plantations for wood and for environmental protection;

4) reducing dependence on wood and charcoal as fuels by supporting development of alternative sources of energy; and

5) improvement of agriculture.

5.2 Water [31]

Water problems in Senegal fall into the categories of (1) problems of supply, (2) problems of health, and (3) industrial pollution.

5.2.1 Water Supply

The problems of supply are described in Section 3.1.1. Variations in amounts and timing of annual rainfall cause fluctuations in productivity of the agricultural, livestock and forestry sectors and make life very problematical for most rural dwellers. Groundwater is either inadequate or inadequately exploited.

Both well-drilling and management of surface water play a major role in Senegal's Fifth Plan (1977-1981). Over the next 40 years, 13 dams will be constructed either by Senegal alone or in cooperation with neighbouring states. When all of these projected dams are in place, the associated irrigation schemes will raise cereals production to five times present levels.

The most important of the surface water management schemes are those to be developed on the Senegal River by the Organization pour la Mise en Valeur du Fleuve Senegal (OMVS). The OMVS is a river basin development agency, a collaborative effort among the three countries whose territory is crossed by the Senegal River: Mali, Mauritania and Senegal. Established in 1972, the OMVS is the exception among river basin organizations in that it has the power to make decisions and draw up resource management plans that have a binding effect on member states. In addition, it is empowered to accept grants, loans and technical assistance and to manage funds and expertise for projects of benefit to all member states.

To quote from Gannet et al Inc., page 8: "The first phase of the O.M.V.S. development program involves the construction of a dam at the village of Diama and construction of retention dikes on both sides of the river extending from Diama to Rosso. The dam at Diama is designed as a saltwater barrier to prevent salinity intrusion from the area to areas upstream of the dam site during the dry season.

This dam, together with the proposed dike system will allow:

(a) diversion of water to Lac de Guiers for a more extended annual period;

(b) year-round source of fresh surface water for irrigation and municipal/industrial purposes in the delta;

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[31] Source: Gannett, et al. Inc. 1979.
Menes. 1976.
Ministry of Industrial Development and the Environment (MDIE). 1976.
Parnail and Utton. 1977.
U.N.S.O. 1979.
U.S. AID. 1979.

(c) availability of surface water for the annual recharge of Lac R'Kiz and the Aftout es Sahel."

The other major construction planned by the OMVS is the Manantali Dam, to be built in Mali 1200 km. upstream of Saint-Louis. The dam will provide controlled releases which will "permit the following: [32]

(a) Year-round irrigation of 255,000 hectares of land between Manantali and Saint-Louis.

(b) A flow of 100 cubic meters per second in excess of irrigation and other requirements.

(c) The production of 800 gigawatt-hours per year of electric power at the Manantali dam."

Such large-scale management of the Senegal River is bound to have far-reaching effects on the economy, the social milieu and the environment of the region. The traditional use of flooded lands for agriculture will be interrupted and lands once used for rainfed farming will be turned over for use as pasture. Transportation will be much improved by the ability to navigate on the river, thus contributing to the development of industry and commerce. The combination of improvement of navigation and development of agro-industries in the basin is expected to promote six-fold growth of the urban centers in the region, necessitating the planning for provision of services for the newcomers. There will be an improvement in the availability of food. An increase in the incidence of communicable disease, of malaria, and possibly of other environmental diseases is also expected.

The increased use of pesticides and fertilizers associated with the OMVS projects may result in polluted runoff and recharge to the groundwater, if use of these chemicals is not carefully managed. The fishing industry on the Senegal will suffer the loss of estuarine fish and fish-breeding sites in the middle valley. The dams on the river will reduce the extent of present bird and wildlife habitat, but new habitats are expected to develop on the fringes of the reservoirs at certain locations. Finally, the Langue de Barbarie National Park is threatened by Saint-Louis boat traffic and harbor pollution in the lagoon created by the Diama dam. However, many of the negative effects of the OMVS projects can be mitigated or eliminated by careful planning, and the effect of the project as a whole will be greatly beneficial to Senegal and its neighbor states along the Senegal River.

5.2.2 Health Problems

Water-related diseases in Senegal are of two types: those transmitted by drinking water contaminated by excreta and dejecta, and those caused by pathogens transmitted by insect vectors which spend at

[32] Source: Gannet et al Inc. 1979.

least part of their life cycle in or near water.

Of the two types, the latter is responsible for the most reported cases of disease, chiefly because of the high infection rate of malaria; 76 percent of the population under the age of 30 has the disease. The other insect-transmitted diseases, although locally virrulent, do not affect such a large proportion of the population. Schistosomiasis affects about 10 percent of the people in the Senegal delta and about 40 percent of those who live along the Malian border, but in the country as a whole, schistosomiasis is about seventh in the list of most common diseases. All of Senegal-Oriental is highly infected with onchocerciasis (river blindness), to the point that the most fertile land near the river bottoms cannot be permanently settled. The WHO is beginning a vector control program for the simulid flies which transmit the disease. Trypanosomiasis is a potential problem, due to widespread infection of wild antelopes and domestic dogs, pigs and goats in the endemic areas of Cap Vert, the Gambia River Basin, Casamance, and Senegal-Oriental. Yellow fever and dracuntiasis (Guinea worm) have also been reported.

Diseases related to poor sanitation and overcrowding account for almost the balance of health problems in Senegal. Most drinking water supplies are polluted: only 37 percent of the population in 1975 had reasonable access to a safe supply of potable water. The principal diseases transmitted by unsafe drinking water are dysentery, gastrointestinal diseases of children (a leading cause of death in children under the age of five), typhoid fever, cholera, and hepatitis.

