DEG/Louis Berger International, Inc.
Institute for Development Anthropology

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SENEGAL NATURAL RESOURCES MANAGEMENT ASSESSMENT

UNDER

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FINAL REPORT

Prepared By:

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ACRONYMS

BRGM	Bureau de Recherches Geologiques et Minieres.
CCCE	France's Caisse Centrale de la Coopération Economique.
CDSS	Country Development Strategy Statement.
CILSS	Comité Inter-Etats de Lutte Contre la Sécheresse au Sahel.
CONGAD	Conseil des Organisations Non-gouvernementales d'Appui au Développement.
CTFT	Centre Technique Forestier Tropical.
EA	Environmental Assessment.
EDF	European Development Fund (of the EEC).
EEC	European Economic Community.
ENDA	Environement et Dévelopement du Tiers Monde.
FAC	France's Fonds d'Aide et de Coopération.
FAO	United Nations Food and Agriculture Organization.
FED	French acronym for EDF.
FONGS	Federacion de Organisations Non-gouvernementales du Sénégal.
GOS	Government of Senegal.
GTZ	Gesellschaft fur Technische Zusammenarbeit.
IBRD	International Bank for Reconstruction and Development.
IDA	World Bank's International Development Agency.
IEE	Initial Environmental Evaluation.
ISRA	Institute Sénégalais de Recherches Agricoles.
IUCN	International Union for the Conservation of Nature.

SONAR	Société Nationale d'Approvisionnement du Monde Rural.
SZWM	USAID's Southern Zone Water Management Project.
UNESCO	United Nations Educational, Scientific, and Cultural Organization.
UNDP	United Nations Development Program.
USAID	United States Agency for International Development.

EXECUTIVE SUMMARY

Senegal has been battered by a series of droughts, a major change in its international terms of trade, and a burgeoning population. Although there has been some amount of industrial development since independence, Senegal still relies heavily on its agricultural sector for employment, generation of foreign exchange, and value added. Because Senegal relies so heavily on agriculture, any decline in agricultural productivity, whether slow or rapid, will affect the country's economy.

The basis for the productivity of the country's agriculture is its natural resource base. If this resource base becomes less productive or if parts of it are irreversibly destroyed, the agricultural sector will suffer, the economy will suffer, and the Senegalese people will suffer. In addition to the strictly agronomic production which relies on the natural resource base, livestock, forestry, fisheries, and tourism also rely on this same resource base.

Senegal's population is predominantly rural and agricultural. As the population has grown over the last decades, more and more pressure has been placed on the land to produce enough food to feed the country and to generate enough export earnings to satisfy the country's need for consumer goods. This increased pressure on the resource base has not been without effect. In many areas the soils are much less productive than they were 20 years ago. Vegetation is less dense, less varied, less protective, and less productive. The animal resources of Senegal have also suffered, both directly from fishing and hunting, and indirectly from destruction of the habitat necessary for their survival. One resource seems to have escaped serious deterioration of productive potential: water.

Senegal is fortunate to have access to such large quantities of high quality water. Over the past decades these sources of water have been tapped through an evergrowing system of dams, dikes, pipes, and wells. This infrastructure assures an adequate supply of water for urban and household needs, allows irrigation of agricultural land, and permits the watering of livestock herds.

The purpose of this study is to give the USAID Mission in Dakar all or part of the analysis it needs to prepare the natural resources management portion of the CDSS. DEG/Louis Berger International, Inc., the Institute for Development Anthropology, and Dames and Moore were asked to send a three-person team to Dakar under the Indefinite Quantity Contract (IQC) they jointly hold. The Washington-based Natural Resources Management Support Project (NRMS), being implemented by Energy/Development International

financed an additional two consultants who joined the IQC team in Dakar.

The primary responsibility of the team was to report on the natural resource management problems faced by Senegal. This included a survey of water resources potential and an assessment of problems of conservation of biological diversity. The USAID Mission's major objective is "preserving and protecting the natural resource base of Senegal for the present and the future, particularly as it relates to agricultural production and food security." In keeping with this prime objective, the team was instructed to concentrate on those aspects of natural resources management which affected or were affected by agricultural production.

It should be emphasized that this study is only one part of a continuing process. The USAID Mission in Dakar expects to help establish a process for the continuous re-evaluation of natural resource management in Senegal.

The team spent considerable effort in synthesizing the information found in the numerous documents found in libraries, project and donor offices, and in private collections. Team members, either individually or in groups, also contacted knowledgeable people in government agencies, in donor agencies, and in project offices.

Although this study is referred to as a natural resource management assessment, it does not consider all natural resources, nor does it address all resource management issues. As mentioned above, the resources to be studied are soil, water, vegetation, and animals. The prime focus of the study is on the affect of the management or mismanagement of these resources on agricultural production or the effects of agricultural production on the resources. Specifically excluded from the study are: mineral resources; air quality and air pollution; coastal resources, including mangrove swamps, beaches, breeding grounds, marine fish and shellfish populations; and touristic and esthetic resources.

The various aspects of biological diversity are treated but not in great detail. Rangeland and livestock, although included in the appropriate chapters, are treated much more lightly than they could have been. However, range management and livestock projects are not currently priorities of the USAID Mission.

It is likely that some readers will consider that the report has one major flaw. It contains no recommendations, it proposes no strategies, action plans, or projects. The USAID Mission in Dakar placed this constraint on the team, feeling that it does not want to be constrained to following a certain line of thinking this early in the process of strategy formulation.

GENERAL NON-TECHNICAL PROBLEMS.

1. Many projects are designed or controlled too rigidly. The result is that those who are responsible for project implementation are more concerned about implementing the solutions prescribed by the designers than about actually accomplishing the goals of the project.

2. There are many actors in the development sector. In addition to the beneficiaries of development efforts, these include policy makers, administrators, researchers, and extension personnel from the government and from donors. There is almost universal agreement that these participants need to be in closer contact.

3. In recent years the Government of Senegal has been giving increased attention to natural resource management. More policy statements mention the need to integrate agricultural production and natural resource management. Even though these policy statements have not yet all been translated into action, it is clear that the government recognizes the importance of being able to stabilize and protect the resource base.

4. Producers often are not as motivated to manage their natural resources as they might be. One of the reasons is that they do not have the authority to make management decisions which affect them. Outside authorities replace relatively effective traditional resource management with relatively ineffective control.

5. Planning is often monosectorial. Despite the good intentions of many agencies, they still have a narrow technical view of the proposed activity. The result of this limited view leads to a situation where confrontation is the norm. There are as many or more constituencies against the project or action as there are in favor of it. In addition to the negative impacts that this monosectoral view of the world causes, there are also lost opportunities. By considering protection only, foresters miss the opportunity to contribute to agricultural production. By concentrating on agronomic technologies only, extension services miss the opportunity to integrate livestock management in the overall management of the farm enterprise, often to the benefit of the field crops.

6. Land tenure, like many other issues, must be considered in any strategy or design. However, it will not be a crucial issue in all cases. Land tenure is very important in establishment of irrigation perimeters because land is usually redistributed. Land tenure does not seem to be a problem on land devoted to rained agriculture. Tenure can create problems most frequently on land which at one time was common lands but now has effectively converted to open access land. The Government took away traditional authority to manage common lands but did not replace

the traditional control with a government control. The result is a void which has led to resource degradation.

Tree tenure does not appear to be an important issue to farmers. However, if the government were to enforce all the laws pertaining to tree tenure very strictly, tree tenure would be much more of an issue.

7. The examination of the development strategy for the World Bank, the European Economic Community, and the United Nations Development Program shows that natural resource management will not be a priority for any of them for the next few years. The World Bank has decided to concentrate its limited funds on structural adjustment. The EEC has always invested most of its funds in economic and social infrastructure and will continue to do so. The UNDP will allocate about one-quarter of its budget to natural resources. However, the UNDP budget is very limited, so this amounts to only $8 million. Any major investments in natural resource management in Senegal will have to come from bilateral donors.

SPECIFIC REGIONAL PROBLEMS.

The accompanying table lists Senegal's most important natural resource management problems. As can be seen, the problems have been classified geographically.

The basic problem of the Peanut Basin is that there are too many people attempting to earn a livelihood on a poor resource. An increase in population has led to reduced fallow periods. This reduced fallow has led to reduced soil fertility, acidification of upland soils, and loss of structure in heavy soils of Sine-Saloum. Increased population is not the only cause of the reduced fallow. The Peanut Basin has a higher concentration of livestock than any other region of the country. These animals are generally free-ranging. Their large numbers lead to further deterioration of the vegetative resources which protect and regenerate the soil. Shallow groundwater resources have suffered from reduced rainfall. In many areas, wells are much deeper than they were 20 years ago. Some villages which formerly produced vegetables are no longer able to do so. Deep groundwater resources are suffering from the tremendous demand of the City of Dakar. Deep aquifers are being depleted because Dakar is drawing faster than the aquifer is recharged.

Senegal Oriental has areas which have steeper slopes than the Peanut Basin. The soils are gravelly and sandy like the light soils of the Peanut Basin. However, they have more slope so are more prone to water erosion. Soils are also shallower in this area so a given amount of soil loss is more serious. Senegal Oriental receives more rainfall than the area to its west. More rainfall

will mean increased erosion if the soil is bare, as it is likely to be on agricultural land. However, more rainfall will mean increased vegetative cover on non-agricultural land and thus less erosion. Low human populations and the existence of large reserved areas such as Niokolo Koba National Park have permitted the wildlife in this region to hold on. Forests in this zone are under great pressure from charcoal producers. Over half of all woodfuel used in Senegal is destined for Dakar and most of Dakar's fuelwood comes from this area.

The Ferlo is referred to as a Silvo-Pastoral region. As mentioned above, however, livestock populations are much denser in the Peanut Basin. This area is reserved for livestock production because rainfall is too low to permit agronomic production. The vegetation in the Ferlo is highly dependent on rainfall. The most striking aspect of vegetation is the tremendous annual variation in production. Biomass production fluctuates tremendously from year to year while livestock herd size does not change. The result is a general overgrazing typical of open access lands in most years and a severe overgrazing in years of low rainfall. It is likely that the more desirable species are slowly being replaced by less desirable species but this cannot be confirmed.

The major problem in the Niayes is the moving sand dunes which must be stable to protect areas of vegetable and fruit cultivation. The coastal dunes have been stabilized with tree plantations but the particular species chosen has limitations. The vegetable gardens in the area are dependent on water from shallow aquifers. A relatively thin layer of fresh water rests on salt water from the ocean. If fresh water is drawn too quickly, the wells become saline. Potential is thus limited.

The main crop in the Casamance has always been rice. Recently, however, there have been increased areas planted to peanuts, millet, and corn. Rice production has suffered in low-lying areas of the Lower Casamance. These areas are susceptible to saltwater intrusion at high tide. The reduced freshwater flows which are a result of lower rainfall, are no longer able to flush the salt from the soil. Mangrove swamps are susceptible to acidification because the soils have a high sulphur content. If the soil is drained, the sulphur oxidizes to form sulfuric acid. The upland soils which have been cleared in recent years are susceptible to water erosion when unprotected by forest cover.

The management of natural resources in the Senegal River Basin depends almost entirely on the management of water. There do not seem to be any abusive management practices at this time, with the exception of overcutting in the regions forests. Also, there do not seem to be any important problems attached to the management of the irrigated perimeters which are planned. The major issue is whether the streamflow should change to a completely regulated flow, should have a modified flow with an artificial flood, or

should not have been changed at all. Many feel that there are negative impacts associated with the change in streamflow which should be mitigated. The problems which have been pointed out are: the degradation of floodplain forests which rely on annual flooding; the reduction or elimination of fish spawning grounds; the reduction in the area which can support flood recession agriculture; and the reduced area which will be devoted to dry season grazing.

SECTORAL PROBLEMS.

The harvest of wood from the nation's forests and woodlands is considerably greater than the sustainable yield. The primary use of wood fiber in Senegal is as fuelwood. The demand for and harvest of fuelwood is generally distributed as the population is distributed. However, there is also the demand of the urban centers and especially of Dakar. The fuelwood harvested and converted to charcoal for Dakar is equal to the volume of fuelwood harvested for all of the rest of the country. Two basic problems exist. First, the forests are expected to satisfy a demand they cannot possible satisfy continuously. Secondly, while it would be possible, technically, to increase the productivity of the country's forests, it would be very difficult to do because of a lack of administrative ability.

In order to manage the country's rangeland, one must be able, on a year-to-year basis, to control the number of animals which use any given area. This is because rainfall is the prime determinant of biomass production. In years of low rainfall, herds should be reduced. However, this is difficult because there is open access to rangelands in Senegal, because the livestock markets are not well developed, and because there are few alternative investments available to the herder who finds himself with extra cash.

There are opportunities for addressing the soil fertility problem in the agricultural areas by use of agroforestry techniques which are now being adapted to Senegalese conditions. USAID through the reforestation project has experience at the national level of farm forestry through Eaux et Forêts agents. The accent of this program has been to get the farmer to plant trees. This has been a successful program but much of the planting has not been multi-use or agroforestry applications but income generation of trees as a crop. The next logical step with these farmers is to work with them to protect their Acacia albida and other field trees and bushes, and to develop management of natural forests and plantations which have been created by village action.

Although there seems to be some potential for using groundwater resources in much of the country, special studies are needed to quantify any proposed use of groundwater.

This study shows that there is great potential for surface water in the Senegal River for multipurpose development of the Valley, including recharge of the aquifer. Manantali dam is expected to release 300 m3/s at full operation. This potential is estimated to be 9.5 billion m3/yr.

Commercial bushmeat, subsistence game, trophy and craft hunting, trapping birds for the pet trade are all important consumptive uses of Senegalese wildlife. Tourism, research, and birdwatching are potentially profitable non-consumptive uses. The government has been ineffective in controlling trade, trapping, sales, and hunting of wildlife. The most dramatic example is that ivory poaching is sending Senegalese elephants to rapid extinction. There appears to be little hope that Senegal can maintain a renewable wildlife resource for consumption purposes and, even, in Nickolo Koba for non-consumptive income generation.

The fish and shellfish resources have great importance to the economy and protein nutrition of Senegal. The freshwater fisheries have no management for long-term sustained yields. The government is beginning to monitor and regulate the fisheries for sustainable yields. The main source of freshwater fish in Senegal -- the Senegal River Basin -- has much lower productive potential than before the Diama dam was built. In order for this resource to continue to contribute to the economy corrective measures must be taken to create an artificial estuary. The Manatalli Dam release schedules will have an important effect on floodplain fish production. Considerations for the future fish production could be included in the water release program.

The most important problem in the livestock sector is that virtually all animals graze on open access land. Because of this, there is no control over the number of animals which graze on any given area or on the timing of the grazing.

Senegal has several unique and biologically significant communities. These include inland wetlands; coastal landforms; niayes; gonakie forests; relict Guinean forests; Niokolokoba National Park/Faleme Hunting Reserve complex; and the Sahelian region which is important to dry season raptors. Certain areas are protected by Senegalese laws. However, even with this "paper" protection, the areas suffer from being undersized, having no buffer zones, being isolated from other protected areas, and having no safe passage corridors between "habitat islands." They also suffer from lack of appreciate by both donors and the upper levels of the GOS of the value of protected areas; from the impacts of the drought and non-mitigated river basin development; and from inadequate financing of all aspects of support for personnel, local villagers in buffer zones and equipment needed for effective protection.

The situation for protected animal and plant species is similar. There is good paper protection but ineffective implementation of the law. The giraffe, Dorcas and Damas gazelle, and a species of hartebeest are already extinct. Every major large mammal appears to have populations to small or too scattered to be viable over the next twenty years. For instance, the elephant, wild dog, Ferlo ostrich, and cheetah will probably go extinct in the near future.

It appears that many donors do not have strong environmental assessment regulations or procedures. The mitigation measures should be included as separate line items so that it is easy to discover if mitigation has been budgeted or included in the project papers. The assessments need more attention to the criteria for "significant" impacts; on-site vs. off-site impacts; cumulative impacts; as well as the natural resource management need for the project.

CHAPTER 1

INTRODUCTION

Periodically, each USAID Mission prepares a Country Development Strategy Statement (CDSS) which defines the Mission's broad programming goals in its assistance to the host country. The next CDSS to be written for Senegal will cover the period 1991 to 1996. Before elaborating a strategy, USAID generally conducts a series of background studies. These studies are then used by the Mission to assist in preparing the CDSS. This report is one such report.

In July of 1989, the USAID Mission prepared a Natural Resources Management Action Plan. This study has been undertaken to complete Actions 8 and 9 of the Action Plan: Synthesis of Existing Information and Detailed Natural Resources Management Assessment. Although this study has a specific purpose which is discussed below, it should be emphasized that this study is only one part of a continuing process. The USAID Mission in Dakar expects to help establish this process for the continuous re-evaluation of natural resource management in Senegal.

A. PURPOSE OF THE STUDY.

The purpose of this study is to give the USAID Mission in Dakar all or part of the analysis it needs to prepare the natural resources management portion of the CDSS. Louis Berger, International, Inc., the Institute for Development Anthropology, and Dames and Moore were asked to send a three-person team to Dakar under the Indefinite Quantity Contract (IQC) they jointly hold. The Washington-based Natural Resources Management Support Project (NRMS), being implemented by Energy/Development International financed an additional two consultants who joined the IQC team in Dakar.

The primary responsibility of the team was to report on the natural resource management problems faced by Senegal. (See Scope of Work in Annex 1.) This included a survey of water resources potential and an assessment of problems of conservation of biological diversity. The USAID Mission's major objective is "preserving and protecting the natural resource base of Senegal for the present and the future, particularly as it relates to agricultural production and food security." In keeping with this prime objective, the team was instructed to concentrate on those aspects of natural resources management which affected or were affected by agricultural production.

The team spent considerable effort in synthesizing the information available in the numerous documents found in libraries, project and donor offices, and private collections (see bibliography in Annex 1 and list of libraries visited in Annex 7). Team members, either individually or in groups, also contacted knowledgeable people in government agencies, in donor agencies, and in project offices. (See list of persons met in Annex 3.)

B. ORGANIZATION OF THE REPORT.

The information acquired from documents, from interviews, and from field visits has been summarized and is presented in this report. Each of the chapters will cover one main area. Chapters 2 through 6 cover the bio-physical areas of water, soils, vegetative and animal resources, and conservation of biological diversity, respectively. Chapter 7 covers a number of social institutions which can affect the management of natural resources in Senegal.

Each chapter summarizes the information found in the documents consulted and describes the relevant problems. The severity and geographic distribution of these problems is discussed. Following this discussion, the various interventions of development projects which are attempting or will attempt to address these problems are described. However, not all problems are being addressed in all parts of the country. When this is the case, those unaddressed problems or areas are pointed out.

There are a number of management practices which have been used traditionally to maintain the stability and productivity of the natural resource base. These are presented in the appropriate chapters. When possible, a brief discussion will show to what extent these traditional land management practices might contribute to stabilizing and perhaps even improving resource productivity. Finally, each chapter contains a brief section which highlights the major problems discussed in the chapter.

The chapter on water resources is slightly different. This chapter, rather than concentrating on resource management problems, examines water resource potentials.

Chapter 8 discusses the environmental assessment procedures used by several donors. A number of assessments conducted prior to the implementation of development projects are examined and discussed. Finally, the concluding chapter attempts to give the overall impressions of the team.

C. LIMITS TO THE STUDY.

Although this study is referred to as a natural resource management assessment, it does not consider all natural resources, nor does it address all resource management issues. As mentioned above, the resources to be studied are soil, water, vegetation, and animals. The prime focus of the study is on the effect of the management or mismanagement of these resources on agricultural production or the effects of agricultural production on the resources. Specifically excluded from the study are: mineral resources; air quality and air pollution; coastal resources, including mangrove swamps, beaches, breeding grounds, marine fish and shellfish populations; and touristic and esthetic resources.

The various aspects of biological diversity and its conservation are not treated in great detail. This study is not meant to be a "biodiversity" study. Rangeland and livestock, although included in the appropriate chapters, are treated much more lightly than they could have been. However, range management and livestock projects are not currently priorities of the USAID Mission.

It is likely that some readers will consider that the report has one major flaw. It contains no recommendations, it proposes no strategies, action plans, or projects. The USAID Mission in Dakar placed this constraint on the team, feeling that it does not want to be constrained to following a certain line of thinking this early in the process of strategy formulation.

D. ECONOMIC IMPORTANCE OF NATURAL RESOURCES MANAGEMENT.

The proper management of natural resources in Senegal is more than just a matter of concern for the environment. Senegal's economy is an agricultural based economy, dependent on its natural resources. Soil, vegetation, and access to water are absolutely essential to the rural population. This section discusses briefly the relative importance of agriculture in the economy and its contribution to employment and foreign exchange earnings.

1. Contribution of Natural Resources to Gross National Product.

The agricultural sector generates approximately 20% of GDP (Ross, et al, 1987). In addition, between 10 and 12.5% of the industrial sector output is due to oil milling (Commander, et al, 1987; Ross, et al, 1987).

Not only does the natural resource base contribute to the GDP through the primary sector, a significant portion of the secondary sector's contribution is based on this same natural resource sector. Some of the major manufacturing industries include four peanut oil mills with a capacity of 920,000 tons of peanuts, four

cotton gins, three cotton spinning mills, three weaving plants, two fabric printing plants, tomato paste canners, a sugar mill, and fish packing plants.

a. Field crops.

The area planted to agricultural crops in 1986 was 2.1 million hectares, essentially the same as in 1963. However, during the 1970's, slightly more land was cultivated, approximately 2.3 million hectares. The decline from the 1970's to the 1980's is attributed to poor rains, over-cultivation, and migration (Ross, et al, 1987). The cultivation of this land employs approximately 70% of the population. Around 90% of the annual cropped area has been devoted to peanuts and millet. Maize and cowpeas cultivation has been increasing in recent years. Maize is replacing millet in

Table 1-1. Industrial origin of gross domestic product at 1982 prices. In billions of CFA francs.

	1979	1980	1981	1982	1983	1983 % of GDP
Primary sector						
Agriculture	124.2	84.9	75.2	111.9	118.9	13.5
Livestock	44.4	43.5	44.4	45.7	47.1	5.4
Fishing	16.3	17.1	16.5	18.0	18.9	2.1
Forestry	9.8	10.2	10.1	10.1	10.1	1.1
Total	194.6	155.7	146.2	185.7	195.0	22.2
Secondary sector						
Total	170.7	171.1	181.2	205.0	214.5	24.4
Tertiary sector						
Total	396.2	415.1	401.9	453.4	470.1	53.5
GDP at mkt price						
	761.5	741.9	729.3	844.1	879.6	100.0
	581.9	627.6	669.8	844.1	977.7	

Source: Medium and Long Term Economic and Financial Adjustmant Programme, 1984.

the higher rainfall areas and cowpeas are replacing peanuts in the lower rainfall areas. In the Casamance and along the Senegal River, rice is an important crop. Cotton is important in Senegal-Oriental (Commander, et al, 1987).

In the early 1980's, 75% of the total cultivated area was in the Peanut Bassin. Half the country's population lived there and

85% of all peanuts were produced there. However, the importance of peanut production has declined dramatically. Peanut's share of GDP in the period 1980 to 1986 was half of the level in the 1960's (Commander, et al, 1987).

b. Livestock.

In 1983 there were an estimated 2.2 million cattle in Senegal. In addition, there were 3.4 million sheep and goats and 9.7 million poultry. Despite the large number of animals raised, the country is still a net importer of meat.

Livestock contributes approximately 6% to GDP. Per capita consumption of red meat has fallen from 16 to 12 kg per person per year over the period from 1977 to 1987 (Ross, et al, 1987).

Table 1-2. Estimated production of food crops 1000's of tons.

	1980	1981	1982	1983	1984	1985
Millet/sorghum	545.1	986.1	585.2	351.8	471.4	950.0
Paddy rice	64.7	127.0	95.0	108.5	135.8	147.0
Maize	56.8	94.8	82.3	60.6	98.5	146.9
Niebe	17.1	28.8	13.2	12.9	15.8	79.7
Groundnuts	523.0	872.3	1004.0	511.6	669.2	590.0
Seed cotton	21.9	41.0	47.1	30.5	46.9	30.0
Sugar (refined)		86.0	88.0	88.4		
Gum arabic	56.8	94.8	82.3	60.6	98.5	

c. Fishing.

Fish and fish products account for one-quarter of total merchandise exports. Traditional marine fishing employs 29,000 people while inland fishing employs 10,000. The canning factories employ another 5,000.

Annual fish consumption is 27.5 kg per capita and in 1985 was the leading export earner (Ross, et al, 1987).

d. Forestry.

Estimates indicate that 960,000 tons of firewood and 220,000 tons of charcoal are consumed in Senegal each year.

2. International Trade and Foreign Exchange.

Peanuts accounted for 75% of export goods earnings in the 1960's. In the 1970's this fell to 42% and even further to 17% between 1980 and 1986 (Commander, et al, 1987).

Virtually all of Senegal's exports are raw or transformed natural resources. All exports except the petroleum products originate in Senegal. (Senegal imports crude oil, refines it, and exports surplus production to neighboring countries.) Peanuts, phosphates, and fish are the major exports.

The 1986 real price of unrefined peanut oil was 45% of its 1984 level and less than one-third of the 1980 level. At the same time, processing costs remain high because 95% of total processing costs are fixed costs. This is partly due to government guarantees to the oil mills but also to excess capacity (Commander, et al, 1987).

In 1987, Senegal exported 54 billion francs worth of fish. This represented more than 25% of all exports. This exceeded the export value of peanuts, phosphates, and petroleum products.

In 1985, cotton was the number two export crop, generating export revenues of $15.8 million.

Table 1-3. Senegal's exports, 1982 to 1987.

	1982	1983	1984	1985	1986	1987
Peanut prods	42.1	55.3	54.5	23.7	22.6	21.1
raw oil	31.1	36.3	39.3	18.4	16.7	15.1
refined oil	0.3	1.6	3.3	1.0	0.1	0.2
peanut cake	10.0	13.5	7.7	4.2	5.6	5.6
seed	0.7	3.9	4.2	0.1	0.2	0.2
Phosphates	18.3	18.7	28.6	26	23.4	19.8
Fish	30.2	37.3	49.5	54	56.6	59.5
fresh	18.5	21.1	28.3	31		35.0
preserved	11.7	16.2	21.2	23	23.6	24.5
Cotton	4.8	8.1	6.9	7.1	2.5	2.7
Salt	2.9	3.1	5.2	5.2	4.1	2.1
Fertilizer	2.2	4.1	6.7	---	0.9	1.0
Petro. products	45.8	40.8	43.2	23	19.1	14.5
ICS	---	---	12.2	18.4	17.0	16.4
Other products	33.8	39.4	37.3	39.9	46.0	49.5
Total exports	180.1	206.8	244.1	197.3	192.2	186.6

In 1984, tourism was the third largest export industry. Only peanuts and processed petroleum products ranked higher. In 1985, approximately 275,000 tourists visited Senegal. Most stay in Dakar or visit the Petit Côte or Ziguinchor.

E. SUSTAINABILITY.

The word "sustainable" seems to mean many things to many people. It is often used in terms such as sustainable agriculture or perhaps sustainable resource management. In this report, the term sustainable should be applied to productivity. That is, the attempt should be made to sustain productivity, not just to sustain agriculture.

The term will be applied to a number of graphs to demonstrate what is meant by sustainable. Figure 1-1 shows the yields obtained from a field which is managed under the wooded fallow system

(described in Chapter 4). This field is cultivated for a period of years during which yields gradually diminish. Then, at a certain point, the farmer allows the field to lay fallow while he clears and cultivates a new field. Many years later, the field is cleared and the cycle begins again. Even though yields drop over the cultivated period, and even though the yields periodically drop off to zero, this is a sustainable system. It is sustainable because the basic productivity of the system has not changed and will not change if the system continues to be managed in the same way.