The open sewers of Dakar discharge into the ocean and cause pollution of the beaches and of the seawater to a distance of one kilometer offshore. In addition to the health problems caused by this approach to sewage disposal, the foul beaches act as a constraint to development of the tourist industry.

5.2.3 Industrial Pollution

References in the literature to this problem are scanty but consistent. The Fifth Plan [33] lists among Senegal's environmental goals plans to reduce hydrocarbon pollution in the port of Dakar, to prevent coastal water pollution by using aerial surveillance techniques, and to inaugurate a study of the effluents released by industry. As Senegal continues to develop its industrial sector, these concerns will increase in importance.

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[33] Source: Ministry of Industrial Development and the Environment (MDIE). 1976.

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APPENDIX I

ENVIRONMENTAL ORGANIZATIONS

(governmental and non-governmental, Senegalese, foreign and international institions whose missions at least partially embrace environmental concerns.*)

Note: the classification of the following organizations constitutes the best guess of the author as to their nature, based on sketchy and contradictory references to these entities in the literature.

*Assistance with this section was provided by Deborah Carynnyk.

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I. Senegalese Government Organizations

A. Government Development Societies

1. Société d' Aménagement et d'Exploitation du Delta (SAED)

Under the direction of the Ministry of Rural Development, SAED steers the development of irrigated agriculture in seven "perimeter regions" along the Senegal River: the Delta, Dagana, Nianga, Aere Lao, Guede, Matam and Bakel. Each perimeter region has its own organization and staff.

a. Division de la Recherche Agronomique de la SAED
B. P. 74
Saint Louis

Conducts research in soil science, crop protection and genetics.

2. Société d'Exploitation des Ressources Animales du Sénégal
B. P. 14
Km. 2.5, Route de Rufisque
Dakar

Founded in 1962, this group supports livestock development for integration of the livestock sector with trade and industry.

3. Société de Développement des Fibres Textiles (SODEFITEX)
B. P. 3216
30 ave. Jean-Jaures
Dakar

SODEFITEX is the regional development office for Eastern Sénegal and the Upper Casamance, stressing production of textile fibers (especially cotton) and maize.

4. Societe des Terres Neuves
B. P. 440
Dakar

-supervises the colonization of an under-populated area of Senegal Oriental through resettlement of people from groundnut-producing areas of Sine-Saloum, Thiès and Diourbel.

5. Société Financière Sénégalaise pour le Développement de l'Industrie et du Tourisme (SOFISEDIT).

A financial institution.

6. Société Industriel pour l'Application de l'Energie Solaire (SINAES)
B. P. 1277
Dakar

SINAES is a Senegalese company (jointly owned by French and Senegalese public and private interests), created for the purpose of installing and manufacturing solar technology in Senegal, including windmills. An INFO TERRA contact.

7. Société Nationale d'Études et de Promotion Industrielle (SONEPI)
   B. P. 100
   4 rue Maunoury
   Dakar

   SONEPI exists to promote small and medium-scale business in Senegal.

8. Société Nationale d'Exploitation des Eaux du Sénégal
   B. P. 400
   97 ave. André Peytavin
   Dakar

   Founded in 1972 to develop water works and expand water supply.

9. Société Nationale des Études de Développement (SONED)
   B. P. 2084
   45 Blvd. de la République
   Dakar

10. Société pour la Mise en Valeur de la Casamance (SOMIVAC)

    -the regional agency for planning and development in the Casamance.

11. Société Sénégalaise de Distribution d'Énergie Électrique
    B. P. 93
    rue Vincens
    Dakar

12. Société de Développement et de Vulgarisation Agricole
    B. P. 3234
    142 rue de Bayeau
    Dakar

    Founded in 1966 to develop intensive farming methods and diversified livestock breeding.

    Société d'Aménagement et d'Exploitation des Terresdu Delta du Fleuve Sénégal.
    B. P. 74
    Saint-Louis

    Responsible for 30,000 hectares that lie outside the competence of ONCAD, this society basically controls the agricultural development of the Senegal River Delta.

B. Government Bureaus

1. Direction Général de la Recherche
Scientifique et Technique (DGRST)
61 Blvd. Pinet Laprade
Dakar

DGRST is the agency responsible for coordinating all research and development in Senegal. An INFOTERRA contact.

a. Institut Sénégalais de Recherches Agricoles (ISRA)
B. P. 3120
3 rue de Thoong
Dakar

ISRA conducts research in agriculture, forestry and fisheries at the following centers throughout Senegal:

i. Centre National de Recherches Agronomiques de Bambey
B. P. 41, Bambey

Founded in 1921. Applied agricultural research at its station at Darou, Djibelor, Louga, Nioro-du-Rip, Richard-Toll, Sefa, Sinthiou-Maleme. Library of 6700 volumes. Publications: Rapport de synthese; Annuaire analytique des travaux de l' IRAT au Sénégal(each annually).

ii. Centre National des Recherches Forestières (CNRF)
Route des Pères Marisfes
B. P. 2312
Dakar - Hann

iii. Centre de RecherchersOcéanographiques de Dakar - Thiaroye (CRODT)
B. P. 2241
Dakar

Founded in 1956 for the study of physical and biological oceanography, particularly the dynamics of commercial fish and mollusk species. 450 volumes and 74 periodicals in its library. Managed by ORSTOM.

iv. Centre de Recherches Zootechniques de Kolda.

Founded in 1952. Research on improvement of local cattle and sheep breeds and fodder crops.

v. Centre de Recherches Zootechniques de Dahra Djoloff

Studies of sheep and cattle breed selection; continual trials of crossing local and imported breeds; use of artificial insemination with cattle and horses; placement of selected breeding stock in rural areas; training in these topics.

vi. Station de Recherches Agricoles du Fleuve
B. P. 29
Richard-Toll

Conducts research on rice culture: varietal trials and adaptation of high-quality rice productivity. Research in crop diversification and vegetable crops.

vii. Station ISRA de Darou
B. P. 75
Kaolack

Problems of agronomy are researched: selection and study of new varieties, crop protection techniques, studies of groundnut cultivation.

viii. Station ISRA de Louga
B. P. 8
Louga

Investigates methods of rain-fed agriculture in northern Senegal.

ix. Station ISRA de Sefa
B. P. 46
Sédhiou

Research on varietal improvement and crop protection.

x. Station ISRA de Sinthiou-Maléme
B. P. 4
Tambacounda

Conducts research on rainfed agriculture in eastern Senegal.

xi. Station Rizicole de Djibelor
B. P. 34
Ziguinchor

Rice culture research.

xii. Laboratoire National de l'Élevage et de Recherches Veterinaires (LNERV)
B. P. 2057
Dakar

Studies of animal health (virology, bacteriology, helminthology, entomology, and protozoology), physiology and nutrition, and agrostology. Library of 12,000 volumes.

- Ferme de Sangalkam
-Experiments with improvement of meat and milk production.

b. Institut de Technologie Alimentaire (ITA)
Route de Peres Maristes
B. P. 2765
Dakar - Hann

Conducts research on cereals, fruits and legumes, fresh fish and meat; economic and production studies; research on storage and processing of food grains, especially for larger scale commericialefforts. An INFOTERRA contact.

c. Directorate for Innovation and Technological Progress.

-The arm of DGRST responsible for implementing research results.

2. Ministère du Développement Industriel et de l'Environnement
Building Administratif, Dakar

a. Direction des Mines et de la Géologie
Route de Ouakam
Dakar

b. National Center of River Basin Development

3. Ministère du Plan et de la Coopération
(=Ministry of Planning and Industry?)

a. Department of Water

i. National Hydraulics Laboratory

ii. Senegal River Development Mission

iii. OMVS

iv. Permanent Senegambian Secretariat for the Organization de la Mise en Valeur de la Gambie (OMVG)

v. Direction de l'Hydraulique Vrbaine et Rurale

4. Ministere de Développement Rurale
B. P. 1831
Dakar

-Overall responsibility for agricultural development.

a. Direction des Études

b. Direction de la Santé et Production Animale

c. Direction Général de la Production Agricole.

d. Division de la Protection de la Nature, Chasse et Pêches Continentales

i. Division de la Production Forestière

ii. Centre Technique Forestier Tropical
Division des Recherches Piscicoles

iii. l'Inspection Régionale des Pêches Maritimes (lower Senegal delta)

iv. l'Inspection Régionale des Eaux et Forets (upper Senegal delta)

v. Service des Eaux et Forets et de la Chasse

-a member of IUCN.

vi. Service des Parcs Nationaux

e. Direction de l'Hydraulique Rural
Building Administratif, Dakar

f. Institut de Recherches sur les Fruits et Agrumes (IRFA)
B. P. 486
Dakar

g. Secretariat Executif des Centres d'Expansion Rurale
Building Administratif, Dakar

Involved in coordinating rural expansion centers, animal and plant production, rural planning and transformation. An INFOTERRA contact.

7. National Geographic Institute
7 rue Mermoz
B. P. 4016
Dakar

8. National Office for Cooperation and Assistance for Development (ONCAD)
B. P. 29
Dakar

ONCAD is responsible for all aspects of agricultural activities: it supplies seed, fertilizers and agricultural equipment to producers through cooperatives, markets all produce and manages producers' debts. 1600 of its 2000 cooperatives deal with groundnuts.

9. Mission permanente de coopération
   B. P. 2014
   Dakar

   - Center for administering bilateral aid from France according to the agreements signed in March 1974.

10. Service Météorologique
    B. P. 4014, Bâtiment administratif
    Dakar

II. Educational Institutions

A. University of Dakar

1. Centre de Recherches Economiques Appliquees (CREA)

2. Department of Geography, Faculté des Lettres et Sciences Humaines

   Involved in research conerning desertification processes in the north of Senegal and in Mauritania. Topics include: evolution of climate, geodynamic processes, and sand dune morphology.

3. École Interétats des Sciences et Médecine Vétérinaire.
   B. P. 5077
   Dakar

   Higher education and theoretical and applied research. Twelve Francophone African countries are represented.

4. Faculté des Sciences
   Involved in solar energy research.

5. Institut de Médecine Tropicale Appliquée

6. Institut de Physique Météorologique (IPM)

   Established in 1955, the IPM is the principal solar research institution in Senegal. They have logged 20 years of solar radiation measurements in cooperation with the World Meteorological Organization (WMO) and the USSR. They have conducted prototype experiments with solar collectors, distillers, fish dryers and hot water heaters as well as theoretical work on atmosphere physics, atmospheric condenstions, radioactivity of soil and air, radiatration in the lower troposphere, and thermal balance.

7. Institut de Recherches sur l'Enseignement de la Mathématique, de la Physique et de la Technologie.

8. Institut Fondamental d'Afrique Noire (IFAN)
   B. P. 2006
   Dakar

Founded in 1936 and reorganized in 1959, IFAN promotes research in the sciences and humanities on topics related to black Africa. Maintains a library and museums. Publishes: Bulletin de l'IFAN, Série A -- Sciences Naturelles (every 3 months) and Série B -- Sciences Humaines (every 6 months); Notes Africaines (every 3 months); Mémoires de l'IFAN; Initiations et Études Africaines; Instructions Sommaires; a catalogue and other occasional documents. IFAN is a member of the International Union for the Conservation of Nature and Natural Resources (IUCN).