Figure 1-2 represents what may have happened in the Peanut Basin. That portion of the graph marked "a" represents the average of yields on land which is managed under a wooded fallow system as described above. Using this type of management, the farmer could continue to produce the same levels of peanuts and millet year after year. The portion of the graph market "b" is the transition phase from a wooded fallow system to a grass fallow system, which is indicated with a "c" (see description in Chapter 4). This grassed fallow system is also a sustainable system. That is, the farmer can continue to have the same yield levels year after year, even though these levels are slightly lower than they were previously.

These two examples show that sustainability has nothing to do with the absolute levels of production nor with periodicity of yields. Rather, sustainability refers to the possibility of continuing a particular management system cycle after cycle without declining yields over the cycles.

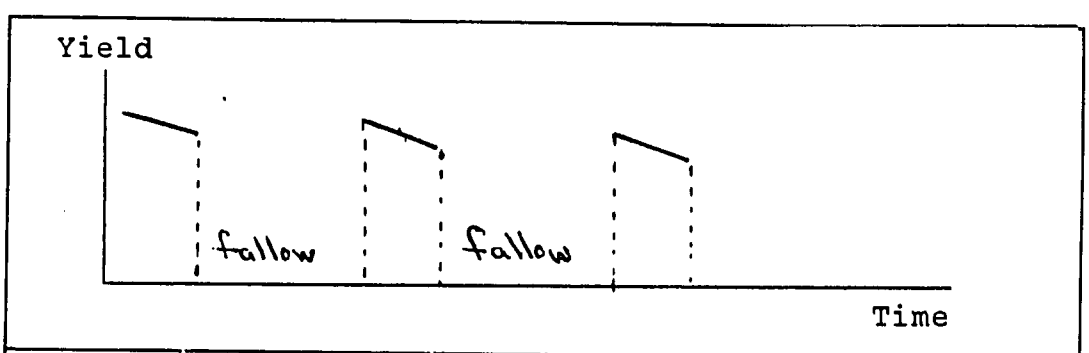


Figure 1-1. Evolution of agricultural yields on a wooded fallow.

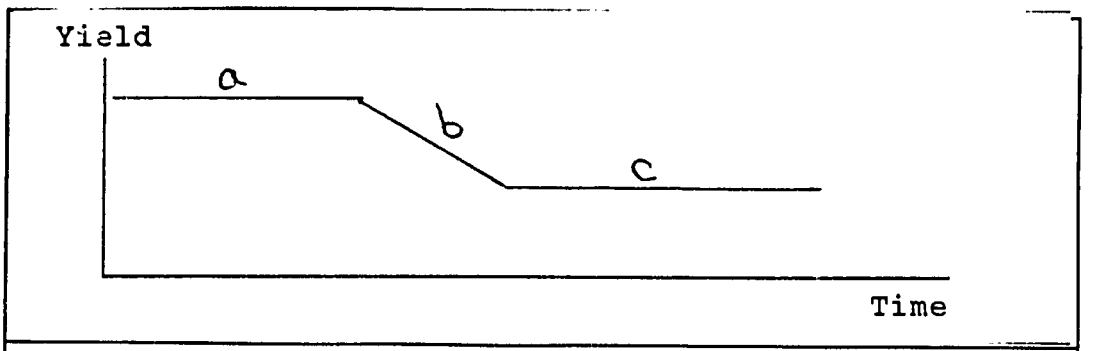


Figure 1-2. Transition of yields from a wooded fallow to a grass fallow management system.

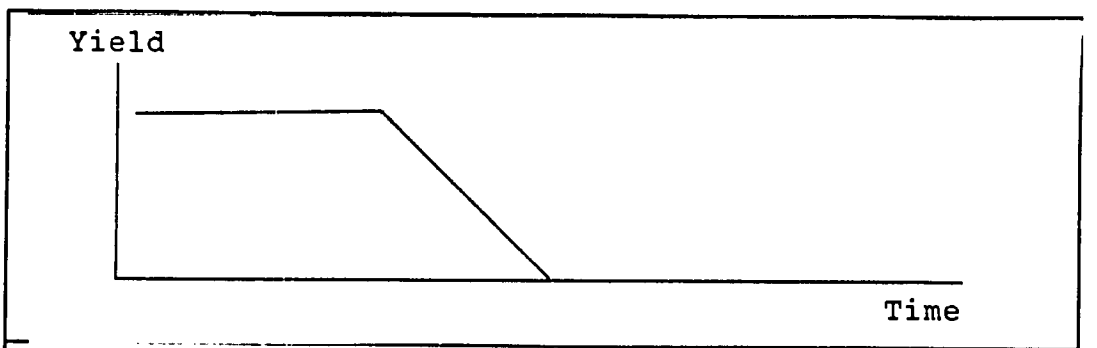


Figure 1-3. Transition of yields from woodland to an agricultural field.

An example of a nonsustainable system is shown in Figure 1-3. In this example, a sloping field with a thin soil is cleared of tree cover and planted. Because of intense rainfall, soil erodes quickly. In a very few years the soil has eroded to the point where the field will no longer support agricultural crops.

The idea behind sustainable agriculture is to insure that the average yields of each agricultural system are constant rather than declining. Sustainable agriculture is not about increasing yields. It is about preventing decreases in yields. It is about protecting the natural resource base which allows agricultural production, forestry production, livestock production, and the yields of all other production systems.

F. AGRO-ECOLOGICAL ZONES.

Throughout this report are references to different agro-ecological regions. In all cases, these geographic regions are the six shown on Figure 1-4. They are the Niayes, the Senegal River Valley, the Peanut Basin, the Ferlo or the Silvo-Pastoral region, Senegal-Oriental, and the Casamance. These agro-ecological zones are used in this report because they are well known and have been used by numerous authors.

As with many such systems, it is often difficult or impossible to say where one zone ends and another begins. This is because changes in ecological factors such as rainfall, temperature, soils, and elevation are seldom discrete. These factors change gradually. To complicate matters, factors such as rainfall change from year to year and may also follow long-term trends or cycles. Thus, it is virtually impossible to determine, by observation or measurement of the different ecological factors, where the boundaries of the different zones are. In a sense, the establishment of the exact boundaries is arbitrary.

This division of the country into different zones is meant to facilitate the discussion of natural resource management. Although it may be argued that the six major zones could be further subdivided according to certain ecological criteria, this approach would lead to a large and unmanageable number of subzones. Since the purpose of this report is to help USAID formulate a country-wide strategy, it would be inappropriate to divide the country into more than about six zones.

As can be seen on Figure 1-4, the boundaries of the agro-ecological zones have been drawn, in some cases, along the boundaries of administrative districts. In other cases, the administrative districts have been divided in two, half of the district going to each zone. Since the boundaries of the zones are arbitrary in any event, it was decided that the boundaries should

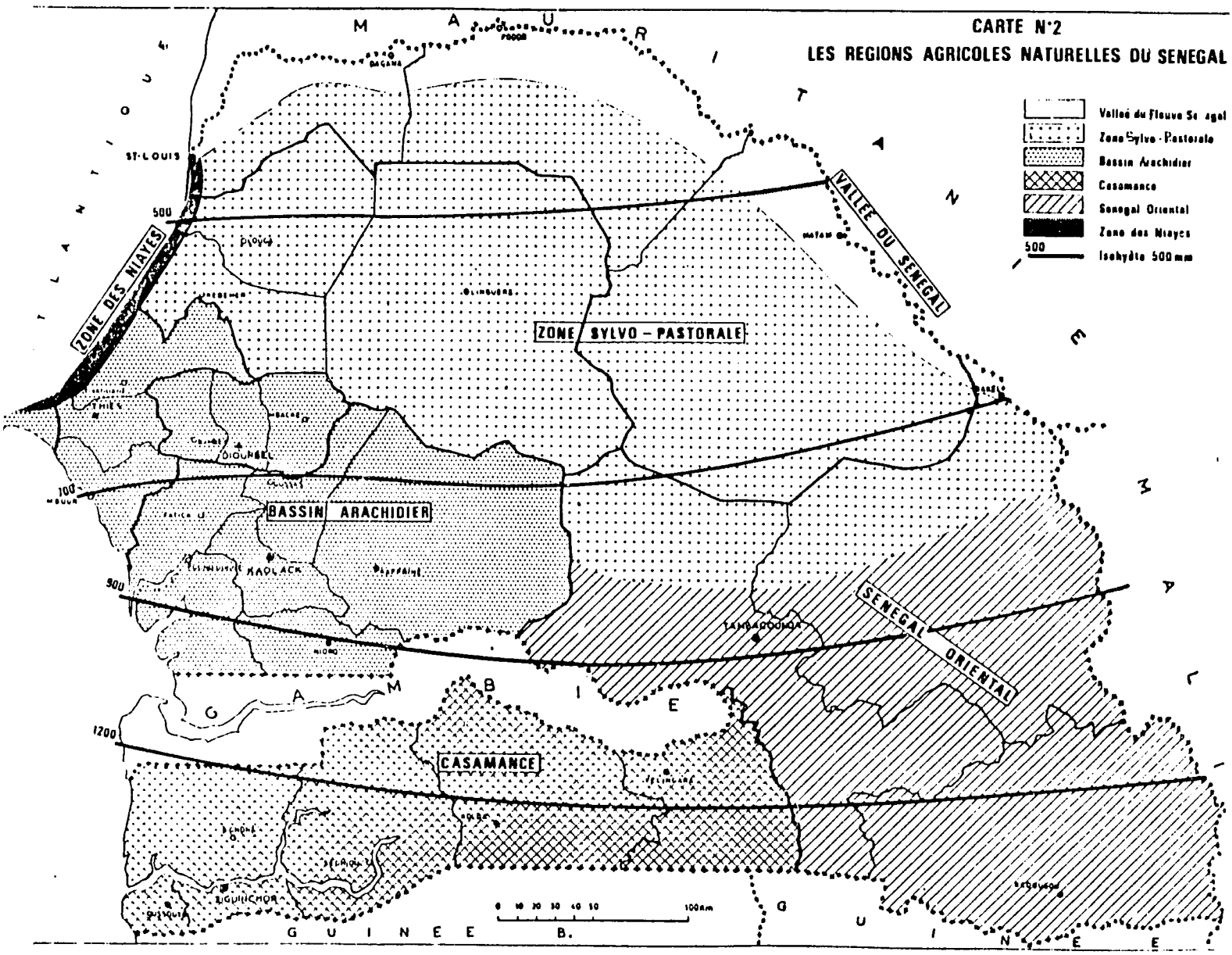


FIGURE 1-4. MAP OF AGRO-ECOLOGICAL ZONES

correspond to administrative boundaries. Thus, statistics, which are generally collected by the administrative district, can be attributed easily to the appropriate agro-ecological zone.

These agro-ecological zones have the advantage of being useful in the study of surface water. The Senegal River Valley corresponds exactly to the immediate watershed of the Senegal River. The Ferlo as described above corresponds closely to the Ferlo River watershed. The Casamance River watershed and the Casamance agro-ecological zone are very similar. Finally, the Sine-Saloum watershed describes the southern portion of the Peanut Basin (see watershed map in Chapter 2).

As stated above, references to these agro-ecological zones will be made throughout this report. For each of the zones, most of the information given for water, soils, and vegetation will be found in the appropriate chapter.

Figure 1-5, parts a and b give a summary of land use patterns for each of the agro-ecological zones.

Figure 1-5a. Areas in agroecological zones, by land use and land capability classes. In hectares.

Location, by Region.	Land management system	Land area in ha.		
Casamance	Agricultural land			7500
	Rainfed crops		2973	
	Irrigated crops		12	
	Arable but not cultivated		4515	
	Forest, woodland, range			6850
	Classified		4836	
	Sudano-guineen forest	2419		
	Sudano-guineen park	500		
	Guineen forest	1917		
	Unclassified		2014	
	Unarable land			14000
	Total land area			28350
Senegal-Oriental	Agricultural land			4000
	Rainfed crops		1615	
	Irrigated crops		8	
	Arable but not cultivated		2377	
	Forest, woodland, range			20000
	Classified		12933	
	Sudano-sahelian forest	2751		
	Sudano-guineen forest	2554		
	Sudano-guineen park	7628		
	Unclassified		7067	
	Unarable land			30007
	Total land area			54007
Peanut Basin	Agricultural land			21687
	Rainfed crops		17489	
	Irrigated crops		6	
	Arable but not cultivated		4192	
	Forest, woodland, range			7618
	Classified		3958	
	Sudano-sahelian forest	2426		
	Salt flats forest	51		
	Thies forest	432		
	Sudano-guineen forest	1049		
	Unclassified		3660	
	Unarable land			13137
	Total land area			42442

Figure 1-5a

Figure 1-5b. Areas in agroecological zones, by land use and land capability classes. In hectares.

Ferlo	Agricultural land			1500
	Rainfed crops		1078	
	Arable but not cultivated		422	
	Forest, woodland, range			20384
	Classified		25312	
	Sahelian sableux forest	763		
	Sahelian sableux, RSP	4766		
	Sahelian cuirasse forest	56		
	Sahelian cuirasse RSP	3340		
	Sahelian cuirasse RF	5070		
	Soudano-sahelian forest	2080		
	Soudano-sahelian RSP	2800		
	Soudano-sahelian RF	6437		
	Unclassified		-4928	
	Unarable land			18881
	Total land area			40765
Senegal River	Agricultural land			3000
	Rainfed crops		400	
	Irrigated crops		300	
	Recession agriculture		400	
	Arable but not cultivated		1900	
	Forest, woodland, range			7500
	Classified		954	
	Sahelian, walo forest	252		
	Sahelian, dieri forest	178		
	Sahelian, delta forest	524		
	Unclassified		6546	
	Unarable land			17858
	Total land area			28358
Niayes	Agricultural land			362
	Rainfed crops		172	
	Irrigated crops		64	
	Arable but not cultivated		126	
	Forest, woodland, range			893
	Classified		893	
	Sahelian forest	30		
	Perimetre reboisement	862		
	Park	1		
	Unarable land			1547
	Total land area			2802

Figure 1-5b

CHAPTER 2

WATER RESOURCES

A. OVERVIEW.

This first technical chapter is devoted to water resources. Water is being presented first because it is arguably the most important of all resources. Also, since much of what will be said in later chapters is based on the availability of water, it was felt that it would be best to present a background on water resources before discussing the others.

The water resources potential, problems and management are summarized in this section and dealt with in more detail in the remainder of this chapter.

1. Guidelines.

There is a potential for groundwater development in the four major aquifers of the Senegal River Valley, the Silvo-Pastoral zone, the Peanut Basin, and the Casamance which are: the shallow aquifers, marl-calcareous of Eocene, Paleocene limestones, and Maestrichtian sands. Sometimes two or three aquifers can be found below any given point. The bulk of studies and drilling programs performed were for rural or urban water supply and to a lesser extent for irrigated agriculture, except in the Casamance where shallow aquifers are most important, and are often used for irrigation of small dry season gardens. Therefore, the capacity of the aquifers to provide the irrigation water requirements needs to be determined. Further studies of these aquifers supported by a pumping test would provide estimates of the borehole/well yield and also determine whether there is groundwater renewable potential or depletion on a long term for irrigation.

The Niayes, the coastal area north of Dakar, has a shallow aquifer supplied from precipitation, but its potential is not great.

The aquifers in the Senegal Oriental, including east and north of Tambacounda are not well known. Further study of these aquifers will be required.

Problem areas for each aquifer identified include mainly water quality with a mineral content of about 3 g/l, inappropriate for domestic uses, but acceptable for irrigation. There is also an over-exploitation of groundwater in the Peanut Basin where the discharge drawn from the aquifer for multiple purposes, including water supply for Dakar, exceeds the average capacity of the

aquifer. The depletion of this aquifer has already been felt north of Thies. Until the Canal de Cayor becomes operational in 1992 and recharges the aquifer, its further depletion can be expected to continue for some time in the future.

2. Surface Water.

There is also great potential for development of surface water of two major rivers: the Senegal and the Casamance. The Senegal River represents the greatest potential for multipurpose development of the Valley, including recharge of the aquifer and transfer of water to the Lac de Guiers, the Canal de Cayor, and the Ferlo Valley. This potential depends on the hydrology of the Faleme and the Bakoye Rivers; the most dependence is on water released from Manantali dam. The regulated surface water potential of the Senegal River is estimated to be 15 billion m3/yr at Bakel when Manantali dam is fully operational. This excludes the unregulated natural river peak flood and the required Manantali flow for energy production. When this energy production function is considered, there will be certain constraints on the river runoff, and their adjustment should be considered.

The Casamance River is also another potential, with an estimated unregulated average annual runoff ranging from 129 billion m3 at Kolda to 19 billion m3 at Madina Omar. However, the major problem here is the salinity of the river and its tributaries, due to tidal surges traveling upstream. Tidal amplitude and magnitude, and water quality should be considered before planning using Casamance River water for agricultural development. The most ideal use of surface water for irrigation in Casamance where the salinity of water is higher appears to be through the construction of anti-salt dams. This report provides information on lessons learned from existing anti-salt dams.

The Ferlo River is intermittent, and no flow occurs during the dry season. Its hydrology-climatology regime is not well known. The Government of Senegal is considering providing the Valley with sufficient surface water diverted from the Senegal River at Bakel or the Lac de Guiers for its agricultural development.

The Gambia River runoff yields are estimated to be from 1.4 billion m3 to 3 billion m3/yr. This represents a good surface water potential for multipurpose development. However, investigation of its hydrology regime and water quality needs to be considered. The tidal reach of the river extends upstream through its entire length up to 540 km.

Other alternatives for developing surface water for agricultural development consist in constructing catchment storage reservoirs. This report indicates that there are some possibilities of impounding some 93 to 97 million m3/yr for irrigation within the Peanut Basin, the Upper Casamance, and the Senegal-Oriental

watersheds south of isohyetal 800 mm average annual rainfall.

The report shows that there is water resources potential for both ground and surface water, and some studies may be required to assess this potential. Water resources management problems are not always emphasized in the literature due to lack of basic information, and further hampered because the responsible institutions do not often mention them.

The Water Code for development and implementation of water resources is not very specific as to which extent these resources can be utilized.

B. THE HYDROLOGIC CYCLE.

The basis for understanding the complex interrelationships between the various water resources in Senegal is the relatively simple model called the water cycle or hydrologic cycle. Figure 2-1 shows the major elements of the water cycle which are relevant to Senegal. As rain falls to earth, a portion of it is absorbed by the soil. Another portion flows overland and eventually ends up in bas-fonds or marigots. Alternatively, this water will enter a stream or river and flows to the Atlantic Ocean via the Senegal, the Sine-Saloum, the Gambia, or the Casamance River. A third and not insignificant portion of rainfall will evaporate and again become atmospheric moisture.

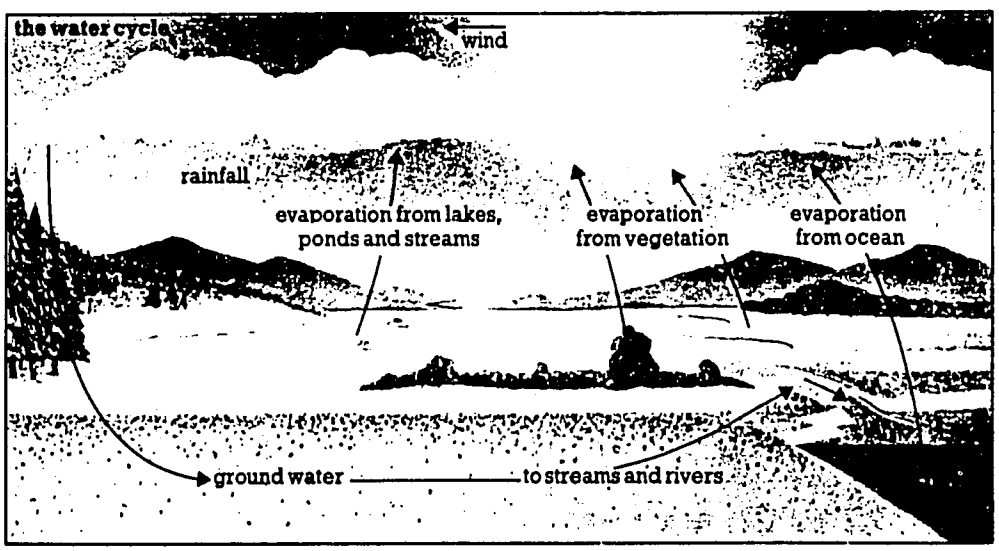


FIGURE 2-1. The hydrologic cycle.

Knowingly or unknowingly, man does control, to a great degree, the amounts of water which infiltrate into the soil or flow overland to become surface water. Those involved in agricultural and forestry production have developed methods of increasing infiltration and thereby increasing the amounts of water available for plant growth. The USAID Southern Zone Water Management project will use water conservation techniques to increase rained rice production in the Casamance. Watershed management techniques can either increase or decrease runoff, as desired.

All of the water which is pulled by gravity into the soil is not all available for plant growth. Any soil can hold only a certain amount of water. This amount of water is referred to as "the field capacity of a soil" and varies with soil texture. For example, a sandy soil is not able to retain as much water as a soil with more silt or clay. Any water in excess of field capacity is pulled down to lower levels by gravity until it becomes part of groundwater. The water in the soil which is used by plants returns to the atmosphere as the leaves of the plant transpire. This process is called transpiration or, when a more global term is needed for evaporation as well as transpiration, evapotranspiration.

As mentioned above, rainfall can become surface water in rivers and marigots or it can become groundwater. However, surface water can become groundwater and groundwater can become surface water. For example, the Senegalese government is considering the construction of small dams to create reservoirs. The water retained in these reservoirs would soak into the soil, increase the amount of groundwater, and thereby make more water available to existing wells.

Senegal has two characteristics which, in combination, complicate the country's water cycle and impose certain constraints on the use of water in the country: (i) Senegal borders the Atlantic Ocean and (ii) Senegal is extremely flat. The result is that relatively large areas of the country are affected by seawater. Even in normal times, tidal surges travel several hundred kilometers inland. Thus, it has always been normal for the water, the fish, and the soil to be exposed to salt concentrations which are greater than those in fresh water. The ecology of the lower valley of each of the rivers reflects the adaptation to this condition. Also, the groundwater along the coast is influenced by the seawater. In the Niayes, for instance, water is drawn from shallow wells to water vegetable gardens. These gardens are limited in size because limited fresh water is available from these wells. If the layer of fresh water were drawn down excessively, it would be replaced by the salt water underneath.

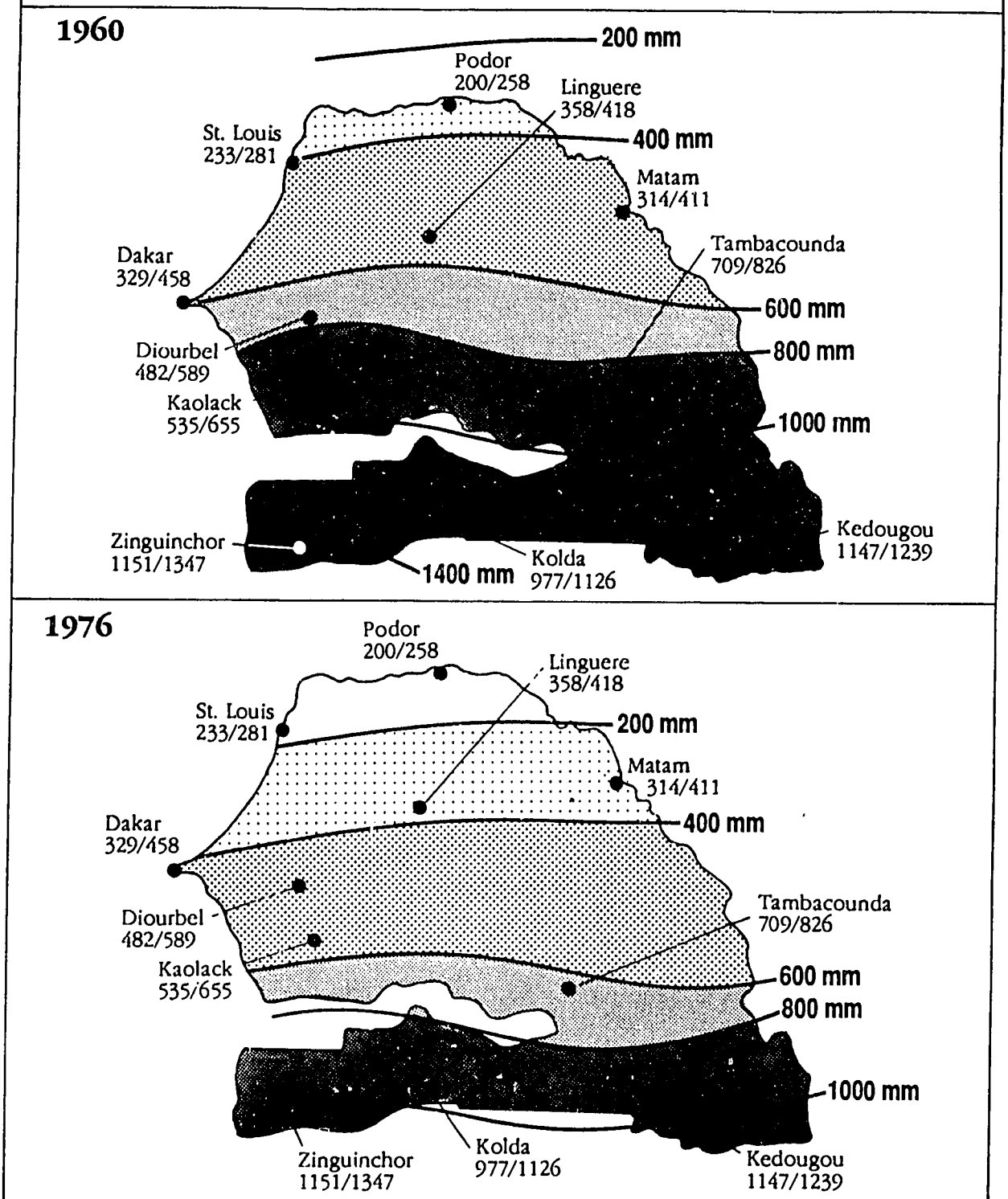
Rainfall is the crucial element in the water cycle. Although the amount of rainfall is important, the timing of the precipitation also has important effects on water availability. In Senegal there is a definite rainy season and a definite dry season. Thus there are seasons of high streamflow and seasons of low streamflow. At times, there seems to be too much water while at other times there is too little. When the advantages outweigh the disadvantages, and if technically feasible, it is useful to store water during the season when there is an overabundance of water for later use during the drier seasons. On an even larger scale, it is possible, and sometimes practical, to store water from relatively rainy years to be used during relatively dry years.

As can be seen on the rainfall maps in Figure 2-2, precipitation in Senegal has been significantly lower since 1960 than prior to 1960. This has caused a number of changes. Farmers have changed to crops which require less water. For instance, near Louga, some farmers are switching from peanuts to cowpeas. In other areas, farmers are planting the same crops but using varieties which mature more rapidly, say in 90 days rather than 120 days. At the extreme northern limits, some farmers have stopped planting altogether.

Reduced rainfall is not always the direct cause of problems. In the Casamance, for example, reduced rainfall has led to reduced streamflow in the Casamance River. The reduced streamflow allows the normal tidal surges to travel much farther upstream. Thus, significant areas, that never had the problem before, are now having problems with salt intrusion.

This chapter is organized to discuss the various water resources. Immediately following this introduction is a discussion of the groundwater resources available in each agro-ecological zone. Next, is a discussion of the surface water resources on a watershed by watershed basis. Thirdly, there is a brief discussion of the efforts to improve rained agriculture through water conservation techniques.

Sixteen Years of Climatic Change in Senegal



Isohyets of mean annual rainfall in 1960 and 1976 showing southward migration of drought by 113 km. Each city shows the mean amount of rainfall for the last 16 and the last 30 years. The last 16 years show reduced mean rainfall at all stations.