9. Institut Universitaire de Technologie (IUT)
B. P. 3266
Dakar

Conducts research on various systems for:
-pumping water, including low-temperature solar collectors, photovoltaics and windmills;
-refigeration via solar cells or windmills, for preserving vaccines, dairy products and vegetables.
The IUT is an INFOTERRA contact (see International Organizations, below.)

10. Laboratoire des Semi-Conducteurs

B. Centre des Hautes Études Afro-Alero-Américaines.

Concerned with all matters of interest to Africa and Latin America in the fields of law, science and the arts.

C. Colleges:

1. École Nationale d'Administration du Senegal
B. P. 5209
Dakar

2. École Nationale des Cadres Ruraux,Bambey

For secondary school graduates with a baccalaureate degree; awardsan Ingénieur des Travaux diploma in two years.

3. Institut Africain de Développement Économique et de Planification
Rue 18 Juin
Dakar

The Institute provides training for specialists and officials of African government services responsible for economic development and planning; conducts research in order to prepare the teaching material and documentation required for the organization of seminars, conferences and courses; and offers fellowships for a six-month research training course. Administered by the U. N.

D. Technical Education

1. École Nationale d'Économie Appliquée (ENEA)
   Route de Ouakam
   B. P. 5084
   Dakar

   Senegal's chief training institution for mid-level rural management, ENEA stresses practical training programs of two years, including at least six months in the field. It also offers short courses tailored to the needs of various government agencies. Students enter directly from secondary school. The faculty is part resident, part drawn from government service on a part-time basis. Students receive instruction the first year in agriculture, economics, sociology and other topics as applied to rural analysis. They then spend six months doing field analysis of a Senegalese village and its surroundings (history, social-spatial-economic organization, equipment, etcetera). The second year is specialized into four or five courses, called "colleges":
   Collège d'Animation--instuction in teaching and organizational techniques for development workers.
   Collège de Coopération--for cooperative agents and inspectors.
   Collège de Planification, for local planning officers (Chiefs of Rural Expansion Centers), including development planning, project design and management, and rural organization.
   Collège de Statistique. This latter is four-year course for officers at central and local levels,and its students do not take the first-year course described above.

   ENEA is an INFOTERRA contact.

2. École Nationale des Travaux Publics

3. Lycée Technique Maurice Delafosse
   Dakar

4. Lycée Technique André Peytavin
   Saint-Louis

5. Centre d'Enseignement de Pêche
   Thiaroye-sur-Mer

6. Enseignement Moyen Pratique (EMP)
   Centre National de M'Bour
   Fissel-Langomak
   B. P. 31
   Dep't de M'Bour
   Région de Thiès

   EMP is designed to offer practical rural training to illiterate youth and those with only a primary school education. It is concerned with various aspects of alternative technology, and is an INFOTERRA contact.

7. École Polytechnique de Thiès (EPT)

Has carried on experiments with solar cookers.

III. Research Institutions

A. Institut Pasteur
B. P. 220
Dakar

Founded in 1896, the Institute conducts medical research, maintains a library of 1126 volumes and 54 periodicals, and publishes an Annual Report.

B. Institut de Recherches pour les Huiles et Oléagineux
Bambey, with branches at Louga and Darou

C. Centre de Recherches et de Documentation du Sénégal (CRDS)
B. P. 382
Saint-Louis

Founded in 1943 as Centre IFAN-Senegal, CRDS maintains a library of 18,021 volumes.

D. Centre Experimental de Recherches et d'Études pour l'Equipement (CEREEQ)
B. P. 189
Hann, Dakar

An INFOTERRA contact.

E. Centre d'Études des Pêches de Joal
Joal

Research on marine fisheries and oyster culture since 1947.

F. Centre Technique Forestier Tropical: Division des Recherches Piscicoles
Résidence Faidherbe
B. P. 28
Richard-Toll

Fisheries research since 1966.

G. Laboratorie d'Océanographie de Tiaroye/Mer-Senegal
B. P. 289
Dakar

Research on general oceanography and plankton. Founded in 1960.

IV. Libraries and Learned Societies

1. Archives de Sénégal
   Immeuble administratif
   Av. Roume
   Dakar

   Founded in 1913, the national archives has 18,330 volumes and 1,011 periodicals. Publication: Bibliographie du Senegal (Twice annually).

2. Association africaine pour l'avancement des sciences et techniques.

3. Bibliotheque de l'Institut Fondamental d'Afrique Noire (IFAN)
   B. P. 206
   Dakar

   Founded in 1938, the library of IFAN supports the institute's research in the natural and social sciences with a collection of 60,000 volumes, 7,000 brochures, 4,002 periodicals, 1,600 microfilims, 2,565 maps, 32,000 photographs, 2,100 slides, and 12,200 files of documents.

4. Bibliothèque de l'Université de Dakar
   B. P. 2006
   Dakar

   A collection of 184,841 volumes, 11,700 pamphlets, and 4,800 periodicals in the fields of law, the humanities, medicine, pharmacy, veterinary science, and the sciences. Established in 1952.

5. Institut d'Hygiene Sociale
   Av. Blaise - Diagne
   Dakar

V. International Organizations

A. French - supported

1. Bureau de Recherches Géologiques et Minières (BRGM)
   B. P. 268
   Dakar

   Directs research in Mali and Mauritania as well as in Senegal. Topics of research include soils survey and hydrology.

2. Caisse Centrale de Coopération Économique (CCCE)

   The CCCE is the official French loan agency.

3. Fonds d'Aide et de Coopération (FAC)

   -France's special appropriation for project assistance.

4. Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM)

ORSTOM is a French public corporation to aid Francophone developing countries in non-temperate regions. Its focus is on fundamental and applied research on problems of food production and of the human environment.

a. Centre Orstom de Dakar
Route des Pères Maristes
B. P. 1386
Dakar-Hann

Research on: geology, soil science, geophysics, hydrology, medical entomology, microbiology, nematology, vegetation ecology, zoology, agronomy, geography, economics and nutrition.

b. Observatoire de Géophysique de M'Bour
B. P. 50
M'Bour

Research on: magnetism, seismology, meteorology, magneto-telluric and geomagnetic prospecting. Publications: Bulletin mensuel seismique and Bulletin mensuel magnétique.

c. Station de'Écologie Tropicale
B. P. 20
Richard-Toll

Basic research in ormithology and ecology, applied research on agriculture in dry and humid tropical zones.

B. UN Organizations

1. African Institute for Economic Development and Planning (IDEP)
P.O. Box 3186
Dakar

An autonomous institute under the UN Commission for Africa, with activities in the fields of training, research, advisory services and publications.

2. Food and Agriculture Organizations (FAO)
Rue Elhadj
Dakar

Extensive work in fisheries research.

3. UN Development Program (UNDP)
Place de l'Indépendance
Dakar

4. UN Educational and Scientific Organization (UNESCO)
Place de l'Indépendence
Dakar

Bureau Régional pour l'Éducation en Afrique (BREDA)
B. P. 3311
Dakar

Founded in 1970 BREDA organizes regional activities which contribute to national programs of educational development in African countries south of the Sahara. Regional and national training courses are offered in the fields of educational facilities, teacher training, adult education, and new methods and techniques of education. Library of 9,000 volumes. Publications: Liste trimestrielle des nouvelles acquisitions, Rapports trimestriels d'activites, Educ Africa (twice yearly), various studies, reports and papers.

C. Miscellaneous

1. African and Malagasy Common Organization

2. African Development Fund (ADF) (FAD)

3. Agency for Cultural and Technical Cooperation for French-speaking People

4. Arab Bank for Economic Development in Africa (ABEDA) (BADEA)

5. Comité Permanent Inter-États de Lutte Contre la Sécheresse dans le Sahel (CILSS)

The West and Central African Sahel countries have banded together in CILSS to identify and collaborate on projects to reduce the impact of periodic drought on their populations and land base.

6. Canadian International Development Agency (CIDA)
45 Ave. de la République
Dakar

7. Economic Community of West African States (ECOWAS)

8. European Economic Community (EEC)

9. European Investment Bank (EIB) (BEI)

10. Fonds de Development Européen (FED)
57 Ave. Albert Sarraut
Dakar

FED is the Common Market's development fund.

11. INFOTERRA

INFOTERRA is the UN Environment Program worldwide network of contacts with those working in environmental research and/or protection. There is no INFOTERRA office, per se, in Senegal, but a number of Senegal-

based organizations listed in this Appendix are INFOTERRA contacts, as indicated.

12. Institut Géographique National (Agence de Dakar)
7. rue Jean Mermox
B. P. 4016
Dakar

Prepares maps of Senegal, Mauritania, The Gambia, Guineau-Gissau, and Cap Verde.

13. International Bank for Reconstruction and Development (IBRD)
Place de l'Indépendence
Dakar

Widely known as World Bank,the IBRD provides loans for development projects. The International Development Association (IDA) is the soft loan window of the IBRD.

14. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
28 Rue Thiers
B. P. 3340
Dakar

An INFOTERRA contact.

15. International Development Research Center (IDRC)
66 Ave. de la République
Dakar

16. Kreditanstaff fur Wiederauftan
The German foreign aid agency.

17. Maisons Familiales Rurales
B. P. 55
Thiès

An organization of agencies in a number of African countries (including Cameroon, Rwanda, Togo, Chad, and Congo) involved in lowcost housing programs.

18. Organisme de Recherches sur l'Alimentation et la Nutrition Africaines (ORANA)
39 Ave. Pasteur
B. P. 2089
Dakar

Research, teaching and documentation on African foods and nutritional values.

19. Organization of African Unity

20. Environment and Development in Africa (ENDA)
B. P. 3370
Dakar

ENDA is a non-profit, non-governmental organization based in Dakar with activities throughout the Third World. A joint project of IDEP-Dakar, UNEP-Nairobi, the Swedish International Development Authority (SIDA-Stockholm), and Swiss Technical Cooperation (CTS-Bern), ENDA supports training, research and popularization in the field of environment and development. Publications: African Environment (quarterly journal and occasional papers); Environment and Planning in the Third World (a book series published in English and French); and Environment and Development in Africa (working papers).

a. Technology Relay for Ecodevelopment and Planning in African Environments (RETED)

RETED has established an information exchnage on the use of environmentally sound technologies, with particular attention to existing indigenous technologies and their improvement through promotion of popular inventiveness and technical competence. An INFOTERRA contact.

21. Senegal River Development Organization (OMVS)

An arrangement among the states of Mali, Mauritania and Senegal to cooperate on the development of the Senegal River and its adjacent lands.