FIGURE 2-2. Rainfall Maps

C. GROUNDWATER RESOURCES.

This synthesis of hydrogeological information, and the identification of groundwater potential and management is based on a study recently prepared by the Bureau de Recherches Géologiques et Minières (BRGM). This BRGM study was to prepare the master plan for groundwater resources in Senegal. The study utilized data collected from studies, programs, and drilling work accomplished throughout Senegal since 1975. Additionally, BRGM used cartographical tools and computer programs for planning the management of groundwater resources (Figure 2-3). These two maps can be used to locate existing potential aquifers; evaluate and select an aquifer; estimate the depth of a borehole, a well, or the groundwater table; or define the salted zones of the aquifer.

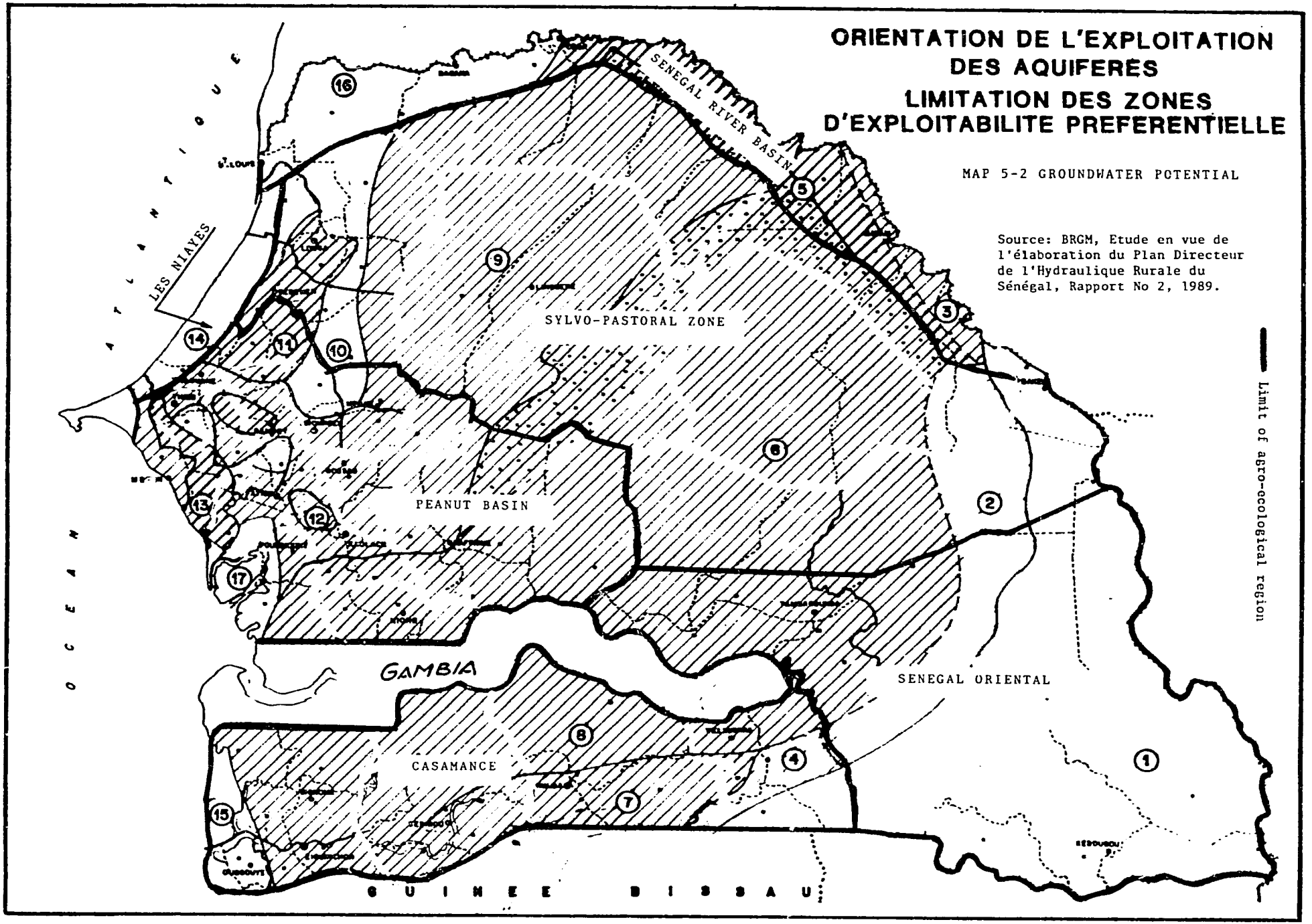


FIGURE 2-3. Groundwater Potential

The BRGM study was prepared for the former Ministère de Hydraulique, Direction de l'Hydraulique Rurale. It gives a short overview or summary of groundwater potential, management and problems. The Government of Senegal is trying to obtain the 180 million francs necessary to conduct a more detailed study.

1. Groundwater Potential.

A number of important cross-sections (Figure 2-4) are presented to illustrate groundwater potential. These Groundwater Identification figures indicate the geological formations capable of containing groundwater at any given location. The Groundwater Potential Map (Figure 2-3) shows, for each region of Senegal, those aquifers with the greatest potential and probability of success.

Until two decades ago, the basement geological formations of Senegal-Oriental were considered unproductive. Since then, a few drilling exploration programs have been conducted in the basement and associated geological formations. The alterations of the basement formations revealed that these aquifers can have a good potential with a capacity ranging from 1 to 10 cubic meters per hour.

Information collected on the sedimentary basin, which covers essentially all of Senegal except the extreme southeast corner, indicates the presence of several geological layers with great groundwater potential. At some locations, two or even three aquifers are identified.

As was mentioned in Chapter 1, the natural resources will be described, whenever possible, according to the six agro-ecological regions of the country.

a. The Senegal River Valley.

Between Saint-Louis and Podor there is a shallow aquifer with limited potential in the lower valley of the Senegal River in the alluvium and quaternary sand. This lower aquifer is brackish and salty. The study also showed that in the vicinity of Dagana the shallow aquifer (Eocene and Maestrichtian) is mineralized with a mineral content of about 3 grams per liter. This water quality is inappropriate for domestic uses, but it is good for irrigation purposes (the limit for agricultural uses being 4 grams per liter).

This study disclosed that two apparently separate aquifers underlay the plain, one a shallow aquifer, and one a deeper aquifer. The zone extending from Podor to Matam contains an aquifer in the Eocene limestones or sandstones. There is a continuous hydraulic gradient between the quaternary alluvium sand

FIGURE 2-4: SUBSURFACE SECTION: GROUNDWATER IDENTIFICATION
Source: BRGM Etude en vue de l'élaboration du Plan Directeur de l'Hydraulique Rurale au Sénégal Rapport No 2, 1989 (see explanation note)

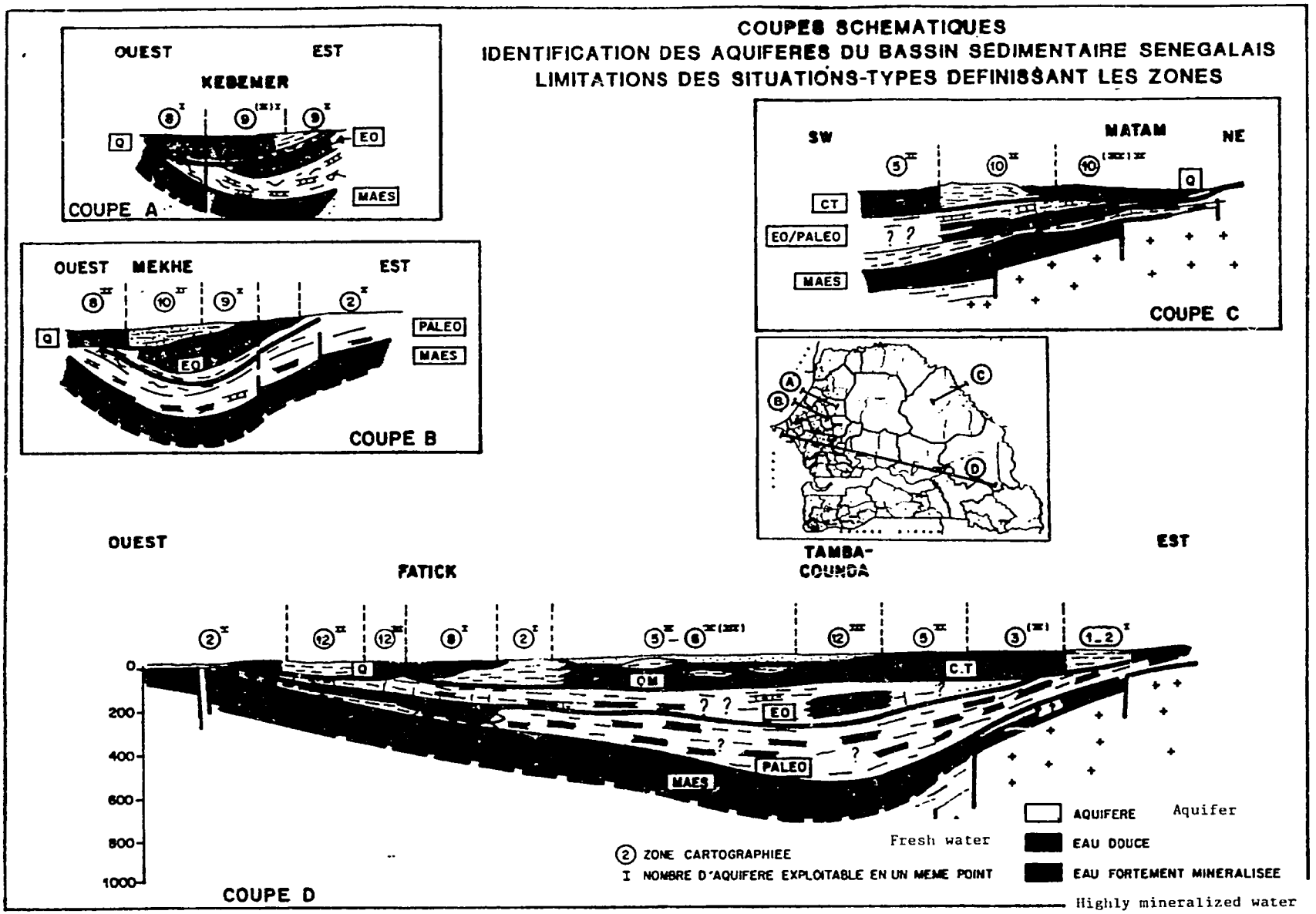


FIGURE 2-4. Groundwater Identification

and the subjacent Eocene and Paleocene. The aquifer is located at a depth of about 20 meters. The depth rapidly increases toward the west (Figure 2-4, section C). Podor forms the frontier of problem area in salt concentration, which exceeds 2 g/l in upper aquifer between Podor and Bogue. The presence of a free Maestrichtian aquifer in the sand and river alluvium was also identified at about 30 m depth near the river. Its depth increases with the distance from the river (Figure 2-4, section C).

These aquifers can readily yield large quantities of water to wells. However, it is not known whether the aquifers have the capacity to provide the quantities of water which would be necessary for irrigation. There would have to be an effective recharge of the shallow aquifer from the river. The extent of the aquifer and the effectiveness of the recharge from the river must be better understood before an irrigation project can be undertaken. The deeper Maestrichtian aquifer hydraulic connection to the shallow aquifer and/or the river needs also to be determined, including its thickness.

USAID is financing a groundwater monitoring project through the Organization pour la Mise en Valeur du Fleuve Sénégal (OMVS). This monitoring project has collected a considerable amount of data in this area. The eventual compilation of these data will enable one to determine the areal extent of the aquifers and the existence of any hydraulic connections. This compilation, supported by a pumping test and further study would determine whether there is groundwater potential or depletion on a long-term.

b. The Ferlo.

There are two zones encountered within the Ferlo. The first zone indicates the presence of a captive Maestrichtian aquifer with possible high probability of groundwater potential. This zone is located between Koki and Linguere, and it includes the Lac de Guiers (Figure 2-4), and extends beyond the Ferlo region to Kaolack, Fatick, Diourbel, Thies, and the Horst de Ndiass. The main limitation here is that the distribution of the aquifer, including the exact location of groundwater potential is not well known, in particular in the Continental Terminal and in the Eocene and Paleocene limestones. Therefore, further geophysical investigations would be required to better delineate the aquifer prior to any groundwater drilling program. Additionally, borehole drilling followed by pumping test would be necessary to determine the hydraulic and potential of aquifer, including water quality on a long term for irrigation or for any other purpose.

The second zone is larger than the first. It lies in the Continental Terminal and the Oligo-Miocene that can contain potential aquifer with a variable hydraulic gradient. The depth of groundwater table can exceed more than 60 m throughout the entire zone. The water has a pH of 6 and is slightly mineralized.

Again, further study will be required in the Continental Terminal west of Linguere to assess groundwater potential prior to any irrigation project. In the event this aquifer does not have the capacity to supply irrigation requirements, the subjacent Maestrichtian aquifer at depths between 200 and 350 m appears to have a good potentiality. Use of this aquifer could be considered, if permitted by the Government of Senegal. There is a law that forbids drilling a borehole in the deeper Maestrichtian aquifer for irrigation, but the extent to which this law is enforced is not known.

c. The Peanut Basin.

This basin also contains a captive Maestrichtian aquifer with potential for groundwater development. This was confirmed by existing piezometers, and recent studies in the Kaffrine and Tambacounda area. The drilled borehole reached the limestone or the marl-limestone of the Eocene era. An aquifer with good potential was identified at a depth of more than 60 m throughout the entire zone.

The limestone karstified Eocene, between Kebemer and Bambey, and the quaternary sand, and the Continental Terminal contain a very low potential aquifers, in particular between Kaolack, Fatick, and Thies. Subjacent aquifers have a better potentiality, but they are mineralized (from 2 to 3 g/l), in particular north of Fatick.

The best aquifer with possible high potential and specific capacity was identified in the Paleocene formation between Sebikotane, and north and south of Pout. This aquifer is estimated at more than 100 m3/hr/m, but subject to salinization. A mathematic model was recently elaborated by the Société National d'Exploitation des Eaux du Sénégal (SONEES) to further study the ability of this Paleocene-Maestrichtian aquifer to provide an adequate water supply for Petite Côte south of Dakar. An aquifer with a specific capacity of more than 100 m3/hr/m represents a good potential for irrigated agriculture, but the area of Petite Côte seems to be more appropriate for tourism than agriculture, the use of this potential will be of greater benefit to the tourism industry.

As for the Sine-Saloum Delta, it delimits a deeper mineralized Maestrichtian aquifer with a mineral content of more than 2 grams per liter.

The above mentioned studies were mostly performed for water supply. Therefore, further geophysical investigation, study and pumping tests would be required to determine their potential and suitability for irrigated agriculture, and in particular that the yields could be sustained during the life of any proposed project.

d. The Casamance.

Two aquifers consisting of one or more sand beds separated by yellow clay are identified in the quaternary alluvium of the Continental Terminal and the Oligo-miocene sand of Casamance. These aquifers are shallow and are the most important, if not the only, water source for most villages. They can generally yield from one to over 10 m3/hr, averaging about 3 m3/hr. Wells tapping these aquifers are often used for irrigation of small dry season gardens. They extend practically throughout all the Lower Casamance basin. In some areas such as Ziguinchor and Bignona, wells drilled to a depth of 50 m in the Continental Terminal showed substantially higher yields, averaging 30 m3/h, and in some cases exceeding 50 m3/hr. Some areas in the lower Casamance appear to show a great groundwater potential for irrigated agriculture. The major concern in some areas is the high iron content of the aquifers. The depth to the water table depends on land elevation and seasonal precipitation. The annual rainfall recharges the shallow aquifer.

In the southern and eastern boundary of Kolda some shallow aquifers were identified in the Continental Terminal and the Oligo-Miocene. The water table appears in general at a depth of less than 20 meters. There is a good indication of an aquifer with high yield and potential for irrigation. However, the deeper Maestrichtian aquifer identified at depths between 150 and 400 m seems to have a higher potential.

South of Velingara a shallow Maestrichtian aquifer was also identified, but it is considered as not having a good potential. West of Oligo-Miocene in the vicinity of the coast, the aquifer is mineralized due to salt water intrusion into the aquifer.

Further groundwater investigation and study should be conducted in these areas, including east of Ziguinchor to confirm the aquifer quality, yields, and hydraulics for sustainable irrigation.

e. Senegal Oriental.

The aquifers in this area are not well known because there have been few groundwater exploration programs and there is little data available. The Direction des Etudes Hydrauliques of the Ministère du Développement Rural et de l'Hydraulique is considering an hydrogeology study of this basin to assess groundwater potential and exploitability for economic development. The terms of reference for the study called Etude hydrogéologique de la Bordure Sedimentaire du Sénégal Orientale have already been prepared, and the government is seeking financing.

f. The Niayes.

This zone is dominated by a shallow aquifer in the Continental Terminal or quaternary, with a deep captive Maestrichtian aquifer containing high concentrations of salt. Boreholes drilled west of Louga and Kebemer indicated that a specific capacity of more than 10 m3/hr/m can be obtained in the sand-clay of the Continental terminal. In the southern zone, a specific capacity from 0 to 5 m3/hr/m could be expected.

Most of the water that accumulates in the shallow aquifer originates from precipitation. The high porosity (30 to 35%) of the aquifer and its extreme permeability provide for rapid concentration and accumulation of atmospheric water. The main problem with the aquifer, in addition to water quality, is that during periods of drought the aquifer is quickly depleted. It is also heavily exploited at Thiaroye, and any further pumping of the aquifer may result in the replacement of fresh water by salt water. Therefore, this resource should not be considered as having a groundwater potential. However, should this area need to be developed, further field reconnaissance and study would be required to assess the hydraulics of the deeper aquifer, its yield, potential, and water quality.

2. Groundwater management problems.

Except for the water quality problems and constraints in evaluating the potential of some aquifers mentioned above, problem areas on the management of groundwater resources are not emphasized in the literature. However, some problems encountered concern the over-exploitation of the Peanut Basin aquifer near Sebikotane, Pout-M'Bour, and along the northern littoral. The discharge drawn from the aquifer to meet Dakar water supply demand exceeds the estimated capacity of the aquifer, thus tapping into groundwater reserve. This overwhelming problem is emphasized on Table 2-1. With increase of Dakar population every year, the water demand will probably follow the same pattern. Therefore, unless there is an artificial or natural recharge of these aquifers, their depletion can be expected some time in the future. This depletion has already been felt north of Thies. The groundwater table has a decrease of about 15 m in a 15 year period.

Table 2-1. Capacities of various aquifers.

Aquifer	Capacity m3/day	Discharge withdrawn m3/day
Infra-basaltic	18,000	21,000
Limestone of Sebikotane	20,000	31,000
Limestone of Pout-M'Bour	38,000	35,000
Maestrichtian of Pout-M'Bour	20,000	26,000

Source: BRGM, report No 2.

The region of Louga is also of great concern because of its heavy consumption of groundwater to supply Louga, Mpal, Fass, and Rao with municipal water and irrigation from the two boreholes of Ndiak Sall. An evaluation of this aquifer is recommended should the need to further exploit the aquifers arises.

3. Projects relating to groundwater.

a. Senegal River Groundwater Monitoring Project (OMVS/USAID Project 625-0958).

Approximately 1064 piezometer wells were installed in the Senegal River Basin in Senegal, Mali, and Mauritania. Of these, approximately 320 are located in Senegal both inside and outside of irrigated perimeters to gather accurate hydraulic data that will be used to:

- evaluate the extent of salt water intrusion into irrigated perimeters,
- determine the hydraulic head difference between the shallow and deep aquifers in the alluvium in the Senegal River Valley,
- determine the head between aquifers and the Senegal River,
- evaluate changes in the groundwater regime caused by the construction of Diama and Manantali dams and the resulting alterations of river-flow regime,
- monitor water quality,
- evaluate the potential for irrigation development from groundwater in selected areas.

A considerable amount of accurate and reliable data from the Senegal River basin exists. Hydrographs illustrating groundwater seasonal fluctuations including hydraulic conductivities of the aquifers are available for the Delta region from Saint Louis to

Richard-Toll. Piezometric data from Richard Toll through Bakel exist for the Senegal River Basin.

The project has developed a mathematic groundwater model appropriate to Senegal River Basin (GROUNDWATER, GES, AND SURFER), capable of producing useful maps and graphs such as cartographic maps and fluctuations in groundwater levels. A technical report providing a detailed study of the Senegal River basin is being prepared. However, an analysis of data collected will be of great importance to help in the planning and design of projects using groundwater in the Senegal River Basin.

b. UNDP project Planification des Resources en Eau (SEN/87/007/006/A/01/01).

This project was approved in March, 1990. Its objectives are to assist the Ministère du Développement Rural et de l'hydraulique to set up an institution within the Ministry for the planning, management, and implementation of groundwater projects in Senegal.

4. Conclusion on groundwater.

In this section we present a synthesis and analysis of relevant information available for groundwater resources. A large number of studies and groundwater exploration programs have been conducted in Senegal and the brief summary given here is far from exhaustive. It is based on the study prepared by the BRGM, and others after analysis and evaluation of more than 137 reports and groundwater exploration programs performed in Senegal between 1975 and 1989. The complete bibliography of the documents used is provided at the end of the BRGM report. The bulk of studies and drilling programs were for rural or urban water supply and to a lesser extent for irrigated agriculture.

There is a potential for groundwater development in four major aquifers of the Senegal River Valley, the Silvo-Pastoral zone, the Peanut Basin, and the Casamance. These are the shallow aquifers, marl-calcareous of Eocene, Paleocene limestones, and Maestrichtian sands. The Niayes, the coastal area north of Dakar, has an aquifer which may present water quality problems because of possible intrusion of salt water into the shallow aquifer. Its potential is not great. The aquifers for which there is no information, and for which further study may be required include: the aquifers in the Senegal Oriental, the shallow aquifer of the Continental Terminal east of Ziguinchor, the shallow aquifer in the Continental Terminal and Miocene east and north of Tambacounda (extension of the Kaffrine-Tambacounda zone).

Much of the information presented in this report would require a follow-up and further investigation before definite conclusions could be drawn, and a set of comprehensive recommendations made.

The data included in this report could become outdated due to the dynamic nature of the aquifers. The value of the data may be lost before any operational decisions are made.

Government regulations and policies concerning use of groundwater should be assessed before designing any project. Some regulations on groundwater, in particular for the Maestrichtian aquifer exist, but the extent to which they are enforced is not known.

Problem areas for each aquifer identified include mainly water quality. There is also an over-exploitation of the Peanut Basin aquifer in relation to its average yields, to meet Dakar water supply demand. Therefore, the use of these aquifers for any purpose may require further investigation.

D. SURFACE WATER POTENTIAL.

As explained in the introduction to this chapter, surface water includes all the water which flows in streams and rivers and as well as that which rests in lakes, marigots, and bas-fonds. Figure 2-5 shows the limits of the Senegal River Basin. This map also shows the Ferlo River, which is a watershed within the Senegal River Basin, the Casamance River, and the Gambia River.

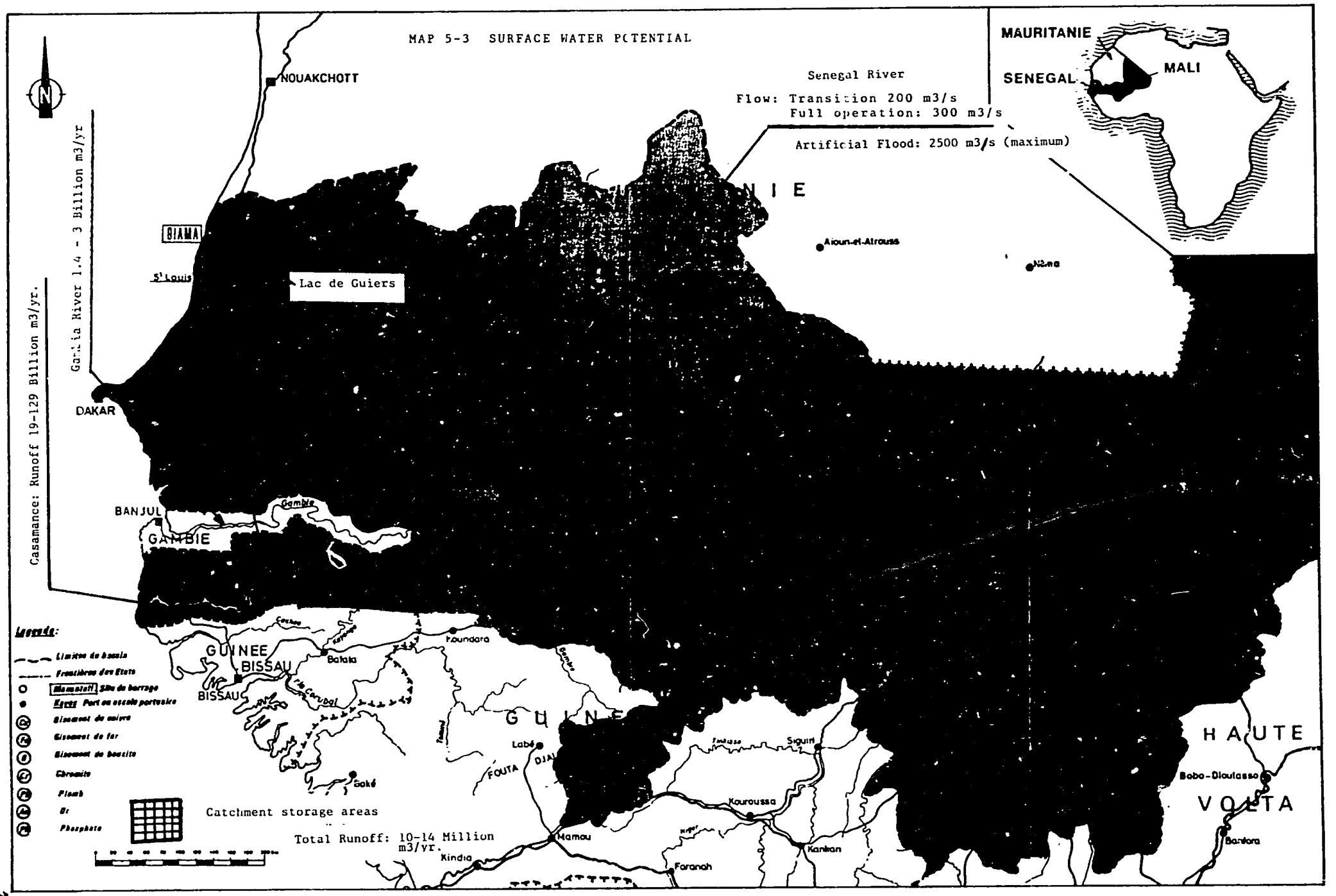


FIGURE 2-5. Surface Water Potential Map

1. Senegal River Basin.

a. Generalities.

The Senegal River is approximately 1,800 km long and drains an area of approximately three million square kilometers. The river basin can be divided into three main regions: the Upper Valley in Mali, the Valley, and the delta, each of which are quite different in their hydrographic and climatic conditions.

The Upper Valley extends from the Fouta Djalon down to Bakel. It is a relatively wet region with an annual precipitation varying from 700 mm to 2,000 mm. The rains fall from April to October in the mountainous area, and are the source of the annual flood that occurs between July and October. The Senegal River itself is formed by the junction of two main streams, the Bafing and the Bakoye, near Bafoulabe, Mali. With an annual mean flow of 430 m3/s, the Bafing supplies more than half of the total discharge of the Senegal River. Since the construction of Manantali dam on Bafing River, its flow is subject to control. The discharge of the Bakoye is approximately 170 m3/s. Farther downstream, on the left bank in Senegal, the Faleme is the largest tributary to the Senegal River with a mean annual flow of 200 m3/s at Bakel.