22. Société Africaine d 'Études et de Développement (SAED)
B. P. 593
Ouagadougou
Upper Volta

23. West African Common Market
(WAEC, CEAO)

APPENDIX II

Counter-Desertification Activities in Progress

Counter-Desertification Activities in Progress

Code No.	Title and Location	Description and Objectives	Estimated Cost (million $US)	Status (1979)	Financing
	A. LIVESTOCK AND PASTORALISM				
	Livestock development in Senegal-Oriental.	- improvement and development of 1.4 million ha. of of pastures - construction of 100 wells - organization of 6500 families into working units - creation of game parks - human health	4.2	in progress	Financed by World Bank/ IDA
	Livestock development in Senegal-Oriental.		1.737	beginning	Contribution from BADEA
	Cattle development in the pastoral zone of Ferlo.	- construction of watering points - creation of a polot zone around 16 watering points	8.268	in progress	Financed by FED
	Livestock development in Senegal-Oriental.		4.789	beginning	Financed by Kuwait
10202	Livestock and pasture development in the Sahel region.	- pasture improvement - restructuring livestock-rearing practices	3.125	in progress	Finances by U.S. AID
4)/CD/76/VI/	Pasture study in the zone made up of Matam, Kidira, and Tambacounda	- agrostologic study on 18,000 km^2 area - soil study on same area	0.75	in progress	Financed by FAC
	B. FORESTRY				
	Forest protection in Casamance (2nd phase)	- creation of fire-breaks - equipment of bush-fire fighting brigades	2.385	in progress	Contributions from World Bank and potentially from ACDI
	Creation of bush-fire-fighting brigades.		0.725	in progress	Financed by Government of Senegal
	Fire-fighting in Senegal-Oriental	- creation of firebreaks - equipment of brushfire-fighting brigades	3.5	beginning	BAD has contributed $0.55 million US
	Forest improvement in Casamance	- creation of firebreaks - allowing natural regeneration - plantations - creation of a society to manage exploitation of the forests of Casamance - charcoal production and marketing	2.39	in progress	Financed by: UNSO, UNDP, FAO, and Government of Senegal
	Management and reforestation of the forests of the Eastern Central region	- natural regeneration - plantation - protection measures	1.085	in progress	FAC has contributed 0.210 $US
	Plantation of teak and Melina in Casamance		0.995		
	Plantation of casnews in Cape-Vert, Djourbel, Thies and Sine-Saloum		1.35	in progress	Financed by RFA.
	Gum tree plantations and reforestation in pastures of the Mbiddi region		0.44	in progress	Financed by CRDI
	Reforestation in irrigated zones of the delta in the Fleuve region		0.4		Contribution from the CCCE/FAC of $0.075 million U.S.
	Reforestation & management of the sylvo-pastorale zone		1.18	in progress	RFA has contributed $0.43 million U.S.
	Reorganization of agricultural lands		0.4	in progress	Financed by the Government of Senegal
	Sand dune fixation and protection of Niayes on the Grande Cote	- plantation for dune fixation	8.655	in progress	Financed by UNDP, U.S. AID, ACDI and the Government of Senegal

- continued -

Code No.	Title and Location	Description and Objectives	Estimated Cost (million $US)	Status (1979)	Financing
	Creation of urban peripheral forests around Thies and Diakhao	- plantations - protection	1.995	in progress	U.S. AID has contributed $0.75 million U.S.
	Popular reforestation actions		0.725	in progress	Financed by Government of Senegal
	Reforestation along roads	- plantation	1.14	in progress	Financed by Government of Senegal
	Equipment of hunting zones		1.25	in progress	Finances by Government of Senegal
	Gum-tree plantations Bakel region		0.2	in progress	$0.05 million U.S. financed by Government of Senegal
	Regional forest management in Senegal-Oriental		0.12	in progress	Financed by Government of Senegal
C.	OTHER PROJECTS				
y/77/006	Land-use planning	- inventory of natural resource wealth and potential - determination of uses of soils - rational exploitation of national resources	0.815	in progress	Financed by UNDP
	Irrigation III at Dabi Lampsar	- creation of 3,000 ha of rice and 140 ha of tomatoes - re-enforcement of the SAED - various studies and research	20	in progress	Contributions from World Bank/IDA, FAC and Kuwait
	Sine Saloum II	- re-enforcement of the SODEVA - training for 34,000 farmers	14	in progress	Contributions from World Bank/IDA, CCCE
	Management and micro-hydro projects in Casamance, Sine-Saloum and in the Fleuve region	- rice culture improvements - creation of irrigation perimeters for truck-farming	51.643	in progress	Contribution from China (loan)
	Management of the [cuvettes] of Tellel	- improvement of rice culture	7.981	in progress	Financed by CCCE/FAC; carried out by SAED
	Management of small village perimeters in the departments of Podor and Matam	- development of rice cultivation	3.286	in progress	Financed by CCCE/FAC, executed by SAED
506A	Evaluation of the environment	- Evaluation of impacts of major water management projects on the environment of the Senegal River Basin	2.956	in progress	Financed by U.S. AID
	Extension of small perimeters in the Fleuve region		2.0	in progress	Financed by Holland
0205	Regional development in the Casamance	- supporting SOMIVAC	23.71	in progress	Contribution from U.S. AID
0208	Small perimeters in the Bakel region		6.559	in progress	Contribution from U.S. AID
/CD/76/VI/A/13	Small irrigated perimeters near Matam	- development of intensive rice culture - training - counter-emigration activities	0.239	in progress	Contribution from FAC/ CCCE (loan)
/CD/76/VI/A/13	Feasibility study of hydro-agricultural perimeters at N'Dombo, Thiago and Khouma	- study of the potential of 7,000 ha.	0.399	in progress	Contribution from FAC
/07007804	Rural energy center	- study of the economic possibilities of energy production	0.388	in progress	Financed by UNDP
067/1527	Village hydraulic works	- providing technical assistance - providing shallow and deep wells	5.164	in progress	Financed by FED
	Groundwater development and rural development in Thies region	- development of water systems for pastoral and domestic use - agricultural development - promotion of community activities	0.648	in progress	Contribution from CARITAS/Switzerland