The streamflow regime of the Senegal River downstream of Bakel depends essentially on release flows from Manantali dam, and the uncontrolled streamflow of the Faleme and Bakoye. This uncontrolled streamflow is characterized by a high flow season from July through October, and a low flow season gradually decreasing between November and May or June. Peak flow is recorded in late August or early September.

Bakel is the limit between Upper Valley and the Valley. It is the key station of the Senegal River for hydroclimatology data and regulated flows for downstream users. The Valley, which extends from Bakel to Dagana, is an alluvial plain surrounded by semi-desert regions, with no significant runoff contribution to the river. The Delta, downstream from Dagana is a totally flat area which was regularly inundated by sea water during the dry season before construction of Diama dam. The intrusion of sea water into the delta is now prevented by the dam.

Studies conducted by the OMVS have demonstrated that in order to achieve the fundamental objectives of integrated development of the Senegal River Basin, a river flow of 300 m3/s should be secured from the start at Bakel. This flow includes the contributions of the Faleme and Bakoye rivers as well as releases from Manantali. The Manantali reservoir releases should be based on the flows from Faleme and Bakoye rivers, recorded at Bakel. A flow of 300 m3/s should permit the irrigation of 255,000 hectares in the Valley (full development scale). Therefore, when the Manantali dam

becomes fully operational, the regulated surface water potential downstream of Bakel can exceed 15.0 billion cubic meters per year. This streamflow will be available for river users for irrigation, flood recession agriculture, agro-industrial uses, water supply, and recharge of the aquifer.

Seasonal and annual floodplain maps arranged by type year are not available. This kind of map would have greatly improved the planning process for the Senegal River Basin as the flooded area, duration, and depth are directly responsible for fishery production, range and browse production, riparian wood production, and floodplain recession agricultural crop yields. (SOGREAH's model is not a map.)

b. Structures.

i. Manantali dam.

The long-term management objectives for the Manantali dam are to maintain a base streamflow of 300 m3/s at Bakel and to secure a maximum streamflow of 2,500 m3/s for one month in August-September. This second objective is to create an artificial flood in order to maintain optimal conditions for traditional flood recession farming, pending expansion of irrigated agriculture throughout the Senegal river valley. This exact streamflow objective will depend on the area of the flood recession agriculture lands to satisfy. Three scenarios are considered for the artificial peak flow as shown on Table 2-2 for the month of August-September.

Table 2-2. Area of irrigable land along the Senegal River as a function of total runoff.

Scenario	Irrigable land (ha)	Runoff billion m3	Maximum flow m3/s	Days with >2000 m3/s
1	50,000	7.5	2500	10
2	75,000	8.5	2750	15
3	100,000	10.0	3000	20

The total regulated streamflow is estimated to be 15 billion m3/yr when Manantali dam is in full operation in 1991. Average monthly runoff from May to August, 1988, recorded at Bakel, and including releases from Manantali dam and flows from the Faleme and Bakoye rivers, was 900 million m3. For the same period in 1989, the average monthly flow was 1.1 billion m3. For comparison with

dry season flows, the average monthly runoff from December, 1989 to April, 1990 was 122 million m3.

ii. Diama Reservoir.

This dam has several purposes. The dam acts as a saltwater barrier and prevents seawater intrusion into the Delta. With a water storage elevation at 1.5 meters above mean sea level, the dam provides year water for the irrigation of some 42,000 hectares. The dam would be capable of providing enough water to irrigate an additional 100,000 ha if the storage capacity were increased by increasing the storage elevation by 1 meter. The dam also was meant to improve the annual recharge of Lac de Guiers in Senegal and Lac R'Kiz and the Aftout es Sahel depression in Mauritania. Water transfer from Diama into Lac de Guiers averaged from 1000 to 1400 m3/s in June 1989. The volume of the transfer also ranged from 139.6 million m3 to 562.1 million m3 from June to September 1989. This transfer of fresh water to Lac de Guiers assures an adequate supply of municipal water for Dakar.

iii. Canal du Cayor.

The government of Senegal is investigating the possibility of constructing a canal from the Lac de Guiers to Dakar. This canal would help meet Dakar's demand for municipal water through the year 2020 and ensure the development of 8,500 ha for irrigation in two areas located along the canal: the Cap-Vert area from southwest of Thies to Sebikhotane and the Cayor area from Lac de Guiers to Thies.

It is estimated that a daily average discharge to supply Dakar with municipal water will range from 386,880 m3 in 1995 to 922,880 m3 in 2013. Water available for irrigation will increase from 13.60 Mm3 in 1995 to 118.40 Mm3 in 2013. An additional function of the canal would be the recharge of the groundwater aquifer in the Pout area, which forms the upper stratum of the Maestrichtian-Paleocene formation. This function will not be initiated until the municipal water supply and irrigation demands are met.

The final design of this project which is financed by the African Development Bank is expected to begin in June 1990, and be completed at the end of 1991.

c. Conclusion.

This brief review shows that there are great quantities of surface water available in the Senegal River for multipurpose development of the valley, including recharge of the aquifer and transfer of water to the Lac de Guiers and the Ferlo Valley. The quantity of water available at any given time depends on the hydrology of the Faleme and the Bakoye Rivers, but mostly on water released from Manantali dam. The dam is expected to

release the supplemental flow required to reach 300 m3/s at Bakel at full operation. This potential is estimated to be 15 billion m3/yr. A monthly average of 122 million m3 has been recorded at Bakel between December, 1989 and April, 1990.

Possible problem areas and constraints include the hydrology of the Faleme and Bakoye Rivers and Manantali dam watershed, water release management at Manantali, sedimentation of the Manantali reservoir, water losses from evaporation both in the reservoir and downstream of Bakel. These factors can affect the volume of water available to river basin users.

2. The Ferlo River Valley.

Lac de Guiers is one of the sources of fresh water for the city of Dakar. It also supplies water for irrigation in the Ferlo Valley. The flow required by the lake is diverted from Senegal River and stored in the lake. Intermittent transfer of surplus water into the lower Ferlo can also be accomplished by opening the gate at Keur Momar Sarr control structure. The peak flood in the Senegal River can also be impounded in the lake and released into the Ferlo Valley if necessary for irrigation. The monthly water requirement to withdraw from Lac de Guiers to meet Dakar water supply demand amounts to 1.26 million m3.

Rainfall at Linguere has averaged 463 mm per year over the period 1934 to 1988. Yearly rainfall is highly variable, ranging from 190 mm in 1983 to 853 mm in 1936. 98% of rain occurs between June and October with the greatest precipitation in August.

Prior to 1956, the lower valley was frequently flooded during the Senegal River's peak flow. Since the construction of Keur Momar Sarr control gate in the Lac de Guiers, the river valley has been isolated from the lake. After 32 years, the lower Ferlo was flooded for the first time in 1988 by waters flowing from the Senegal River through Lac de Guiers. The volume of water released into the Ferlo was estimated at 48,000 million m3, and the land flooded up to 37 km west of Linguere. This flood was caused by unusually high rainfall in the Fouta Djalon highlands in the upper Senegal River watershed.

The government is concerned about providing the valley with sufficient surface water for its agricultural development. Two alternatives have been considered. Under the first alternative, water would be transferred from the Senegal River into the Ferlo through Lac de Guiers. Alternatively, water could be diverted from the Senegal River into the Ferlo valley at Bakel. The Ministère du Développement Rural et de l'Hydraulique, Direction des Aménagements et des Infrastructures Hydro-Agricoles has prepared the Terms of Reference to perform a feasibility study.

3. The Casamance River.

The Casamance River is formed by the junction of several small streams from Sare Bailo Mali to Ziguinchor. The area has a five-month rainy season, from June to October. Analysis of rainfall data revealed that area has been affected by the last 18 years of drought. This period saw a succession of years with relatively low rainfall. However, rainfall data over longer periods show that average annual rainfall is estimated at about 1400 mm for the period 1924 to 1986 and for the period 1951 to 1980.

Groundwater recharge and streamflow were also affected by the drought. Aquifer recharge in the Kolda area was insignificant. Records from 1935 to 1986 show average annual runoff in the Casamance River to be 129 billion m3 at Kolda, 42 billion m3 at Sare, and 19 billion m3 at Madina Omar (Table 2-3). The same table shows also the monthly distribution of runoff through the year. This distribution provides useful information for planning of irrigated agriculture projects.

TABLE 2-3

Annual average runoff in thousand of m3 for Casamance River and its affluents (1935/1986)

STATION	VOLUME MOYEN MENSUEL ECOULE												VOLUME
	J	Jt.	A	S	O	N	D	J	F	M	A		Moyen annuel
Kolda	387	1161	9933	23607	49020	25929	8385	3999	2838	1935	1161	645	129000
Saré Saré	168	546	3570	7392	18018	7602	1890	1050	756	504	294	210	42000
Madina Omar	6	152	2090	4123	7676	3306	798	361	266	152	57	13	19000

Source; Université Chikh Anta DIOP/ORSTOM
Précipitation et Ecoulements sur le Bassin de la Casamance, par Honoré DACOSTA, Juillet 1989, page 75.

One problem in this watershed is the salinity of the river and its tributaries. Since the Casamance River has such a small slope, tidal surges travel far upstream under ordinary circumstances. When streamflow is particularly low at the end of the dry season, tidal surges travel even farther upstream. Thus salinity is highest at the end of the dry season in May and June and lowest at the end of the rainy season in October and November. In July and August, at the early part of the rainy season, there is an increase in salinity of the water in certain marigots because the salt in the soil dissolves into the water. In order to restore the fertility of the soils affected by salt water, a number of anti-salt dams have been constructed.

a. Guidel anti-salt dam.

Guidel dam is the first anti-salt dam constructed in Senegal. The project was intended to serve as a pilot project to provide some experience for other large development projects involving the reclamation of salinated lands. The dam consists of an earthen dike and concrete control structure. The intrusion of seawater into the reservoir in the dry season, and release in the wet season results in diluting and washing salts from upstream lands. However, by the end of dry season, salt concentrations were again found to be at previous high levels. Experience showed that this was mainly due to evaporation of water. These high salt concentrations prevented traditional rice cultural practices. The development of upstream rice fields was limited by the hyper-salinization of the shallow aquifer. There was no major change on salt content of the shallow aquifer.

The dam never reached its objective. Only 20 ha of land were reclaimed. However, Guidel Dam helped to better understand the management of mangrove lands, and the techniques to use for reclamation of salinated land. The experience also showed that desalinization is a function of rainfall and drainage of shallow aquifer. Guidel's failure explains the many social and implementation problems encountered by SOMIVAC with farmers, including water rights.

b. Djiguinoum/Djilakoun anti-salt dam.

This dam is located in the Djiguinoum Valley northeast of Ziguinchor. ORSTOM and ISRA are conducting research at the site to reclaim the salt and acid land by hydraulically controlled structures. The experimental research conducted by ORSTOM focuses on optimizing management of water, land, monitoring salt and groundwater behavior. It has been shown that the experience gained at this dam allowed better control of salt intrusion and rice submersion; decreased the salinity in the rice fields; increased rice yields; increased control of water levels in the rice fields; allowed better management of reservoir releases

to reclaim the land; and improved monitoring of groundwater table and quality.

c. Affiniam anti-salt dam.

This dam, whose design is very similar to that of the Guidel dam, was intended to reclaim some 12,360 ha of salinated land in the Valley of Bignona. The gates were closed for the first time at the end of the 1987 rainy season. During the first year of its operation an hyper-salinization of the reservoir water, including the shallow aquifer was noticed. However, the impact of this dam on upstream lands is not well known.

d. The Southern Zone Water Management Project.

The Southern Zone Water Management Project (SZWM) is to build anti-salt dams and control structures at ten sites in the lower Casamance. Each system will be constructed only if there is agreement among the villages located within the affected area as to the construction and operation of the facility. The goal of the project is to increase rice and other cereals production by assisting villagers to better manage water and salt intrusion into agricultural land. Also, land unaffected by tidal flows will have increased rice production through improved management of rainfall.

An analysis at each site showed that a shallow aquifer lies in the various deposits of the Continental Terminal. The river drains the aquifer in all of its ramifications. The fresh groundwater flows toward the tributaries over almost all the bank, and the magnitude of the flow will depend on the rainfall intensity. Groundwater quality depends upon its hydraulic flow. Programs to monitor evaporation and groundwater quality and aquifer behavior ensure a better management of both water and anti-salt dams.

ORSTOM is conducting a valuable resource and water management experiment at Djilakoun anti-salt dam. Collaboration with this institution is suggested to share their experience and conclusions, and determine their applicability and connection to other watersheds. Some correlations can be established where appropriate, and adjustment can be made where applicable.

4. Gambia River.

The mean annual rainfall increases from 700 mm in the northern part to 1700 mm in the extreme southern part of the Gambia Basin. This increase is caused by the combined influence of the longer rainy season and of the higher elevation in Highlands.

The principal source of the flow in the Gambia River is its mountain watershed located in the Fouta Djalon in northeast Guinea. High flows extend approximately from June to January, with minimums

most often in May and maximums generally in September. Runoff yields are estimated to be between 1.4 billion m3 and 3 billion m3 per year. This represents a great surface water potential.

Hydroclimatological data in the Gambia River is very irregular, due to the inaccessibility of stations. Data records are less than 20 years in length. This lack of reliable data would pose a major constraint on the proper design of hydraulic structures and irrigation schedules. The tidal reach of the Gambia River extends upstream through the entire 540 km length of the river. The intrusion of salt water upstream in the river is thus another concern, in particular the role the Balingho dam would play if it is constructed.

The Gambia Water Resource Management Project (685-0012) was to provide the Gambia, Guinea, Guinea-Bissao, and Senegal with surface water to generate hydro-electric power and to increase irrigated agricultural production. Five dams were proposed for construction on the Gambia River and its tributaries. These dam sites are at Balingho and Kekreti in Senegal, and at Kouya, Kankakoure, and Kogou Foulbe in Guinea. Figure 2-5 provides an overview of the features of the proposed Gambia River Basin dams and reservoir.

The management of the water resources of the Gambia River Basin involve analysis of a considerable number of various combinations of structures, operating procedures, and nonstructural measures. Two studies of the Basin were prepared by the University of Michigan and Ronco Consulting Corporation. These reports point out a number of resource management problems which would have to be resolved before the construction of the proposed dams could begin.

The basin-wide development program would cause a number of changes and water management problems. Streamflow and annual discharge would be affected and will depend on downstream releases, irrigation withdrawals, return flows, sedimentation, and evaporation. The annual discharge would be reduced due to the presence of the Kekreti reservoir. It is assumed that the streamflows will be reduced.

Another problem is that the baseflow, the minimum discharge that is to be maintained at all times, has not been determined. This flow is very important for fishery survival and other downstream uses. It is a project criteria that must be considered with accuracy. The same problem exists between Kekreti and the Guinea dams.

Another major problem area is the lack of reliable hydroclimatological data for appropriate planning and management of water resources and irrigation. Management of water resources and irrigation scheduling through construction of hydraulic structures

require hydroclimatology input such as rainfall, streamflow, evaporation, sediment, temperature, wind, and humidity. The data must be of sufficient accuracy and length of record. In the Upper Valley watershed in Guinea, rainfall data is especially deficient. Runoff yields give better indications on the contribution of the various watershed. Additionally, the quality, reliability, comparability, and usability of the data which is available is a major concern.

Many of the difficulties encountered in past use of Gambia River Basin models resulted from this lack of reliable data. This is also the case in the attempts made to develop the rainfall simulator model to estimate the runoff rainfall data. If there is to be further consideration of developing these structures, a long-term top priority should be given by Organization pour la Mise en Valeur du Fleuve Gambie (OMVG) to improve the climatological data collection network in general, and in particular for precipitation and evaporation.

5. Catchment storage reservoirs.

Two studies investigated the feasibility of constructing small water storage reservoirs in southern Senegal. One was conducted by a joint venture of Louis Berger International, Inc. and Coyne and Bellier, Consulting Engineers and the second by Technical International General Engineering, Inc. and IL Nuovo Castoro joint venture. The first study examined 132 potential damsites in the Peanut Basin, the Ferlo, Senegal-Oriental, and the Casamance. After examining aerial photography, field reconnaissance, and review, only ten sites in the Peanut Basin and the Casamance were selected for further study (Figure 2-5). In spite of the technical, economic, and hydrological feasibility, two of these sites were eliminated because they risk being flooded if the Kekreti dam (OMVG) were constructed and operational. Each of these selected sites was considered for irrigated agriculture only, since the component groundwater recharge appeared unfeasible due to hydrogeology and geotechnical problems of the storage areas.

The second joint venture screened 81 damsites in the southern regions of Senegal below the 800 mm average annual isohyetal contour in Peanut Basin, the Ferlo, Senegal Oriental, and the Velingara region of the Casamance. Only six sites were selected in the Casamance and Senegal-Oriental for further study for irrigated agriculture.

In the Peanut Basin, four watersheds with runoff potential ranging from 10 to 14 million m3 were identified, while six watersheds with a runoff potential estimated at 53 million m3 in th Upper Casamance. Finally, four watersheds with a total annual runoff potential estimated at 30 million m3 were identified in Senegal Oriental.

The total average annual runoff at these 14 selected sites is estimated to be from 93 to 97 million cubic meters. The regulated surface water potential through construction of small dams would permit the development of 3,404 ha of land for irrigation by pumping. The criteria set for evaluating these dams was based on the hydrology, soil suitability, agronomy, technical, and economic feasibility.

Senegal is a relatively flat country. Suitable sites for construction of small dams are limited, and they can only be identified on certain areas where the topography is appropriate. In these areas, it appears that suitable remaining sites have been identified by these joint ventures. Perhaps future agricultural development will use groundwater aquifers or pump irrigation water from major rivers, if feasible. Construction of anti-dams where appropriate is also another alternative.

a. Problem areas.

The majority of sites selected are located in the valleys or bas-fonds where the streams are intermittent, and no flow occurs during the dry season. Streamflows and annual runoff shown were only estimates, due to lack of data. Rainfall data were available for certain nearby sites or were correlated from different watersheds to determine the runoff. Sedimentation and evaporation data did not always exist. Nor did accurate topographic maps. Therefore, hydrological information reported here should not be accorded a high degree of reliability.

E. WATER CONSERVATION.

This section deals with those techniques which are used to encourage a larger percentage of rainfall to infiltrate into the soil, rather than flow overland to a stream or river. These techniques are generally used in conjunction with agricultural or forestry production although they are sometimes used to protect houses, roads, bridges, or other infrastructure.

Water conservation measures and techniques are used throughout West Africa. Diola rice farmers in Senegal have long controlled precipitation runoff and river water to practice irrigated rice cultivation. Water conservation techniques have recently been introduced in Senegal. Below are several examples.

1. Bougoutouts Project.

Case studies are still very limited in Senegal. However, Bougoutouts Salt Barrier and Water Retention Dam in Lower Casamance can be cited. Dam construction was initiated by the Comit d'Action pour le Dveloppement du Forgny (CADEF), under outside funding, including the USAID. The labor was organized and supplied

by CADEF associations from nearby villages, and the technical support, material, and equipment were provided by CADEF.

The headworks consist of an earthen dam. It includes two concrete and wooden gates to control upstream water level, and to store water for releases in order to flush the fields downstream after the tidal flood recedes. The fresh water stored has reduced some of the risks of agricultural production and allowed an intensification of agriculture which utilizes human energy more efficiently. During the seven months each year when the drainage way is flooded, rice is grown. The reservoir also attracts livestock and wildlife.

The project benefits four villages directly and seven villages indirectly. The increased yields which resulted from the dam, both upstream and downstream, insure that the villages will maintain the structure.

2. Project de Boisement Villageois de Bakel (PROBOVIL).

This project is located in the Fandale Valley of Senegal River Basin near Bakel. It is financed by a joint venture of FAO and Swedish Government. Water conservation and erosion control is accomplished through a combination of several small structures and cultural techniques: check dams, contour levees, and strip-cropping.

A series of small check dams are constructed in the depression of the watershed to slow down the velocity of the runoff. These structures provide temporary or permanent means of (i) trapping and storing sediments from eroding areas; (ii) stabilizing upstream channels by lowering the hydraulic grade line; (iii) reducing velocities; (iv) and reducing long-term stream bed and bank erosion. On sloping areas, surface soils are usually highly erodible. Severe erosion leads to abandonment of fields. Therefore, a combination of water and soil conservation practices was implemented in constructing contour levees or using strip cropping across the sloping areas.

These types of techniques, in particular the contour levees, cannot be applied on areas where the slope is too great. It is therefore expected that on steeper sloping areas, an adverse result will be attained. The type and magnitude of water conservation and soil erosion measures will depend on the area's slope, rainfall intensity, and runoff magnitude. The characteristics of the structure to be implemented will depend on these factors.

The project is implemented by villages under PROBOVIL supervision, but in certain areas, villagers are implementing their own project based on techniques learned from PROBOVIL.

3. The Southern Zone Water Management Project.

The SZWM project is considered by some to be a project which will construct anti-salt dams to reclaim land whose fertility has been reduced by salt deposits. While this is true, it is likely that a much larger area will be treated with water conservation measures to increase rice production on land which never was affected by seawater. Normally, farmers cultivate rainfed rice. Rainwater which does not immediately infiltrate into the soil runs off the field and into the Casamance River or one of its tributaries. The SZWM Project will help the farmers build small contour dikes across their fields so that rainwater will remain on the field. It is expected that these simple techniques will double or even triple yields.

F. GOVERNMENT OF SENEGAL PRIORITY WATER RESOURCES PROJECTS.

In March of 1989 the former Ministry of Hydraulics prepared an important document entitled Rapport Sectoriel sur l'Hydraulique. The document provides information on priority water resources projects for which the government is determined to seek financing. Emphasis is given toward the following areas:

1. Groundwater study and management.

- Preparation of a study of aquifers to better understand their hydraulics and management.
- Structural organization of SONEES to provide this government implementing agency with an autonomous status for better planning and implementation of water supply projects.

2. Water supply for the Region of Dakar.

- Rehabilitation of existing water supply systems, and construction of a new network.
- Final design and construction of Canal du Cayor and appurtenant structures.
- Construction of Diatmet structure for Dakar water supply which will include a pumping station, a water treatment plant and water conveyance system.

3. Rural water supply.

- Extensive groundwater drilling programs for rural water supply.

- Provide the rural areas with water distribution and pumping systems appropriate to the environment, and based on a minimum of 25 l/person/day until 1990. Thereafter, a minimum of 35 liters should be considered. The rural population is estimated at 4,200,000 in 1990, and 5,400,000 in 2005.

4. Operation and maintenance of rural water supply facilities.

- This component is of great concern for the government, because there have been in the past many problems in operating and maintaining these facilities. The constraints are mainly due to lack of equipment, trained personnel and financing to reinforce and intensify these activities.

5. Wastewater and wastewater recycling.

- Rehabilitation of existing wastewater systems, including their reinforcement and intensification in particular for the region of Dakar and cities of more than 5000 habitants.

- Construction of new wastewater network.

- Recycling and re-use of wastewater for vegetable garden and trees planting.

6. Construction of large dams.

- Balingho anti-salt dam and the Kekreti and Kouya dams on the Gambia River.

- OMVS projects for the regulation of Senegal River for navigation between Saint Louis and Kayes in Mali, including the construction of river ports between Saint Louis and Kayes, in particular at Saint Louis.

7. Other Projects.

- Creating institutions for planning, management, and implementation of water resources projects.

- Strategic planning for establishment and financial participation of private sector in water resources development projects.

A complete list of the above including the financing required to implement the project is provided in the March, 1990 Plan Directeur Sectoriel de l'Hydraulique.

G. SENEGAL WATER CODE (Law No 81-13 of March 4, 1981).

Annex 6 provides some extracts from the Code with regard to ground and surface water development and management. This Code is considered by the government as a preliminary measure until a more elaborate Code is drafted. The Code, in its article 75, specifies that the priority for utilization of water resources remains the supply of water for the population. Only after human water needs have been met shall priority be given to other uses, such as for agricultural development. The extent to which both ground and surface water can be developed is not clear. However, the Code appears not to prohibit development of water resources for irrigation (Articles 9, 30, 33, 40 and 41) provided that an authorization is requested from the responsible Ministry.

CHAPTER 3

SOIL RESOURCES

A. OVERVIEW.

Soil resources management problems in Senegal include:

- Chronic degradation and wind erosion on upland soils.
- Acidification of upland soils.
- The preference of farmers for extensive farming.
- The lack of economic stimulants for good management.

Peanut Basin.
- Soils are degraded and vulnerable to wind.
- Soils are never regenerated.
- Soil fertility has declined.
- Breakdown in structure of heavy soils of Sine-Saloum.

Senegal-Oriental.
- Extensive, poor, shallow upland soils on lateritic pans.
- Southeastern soils vulnerable to water erosion when bare.

Ferlo.
- Boreholes, passages between Senegal River Valley irrigation projects, and the strip of land which borders the Senegal River Valley are examples of areas where grazing and trampling of ground cover are acute.
- Areas susceptible to water erosion.

SRV.
- Salinization of heavy, poorly drained soils, below Bohge.
- Alkalinity problems in the Upper Senegal River Valley.
- Threat in the form of drainage water and chemicals.

Niayes.
- Dunes threaten truck gardens and roads.
- Soil and wells becoming saline.
- Vegetation on the dunes rarer.
- Low lying areas are recently covered with sand.

Casamance.
- Acidification of low-lying, containing sulfides.
- Water erosion.
- Erosion of shallow soils on lateritic hardpans.
- Chronic salinization of rice soils.

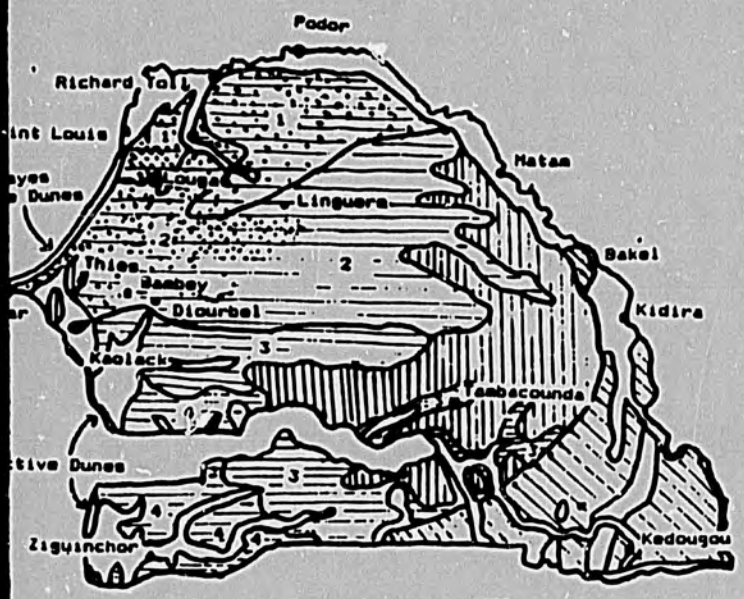
Claude Charreau, a soil physicist who worked for many years in Senegal described the harshness of the climate and then contrasts a pessimistic and an optimistic approach to soil management (Chareau, 1974):

> "The climate is harsh and the risks of erosion are high, especially on sloping land. The soils are said to have poor structure and to be infertile. Shifting or half-shifting cultivation involving fields periodically left to volunteer weeds are common practices.
>
> "Agronomists, themselves, believed for a long time that the potentiality of these regions is low and that it is necessary to cut the productive cycles by long resting periods to restore the soil. In this context, the possible cropping alternatives seemed limited, and the modifications they proposed did not really change the traditional systems of cropping.
>
> "But now, some agronomists (including myself), relying upon a series of experimental observations, consider that the potentialities of this zone were greatly underrated and that a settled, permanent and intensive cultivation is possible. We believe that a drastic change in the traditional systems can bring levels of production unknown before...."

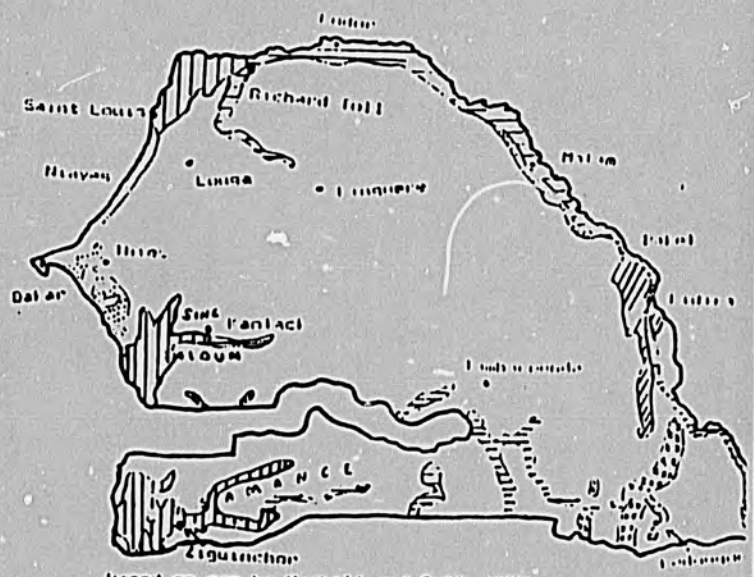
For Charreau there is an approach to soil resource management which proposes to stay as close to traditional systems as possible and an approach which proposes drastic change. The latter approach includes the use of animal traction, chemical fertilizers, and pesticides. This traditional systems vs drastic change debate among agronomists in Senegal pre-dates the current dry climatic cycle. Both Charreau (1974) and Sivakumar (1989) make the point that it is the climate which is the most serious problem for soil resource management in the Sudano-Sahelian climatic zone. The last twenty years have been especially severe. But extended drought is not a new phenomenon in this region.

While Charreau (1974) says that a doubling of yields is possible north of the 750 mm isohyet, it is clear that optimism for continuous, intensive agriculture is centered south of this isohyet. ISRA scientists consider the 400 mm isohyet to be the northern limit of acceptable risk for producing drought tolerant crops such as peanuts and millet (Magnuson, et al, 1985). For cropping, the erratic nature of the rainfall is more of a problem than the total amount of rainfall in a growing season. Equally important characteristics of Senegal's climate are that it is always hot and that the entire country has a long, dry season.

groups of soils will be differentiated on the basis of their most common positions on the landscape and will be identified as upland soils and lowland soils (Figure 3-1).



Based on map by Michell and Sall, 1980.



Based on map by Michell and Sall, 1980.

Stable Dunes

1. Sols bruns et bruns-rouge
2. Sols ferrugineux non lessive
3. Sols ferrugineux lessive
4. Sols ferrallitiques rouges

Soils 1 - 4 are similar in their management requirements but they are differentiated on the basis of weathering with 4 being the most weathered. These soils are all characterized by a sandy surface layer.

Shallow and stony soils on lateritic pans.

Stony, weathered soils on slopes, hills and isolated minor mountains.

LEGEND

Sand, Silt, Evaporation [illegible] Mangroves, Saline Soil

Alluvial soils, Sand, Silt [illegible]

Calcareous soils and [illegible] on [illegible] plains

Vertisols on clay plains.

Hamitic, Brown red [illegible] soil and Vertisol.

FIGURE 3-1. Uplands and lowlands soils of Senegal.

physical characteristics of the soil. Consequently they never became severely degraded. Also, because of the vegetative cover, the soils were not vulnerable to wind erosion.

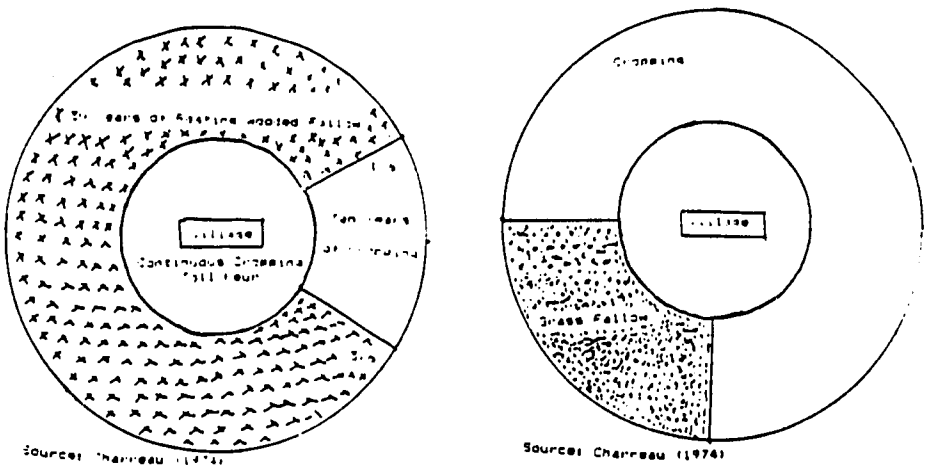


Figure 3-2. The traditional wooded fallow soil management system and the grass fallow soil management system.

Continuous cropping was practiced on land in the immediate vicinity of the village. This land was called the toll keur and was used to produce short season crops which were used for food immediately before major crops were harvested from fields further from the village. Household refuse and animal manures were used to maintain soil fertility under continuous cropping in the toll keur. Animals grazed on the fallow ground during the day and were kept in the village or on toll keur at night. Sandford (1989) refers to this process as the "internal transport" of plant nutrients by livestock. The effect was to import plant nutrients from fallow land to the village and toll keur. The wooded fallow not only protected and regenerated outlying fields, it was also a major source of plant nutrients for the toll keur.

By the early 70's, when Charreau wrote, the fallow system had degenerated to a short term grass fallow rather than a long term bush or wooded fallow. The grass fallow left most of the land unprotected most of the time and was not effective for recycling nutrients from deep soil horizons. Also, it did not have the vigorous root systems required to improve the physical characteristics of sandy soil (Charreau, 1974). Finally, grazing land for livestock was becoming constricted. Sandford (1989) calculates that each cow requires from 2 to 48 hectares of range.

Time requirements for generating various fallows are given in Figure 3-3. Fallowing is no longer playing any significant role in maintaining the fertility of fields. Continuous cultivation of

all land is the current soil management system in the Peanut Basin. Only incidental fallows occur when labor or capital is limiting (Seyler, 1990, per comm).

Soils Figure 7: Changes in Natural Vegetation with Time (Charreau 1974).

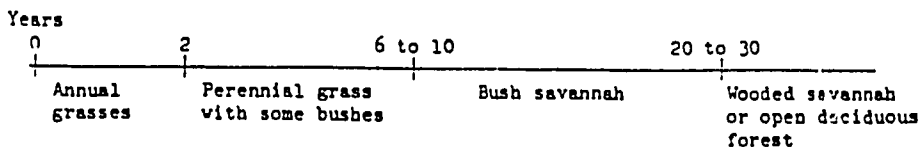


Figure 3-3. Changes in natural vegetation with time. Chareau, 1974.

With the collapse of the wooded fallow soil management system, Peanut Basin soils have become degraded and vulnerable to wind erosion. But, in spite of its problems, the Peanut Basin is neither stagnant nor contracting. Rather, as Lericollais (1980) points out, the Peanut Basin is expanding. Pelissier (1979) describes the economic incentive for peasant farmers in Senegal to practice extensive rather than intensive agriculture.

Lericollais (1990, per comm) made a study of three Serer villages in the Peanut Basin. The first part of the study was done from 1965 to 1968 and the second part from 1985 to 1988. After thirty years of continuous cropping it was found that there had not been any decline in yields. In the 1980's, farmers were using shorter season varieties to compensate for the drier weather and animal traction to do a better job with planting and cultivating. And they were maintaining their yields on a per unit area basis.

Rodale (1989) presents data which shows that there was not any significant long term decline in yields per unit area for millet, sorghum, or peanuts from 1960 through 1988 at three locations in the Peanut Basin: Louga, Diourbel and Sine-Saloum.

That is, when the wooded fallow soil management system collapsed, the soils degraded quickly to a new equilibrium under continuous cropping. Production levels at the new equilibrium have been steady for years. With continuous cropping, the soils are

never regenerated and they are not protected from the chronic, incremental effects of wind erosion. The economic link in the wooded fallow system between the maintenance of soil fertility and protection of the soil from wind erosion has been lost.

The loss of the economic link between crop yields and soil conservation is the fundamental soil resource management problem in the Peanut Basin. The sandy, upland soils of the Peanut Basin are resilient but, because of the harsh climate, they are not responsive to management. Consequently, low yields are easily maintained and improved yields are hard to achieve.

In order to understand the soil resource management problems of the Peanut Basin, it is important to understand exactly what was lost and what remains in the wake of the collapse of the wooded fallow soil management system. Charreau (1974) again provides necessary information.

Clearing of a wooded fallow started by girdling trees one year and then, in subsequent years, burning the bush. Trees would not actually fall for several years. Litter and stumps were scattered throughout the field for years after cropping was initiated. Whatever could be burned each year provided nutrients for that year's crops. The remaining heavy litter protected the soil during the subsequent dry season. Because the wooded fallow produced extensive, large roots as well as large, woody surface materials it took a number of crop years to extract the nutrients accumulated by the wooded fallow.

This system was minimally disruptive to the soil and thus preserved subsurface soil and roots which had developed during the wooded fallow. But it did include extensive, hot burning. (As compared to the limited, smoldering burning which is now practiced on fields.) This burning would have destroyed all organic matter in the surface soil. This organic matter served to provide nutrients to the crop but it did not contribute to improved soil structure.

The structureless sandy soils of the Peanut Basin are said to be resilient. Their being degraded consists primarily in the loss of the nutrients contributed by organic matter. They are low fertility soils but, given a minimum of nutrients and tillage, they will produce crops. This can be accomplished without protecting the soil from wind erosion.

Comments about the seriousness of the breakdown of soil structure are common in documents discussing soil resource management in the Peanut Basin (Magnuson, et al, 1985; Rodale, 1989). But as Charreau (1974) points out the sandy, upland soils of the Peanut Basin are structureless. And as ILACO (1985) shows, coarse, sandy textured soils do not suffer serious ill effects from being structureless.

The wooded fallow did improve water infiltration. But not by improving soil structure. Litter which remained scattered on the ground protected the soil from wind erosion and held rainwater on the soil. The ongoing decompositon of woody roots provided channels for good percolation of water and kept the soil loose and open for good crop root penetration (Charreau, 1974). Fryrear (1989) showed that a 30% soil cover reduced wind erosion by 80%. Chase and Boudouresque (1989) showed that a tree branch mulch on a crusted soil reduced runoff to about 1/5th of what it was without the mulch on both crusted and sandy soils. Also, they showed that a tree branch mulch was about twice as effective as tillage for improving water infiltration into the soil.

Charreau (1974) and Rodale (1989) both discuss the importance of organic matter for retaining moisture in the soil. But as Charreau points out, this is a surface phenomenon and therefore has little effect on the total moisture retention capacity of a sandy soil.

The wooded fallow regenerated soil fertility, protected the soil from wind erosion, and improved water infiltration. Its contribution to soil fertility and its protection against wind erosion would have been important throughout the Peanut Basin. Its importance for improved water infiltration would have increased in areas of the Peanut Basin where soils tend to be heavier, e.g. Sine Saloum.

Most of the Peanut Basin soils are sandy. But comparatively small changes in their clay content can have an important impact on their management. Tabor (1990, per comm) found that peanuts were not generally planted on soils with clay contents higher than 9%. Charreau concludes from his studies that there is an important transition point at 18% clay content. Below that point the roots of plants are not effective in improving soil structure. Consequently, deep tillage is more important in the management of these soils.

Freeman (1983) presents statistics from the <u>VI Plan Quadriennal</u> which show that 290,000 hectares or 25% of arable ground is not utilized in Sine Saloum. These soils tend to be higher in clay content and would have suffered more severe structure and water infiltration problems as a result of the collapse of the wooded fallow. In Louga 110,000 hectares or 22% of the tillable ground is not utilized. Louga is actually in the Silvo-Pastoral zone. The current dry cycle explains the non-utilization of tillable ground there. In Diourbel 40,000 ha or 11% of the tillable ground is not farmed. In Thies 10,000 ha or 3% of tillable ground is not cultivated. In Diourbel and Thies where soils are sandy and rainfall is sufficient most of the tillable ground is farmed.

Magnuson, et al, (1985) state, "The estimate of 290,000 hectares of vacant but arable land in the central and southern Peanut Basin is simply inexplicable in view of the common consensus that the crucial problem of the Peanut Basin is the obvious decline in soil fertility over time to the point where cropland is going permanently out of production through infertility and breakdown in soil structure. Aside from certain areas of eastern Sine Saloum that are well north of the Gambia River and its tributaries, there appears to be no vacant but arable land in the area."

In the current context the preceding conclusion that most of this 290,000 hectares is not tillable is correct. Greater care must be taken with the generalizations used to arrive at the conclusion. As Sivakumar (1989) stated, there is "an urgent need to develop new technologies that make the most efficient use of the limited climatic and soil resources." This implies a careful attention to the characteristics of the climatic and soil resources.

There is a common consensus that soil fertility has declined. While a breakdown in soil structure may be part of the problem on the heavier soils of Sine Saloum, it is not part of the "crucial problem of the peanut basin" in general. The crucial problem for soil resource management in the Peanut Basin is the lack of an economic link between protecting or conserving soils and improving yields on these soils. Both Pelissier (1979) and Freeman (1983) make the point that it is in the farmers economic interest to farm extensively on low yield potential ground rather than to intensify cultural practices on less land.

With continuous cropping now being the norm in the Peanut Basin, toll keur soil management practices are being extended to outlying fields. The toll keur were cropped continually. They were fertilized by organic manures. And, they were not burned.

According to Lericollais (1990, per comm), traditional farmers are now using animal manures on outlying fields and household refuse on the toll keur. This is an attempt to deal with the soil fertility problem on an annual basis. Freeman (1983) and Rodale (1989) show that there are not enough animals in the Peanut Basin to provide the necessary manure to maintain fertility on Peanut Basin soils. Consequently, the Rodale project is experimenting with composting and will consider the judicious use of chemical fertilizers to achieve vigorous crop growth.

It is unlikely that the use of animal manures on an extensive basis will increase soil organic matter in the Peanut Basin. High temperatures and low moisture do not favor the accumulation of soil organic matter (Jenny, 1941; Jenny, et al, 1949). Also, the quality of manure as a source of plant nutrients is determined by the quality of feed an animal is eating (Jewitt and Barlow, 1949).

Consequently, the animals of the Peanut Basin which are eating poor quality feeds are producing poor quality manures.

Including chemical fertilizers in a composting program to enhance the efficacy of composting and nutrient application is one option suggested. An important, ongoing source of plant nutrients was lost with the collapse of the wooded fallow system. It is difficult to see how this loss can be compensated for without the use of some chemical fertilizers.

On the other hand, Seyler (1990, per comm), working in the Thies region, has observed an increase in protecting of Acacia albida seedlings since fertilizer subsidies were discontinued. Apparently the suspension of fertilizer subsidies has established an economic link between crop yields and the establishment of trees which have a positive effect on soil conservation. This is a form of agroforestry. Other forms of agroforestry such as alley cropping may also be adapted to the higher rainfall regions of the Peanut Basin. ISRA is currently conducting experiments on alley cropping. These options require long periods of time for testing and establishment.

Freeman (1983) writes about the importance of "stimulants" to intensify production while acknowledging that such a process is "contre-nature" for traditional farmers. He also points out that Dakar markets are a potential ally for improving soil management in the Peanut Basin. What he advocates is a diversified toll keur which includes trees which, depending on their density, would have a greater or lesser effect on conserving and protecting the soil. He recognizes the need for strong economic incentives to accomplish this goal.

The work by Chase and Boudouresque (1989) and Fryrear (1989) cited previously strongly implies that just leaving crop residues on the ground would greatly reduce soil erosion and increase water infiltration. But as Magnuson, et al (1985) point out there is a very strong economic incentive in the Peanut Basin to use crop residues for forage.

The soil resource management problems of the Peanut Basin are difficult to address because they are a part of a complex equilibrium which is difficult to change. The importance of seeking solutions for these difficult problems is a function of the importance of the Peanut Basin to Senegal. Speaking of a greater Peanut Basin without defining its borders precisely, SODEVA (1983) gives the following statistics for this region: 50% of Senegal's total population; 65% of Senegal's rural population; 82% of Senegal's annual peanut production; 67% of Senegal's cereal production; 33% of the total area of Senegal; 64% of Senegal's tillable ground; 75% of Senegal's tilled ground; and 53% of Senegal's coastline.

1. Senegal-Oriental.

Magnuson, et al (1985) describe Eastern Senegal as "Less densely populated and wetter than the Peanut Basin." The Upland Soils of Senegal shows Eastern Senegal to be dominated by "shallow and stony soils on lateritic pans." Magnuson, et al (1985) give the following description of the area:

> "...Soil maps of the area clearly show that existing pockets of moderately good soils lie for the most part in thin ribbons along watercourses, surrounded by low ridges, capped by lateritic crusts (Bertrand 1979). The ridges are useless for agriculture and serve to break up the land sufficiently to make transport difficult. In addition, land that now appears to be vacant in the area north of Tambacounda is reported by residents to be so not because it is virgin, unoccupied soil but because local farmers have already abandoned the area after exhausting its limited soil fertility over the past two decades. Finally, both SODEFITEX and OFADEC officials have expressed doubts as to the availability of any large land areas for development as irrigated perimeters and pointed to the area around Kedougou as the only place where significant expansion in dryland cropping might take place, given the development of necessary infrastructure and the installation of adequate technical and social services in the area.
>
> "A 1982 study financed by the French government described Senegal Oriental as "appearing in effect as an immense table of hardpan, notched by a fossilized hydrographic system. The latter is a network of valley bottom-lands, where the bulk of arable land is located." (Benhamou 1982, 16). The attraction of these bottomlands in the Kedougou Department is becoming apparent. Its current study of the Gambia River basin, conducted a survey in the impact zone of the proposed Kekreti dam, which is located 75 km west of Kedougou. The survey revealed there had been a large increase in migration into the area over the past 25 years. Villagers from more densely populated areas elsewhere in Senegal-Oriental have been abandoning upland fields because of soil exhaustion and lack of rainfall. In fact, 'farmers will often cross a considerable area of empty land to establish farm hamlets or fields directly in river valley areas, avoiding in particular plateau lands....' (West 1984, 42). The latter tend to consist of hard laterite pan covered by thin infertile soil while the bottomlands have deep deposits of alluvial soil, are relatively flat and are rock-free."

Barretto (1990, per comm) pointed out that because of sloping and hilly land combined with high rainfall, the southeastern part of Eastern Sengal is vulnerable to water erosion if the ground is left bare. Charreau (1974) shows that when forest ground cover is

removed, water erosion can be increased anywhere from 20 to 100 times of what it would be under the forest cover.

In its agricultural regions Eastern Senegal shares many of the characteristics of the Peanut Basin except that the soil management problems in Eastern Senegal are not as severe as those of the Peanut Basin because population pressure has not been as intense as it has been in the Peanut Basin. Bush fallows of up to five years are still practiced and the population pressure which resulted from the new lands policy was concentrated in the Tambacounda region which has 800 mm of rainfall (P.B. Bathily, 1990, per comm).

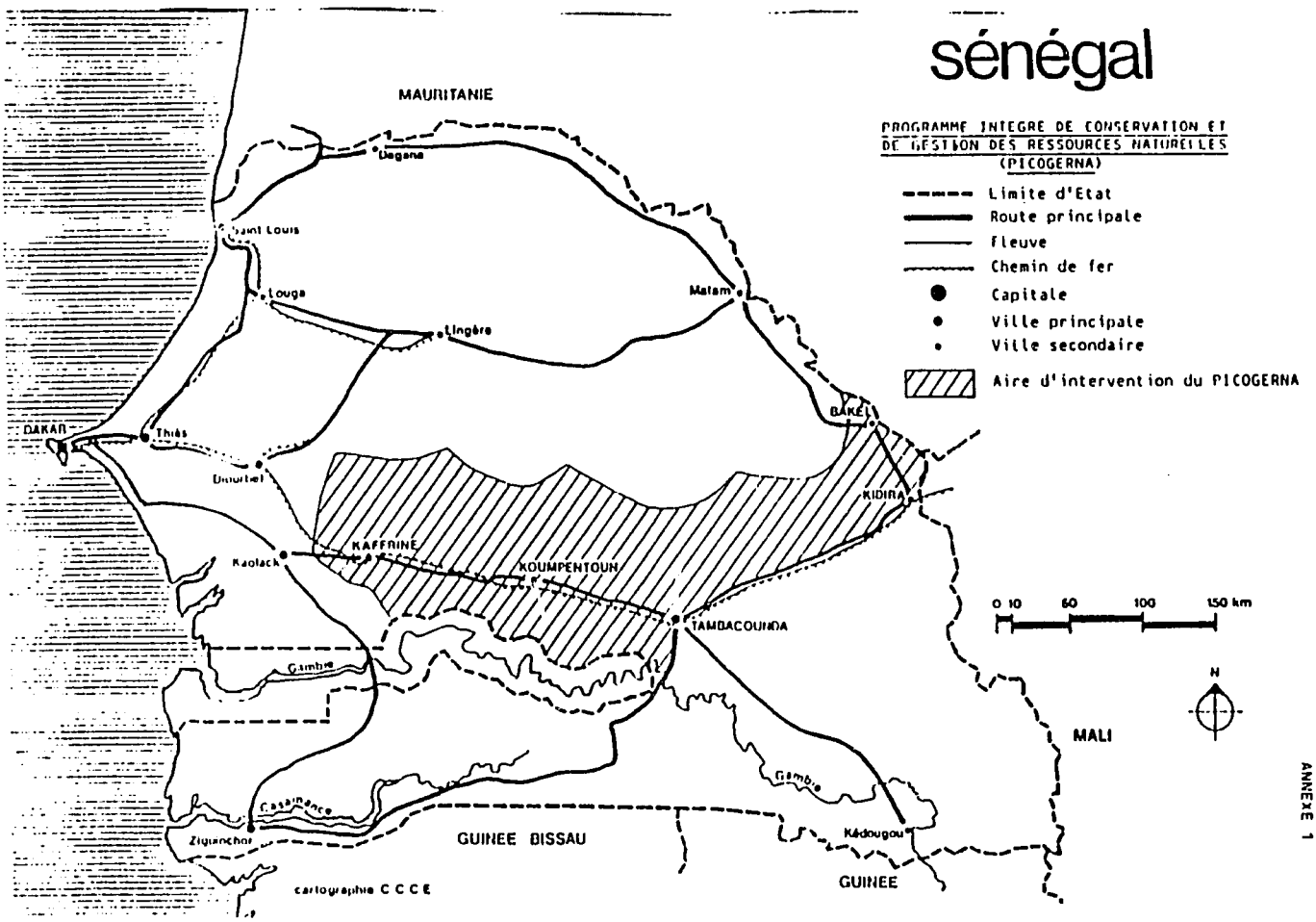
In general though the agricultural region of Eastern Senegal enjoys major soil resource management advantages over the Peanut Basin. More responsive crops such as maize and cotton are grown and subsidized inputs are available for cotton. Most villages still have significant extents of available range so that cattle numbers per farmer are favorable. Consequently there is sufficient internal transport of nutrients by cattle to maintain village farms (P.B. Bathily, 1990, per comm).

Eastern Senegal has agriculture which is similar to that of the Peanut Basin but with major advantages. Rainfall is higher. Responsive crops such as maize can be grown. Cotton can be used in a rotation to put subsidized chemical nutrients into the soil. The shallow, non-tillable ground assures the availability of extensive range for cattle and a corresponding potential for internal transport of nutrients to fields. Peanut hay and cotton seed are available for fattening cattle and generating nutrient rich manures.

A project designed to exploit these characteristics of Eastern Senegal is about to be implemented. It combines the PARCE and PDESO projects into Programme integr de conservation et de gestion des ressources naturelles au Sngal (PICOGERNA). Seck and Vincke (1990, per comm) point out that PICOGERNA will be the only implementation project in Senegal which will have an interministerial component, involving both the Ministre du Dveloppement Rural et de l'Hydrologie and the Ministre des Resources Animales. The interministerial component of PICOGERNA is designed to facilitate dealing with problems of maintaining vegetative cover and conserving soil and water.

The territory covered by the PICOGERNA project includes the southeastern Peanut Basin and the northern part of Eastern Senegal. As such it provides a favorable combination of soil, vegetative cover, and climatic characteristics for testing interventions which may eventually have widespread application in the Peanut Basin.

Soils Figure 9. Area of Intervention of the PICOGERNA Project.



Source: PICOGERNA conference materials, 1989.

Figure 3-4 Area of Intervention of the PICOGERNA Project.

The problem of forging an economic link between cropping practices and protecting the soil exists here just as it does in the Peanut Basin. One of Pelissier's (1979) major examples of the village farmer's preference for extensive, low-yield agriculture comes from Eastern Senegal. Farmers moving from the Peanut Basin to Senegal Oriental preferred to farm large areas extensively rather than small areas intensively. They rejected techniques which would intensify and increase returns per unit area and chose those techniques which would increase returns per unit labor.

2. The Ferlo.

The Silvo-Pastoral Zone integrates with the dry fringes of the Peanut Basin and Eastern Senegal. Peanuts would be an important crop in the southern part of this zone. But the characteristic cropping of this region is some limited rainy season millet where soils are suitable. Otherwise this region is too dry for crop production. Consequently it is used for grazing.

Poor management of rangeland has often been the cause of soil resource management problems. Because of the limitations on production options, the soil resource management problems of the Silvo-Pastoral zone are the problems of vegetative cover management which in turn is a function of livestock management. Livestock management, by its impact on vegetative cover, is the most important influence on soil resource management in the Silvo-Pastoral zone.

Boreholes, passages between Senegal River Valley irrigation projects, and the strip of land which borders the Senegal River Valley are examples of areas where grazing and trampling of ground cover are acute. Because of the dry climate and heavy grazing, the ground will often be bare when heavy early rains arrive. Consequently, there are areas in the Silvo-Pastoral zone, such as Bakel, which have problems with water erosion. Finally, the dunes which threaten roads and the Niayes are a problem of the Silvo-Pastoral zone.

The Projet Zone Nord (GTZ) is a long-term project which is making a major effort to study and remedy the problem of desertification in the Silvo-Pastoral zone. Its work includes ranching, cropping, and forestry. Perennial vegetation is being established in fields by regeneration of natural growth and by planting Acacia senegal. The latter tree is being tested because of the revenue which can be generated by the sale of gum arabic. It is an attempt to forge an economic link between farming and soil conservation.

The Project Zone Nord has been in place for 15 years and has done thorough but inconclusive work at very high cost. The work being done represents the long-term, determined effort which is

required if progress is going to be made in protecting the Silvo-Pastoral zone soil resources of Senegal. Seck and Vincke (1990, per comm) estimate that extreme pressure from the development of the Senegal River Valley will be brought to bear on the soil resources of the Silvo-Pastoral zone in about 20 to 25 years. Given the time required to work on solutions to the problems of desertification, this does not represent a generous time frame.

The effect of the development of the Senegal River Valley on the Silvo-Pastoral zone is a crucial question for this zone. In fact the Cellule Aprs Barrages is concerned with much of the Silvo-Pastoral zone as well as the Senegal River Valley because its area of interest includes the Senegal River Basin below Bakel, including the Ferlo River Valley (see watershed map in Chapter 2). There is the possibility of a river valley-range relationship which could benefit soil resources in both the Silvo-Pastoral zone and the Senegal River Valley. The Cellules Aprs Barrages is advocating an agro-sylvo-pastoral approach to achieving this goal (Ka, 1989; Seck and Vincke, 1990, per comm).

3. The Senegal River Valley.

The Senegal River Valley has the best soil resources in Senegal. It also has the only reliable year round water for agriculture in Senegal. The soils in the Senegal River Valley do not have high yield potential on a per unit area per season basis. But they have a very high yield potential on a per unit area per year basis.