- continued -

Code No.	Title and Location	Description and Objectives	Estimated Cost (million $US)	Status (1979)	Financing
12/CD/76/VI/A/12	Creation of a national hydro-geological service	- collection and analysis of basic groundwater data - definitation of a strategy for exploiting groundwater	0.423	in progress	Financed by FAC
4/CD/78/VI/S/02/ DE/78/SEN	Station using combined wind and solar energy to produce electricity in the rural zone	- installation of the station	0.704	in progrsss	Financed by FAC
4/B/CD/78/VI/S/ 2/C/DDE/78/SEN	Solar electricity center of Diakhaa	- trial of solar collectors	0.235	in progress	Financed by FAC
	Development of domestic and pastoral water systems in the Fleuve region	- equipping with motorized pumps	0.442	in progress	Financed by UNICEF
	Development of the Guidel valley	- construction of a dam	2.387	in progress	Contribution of FAD BA
	Sinking 20 wells				Financed by Belgium
	Village and pastoral water systems in the regions of Fleuve and Senegal-oriental	- sinking 35 wells	2.955	in progress	Contribution KFW/RFA (loan)
	Equipment of a hydro-agricultural program of Caritas Senegal	- placing pumps at 5 watering points in the Thies	0.135	in progress	Contribution of CERMO Netherlands/CEE
	Creation of experimental farms in Lougs region	- establishing 145 ha of truck farms	2.465	in progress	Iran has contributed $1.875 million US and Government of Senegal $0.590 million us
	The project: "Laqbar village: witness of the Sahel"	- reforestation of 314 ha around Laqbar - production of gum arabic - soil protection			Contribution of UIPE and the Government of Senegal

ource: United Nations Sudano-Sahelian Office. 1979.

Counter-Desertification Activities in Progress (Cont. from a different source)

D. ALTERNATIVE ENERGY

Technology	Responsible Organizations	Site of Installation	Date of Installation	Output	Power	Other Properties	Cost (Rate of Exchange: $1 = 215 CFA)	Source of Financing	Remarks
Flate Plate Collectors	Institute de Physique Meteorologique (IPM)	I.P.M. Prototypes (SOMOR, SECMA, ITTA)	1957-1966						
		I.P.M. Prototype (Nadje)	1968						
		I.P.M. Prototype (Segal)	1968	5-6 M^3/hour Depth of 25 m.	1 KW	88 M^2 collectors	17 m. CFA $79,069	GOS Ministry of Agriculture	Still in Operation
		I.P.M. Prototype	1975		1 KW	70 M^2 collectors	8.9 m. CFA $39,534	UNIDO	
	Institut Universitaire de Technologie (IUT)	I.U.T.	1976		1 KW				Uses: Training engineering students
	SOFRETES (manufacture) SIMAES (installation)	Medina - Dakar (Thies)	1976	8-10M^3/hour from 20 m.	1 KW			FAC	Uses: Domestic water
		Meouane (Thies)	1976	8-10M^3/hour from 20 m.	1 KW			FAC	Uses: Domestic water
		Niakhene (Thies)	1976	8-10M^3/hour from 20 m.	1 KW			FAC	Uses: Domestic water
		Diegle (Fleuve)	1976	8-10M^3/hour from 20 m.	1 KW			FAC	Uses: Domestic water
	SOFRETES, SIMAES & THERMO-ELECTRON	Bakel	Proposed for 1979		60 KW		300 m CFA	FAC, US	USES: Water for irrigation; generation of electricity
	SOFRETES & SIMAES	Sine - Saloum	Proposed for 1979					Caisse Central (France)	Uses: Generation of electricity
		Kanel (Fleuve	Proposed		2 KW				
		Dahra	Proposed		10 KW				
Photovoltaics	Laboratoire des Semi-Conducteurs	Laboratoire des Semi-Conducteurs	1975 - 1976	20 M^3/day at 12 metres					
	Institut Universitaire de Technologie (IUT)	I.U.T.						FAC	KFC solar cells replaced twice in one year. Solarex panels now being used instead
	Pompes Guinard & CARITAS	CNRA, Bambey	February 1978	100 M^3/day at 10 metres	900 watts	KFC solar cells	7.5 m. CFA $34,900	Pompes Guinard, Private Sources	Drip Irrigation
		Babak	February 1978	65 M^3/day at 20 metres	1,300 watts	Solarex panels	7.5 m. CFA $34,900	Pompes Guinard, Private Sources	Villages took initiative and constructed three small reservoirs, each 3 M^3. One is used to supply water to Babak; a second for all other neighboring villages; and the third for irrigating one large experimental vegetable garden

- continued -

		Toki	November 1978	45 M^3/day at 18 metres	900 watts				Domestic water, Irrigation
Windmills	I.U.T.	I.U.T.							Savonlus prototype
	SIMAES	Diagle							Savonlus
	SIMAES & CARITAS	l'Ouli	Proposed for January 1979	15-20 M^3/hr.				FED	Aerowat windmill Anenometer installed at L'Ouli in September 1978
	Ecole Polytechnique de Thies		About 1976					Canada	Imported from Austria; testing under village conditions
Biogas	CARITAS Pere Picard Mr. Reichmuth Kilometre 11 DAKAR	Niaming - Centre de Formation Agricole Mdjioukh Fissel		4-6 cubic metres					Uses: Cooking and lighting Special cookers and lamps imported from India Primary source material: animal dung
Solar Dryers	I.P.M.	I.P.M.	1974	250 kilos fresh fish in 48 hours		8 M^2 collectors			I.P.M. collaborating with I.T.A. to perfect prototype; experimenting with cheaper construction materials (i.e., fibrocement)
	Institut de Technologie Alimentaire (I.T.A.)	I.T.A.							
Solar Water Heaters	I.P.M.	I.P.M.		capacity 340 litres					Experimental construction using cheap, lightweight materials such as polyste
	SIMAES	St. Louis (Hotel La Residence)	1978	4 cubic metres (or 4,000 litres)		36 M^2 collectors	5-6 m. CFA $23,255 - $27,930		Heats water to 45-50°C. Supplies 36 rooms and kitchen
	SIMAES	Factory for Mass Production - Dakar	Proposed for 1979						SIMAES negotiating with GOS for preferential treatment and guaranteed market
Solar Distillers	I.P.M.	I.P.M.	1975 - 1976	3 litres per M^2/day					Abandoned du to low output
Solar Cookers	I.P.M.	Faculte des Sciences, Universite de Dakar	1978			Parabolic			Prototype; I.P.M. plans to experiment with heat storage
	Ecole Polytechnique de Thies (EPT)	E.P.T.							