Heavy soils below Bohge, Mauritania are vulnerable to salinity problems. Loyer (1989) and Tabor (1990, per comm) report alkalinity problems in the Upper Senegal River Valley. The development of high performance agriculture will make the Senegal River Valley the first region in Senegal which sees agriculture become a serious threat, in the form of drainage water and chemicals, to water resources (Euroconsult and RIN, 1990).

Indirectly, high-tech irrigation, in the form of very large irrigation projects, is threatening soil resources. Large projects are less likely to exclude poorer soils. Large projects are more cumbersome to manage and thus are less likely to practice good drainage. Large projects are also more likely to have access to inputs which can cause problems for the environment if they are not utilized properly.

There are three soil management practices which are currently important in the Senegal River Valley. Millet production on dunes, irrigation on heavy clay soils, and recession agriculture also on heavy clay soils. With completion of the Manantali Dam, current plans are to develop irrigated agriculture. Millet production is rainfed and needs the sandy soil which can absorb torrential rainfall quickly. This is part of the agricultural and grazing

activity which puts pressure on the Silvo-Pastoral Zone in the immediate proximity of the River. Further development of the Senegal River Valley will increase pressure on this land.

Irrigated agriculture is best practiced on soils which have a good balance between an ability to absorb water and an ability to hold water. Most of the soils of the Senegal River Valley are too heavy to be considered excellent irrigation soils. This is one of the reasons why rice is being promoted as the major irrigated crop in the Senegal River Valley.

Recession agriculture requires very heavy soils because the soil must be able to hold enough water from one saturation to bring a 150-day sorghum crop to maturity. Recession agriculture is extensive and low return but it is not hard on soils. The idea of developing recession agriculture is now receiving some favorable attention.

While the potential of irrigatated rice is high, it is seldom attained, especially during the winter cropping season. In fact, rice paddies often lie idle during the winter growing season. Nuttal (1989) describes a process whereby farmers will migrate from new perimeter to new perimeter in order to take advantage of the economic conditions prevailing at the initiation of an irrigated rice perimeter. Apparently, even if the development of the perimeter is considered a sunk cost, growing rice has economic problems which are neutralized in the early years of a new perimeter when capital is being mined, and some subsidies are in place. When maintenance and upkeep costs go up and subsidies go down the utilization of the perimeter declines. Often to the point of complete abandonment.

This brings into question the classification of the soils of the Senegal River Valley by SEDAGRI (1973). SEDAGRI classified land which was to be planted to orchards and vegetables as class 1 land. Land which was to be used for rice production was classified as 1R land. However, the irrigated crop with the highest return which can be grown extensively without danger of saturating markets is rice--which is not a high-value crop. Hence, farmers will not plant fruit trees or vegetables. Consequently, there is no practical distinction between the Class 1 and the Class 1R classifications of soils on the floodplain of the Senegal River. One of the consequences of this has been an excessively optimistic impression of the potential of this land to respond to investment and management. If land classification had been used to integrate technical, economic and social data, the result would have been a more accurate description of the potential of the floodplain for irrigation development.

According to Lericollais (1990, per comm), by the late 70's many SAED offices had copies of the <u>Cartes des aptitudes des terres</u>...which had been reworked by hand to make the class 1 soils

into class 1R soils. Seck and Vincke (1990, per comm) said that SEDAGRI has recently been awarded a contract to make a new map of the Senegal River Valley.

The Senegal River Valley is the focus of activity for the Cellule Aprs Barrages. It plans to encourage the integration of a variety of agricultural pursuits with a view toward protecting soil, water, vegetative, and fishery resources (Ka, 1989; Seck and Vincke, 1990, per comm).

ISRA (1986) is showing an interest in developing the flexibility which water development offers. Maize is discussed. Animal production includes forage crops. These crops have extremely high production potential in the arid tropics with irrigation. Also, forage crops will benefit the heavy valley soils in a rotation. ISRA (1986) sets the following research priorities for its Senegal River Valley work:

- Priority 1: Double cropping of rice on Fonde and Hollalde soils; water management and conservation; mechanization; animal production.
- Priority 2: Fruit trees, forestry, and fish.
- Priority 3: Sprinkler irrigation of the dieri (Dune millet.); Recession and rainfed agriculture.

USAID has two projects which relate to the Senegal River Valley. The Irrigation and Water Management I project (USAID 605-0280) is a small scale irrigation project. This is proving to be the most viable size of irrigation project in the Senegal River Valley. The Bakel region does not have any serious soil resource problems in connection with irrigated agriculture. Consequently, this is strictly a production project and does not solve or cause any threats to soil resources.

The Senegal Agricultural Research II project (USAID 685-0957) was to strengthen agricultural research in the Senegal River Valley. In actual practice the project has been concerned with macro-economic work and some general strengthening of ISRA but not of the targeted station in the Senegal River Valley. Some work on cowpeas and millet has also been supported. Currently field research on field use of Acacia albida by farmers is being conducted. This latter effort would be the most relevant to soil resource management.

4. The Niayes.

Between Dakar and Saint-Louis, a thin strip of land along the coast is dominated by dunes interlaced with Niayes. The Niayes represent a unique convergence of good soil, shallow water, and a maritime climate which makes them ideal for vegetable production. Although of limited extent they are producing good quality, high value crops. The soils are comparatively heavy and are irrigated by hand from shallow wells.

The Niayes are located between dunes immediately adjacent to the Atlantic Ocean. Dune stabilization is important primarily because of the threat which the dunes pose to truck gardens and roads. Salinization is the other major soil resource management problem in the Niayes.

The Niayes are an example of an intensified agriculture which is vigorous and expanding because of the economic incentive provided by truck gardening.

Magnuson, et al. (1985) gives an excellent description of the Niayes.

> "...The soil is composed of grey or black sand rich in humus and organic matter. Regular flooding, caused by the aquifer overflowing during the rainy season, has enhanced the richness of the soil over time...
>
> "In comparison to the ground-nut basin immediately to the East, the Niayes have a three dimensional exploitation: maritime fishing, market-gardening during the dry season and peanut cultivation in fields of dioritic soil. This last sector has experienced a serious decline during recent years, however....
>
> "Animal husbandry is the final activity of the primary sector. The presence of large herds belonging to Peuls and Wolofs is explained by the rich grazing areas in the semi-stable and stable dunes, and by the numerous water holes providing water for the cattle. The whole region is characterized by a very strong association of agriculture and cattle-raising, as can be seen in the rural landscape, the presence of live hedges around every field, and by the general use of animal manure in the market gardens.
>
> "There is also some arboriculture (mango and coconut trees) bordering the gardens and contributing modestly to the diversity of the Niayes' economy...
>
> "...the Niayes possess large quantities of peat for which several uses are planned. Depending on the method of

extraction adapted, peat extraction may or may not be detrimental to market-gardening. The proposed exploitation of 50 million cubic meters could cost up to 240 billion FCFA....

"...The North Ndiuki appeared later, as if in response to the drying up of the Niayes, which for the last ten years have experienced little flooding and all the metamorphoses attached to desertification: salt rising to the surface causing the soil and wells to become saline, vegetation on the dunes rarer, and low lying areas are recently covered with sand. Surprisingly, the Ndiuki, only a small distance away, are protected from salinization by a pocket of soft water near the surface which reaches a depth of betweeen 2 and 6 meters. However, a modification in the system of extraction (motorization) could provoke the salinization of this water."

5. The Casamance.

The Flooded Rice/Salt Dam soil management system is unique to the Casamance. Other areas cultivate rice and other areas have salinity problems but this particular combination of soil management practices is identified with Casamance.

The important characteristics of the soil management in this system are that rice is produced by paddy methods but it is not irrigated. Rather it is flooded by means of confining rainfall and controlling surface flow of runoff water. Rice production soils are subject to dry season salt water intrusion.

Because of high levels of sulfides in the soils which are low on the landscape, they are vulnerable to severe acidification if they are subjected to prolonged drying.

Since rice production depends on an annual flushing of salts from soils where the sea has intruded, if rainfall is insufficient the process will be inadequately affected and rice production correspondingly reduced. This is a weather dependent threat to the soils, not a perennial threat such as that found in the Senegal River Valley where salinity is a function of the characteristics of the soils.

Because of the current dry cycle the flow of fresh water through rice producing areas has been reduced. The ability to control the flow of fresh water off of these soils and the flow of salt water onto these soils represents an improvement over depending on rainfall and runoff to provide these services. Given this capability, traditonal knowledge of soil management practices can be used to boost yields and achieve significant returns quickly. In the process, vulnerable soil resources are saved from severe degradation by salinization and acidification.

Peasant farmers have traditionally used salt-dams to enhance rice production. But low rainfall conditions which have prevailed over the past two decades have in many cases made traditional methods of water control inadequate. A potential danger of anti-salt dams is that soil which is vulnerable to acidification may be allowed to dry and oxidize. The result is severe acidification which occurs immediately when the soils are dry. Extensive former mangrove swamps have been severely acidified in this manner. While it is anticipated that approximately 40 years of continuous flooding will be required to reclaim these soils, the reclamation process has now been in progress for 15 years and progress is limited to very slight recolonization by mangrove (Barretto, 1990, per comm; Seck and Vincke, 1990, per comm).

Another major problem in Casamance is water erosion. The "plateau" soils of lower and middle Casamance are deep oxisols. As a result of the problems with the lowland rice soils utilization of upland soils has increased (Magnuson, et al, 1985). When they are cleared these soils are very vulnerable to erosion. Charreau (1974) considers the threat of water erosion extreme on soils with slopes of 3% or more. However, since these soils are deep, they can still be farmed after an occurance of erosion (Barretto, 1990. per comm). The soils of Upper Casamance are similar to the dominant soils of Eastern Senegal and are characterized by shallow soils on lateritic hardpans. These soils are quickly destroyed if cleared and left exposed to the torrential rainfall (Barretto, 1990, per comm).

Magnuson, et al, (1985) give the following information on soil management in Casamance: "By 1982 swamp rice (riz aquatique) accounted for only 14 percent of the land cultivated in the Lower Casamance (ISRA 1983a, 50)." "About 75 percent of the cultivated land in the Lower Casamance is now plateau land, and the percentage is even higher in the Middle Casamance, where the predominance of peanuts over rice has been apparent for years." Besides peanuts, "plateau" crops include: "millet, sorghum, maize and other crops."

While the process of migration to the upland soils has been in progress "for some time the drought has accentuated it." "Between 1969 and 1982, some 13 percent of the forest land in the study area was cleared for agriculture and 'an additional 13 percent of light and dense forest land was degraded in tree density to such an extent as to be reclassified as bush land or savanna....' (Harza 1984, 8-24)."

> "...the fresh water underflow down into the lower valleys has been reduced and the salt and fresh water interface has been altered (Harza 1984, 3-2). This has caused continuing encroachment of salt water into areas where rice fields are not protected by dikes. The amount of swamp rice land that has been lost is not known with any

precision, but the figure could well be about ten percent.

"The picture that emerges is of a fragile riverine ecosystem heavily dependent on substantial annual rains to support its traditional swamp rice cultivation system. In the absence of these rains, agriculture has moved increasingly to the plateau lands and has contributed to further degradation of the ecosystem. It has also damaged the system's ability to recover if and when a good rain cycle returns."

Again the problem of extensive agriculture being more attractive than intensive agriculture appears. "The expanding agriculture on the plateau is extensive in nature. Very little fertilizer or other purchased inputs are used. Forest cover has been severely depleted as a consequence of expansion." "It is interesting to note that the plateau areas where animal traction farming has been adopted are the areas with the highest farm incomes. At the other extreme, the Oussouye Department, where swamp rice is cultivated to the virtual exclusion of other crops, has the lowest agricultural incomes (ISRA 1983a, 48)."

The Southern Zone Water Management Project (USAID 685-0295) is to be implemented in lower Casamance. It is one of numerous projects designed to control water on rice production land. These structures are referred to informally as anti-salt dams. There is a traditional rice production system which uses primitive anti-salt dams. Consequently, the technology is understood. If properly managed the structures will improve rice yields and protect some vulnerable soils from acidification and salinization.

C. SOIL RESOURCE MANAGEMENT PROBLEMS IN SENEGAL.

1. Soil erosion.

There are major differences between wind erosion and water erosion. Wind erosion is usually incremental in its effects and has been difficult to measure (Fryrear, 1989). Water erosion is often immediately destructive and obvious in its effects (Charreau, 1974; Barretto, 1990, per comm).

Because of the torrential nature of Senegal's rainfall, any bare ground on even a slight slope is vulnerable to water erosion. Casamance, Eastern Senegal, and the area around Bakel in the Silvo-Pastoral Zone have the most serious problems with water erosion in Senegal.

Chronic wind erosion is the most common erosion problem on upland soils. But the percentage of fine materials in these soils is not in steep decline. That phase was passed long ago. These

soils are not exposed to an imminent threat of destruction. But there is a long term threat to these soils and it is difficult to know how to remedy it.

The economic benefits of remedying water erosion are usually evident because the problem is often drastic and immediate in its adverse effects. Wind erosion tends to be more incremental in its effects. Consequently, water erosion problems are more likely to be remedied. Wind erosion is difficult to remedy because it is difficult to link it to any economic reinforcement.

The fact that most of Senegal has sandy soils on flat topography helps to minimize the effects of erosion in most of the country.

2. Soil degradation.

Soil degradation refers to changes in soil characteristics which reduce yield potential. Loss of soil organic matter, loss of soil structure, soil salinization and soil acidification are all examples of soil degradation. Soil salinization and soil acidification will be discussed in subsequent sections of this Chapter. Soil degradation as the combined loss of soil organic matter and soil structure will be discussed here because this problem is often referred to in documents concerning soil resource management in Senegal.

Soil degradation is a general characteristic of all agricultural soils. Degraded soils are often referred to as "worn out", or "tired" soils. "Soil Building" is a term often used to describe crops which remedy soil degradation. "Reclamation" is a broader term employed to describe crops which are used to reverse soil degradation processes. Soil "regeneration" was the most common term used in USAID/Dakar documents to desribe this process. (These usages are general and do not represent technical convention of any kind.)

Desirable soil characteristics such as tilth, friability, and permeability are a function of soil structure which is in turn a function of microbial action in breaking down plant residues in an oxidation process which produces soil organic matter or "humus." Soils attain their highest level of desirable characteristics if they are left undisturbed under a covering of vigorously growing vegetation. Utilization of soils for agricultural production will usually result in a decline in their desirable characteristics. This decline is referred to as soil degradation. Removing crops, working the soil, and allowing the soil to lie bare or only partially covered by vegetation for long periods of time will degrade soil. This is true even under the best of agricultural management practices. Except for some unique cases, there is no question as to whether or not soil degradation will occur when

undisturbed land is brought into production. The only question is the degree to which it will occur.

Soil organic matter is also important for its ability to hold water and nutrients in the soil. It is also a source of nutrients in the soil. Soil organic matter is by far the most important source of soil nitrogen and it is also an important source of soil phosphorous. Consequently, changes in soil organic matter percentages often serve as the most convenient indicator of the degree of soil degradation.

The soil organic matter production process requires moist but not wet conditions and does not proceed at all when the soil is dry. Also it is inhibited by either high or low temperatures. Consequently, it procedes best when the soil is shaded.

The soil organic matter production process is also a function of the amount of plant residues available. The relationship between the quantity of plant residues provided and the accumulation of soil organic matter is more or less direct. Plant residues include roots, and roots are more important to soil organic matter production, soil structure and soil building than are plant residues from above the soil surface. Surface materials are more likely to be oxidized without benefiting the soil or to be carried away by wind or water. Also, roots are more important because they are distributed throughout the upper soil and because they have a direct effect on soil compaction and soil structure. Roots constitute an important percentage, about 30%, of the biomass produced by a plant. Whether in tropical or temperate zones, soil building plants have one characteristic in common. They are always perennials. Consequently, the ground is kept covered, the ground is not worked, and organic matter is constantly being added to the soil. This process must continue for several years in order to have any positive effect on soil organic matter and soil structure.

In temperate climates some soil building does occur by means of the surface application of manures. In hot climates, surface applied materials are much less likely to have a long term effect on the accumulation of organic matter and the improvement of soil structure.

Due to high temperatures in the Peanut Basin, degradation in the form of loss of soil organic matter and soil structure occurred within a few years of the collapse of the wooded fallow soil management system. It is not an on-going acute process.

Heavier soils are more likely to benefit from soil regeneration because the improvement in soil structure and the increase in organic matter gives them better physical characteristics for water percolation and root penetration.

The situation on sandy soils is completely different. They remain structureless even when conditions for improving soil structure are ideal. Degradation of Senegal's sandy upland soils was mostly a case of losing the nutrient effect of having a higher organic matter content.

a. Soil organic matter.

The term "organic" indicates molecules which have carbon as their basic building blocks. Carbon is taken from the air by plants. Nitrogen, phophorus, potassium and other important minerals are taken from the soil by the plant. Legumes can also take nitrogen from the air. A process referred to as "fixing" nitrogen. Photosynthesis delivers the energy necessary to build the organic molecules of which plants are made. Oxidation breaks down this organic matter and in the process releases energy and nutrients.

Burning plant materials, incorporating plant materials, composting plant materials, and feeding plant materials are all methods of oxidizing plant materials. The issue for soil resource management is how the oxidation process will be managed for both the profit of the farmer and the benefit of the soil. Burning oxidizes plant materials immediately and makes nutrients immediately available to crops; but neither benefit for the soil nor revenue is derived in the process of releasing energy, and nitrogen is volatilized in the process.

Incorporating plant materials oxidizes plant nutrients slowly and energy is utilized by soil microbes to the benefit of the soil and the accumulation of organic matter. However, the process can tie up plant nutrients while it is in progress and no revenue is generated by the release of energy. Composting is a means of utilizing microbes to partially oxidize plant residues away from a field so that the process can be completed in the field to benefit the soil without the risk of tieing up plant nutrients for long periods of time. No revenue is generated by the release of energy by composting. Feeding plant materials utilizes livestock to partially oxidize plant materials to the point where they can be used on fields without risk of long-term tieing up of plant nutrients. Energy released in the oxidation process is utilized by livestock which can then be sold to generate revenue.

i. Incorporating plant materials.

Throughout the documentation the incorporation of crop residues is spoken of favorably when it is mentioned. However, when it is not feasible for a farmer to use chemical fertilizers, then incorporating crop residues is seldom a good practice. When Charreau reports favorably on this practice he is speaking in terms of improved water percolation and generally improved soil surface characteristics in the context of French

recommendations, which included application of chemical fertilizers.

The quality of plant residues for incorporation is determined by the amount of carbon which they contain related to the amount of nitrogen which they contain. The relationship between carbon and nitrogen is referred to as the carbon/nitroge or C/N ratio. The soil organic matter production process consists of converting plant residues to the carbon/nitrogen ratio of soil organic matter. The less nitrogen in the plant materials, the longer the time required for the process. It can vary from a few weeks for succulent plant materials which are rich in nitrogen to thousands of years for the complex molecules of woody materials. For instance the leaves of Acacia albida would be broken down much more quickly than millet stalks. And millet stalks would be broken down much more quickly than woody parts of trees or shrubs.

This microbial process of oxidizing products of photosynthesis is good for the soil, but it is hard on any crops which are being grown because soil microbes can out compete crops for the soil minerals which are nutrients for both soil microbes and plants. This is called "tieing up" nutrients. It is not a problem if large quantities of nutrients are being added to the soil by means of chemical fertilizers. However, if plant nutrients are limiting in the soil and high carbon/nitrogen ratio materials such as millet stalks are added to the soil, then the problem of the low nutrient status of the soil is aggravated for the growing crop.

ii. Mulching.

The benefits of mulching are generally appreciated in the documents which mention this practice. However, it is not actively promoted and the disadvantages are not discussed. Mulching refers to keeping the ground covered with something other than growing plants. It can be anything from compost to plant residues to plastic. Since it effects only the surface, there is not a risk of tieing up plant nutrients. In fact coarse, "unfavorable" carbon/nitrogen ratio materials often make superior mulches because they remain intact throughout the growing season and they are not easily moved by wind or rain.

The purpose of mulching is to conserve soil moisture. It also has a general effect of improving the soil environment for root and microbial activity because it keeps the soil shaded and provides a continuous supply of organic matter. Mulching can also protect the soil surface from wind erosion and improve water percolation. Overall, mulching has a number of very good effects but it is not practiced among traditional farmers. Perhaps because mulch also furnishes a good habitat for pests which are difficult to control without chemicals, and farmers prefer to burn crop residues in order to make plant nutrients immediately available for their new crop. Another consideration is that fields which are kept mulched

would also become "trashy", which, in practical terms, means that it would be difficult to work in them with implements, including the implements used in animal traction.

Mulching is incidently practiced in Senegal in fields which have been used for millet the previous growing season. In such fields it is common to see millet stalks covering a major percentage of surface area during the dry season. This is not of great importance but it is better than leaving the soil surface bare. It does give some protection against wind erosion.

iii. Compost.

The advantage of composting is that the carbon/nitrogen ratio of plant residues is favorably shifted in the compost pile rather than in the field where the process would tie up nutrients. In this way plant nutrients from crop residues with very unfavorable carbon/nitrogen ratios can be recycled without burning. Compost piles do not "fix" nutrients like legumes fix nitrogen. The total amount of nutrients in a compost pile never excedes the total amount of nutrients added to the compost pile. Another advantage of compost piles is that they can be used to convert organic materials which vary widely in texture and size to a uniform product which is easier to handle.

Composting also has numerous constraints. The quantities of organic materials which could be processed through the compost piles observed would be very low relative to needs. Composting requires that the pile be kept moist but not wet so in the dry season it needs to have water added and in the wet season it needs to be kept covered. Covering is also an advantage in the dry season because it keeps the compost from drying out too quickly. The microbes transforming the plant materials are oxidizing the carbonaceous materials and therefore they need air. Consequently, good composting requires that materials be turned regularly.

iv. Livestock.

Throughout the documents the advantages of integrating livestock and crop production for the purpose of improving the management of plant nutrients on fields are recognized and promoted. The majority of farmers do not own enough animals to make them a major positive influence on their soil management programs. However, the usefulness of manures for crop nutrition is widely appreciated among farmers. In this context it should be remembered that farm animals do not "fix" nutrients. If their feed is of poor quality then their manure is of poor quality. Also, of all of the methods of oxidizing plant materials, feeding them to a farm animal is the only way of deriving revenue directly from the process of oxidizing plant residues.

When the integration of livestock and crop production is discussed in the documents it always takes one of three forms. The most common involves the use of cattle and horses for animal traction. The practice of "parking" animals on fields is also mentioned quite often. Finally, the practice of fattening livestock on farms is receiving increasing attention.

Animal traction was introduced by the French to the Peanut Basin in the late 50's and has been widely accepted. Because the rainy season is short and fields are not worked until after the first rain, it is important that field work be accomplished in a timely fashion after the first rain. Animal traction was accepted, and is still practiced because it allows a farmer to work fields quickly and thus exploit available rainfall better than if he works his land by hand. Animal traction also allows a farmer to work more land.

The practice of confining range cattle to fields at night as a means of increasing soil fertility is called "parking" cattle. It is a good, low-labor input system for applying manure to fields but it does require large numbers of animals if fields are of any significant size. Livestock is used to concentrate plant nutrients from surrounding range on cropland.

Fattening cattle is another means of accumulating manure on a farm. An important innovation here is compost stables where the compost pit is dug in the stable and the animal being fattened is teathered in it. With this system the pit is protected from the weather and forage and bedding are trampled and broken up. Also urine as well as manure contributes nutrients and moisture to the composting process.

v. Burning.

A distinction needs to be made between bush fires and field fires. Bush fires are always bad for soils because soils are protected by the accumulation of litter on the soil surface and they are improved by the accumumulation of soil organic matter in the surface horizon.

However, burning crop residues in the field before planting can serve a useful purpose by mineralizing nutrients, destroying pests and making it easier to work a field. Burning of crop residues is widely criticized in documents dealing with soil management in Senegal. The reasons given are loss of organic matter and loss of nitrogen.

b. Salinity.

Salinity problems resulting from irrigation in the Senegal River Valley below Bohge are typical of salinity problems. Salts accumulate in soils when the water in which they are

dissolved evaporates and the salts remain in the soil. In this manner they are concentrated to levels which are detrimental to plant growth. Given the same concentrations of salt, the effect is more serious in a heavy soil than it is in a light soil.

The most common method of dealing with salinity is to keep the salts leached below the root zone of crops by including a leaching fraction in irrigation water applied and then draining it off. Again it is an advantage to have light soils rather than heavy soils because they are more permeable and thus easier to leach and drain.

There is potential for salinity problems in the Senegal River Valley because of salt deposits in the soil related to past intrusions of the sea. The presence of salt in the soil at some locations and the fact that the soils are heavy are the sources for concern relative to this problem.

A more serious problem than salinity is alkalinity. Alkaline refers to saline conditions where the salt is dominated by sodium. Sodium is dangerous for soils. Especially for heavy soils because it can disperse the clay in the soil which then becomes hard and compact when it dries. Apparently there is some potential for alkalinity problems due to the characteristics of soil parent materials in the Upper Senegal Valley (Loyer, 1989. Tabor, 1990, per comm).

A unique salinity problem exists in Casamance where salt water intrudes on rice paddies during the dry season. The effects of evaporation are limited but the soil profile is saturated with salt water. The salty water is then flushed out of the field by surface flow fresh water at the start of the rainy season. In this context salinity becomes a problem if there is not sufficient fresh water to flush out the salt water and to keep it out during the entire growing season.

c. Acidification.

There are two completely different forms of soil acidification in Senegal. The first and most severe occurs on lowland soils in Casamance where there are mangrove swamps. If the soil in these swamps is allowed to dry, it oxidizes immediately to an extremely acid state. Apparently this acidification can be reversed but it requires many years. Forty years was given as a rough estimate.

The second form of acidification occurs on upland soils and is more typical of common soil acidification processes. The ability of a soil to hold nutrients is called cation exchange capacity (CEC) and refers to the fact that clay has a negative charge and most plant nutrients have a positive charge. Calcium and potassium, for example, have a positive charge and are referred

to as "basic cations." Acidification means that basic cations are being replaced by hydrogen which also has a positive charge but is not a plant nutrient and has unique chemical activity properties.

Many of the soils formerly used for wooded fallow in Senegal tend toward acidity because parent materials are acidic and because cation exchange capacities are low. Consequently, if basic cations are leached from the crop rooting zone and not recycled by deeper rooted plants such as trees the effect will be to lower the soil pH. The most direct method of remedying this situation is by liming which has the dual effect of removing hydrogen from the soil exchange system and putting calcium on clay cation exchange sites.

3. Reduced soil fertility.

Reduced soil fertility on upland soils where rainfed agriculture is practiced is the most widespread form of soil degradation in Senegal. The upland soils of Senegal are not highly responsive to chemical fertilizer for several reasons: soils are light and sandy so they do not retain fertilizer. Rains are torrential so they have a strong leaching effect. Rains are erratic so there is a risk of not having enough rain for crop growth. Low value crops are grown. Yet, unless chemical fertilizers are heavily subsidized, farmers show very little interest in using them.

Another important factor is that excessive plant nutrients can actually kill a crop if soil moisture is lacking. Shaikh, et al, (1988) report this happening on a farmer's field in Mali if cattle were parked on the field too many nights. Tabor (1990, per comm) reports farmers varying organic fertilizer applications among fields in order to decrease the risk of losing all of their fields. Farmers in the Silvo-Pastoral Zone varying organic fertilizer applications within a field for this same reason (pers obs). Problems with applied nutrients would decline with increased rainfall.

Applying fertilizers on lowland soils is common because the soils are heavier so the nutrients do not leach. And because lowland soils are not generally farmed unless there is an assured supply of water to bring the crop to maturity. In recessional agriculture where moisture can be limiting, fertilizers are not applied.

Since organic fertilizers must be broken down or mineralized before they are of any use to plants they have the advantage of not being so easily leached and they include an array of micro-nutrients. Also, the presence of the organic materials improves soil conditions for crop roots even if the effect is

short-lived. The vast majority of upland farmers use only organic manures.

The problem with organic manures is that they have very low, unknown concentrations of nutrients, they can be expensive in terms of handling costs and, because they have to be broken down before the mineralized nutrients are available to crops, it cannot be predicted with absolute certainty when the plants will have access to the nutrients.

The advantages of chemical fertilizers are that they are are easy to handle and they are concentrated at known levels of nutrients. Consequently, it is convenient and efficient to use chemical fertilizers, it is known exactly what is being put on the field and when it will be available to the crop. The disadvantage of chemical fertilizers is that they are easily leached and they represent an out-of-pocket financial risk to the farmer. The problem of chemical fertilizer leaching can be partially alleviated by applying chemical fertilizers after the crop root system is well initiated.

The lack of interest in chemical fertilizers by upland farmers does not relate just to crop yields. It is an obstacle to intensifying cultural practices and a problem for soils which are benefited by vigorous plant growth.

Good quality compost can be used for chemical fertilizer efficacy enhancement and banded around hills. Since planting distances are large, there are not many hills per hectare. This would be a means of exploiting the desirable characteristics of both chemical and organic fertilizers.

Lime is a soil amendment. On acidic upland soils lime raises the soil pH, which puts a better array of plant nutrients into solution. Soil amendments differ from fertilizer in that their effect will persist for several growing seasons. Rock phosphate is another soil amendment. However, its efficacy is the subject of more controversy than that of lime.

Table 3.1 Summary of major bio-physical natural resource management problems on Senegal, by agroecological zone.

Summary of major bio-physical natural resource management problems on Senegal, by agroecological zone.
CASAMANCE
Acidification of low-lying soils containing sulfides. Erosion of shallow soils on lateritic hardpans. Chronic salinization of low-lying ice soils. Drained mangrove swamps are useless due to acidification. Runoff = 19-129 billion m3/year. Low streamflows have led to salinization of low-lying soils.
SENEGAL-ORIENTAL
Extensive, poor, shallow upland soils on lateritic hardpans. Soils vulnerable to water erosion when bare. Charcoal production methods causes deterioration of woodlands. Niokolo Koba is too small an area for large animals.
PEANUT BASIN
Soils are degraded and vulnerable to wind. Soil fertility has declined. Soils are not regenerated. Breakdown of structure on heavy soils of Sine-Saloum. Acidification of upland soils. Overgrazing. Reduction of trees on ag land leads to lowered fertility. Water tables reduced over past 20 years. Pumping of groundwater for Dakar exceeds aquifer recharge.
FERLO
Overgrazing and trampling of groundcover acute. Areas susceptible to water erosion. Fires destroy woody plants which provide dry season nutrients. Overgrazing makes species composition less desireable. Average carrying capacity is not indicative for dry years.

Table 3.1 Summary of major bio-physical natural resource management problems on Senegal, by agroecological zone. (cont'd)

Summary of major bio-physical natural resource management problems on Senegal, by agroecological zone.
SENEGAL RIVER
Salinization of heavy, poorly drained soils, below Bohge.
Alkalinity problems in the Upper Senegal River Valley.
Threat in the form of drainage water and chemicals.
Reduced flooding will change some vegetative communities.
Reduced flooding reduces recession agriculture, floodplain grazing potential, fish spawning grounds.
Streamflow = 300 m3/s with 2500 m3/s artificial flood.
Water levels in the Parc de Djoudj have changed, endangering nesting.
NIAYES
Dunes threaten truck gardens and roads.
Soil and wells becoming saline.
Vegetation on the dunes sparcer.
Low-lying areas are recently covered with sand.
Lack of vegetative cover leads to live, moving dunes.
Silviculture and management on dune plantations needs work.
Wells become saline if overused.

CHAPTER 4

VEGETATIVE RESOURCES

A. INTRODUCTION.

The problems in the management of natural vegetation resources are:

- o Overgrazing in range due to the excess dry season forage demand.
- o Local over-cutting of forests for commercial charcoal production.
- o Centralized control over forest and tree management.

The opportunities are:

- o Continue with successful rural forestry initiatives, shifting to agroforestry techniques such as protection of field trees and shrubs.
- o Management and market assistance for village forests.
- o Continued support for local land management authority.

There has been a gradual decline of vegetative cover over the past 20 years. This was caused by drought and human and animal pressure. That tendency may be reversing now. The total amount of vegetation may return to previous levels with increased rainfall. The vegetation may return to the former species composition if excessive use is stopped.

The causes of the decline are interrelated. There was not enough rain and there were too many land users. The effects, when concentrated, as around boreholes in the Ferlo, on land bare of vegetation as in the peanut basin, or massive land use change as in the Fleuve, can cause complete denudation. The increase in soil temperatures, erosion, oxidation, and loss of organic matter result in a loss of the productive capacity of the soil. Vegetative cover is the first defense of soil fertility. [Figure 4.1 is a Vegetative Map for 1989.]

B. VEGETATIVE RESOURCE MANAGEMENT PROBLEMS.

1. Rangelands.

The Fleuve region is the most delicate zone for vegetation, and rainfall is more limiting than elsewhere in the country. There has been major manipulation of the vegetation caused by large dams and irrigated rice culture schemes along the Senegal River.

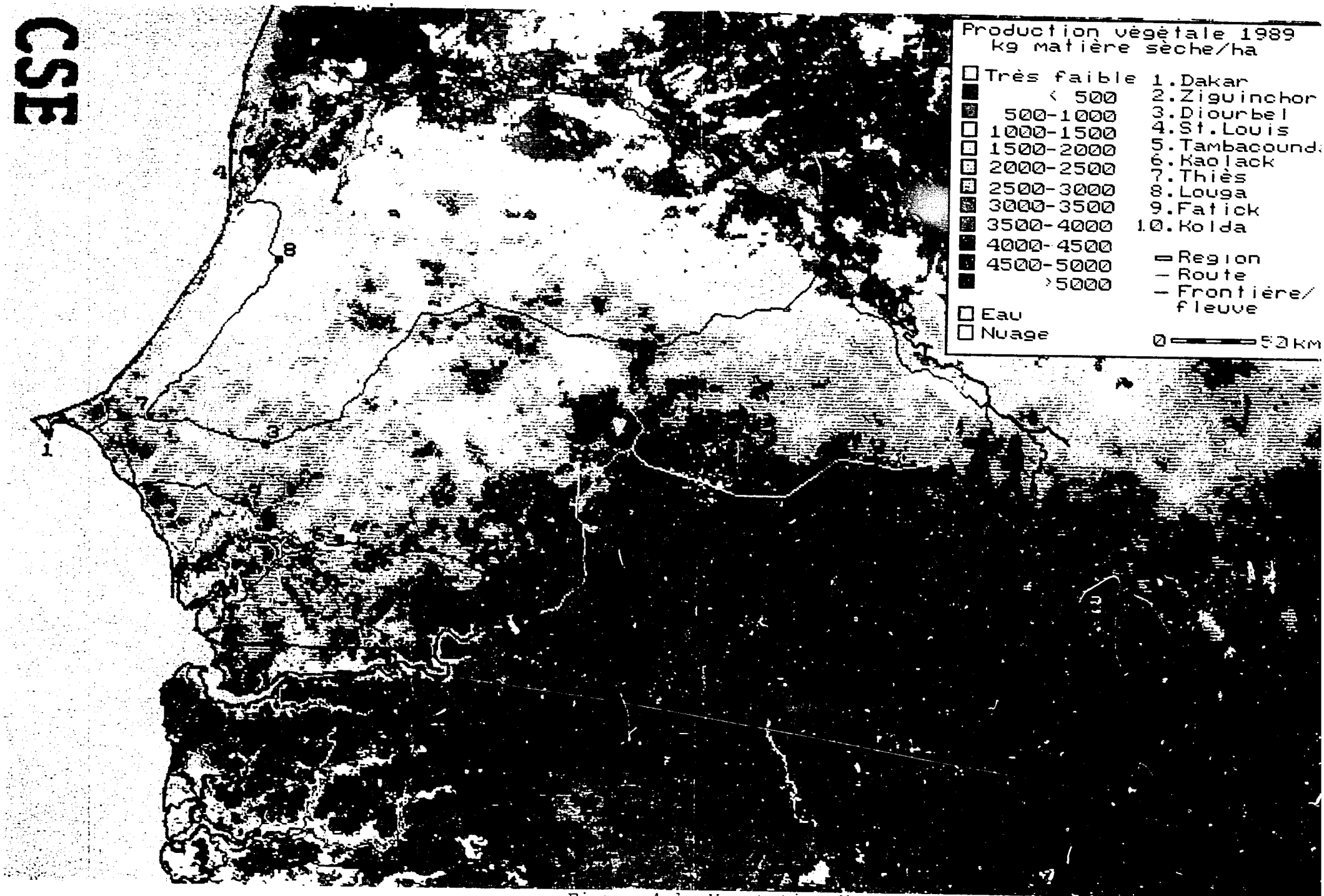


Figure 4.1 Vegetative Map

There are no longer the pastures of bourgou and other forage species that once supported large herds (Toure, 1987; Lavieren, Wetten; Le Houerou, 1989).

The Ferlo is historically and ecologically rangeland. Much of the Ferlo is in an administrative status of silvo-pastoral reserve. This includes the trees and shrubs that serve not only to supplement the intake of annual grasses and forbs but also to complement them nutritionally (Le Houerou, 1989). During the dry season these woody plants make up the nutrients missing in the dried grasses. The woody plants are the limiting aspect on the carrying capacity of this type of range. Where fire takes out the grasses the woody plants offer the only feed available (Le Houerou, 1989).

The management of range, livestock and water cannot be separated in Senegal. The major tool in range vegetation management is the movement and regulation of herds. The upper carrying capacity of an area is the number of actively moving animals that can be supported by the vegetative cover present during the dry season. If the herd is stationary then the amount of vegetation needed per unit area is much higher. Water development may allow access to an area of grazing that was previously inaccessible because of the lack of water. Water development also causes permanent settlements around bore holes and the sedentarization and concentration of animals. One method used to rehabilitate grazing areas around boreholes is to shut off the water forcing herd movement.

The recovery of this area from the drought can occur if the land use pressure is not excessive (Le Houerou, 1989). The time required for recovery to take place is at least 30 years if completely protected (Le Houerou, 1989).

Decreasing fertility of agricultural soils and increasing population requires more extensive culture. As more land is cultivated less is available for grazing (Ministre du Dveloppement Rural, Secrtariat d'Etat aux Eaux et Forts, 1982). More animals, necessary to meet the needs (social, income and food) of more people, are confined to less land. This causes more damage to the vegetation resource. This results in less forage, less recycling of elements (deep nutrient cycling), less shading of the soil, and lowered productive potential (Le Houerou, 1989).

The grazing pressure can be summed up as overgrazing in the Peanut Basin because of less pasture and higher density of animals than any other region (Centre de Suivie Ecologique, 1989). There is a slight overstocking in the Sine-Saloum and the Casamance, with understocking in some parts of the Eastern region. The Fleuve is a special case with a 10 km. band of extreme overgrazing, a region very sensitive to rainfall variations (Ministre du Dveloppement Rural, Secrtariat d'Etat aux Eaux et Forts, 1982).

The interrelationship of water, animals, and vegetation is pointed out in the discussion of the Ferlo. The effect of water management is apparent in the management of Acacia nilotica (gonakie). This tree only occurs on low areas with heavy soils that are seasonally inundated. If seasonal inundation is no longer available then there will be no Acacia nilotica.

The cause of the mangrove die-off was lack of water that allowed the soil to dry. The high organic content of the soil oxidized, causing extreme acidity. This is a vegetation management problem that is a soil management problem and a water management problem. This complex of problems probably will reverse naturally with increased rainfall, which should cause the former mangrove areas to be inundated once more. The upper watershed must be protected if this is to happen.

2. Agricultural Zones.

a. The Niayes.

The Niayes is the vegetable production area of Senegal. Live dunes advancing from the coast caused early concern. A program of dune stabilization started with the colonial government and has continued with donor assistance. The planting of band of Casuarina equisetifolia (filao) from Dakar to St. Louis has stabilized these dunes. The area needs continuous work to hold the gains made from the filao plantations. The natural life cycle of filao is only about 30 years, and some stands are starting to die of old age. There has been an inventory of the plantations and a management plan is now being done by Eaux et Forts. The plan will include harvesting of mature trees without reducing the beneficial effects of the windbreak. The trees are not reproducing naturally, possibly because of the thick litter layer under the trees. This is a silvicultural problem that needs attention. Besides the coastal dune stabilization there is activity in stabilizing roads for the farm to market access. Some vegetable growing basins are also being protected from inland dunes encroaching on the vegetable growing basins.

b. The Peanut Basin.

This is the area of the country where the most change in the natural vegetative cover has taken place. There are very few of the pristine woody species left in this area. Clearing of trees and shrubs for crops starts the decline of soil fertility. Fallow was the system used to restore fertility levels. If land use pressure reduces the fallow period, then other means must be found to replace this fertility. In higher rainfall areas of Senegal, Acacia albida and shrub species such as Guiera senegalensis, or Combretum sp. increase soil fertility by capturing

nutrients from below the area where crop roots feed. These nutrients are recycled from the production of leaves, pods, and seed that are eaten by animals and returned to the soil as manure or returned directly to the soil as litter (Seyler, per comm; Rodale, 1989). The most common species in the peanut basin is probably Guiera senegalensis. Guiera is the bush found in most of the fields and produces most of the fuel wood used in the peanut basin.

Table 4.1. Amounts of elements returned to soil annually from Acacia albida.

Estimates per tree or ha	Kg Dry organic matter	N Kg	P2O5 Kg	K2O Kg	CaO Kg	MgO Kg
Mean surface area /ha under canopy: 231 M2	267.5	4.3	0.2	2.1	7.2	1.6
44 trees per ha no removals	11583	187	9	91	311	69
20 trees per ha partial removals	5350	69	4	39	112	31

Source: Charreau, 1974.

Besides the value for soil fertility enhancement, Acacia albida serves as a forage species. It is used to feed sheep and goats at the end of dry season when other fodder is not available. The feed value of the pods is high enough to be a good fodder product for pen feeding cattle for the finished cattle market.

Table 4.2. Fodder value of Acacia pods compared with other fodder.

Fodder Products	per kg crude product		Production per ha		
	barley equivalent	digestible protein g	Total Yield Kg	barley equivalent	digestible protein g
A. albida pods	0.77	70	2500	1930	175
meadow hay	0.35	30	3000	1050	90
grass mature fallow	0.20	10	4000	800	40
rice straw	0.40	0	3000	1200	0
peanut hay	0.40	60	3000	1200	180

Source: Charreau, 1974.

The field tree system is an old system which has been deteriorating recently from neglect and from introduction of chemical fertilizers and mechanical cultivation. It now is making a comeback in some fields. Farmers are protecting and training individual, naturally regenerated seedlings (Seyler, per comm).

In the Peanut Basin about 75% of household fuel is from wood produced locally while 25% is from crop residues and dung (Rodale, 1989). The wood, usually Guiera senegalensis or other shrubs, is from field clearing (Seyler, 1990). This wood has a value of about 300 CFA per stacked face meter (field interview near Bambey), which is about 750 CFA per stere at the village.

Another agroforestry technique that is promising is alley cropping. Rows of nitrogen fixing trees or bushes are established on fields. They are cut back at least annually. The cuttings will provide organic material to the crops grown in the alley between the rows. This technique must be modified in dry areas for spacing wider than the normal 3 to 5 meters. The roots of woody species feed much deeper than annuals. Woody species cycle nutrients up to the surface as litter for use by the annual crops. There may have to be several cuttings during each growing season to keep the woody species from shading the crop. The later cuttings are used as mulch. They also can be used for compost or fed to cattle.

Techniques such as windbreaks can improve conditions of growth without directly interacting with the crop. This is also the case with live hedges for animal control or border plantings to mark tenure or use boundaries. There are also techniques in support of soil and water conservation that might or might not interact

directly with crops. Examples are trees in a vegetative contour band, or trees managed as nutrient cyclers, or as providers of fodder for animals included in the farming system. Animals included in the system provide a better control of the final location of the nutrients through fencing, staking, or stabling. Labor shortage because of migration to urban areas in search of employment restricts agroforestry methods to those methods with low labor input requirements. Some agroforestry techniques may have lower labor requirements than other types of interventions.

In Senegal, recent projects have emphasized tree planting on agriculture lands. The major species used is Eucalyptus camaldulensis, a fast growing exotic originally planted for fuel wood but more recently for poles. Until recently there has never been a pole market survey to determine whether there was a demand for eucalyptus poles. It appears that there may be a demand but there are no developed market channels (Ferguson, per comm; Livingston, per comm). Block plantings of eucalyptus for the production of poles is a forestry activity and not an agroforestry activity. A block plantation is managed as an even age stand for the production of a forest product. The management objective is not for the effect on soils or other crops, although some intercropping may be possible for the first year.

3. Forest Vegetation Management.

Much of the data in this section is from the Forestry Master plan for Senegal which was prepared in 1980 and is now being updated. The new Plan will be much less optimistic as many plantation goals for fuelwood supply were overly optimistic (Ribot, 1988; Lai, 1986; Freeman and Resch, 1986).

Eaux et Forts divides the country into forest type zones that are suitable for a specific type of forest management according to soil types and rainfall (see Map 4-2). The forest type zones are:

Forest Type Zone	Rainfall
Guinen	1200-1600 mm
Sudano-guinen	900-1200
Sudano-sahlien	600- 900
Sahlo-soudanien	400- 600
Sahlo-saharien	300- 600

The Forestry Master Plan recognizes a number of management types. These are:

- Industrial plantations. Management for sawlogs in the Basse Casamance and on the best sites in the Middle Casamance. There will be management of certain species for sawlogs on the best sites of the Sine Saloum, and

irrigated sites in the Fleuve. There can be management with marginal production of sawlogs for village use in the Peanut Basin.

- Multiple use zones. Silvo-pastoral management for the sandy Ferlo. Protection and production is emphasized in the Niayes. The production of cashew nuts is featured in the Basse Casamance and southern Sine Saloum. Agro-forestry is the main management strategy in the Peanut Basin.

- Natural forest management. Sawlogs can be produced with enrichment in the Basse Casamance and on the best sites with enrichment in the Haute et Moyenne Casamance. There can be some moderate production and no enrichment in Senegal Oriental.

- Protection due to low productivity. Soil conditions dictate light exploitation with control in the southeast. Special cases for fragile soils include those soils susceptible to erosion with risk of irreversible degradation such as thin soils over ironstone. Also a special case is soils susceptible to erosion with risk of reversible degradation such as sandy soils.

(MAP 4.2 FOREST TYPE ZONES)

LES DOMAINES FORESTIERS

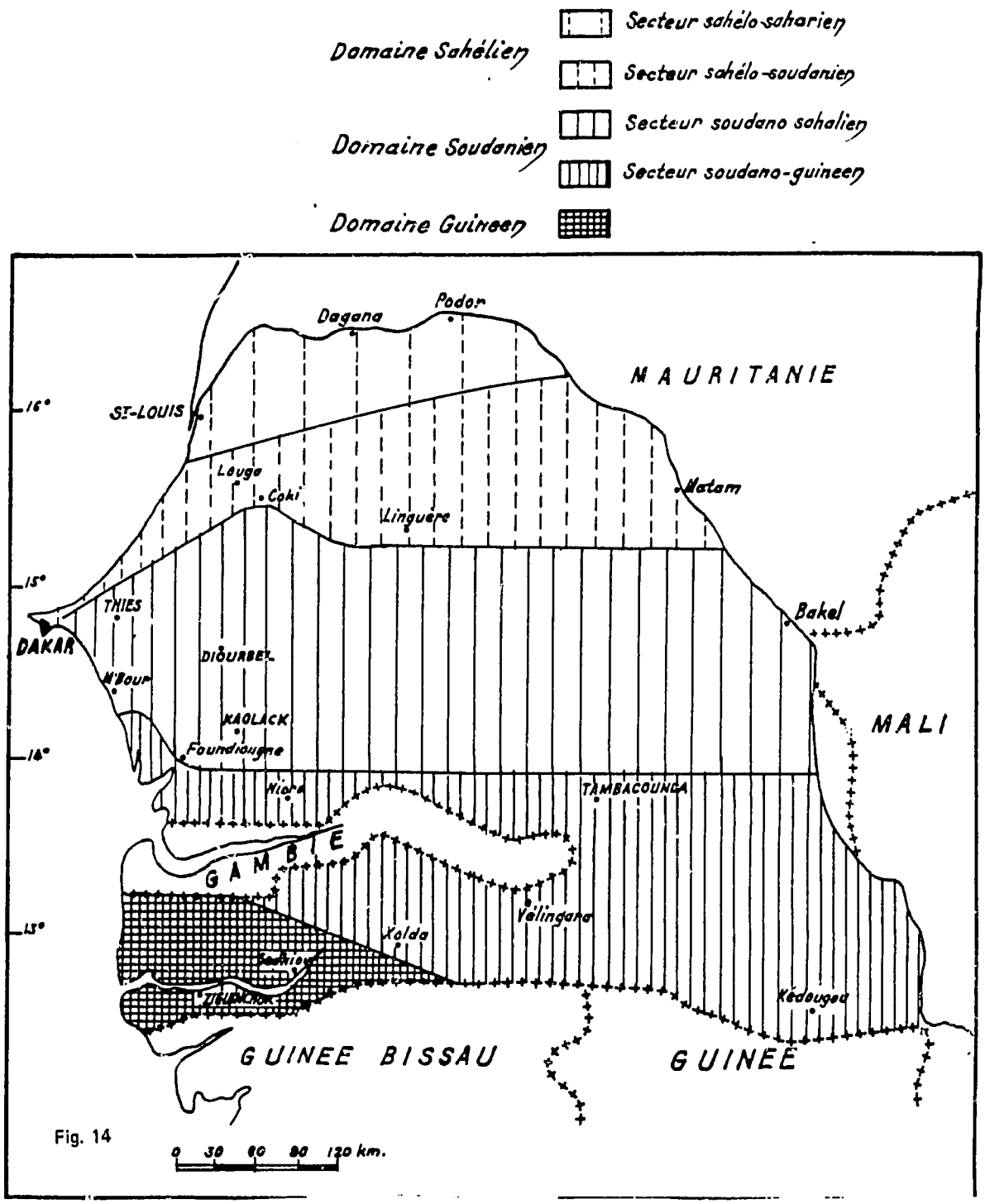


Fig. 14

- Special cases. Overuse fragility such as around Dakar, the Peanut Basin, and over-grazed areas. Also, fragile vegetation ecosystems such as mangroves, roniers, and Parc National de Basse Casamance.

Table 4.3. Forested land in 1978, by forest type, in thousands of hectares.

Forests		Forest grasslands		Bush Forests (shrubs)
Gallery Dense	Mangrove	Forest dominated	grass dominated	
58	168	2,850	8,056	
226		11,906		
12,232				2,630

Source: Ministre du Dveloppement Rural, Secrtariat d'Etat aux Eaux et Forts, 1982.

The total land area covered by woody vegetation in 1978 was 14,862,000 hectares. See Table 4-3. The country's forestland is predominantly forested grasslands. This forest type, which represents 80% of all forest land supplies almost all of the country's fuelwood and much of the other forest products. There are only 226,000 ha of closed canopy forest. The most productive types by area are the forest types and the forest dominated grasslands (wooded savannah). In 1978 these two types were estimated to cover 3,076,000 ha, of which 644,000 was in parks.

Forests are further defined by legal status as unmanaged forest, managed forest, and silvo-pastoral reserve. There are 145 unmanaged forests covering 1,299,000 ha. Hunting and harvesting are excluded in these forests. Nineteen forests covering 155,000 ha are managed for fuelwood production. Twenty silvo-pastoral reserves cover 1,514,000 hectares.

Senegal has a total potential sawtimber production of 11,827,000 m^3 per year, 63% from wooded savannah and 30% from closed forests. However, theoretically, there is only (not considering legal status of the forest) 7,161,000 m^3 annually available and theoretically 1,225,000 m^3 of roundwood. There were only 12,800 ha. of plantations existing in 1980.

The productive potential of all forests is reduced by wild fire, uncontrolled grazing, and extension of cultivation. This

degradation of the forest resources results in low productive potential for all forests. The estimated potential is:

Sahelian zone	0.00-0.25 m^3/ha/yr
Sudanian zone	0.10-1.00
Sudano-guinean zone	0.50-2.50

Wood consumption varies from 0.50 to 1.25 m^3/person/year. This consumption exceeds the productive potential in almost all the country. There is little replacement because of the high cost of reforesting degraded forest (Ministère du Développement Rural, Secrétariat d'Etat aux Eaux et Forêts, 1982).

Clearing for agriculture has progressed at the rate of 40,000 ha per year from 1976 to 1980. This includes about 20,000 ha of savanna woodland and forêt clair and 20,000 ha of tree savanna and steppe. Overcutting also reduced the forests in the Fleuve and Ferlo Regions by about 20,000 ha per year. Thus, forestland is being reduced by 60,000 ha each year.

Degradation of stands by overstocking with animals and from fire has led to an estimated loss of 2 million m^3 per years. This is the equivalent of 100,000 ha of woodland savannah. This represents 1 to 2% of the woody material in the woodlands that are 90% of the forest resources in the country. From the above estimated consumption and degradation rates, the projections of remaining forest area in the year 2000 are in shown in Table 4.4.

Table 4.4. Projected forested area in the year 2000, by forest type, in thousands of hectares.

Dense Forests		Forest grasslands		Bush Forests (shrubs)
Gallery	Mangrove	Forest dominated	grass dominated	
58	162	2,210	7,416	
220		9,626		
9,846				1,835

Source: Ministère du Développement Rural, Secrétariat d'Etat aux Eaux et Forêts, 1982.

4. Forest Products.

a. Fuelwood.

Senegal depends on imported oil and domestic woodfuels for all energy needs. Of the total primary use of energy in 1985, 63% was wood fuels and the remaining 37% was imported oil (Sokono, 1987). Imported fuel consumed 11% of the foreign exchange earnings in 1986 (Leitman, 1988; World Bank, 1983). Almost all the wood fuels used in Senegal are for household cooking. Nationally, Senegal uses 93% woodfuels, 4% electricity, and under 3% gas and kerosene (Ribot, 1988).

In the urban sector, woodfuels account for 89% of the household energy use. Electricity is 8%, gas is 2%, and a slight amount of kerosene is used for lighting. In rural areas, wood fuels supply 99% of total energy while kerosene supplies 1% for lighting. In urban areas 91% of the woodfuel is charcoal with 9% wood while in rural areas the percentages are almost the inverse. Eight percent of wood fuels are charcoal and 92% is wood (Madon, 1987). Because of their bias toward charcoal, "urban dwellers who make up only 25% of the population, consume well over half the primary wood based energy." (Ribot, 1988)

Wood for Dakar comes from as far away as 300 to 450 km (as far as 700 km by road). This is the nearest wood surplus area (Ribot, 1988). World Bank (1983) estimates that the remaining forests of Senegal are declining at a rate of 1.2% per year. This implies a deforestation rate of 16,500 ha per year. The team studying the energy sector for the tropical forestry action plan estimates that fuelwood consumption and forest growth are now about equal (Ferguson, per comm). This was not expected for another 10 years (Ministère du Développement Rural, Secrétariat d'Etat aux Eaux et Forêts, 1982). The allowable cut is probably not exceeded nationally, but individual forest blocks are being cut at a rate much faster than they can produce (Ribot, 1988).

According to Ribot (1988), charcoal production accounts for the clear cutting of between 12,000 and 22,000 ha per year based on: 75 meter radius cut for a kiln producing 15 tons (Niang, 1985), and a demand of 102,000 to 180,000 tons (1986/87 national quota). This gives .12 ha land cleared per ton of charcoal produced. This accounts for between 7 and 13 percent of the annual total deforestation. Missing in this calculation is regrowth from the stumps. The growth rate from stump sprouts in natural forests can be rapid (Heermans, 1985).