Source: Ulinski. 1978.

APPENDIX III

Proposed Projects to Combat Desertification: Dossier Compiled by Government of Senegal in Consultation with UNSO.

Proposed Projects to Combat Desertification: Dossier Compiled by Government of Senegal in Consultation with UNSO*

Title, Location Duration	Description and Objectives	Estimated Cost (million $U.S.)
North Kassack (4 yrs)	Management of 1100 ha. of hydro-agricultural [perimeters] for rice, tomato and maize production in the SAED areas.	6.5
Gum-tree production, Bakel (10 yrs.)	Plant, regenerate or restore 10,000 ha. of Acacia senegal (gum trees) in the department of Bakel, Fleuve region	2.832
Regeneration of the Borassus plantations at Cayor (5 yrs)	Extension of methods to regenerate Borassus palms on 9,250 ha.	0.650
Regeneration of [Gonakeraies] in the Senegal Valley (5 yrs)	- natural regeneration of 5,000 ha of Gonakeraie in the Senegal Valley - Reforestation of 3,000 ha	4.8
Restructuring the forest zone and land uses in Senegal Oriental (10 yrs)	- Restructuring the forest zone - Planning and harmonious exploitation of the forest, rural and pastoral sector	3.2
Reforestation for control of the "Tann" saline soils in Sine-Saloum (5	- Reforestation of 5,000 ha on the periphery of the Tann soils in the departments of Fatick, Kaolack and Foundiougne.	5.5
Brush-fire control in northern Senegal Oriental (4 yrs)	- Emplacement of a structure for brushfire control	4.0
Forest and hydro-biological reserach in the Senegal Valley (4 yrs)	- Forestry research with a view to assuring optimal production of forest products; - Hydro-biological research to determine productive potential of the fishery	2.16
Operation Fisheries on the Lac du Guiers (4 yrs)	- Organization of fishermen to improve fish production	1.250
Equipment of continental fishing operation	- Creation and equipment of an administrative structure charged with the management of inland waters - Equipment of the crocodile farm at Casamance	0.850

Integrated livestock development in the 5th zone (5 yrs)	- Extension and popularization of techniques for ration production and exploitation of animal, vegetal and hydrologic resources	12.0
Research and development concerning an agro-silvo-pastoral production system in the Senegal Valley	Inculcation of improved animal husbandry practices integrated into the zone of irrigated agricultural in the Senegal Valley	5.8
Pilot program of establishing windbreaks in the Peanut Basin (5 yrs)	- Establish a pilot program for creation of a network of windbreaks; - Extension of the concept and practice of establishing windbreaks in agricultural lands	1.65
Protection of mangroves in Senegal (2 yrs)	Setting up mobile brigades adequately equipped to oversee the exploitation of the mangroves in Casamance, Sine-Saloum and Fleuve regions	0.46
Integrated program of dune fixation and protection of truck-farming [curvettes] in Retba, Rayor, and M'Boro sectors (3 yrs)	- Reforestation for fixation of primary dunes; - A measure of protection for 20,000 ha of vegetable gardens in depressions, and plantation of secondary, stable dunes; - Fuelwood plantations	6.64
Equipment of hunting zones (5 yrs)	- Protection of game lands in in hunting zones to be used for development of tourism	1.025
Special protection of the ostrich and red-fronted gazelle in the Senegalese Sahel (3 yrs)	- Creation of a special protected zone for the ostrich and improvement of protective measures for the gazelle by better equipping the Ferlo Faunal Reserves	0.615
Administration and protection of ground water resources in Senegal (2 1/2 yrs)	Establishment of a program of exploitation bearing in mind questions of ground water recharge	8.955 (6.855 have been promised)
Construction of 16 watering holes in the silvo-pastoral zone (1 yr)	Complete the network of watering points in the sylvo-pastoral zone by equipping the wells with mechanical pumps for watering flocks and irrigating fields for forage production	3.07

Title, Location Duration	Description and Objectives	Estimated Cost (million $U.S.)
Management of semi-arid zones (first phase) (3 yrs)	Management of small hydraulic [perimeters] from shallow wells in the arid zone	25.0
Equipment of brush-fire-fighting brigades and committees in the Fleuve, Louga, Sine-Saloum and Senegal-Oriental regions (5 yrs)	- Brushfire fighting by equipping fire-fighting brigades, creation of fire breaks and recruitment of necessary personnel	5.25
Center for Plant and Seed Multiplication for Forage Species, at Thies (1 yr)	- Multiplication and reproduction of seeds of forage species	0.471
Ideas for Projects Requiring Further Research Before Reaching Formal Proposal Stage:		
Urban peripheral forests	Reforestation around urban centers	0.471
Construction of 15 wells and watering points: Djourbel (5), Louga (1), Casamance (5), and Sine-Saloum (4)	Satisfaction of livestock watering needs	4.975
Extend irrigation works to include the riverside villages in the Ben Filane project	Providing irrigation water to riverside dwellers will permit them to intensify their vegetable gardening	0.850
Audiovisual cell in the Direction of Waters and Forests	- A unit to popularize nature protection	
Effects of uncontrolled urbaniaztion on the process of desertification		

*United Nations Sudan-Sahelian Office (UNSO). 1979.

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