Very powerful charcoal patrons (The nearest word in English is charcoal baron, in the same sense as oil baron. Merchant does not convey the aspect of power.) control the market from felling to retail sales and are very influential on governmental charcoal industry regulation policy. Ribot (1989) and Ruse (1982) are

recommended reading for the details of the charcoal production, marketing, and distribution systems and how this affects national forest policy.

The population migration from farm to urban areas causes increases in charcoal demand at the same rate as the urban population growth. Some attempts at substitution to reduce charcoal demand include gas, peanut shells, and solar energy. None of these were very successful in the kitchen except gas, which was accepted but did not result in a lowering of consumption of subsidized charcoal. Attempts to increase the production efficiency of charcoal have had more success in other countries than in Senegal. This is because of the lack of incentive to the producer inherent in the patron system found in Senegal (Karch, et al, 1987).

Improved mud stoves were designed for the rural sector and could be seen in every village we drove through in the Peanut Basin. Efficient metal charcoal stoves can be seen for sale in the markets in Dakar. Most charcoal is still burned in the Forneaux Malagash. This is the square or round charcoal stove seen all over the country.

Other forest products include sawlogs, poles posts and pickets, pirogues, and food items such as gums, oils, leaves and fruits. These products are reviewed in detail in the Forestry Master Plan. These will be updated with new projections in the Tropical Forestry Action Plan for Senegal that is now underway.

b. Production Potential Projections.

Table 4.5. National Wood Balance Projections in thousands of cubic meters

Year	type of use	Need	Resources		National Balance
			Forest	Plantation	
2000	fuelwood	6,500	6,300	236	+26
	service	950	1,100	33	+183
	sawtimber	160	25	4	-131
	pulp (1)	300	0	0	-300
2016	fuelwood	8,140	5,300	506	-2,334
	service	1,100	900	71	+80
	sawtimber	250	25	20	-205
	pulp (1)	540	0	0	-540

Source: Ministère du Développement Rural, Secrétariat d'Etat aux Eaux et Forêts, 1982.
(1) In round wood equivalent.

In the year 2016 the only forest product that Senegal can still be self sufficient in is poles. Sawlogs, fuelwood, and pulp deficits must be imported as they will no longer have the potential to produce enough to meet projected needs.

5. Forest Management.

The management of forest resources to produce the above is largely management by project. The 1980 Master Plan listed 22 different forestry projects and 10 silvo-pastoral projects scattered throughout the country (Ministère du Développement Rural, Secrétariat d'Etat aux Faux et Forêts, 1982). The result of this type of diffused management is often competition between projects for the same clients (Verchot per comm). Management by project also causes differing policy in different locales (Grosenick, 1989), and a short term efficiency at the expense of long term program stability (Taylor and Soumare, 1983).

C. VEGETATIVE COVER RESOURCE MANAGEMENT PROBLEMS.

1. Traditional land management systems.

a. Forests.

Traditionally forests and woodlands were managed locally. In each village there was a master of the axe who was responsible for allocation of forest products and determined where these products could be obtained. The master of the axe received a token tax for the use of the forest. At the time of the creation of the forest service in 1933, this authority was superseded and all trees became the property of the state. Some traditional use rights were recognized such as the gathering of medicinal products and dead wood (USAID 1986). This resulted in villagers considering forests and woodlands as commons with access to forest limited only by the forest service's ability to enforce regulations. This enforcement is limited by lack of trained personnel and lack of equipment and operating funds. There is no possibility of obtaining sufficient funding to field enough police to be effective.

b. Range.

Local management of grazing resources consisted of movements of animals through areas with grazing of plants, then movement to another area, allowing plants to recover. The state intervened by providing boreholes thus sedentarizing the herders. This allowed the nomads access to medical and educational services, but caused concentrations of animals far beyond the capacity of the land to provide sufficient grazing.

c. Cultivated Lands.

The Serer had mixed farming system using Acacia albida and other soil building trees and shrubs in a fallow, with animals integrated into the system. The increase in population, migration, introduction of animal traction and fertilizers have changed the system but some aspects remain. The use of animals integrated into the system has declined because of the lack of pasture formerly provided by the fallow lands (Rodale, 1989).

2. Resource management constraints.

The Forestry Master Plan lists constraints under four categories (Ministère du Développement Rural, Secrétariat d'Etat aux Eaux et Forêts, 1982).

- Natural constraints. Natural constraints such as those ecosystems that are sensitive to any modification of the existing vegetation. Natural constraints of poor soils and rainfall that is often highly variable causing abrupt and unfavorable climatic variations.

- Human constraints. There is a strong pressure on the woody plant cover in the peri-urban zones and in the heavily populated rural areas. This pressure is from direct consumption of wood, agricultural clearing, overgrazing, and the non-integration of agriculture and livestock from ethnic specialization (Peul herders; Wolof, Toucouleur and Serer farmers). There is also a lack of interest by the population in the long term and in those activities without immediate returns. This inhibits the farmers' interest in trees.

  There is a domestic economy that is not well managed and is wasteful of resources. There is an excessive consumption of fuelwood and charcoal. Another constraint is the slow adaptation to new conditions by the population.

- Institutional constraints. There is a National domain law that is dynamic but difficult to interpret and lacks detail concerning public and private forest investment. The circulares interpreting the law are due but have not been published. This law makes the Rural Community the sole interlocutor of the Administration for the plantation, management, and harvest of village forests. There is a rarity of qualified personnel and a lack of sufficient equipment within the projects and institutions nationally, regionally, and locally. Forestry legislation and rules are repressive, though a change is

foreseen, and their effect on the population will remain for a long time.

- Financial and economic constraints. There is a limited investment capacity because of the limited natural resources, and an exterior debt. There is a deficit commercial balance that limits the recourse to imported fuel. There have been large modifications of the resource base from dams and irrigation schemes that disrupt the planning base.

D. VEGETATIVE COVER RESOURCE MANAGEMENT PROJECTS.

There are from 20 to 25 forestry projects active at any time. In 1980 there were 23, today there are 22. The only range management project is PDESO. There are range aspects in all the projects active in grassland zones. There are also agroforestry and farm forestry aspects to almost all the forestry projects. One common point of most projects is the evolution from community actions to individual initiatives with project supports. There have been some donor coordination meetings. The first was by USAID where it was agreed that they should continue, but there has been no action until a new initiative by GTZ. Recently there have been several meetings each of which concentrates on a single project.

1. Senegal Reforestation Project (685-0283).

The Senegal Reforestation Project has five major components as follows:

- Media campaign. To convey tree benefit, marketing and technical information.

- A training program. To help GOS staff and other entities to understand the importance of agro-forestry and promotion of private tree planting and maintenance.

- Matching grants. To support on a fifty-fifty basis, initiatives by individuals and groups in tree planting.

- Private sector promotion. To encourage planting, services and marketing by private, non-governmental organizations.

- A policy dialogue. To encourage the GOS to establish a policy environment that stimulates massive popular involvement in tree planting.

The matching grants activity is a controversial component. PARCE feared that the project would undercut their non-reimbursed initiatives. GTZ felt the contract period should be through the establishment period and not just the survival period (Shaikh et al, 1988). GTZ contracts are for five years (Grosenick, 1989). There are plenty of clients for each donor to try their approach.

Private sector promotion probably has a larger impact on GOS training to handle contracts than any effect on the private sector. The most visible results of the project for the public have been the urban forestry initiatives carried out through this component. Market studies also under this component have filled knowledge gaps that will aid future design of donor projects for all donors. These should be made available to all interested donors besides the GOS.

2. Cereals Production II (685-0235).

In spite of the name, Cereals II was an agroforestry project. The agroforestry phase was a 32 month extension of an existing agriculture project. The major problem was that it was only for 32 months. A project designed for innovation and application of practical research using woody species will see no biological results in this short a period. There will be some social results and some lessons learned in establishment of trees and shrubs. There were many valuable lessons learned in this project that will be useful in any further project design.

The project planned to promote soil and water conservation and agroforestry to 60 villages. The project was also to do applied research on agroforestry techniques, and do studies of ecological degradation. Coordination between agencies, villager reactions, and technological and economic feasibility of various interventions were also included. Lessons learned were:

- You cannot prove the value of trees just by planting trees.
- The protection of trees is a good indication of villages that will try plantations of different species.
- The plantation and maintenance of windbreaks require a method more sophisticated than that used by the project. The use of classic USA plains states shelterbelts take up too much land. They cross fields and do not fit the use right boundaries.
- Building a fence from local material is a hard job with several technical problems that may make barbed wire more attractive. These dead/live fences use branches cut from Acacia albida. That is one thing that would be good to reduce.

- Collection and analysis of data on regeneration require good planning and execution to test the hypotheses of comportment and technique.

- You must consider the dynamics of each community and the management of common resources at the community level in finding a method for project implementation. Comment: This is a reaction against central top down project design in trying to make the village action fit into the design. A better approach is the village participating in a design with which they are comfortable.

- Collection of data and the method of analysis are crucial to the development of projects based on village level studies.

- Soil studies are needed to find the nature of soil degradation to decide the type of intervention needed to restore the soils.

- Agroforestry does not give immediate results on degraded soils. It takes about 5 years for Acacia albida to get established to a level that increases soil fertility.

- The improved management of Acacia albida is necessary. This is mostly protection of naturally occurring seedlings in fields.

- You must attack the degraded dior soils with solutions specific to the problem.

- Training should be done as early in the project as possible.

- Innovative projects with decentralized management need more administrative flexibility.

- Pilot projects need unique mechanisms for coordination.

3. Projet Nord.

This project, funded by GTZ, and located in the Ferlo, has the most continuity of any forestry project in Senegal. It has been active and evolving since 1975. It started as a fire fighting project and now has a range management and reforestation orientation. The problems that the project addresses are animal overstocking and fire. The major tool used is Australian sheep fencing for protection of range. They have fenced over 15,500 ha of rangeland. Outside of the fence the problem of excess animals remains. Fire strategy includes education, early season burning, and firebreaks. The project also plants Acacia senegal for rural

income generation. From 1975 to 1981 the project did the planting. From 1979 till the present, all the interventions are local initiatives. The planting has been by group cooperation but is more frequently plantation by individuals. This is by five-year contracts with the participants. The contract requires care of the trees by the participant in return for fencing. The participants pay back 22% of the cost. If the participants do not carry out the required tree care, the project will remove the fence (Grosenick, 1989; Baum, per comm).

4. PROVBOVIL.

This project is financed by Sweden and UN Sahelian Office (UNSO). It is in both Louga and Bakel. The Bakel project works to reinforce the forest service's ability to manage natural vegetation, windbreaks, and village forests. Other activity includes technical and material assistance to villages for the development of agriculture and range management. Also included are the diffusion of improved stove technology and training of forest service personnel and villagers. The project is also developing locally useful techniques for soil and water conservation.

The Louga project has worked in village reforestation, vegetative restoration and enrichment, diffusion of improved stoves, and reinforcement of the forest service.

5. PREVINOBA.

Financed by the Netherlands, this project is active in over 800 villages in the central Peanut Basin. The emphasis is on village-developed, local natural resource management

6. PARCE-PDESO-PICOGERNA.

This is the new project that combines the actions from PARCE in agroforestry and farm forestry, and the integrated agriculture and range management of the PDESO project. Finance is by World Bank and Caisse Centrale de Coopération Francaise (CCCE). This may be the first project to enable local resource management.

7. N'GAOULE ISRA-DRPF.

This is an experimental project with irrigated eucalyptus to develop hydroagroforestry management techniques.

8. PREMINA.

This project, financed by the EEC, is in Podor and works in the central valley of the Fleuve. This project is working in windbreaks for irrigated perimeters, irrigated plantations, urban forestry, charcoal making, and furniture making from eucalyptus sawlogs.

9. PROGONA.

This is an FAO funded project located in Podor. There are two components: Village level forestry where the project is active in 45 villages, and protection and rehabilitation of Acacia nilotica forests. There are various trials of different methods of water control to try to grow gonakie under irrigation, possibly using drainage water from irrigation.

10. Gandiolais and CTL.

These are the coastal dune stabilization projects from Dakar to St. Louis now financed by Canada. Besides dune stabilization, there are village plantations, some of which emphasize medicinal plants, mostly done by women's groups.

11. Kolda Rural Forestry Project.

This is a project located in the Kolda and Tambacounda area financed by Canada with actions in natural forest management and fire protection with the participation of local populations.

12. Protection and Promotion of the Forests of Casamance.

This is financed by Canada and is their long term presence in the Casamance with village interventions and fire prevention and fire brigades.

13. Dabo Forest Project.

The Canada financed project that is working with the management of classified natural forests.

E. PROMISING PRACTICES FOR VEGETATIVE COVER RESOURCE MANAGEMENT.

There is an almost complete system of production functioning in the PDESO project area. This is an integration of animals into the farming system. This allows an intensification of the agricultural part of the system, and allows nutrients to flow through the system at least three times. First, a cash crop of cotton has sufficient return to allow application of chemical fertilizers. The cotton fiber, which is mostly cellulose, is sold and the major residue is high protein cotton seed. The cotton seed and peanut hay, another crop residue, are used to fatten cattle. This is the second use of these nutrient inputs. The manure from the cattle's stables is used on intensive maize fields that can yield up to 4.5 tons per hectare (Thune, per comm). This is the third return on these nutrients. The only part of the system not yet fully integrated is the role of vegetation in the extensive fields. These are the peanut and millet fields. The role of

millet is crop failure insurance for the maize crop. It is still too early to declare success as there has not been a bad rain year since this new system was introduced. The dietary change was not difficult as these people already ate some maize. The role of the peanut is for cash and fodder. Cut-and-carry forage of grasses, or leaves from woody plants could be a substitute for peanut fodder. Substitution for cotton seed could be fodder peanut, cowpeas, or Acacia albida pods. Extensive fields are periodically fallowed to restore fertility levels.

The team observed an area between Thies and Bambey that was protected by villagers who felt threatened by the degradation of their environment. They protected an area of uncultivated bottom land that had been overgrazed to such an extent that there was no ground cover left. The area was protected by a guardian who controlled access. The area is now well stocked with a variety of trees and shrubs. The next step would be to cut some less desirable species for fuelwood and replace them with higher value multiple use species. There is a need for some technical advice on what to do next.

The team also visited farmers who were protecting Acacia albida. One farmer inherited a field five years ago and immediately started to protect Acacia albida wildlings. Several leading questions were asked to determine the depth of the farmer's knowledge of natural resource management. This farmer explained how leaves from a Bauhinia bush enriched the soil. The farmer also explained that the Bauhinia was better than Guiera for soil enrichment. When asked why the Guiera looked as if it were growing on mounds, the farmer explained that Guiera protected the soil from being blown away by the wind and sand was deposited at the base of the Guiera. The farmer also explained how the fall of the water table had influenced crop selection. The farmer stated that Guiera is collected for fuel when preparing the field for planting and that this had a value of 300 CFA per face meter. This level of knowledge of local resource management is not uncommon.

1. ISRA-DRDF Research in the Casamance.

a. Energy.

DRDF has installed over 100 ha of species trials for rapid growth fuel wood species in the Bayotte forest, south of Ziguinchor near the southern border of the country. All are exotics, mostly eucalyptus. The average growth rate of all trials is 20 cubic meters per hectare. The best trees are selected for grafting into a seed orchard and for vegetative propagation. The average production of these plus trees is 35 m^3/ha. This compares with the natural forest growth in the same area of about 2.5 to 3 m^3/ha with no protection from fire or animals. Without protection from fire and animals, the production of the exotics might be nil.

This points out the production potential but also some inputs necessary to reach that potential.

b. Natural Forest Management.

There have been growth rate studies on native species. Open grown trees have a growth correlation at 20 cm above ground line. Estimates are about 2.5 m^3/ha natural forest yield. Coppice with standards was tried by removing trees with a diameter of less than 20 centimeters. Fire protection, early burning, and wild fire all cause change in species mix. Enrichment was tried using nursery stock grown to above browse height giving a 1.7 m. whip with terminal and 70 cm. root. Species were linke, tali, and khaya (still has problem with stem borer), all of which had passed two years in the nursery and three-year-old vene. Industrial plantations are not possible with native species because of their slow growth rates, thus research concentrates on fast growth species for fuelwood.

Mangroves were not included in the five-year research plan. There have been some small studies on the effect of salinity rates in the nursery with seedlings. Other stations are studying mangroves in relation to fish and oyster production.

c. Agroforestry.

On station studies are an ILCA sponsored study on alley cropping with Gliricidia, Leucaena, and Celtus integrifolia. In two years Gliricidia gave 1.7 t/ha aerial biomass, leucaena 1.5 t/ha, and Celtus was eliminated as too slow. There was no intercropping, only provenance testing. The best provenances were retested in 1988 and the first results will be available in 1990. Maize was intercropped with different fertilizer levels using super phosphate at 200 kg/ha. The first year base data trials were with groundnuts in 1988, the seed was lost because of bad rainfall distribution in the beginning of the rainy season. In 1989 FAC ended the two year financing of this study. Studies on spacing and direct seeding were not done. Researchers are concerned that there is no funding to clear vegetation in 20-year-old trials and the 20 years of research could be lost in fire.

Off station application is carried out in selected villages and includes live fence around orchards, and planting on the plateau above rice fields to reduce siltation problems.

2. Other Agroforestry Research.

Research on live fencing and on species for alley cropping in dry zones is being done at ISRA-DRPF Thienaba and Kaolack.

F. KNOWLEDGE GAPS IN VEGETATIVE COVER RESOURCE MANAGEMENT.

Casuarina equisetifolia (filao) will not coppice from cut stumps (unlike many other species used in Senegal). It is very expensive to grow as nursery stock. The best solution to maintain the filao windbreak is through natural regeneration but this does not occur naturally. The proper silvicultural treatment of filao stands to encourage natural regeneration is not known.

This is typical of the knowledge gaps in the silviculture of specific trees and shrubs. This level of knowledge has yet to be developed but utilization of species in interventions and uses of various forest products are well known. The exact market or the market net is less well known or less developed for new products such as eucalyptus poles. The level of demand for poles is not known. If promotion of pole growing is a major incentive for rural forestry there must be sufficient market to absorb the production.

An example of gaps in agroforestry systems is with the system developed in the PDESO area. To complete the system, the fallow should be managed by scratch seeding leguminous woody plants in lines and protection for two to three years to allow establishment. This fallow should produce a crop of fuelwood at the end of the rotation as well as cut-and-carry fodder each year. Trees could be planted in lines, leaving natural vegetation in the alleys. The natural vegetation can be cleared for cultivation at the end of fallow. This method would establish an alley cropping system that would increase the agricultural potential and reduce the land demand. There is a fallow developing in the Peanut Basin from lack of inputs (Seyler, per comm). This system could be developed by using this method of line planting as land enters fallow.

Many of the knowledge gaps in agroforestry are which species work best for which intervention in each specific ecological zone. Gliricidia will work in the Casamance for alley cropping, but tree species have not been identified for the Peanut Basin or the Tambacounda area. There are trials spread throughout the country working on these questions.

G. CONCLUSIONS.

The techniques of range resource management are known and used, for example by Projet Zone Nord, but socio-political constraints make application doubtful outside project action zones.

The forest resource management technical problems are minor. The techniques of nurseries, plantations, most silvicultural practices, harvesting, and marketing are known. Missing is the will to adequately control resource misuse, give up management of land to local control, allow free market prices to decide the

selection and distribution of wood products, and control the off-take of forest products by private sector.

There are opportunities for addressing the soil fertility problem in the agricultural areas by use of agroforestry techniques that are now being adapted to Senegalese conditions. USAID through the reforestation project has experience at the national level of farm forestry through Eaux et Forêts agents. The accent of this program has been to get the farmer to plant trees. This has been a successful program but much of the planting has not been multi-use or agroforestry applications but income generation of trees as a crop. The next logical step with these farmers is to work with them to protect their Acacia albida and other field trees and bushes, and to develop management of natural forests and plantations that have been created by village action.

CHAPTER 5

ANIMAL RESOURCES

A. INTRODUCTION.

This chapter addresses the production or consumption value of Senegal's major animal resources: livestock, wildlife, and fish and shellfish. Because of time limitations, the section will not completely address those animal species that are pests and disease-agents that reduce production by either competing with farmers, fishermen and pastoralists, or weakening their ability to do labor. Pests include granivore birds, rodents, locusts, and mid-size mammals such as baboons that raid crops. Disease-agents include malarial mosquitos, tsetse flies, simulid flies that transmit onchocerciasis; snails that spread schistosomiasis; and all the livestock disease agents that decrease digestive efficiency of grass/browse utilization. This in no way reduces the importance of these pest and disease-agents as grave constraints on Senegalese productivity. A major animal resource question is how to manage disease agents or pests without harming other productive species (e.g., DDT and fish). The subject is simply too big for this report.

B. WILDLIFE RESOURCES.

Wildlife enters the economy in both a consumptive and non-consumptive fashion. From the consumption/production view wildlife is important directly as a major protein supplement, a source of additional cash income, and a drought-fallback food for many families. Subsistence hunting and commercial bushmeat hunting are old Senegalese traditions. Sport and trophy hunting by expatriates and wealthy Senegalese have also generated government income (permit charges, leased hunting rights) and have a small multiplier effect (guides, hotel, taxidermists). Wildlife skins and parts also enter the local markets as medicines, magic formulas, fetishes and crafts. (One can consider trophies and certain wildlife craft items as European fetishes.) Finally, there is the export market for monkeys used in medical research and birds for sale to Euroamerican pet stores.

The non-consumptive market for wildlife is basically the tourist, birdwatcher, and scientific research sector. Its economic impact (e.g., the long-term commitment of financial resources by ORSTOM) should not be underestimated.

Finally, the wildlife economy is based on an informal and formal sector. The informal sector is the larger of the two. No

good statistics, combining both sectors, are available for Senegal on overall contributions of wildlife protein to the diet, amount of cash income from bushmeat hunting, amount of money generated from the illegal poaching and trade in wildlife, the size of the "animal pharmacopeia and religious objects" market, and the informal market in wildlife-craft items (e.g., reptile skin belts, pocketbooks and warthog ivory jewelry). The number of Senegalese citizens involved in this market cannot be estimated.

There are no complete studies on the informal wildlife economy of Senegal. All information is either anecdotal or limited to one moment in local history. For instance, anthropologists speak of a Maitre de faune and of a specially appointed hunter for each village or region. Vincke, et al (1987) studied a Serrer area during the drought years of 1982-83. Children were the major subsistence hunters killing mostly birds, but obtaining the greatest protein from lizards (10.1 g from reptiles; 0.71 from birds; 2.1 from mammals per person per day). The total (12.9 g pppd) was half the total animal protein on a Senegalese from domestic animals for the same year (24.7 g), excluding fish. From this one study, it appears children either increase their protein intake or meet up to half their daily needs by hunting small game. Monitor lizards, despite a taboo against consumption, supplied about 10% of the total protein intake.

In fact, in Senegal, the informal and formal economy have no clear delineation. The formal economy is supposed to follow the laws of government or, put another way, the laws and policies in the formal sector should be in harmony. In 1982, for instance, fishermen caught an extremely endangered Mediterranean monk seal -- a species protected by the Code de Chasse and CITES (Convention on International Trade in Endangered Species) to which Senegal is a signatory. It was sold to the Hann Zoo where it died in a few months.

Wildlife is theoretically regulated by La Code de Chasse (see Bosh, Dieng, mns; GOS, 1967) and many specific regulations made under the Code. Tables 5.1 and 5.2 show the animals completely and partially protected under the code. There is a general acceptance that protected species and species parts (ostrich eggs, python skins, hippo ivory) can be sold on the open market (Singleton and Vincke, 1987). This, of course, further blurs any distinction between the two sorts of economies and makes any enforcement appear arbitrary. The only import restrictions on species into Senegal are those in CITES. Senegal markets have reptile skins and birds that we were told come from Ivory Coast, Gabon, Guinea, Guinea-Bisseau, and Gambia. There appear to be no restrictions on either importation or sales.

The formal economy has profited from three major revenues: (1) leased hunting grounds (amodies); (2) permits and entrance fees for parks and hunting; and (3) selling birds for pets. This income

has varied. Wildlife-based income has decreased with the drought which reduced the numbers of wildlife both for hunting and viewing; by land clearing which reduces habitat; by increased availability of modern weapons; by government inability to enforce existing

Table 5.1. Protected Species Under Senegalese Law.

MAMMALS

Hippopotamus	Damaliscus Hartebeest
Chimpanzee	Giant or Derby's Eland
West African Manatee	Red-fronted Gazelle
Black-and-White Colobus	Dorcas Gazelle
Western Red Colobus	Damas Gazelle
Colubus	Sitatunga
White-collared Mangabey	White-backed duiker
Senegalese Galago	Cheetah
Pangolin	Leopard
Aardvark	Red River Hog
Giraffe	Scaley-Tailed Squirrel
Seal	All whales and dolphins

BIRDS

Ostrich	Marabout Stork
White Pelican	Wood Ibis
Pink-Backed/Grey Pelican	Saddle-Billed Stork
Red-billed Tropic Bird	Cattle Egret
Hadada Ibis	Great White Egret
Sacred Ibis	Little Egret
Glossy ibis	Denham's Bustard
African Spoonbill	Sudan Bustard
Lesser Flamingo	Greater Flamingo
White-necked stork	White Stork
Abdim's Stork	All vultures and raptors

REPTILES

All marsh,land and sea turtles and tortises
Nile Crocodile
Slender-snouted Crocodile
Dwarf Crocodile

MOLLUSCS

Cypree

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regulations; by the inability to move the informal economy into the formal sector; and by the uncontrolled brush fires that reduce

game habitat.

Wildlife-based income has been favored by (1) cultural restrictions that protect both habitat and particular species; (2)fully protected areas which act as sanctuaries and allow populations to increase; (3) the creation of some watering holes for livestock; (4) the return of rain; (5) the on-going attempts

Table 5.2. Species with partial protection under Senegalese law.

MAMMALS

Lion	Serval Cat
Caracal	Wild Cat
Civet	Zorilla
Otters	Mongoose
Hunting Dog	African water buffalo
Roan Antelope	Bubal's Hartebeest
Buffon's Kob	Bohor's Reedbuck
Onctuex Kob	Oribi
All duikers	Guib harnache

BIRDS

Egyptian Goose	Spur-winged Goose
Knob-billed Goose	White-backed Duck
King Reed-Hen	Allen's Reed-Hen
Brown-necked Parrot	Senegal Parrot(Youyou)
Senegal Long-tailed Parakeet	Senegal Bustard
Savile's Pygmy Bustard	Black-bellied Bustard

REPTILES

Royal python
Seba's Python
Nile Monitor Lizard
Savanna Monitor

by Eaux et Forêts to understand how best to deal with the wildlife resource (e.g., recent CTFT consultancy); and (6) the seemingly endless desire of the industrial nations for tropical birds.

The scale of the wildlife economy is not yet significant in the formal economy. Income from park entrance fees has fluctuated with $80,000 per year being a typical revenue from entrance permits, guides, and payments from commercial film and advertising. (Visitors, not visitor days, were typically 10,000 per year). Income from hunting permits, tree felling, commercial permits, and daily use permits varied from $150,000 to $600,000 US

[illegible] years. In 1988-89, leasing of Eaux et Forets lands for sole use hunting added $200,000 to their revenues. (Fees for leased hunting grounds are 30 CFA per hectare per year, with only a small part of the 3.2 million hectares under experimental lease.) Further details will be available in the upcoming CTFT Report. None of these calculations include a "multiplier effect" as it could not be determined.

The pet bird export industry has a formal aspect in which 1.2 to 2.4 million birds have been exported per year for the last ten years. This number is perhaps much larger as Eaux et Forêts and GOS customs have not had the skills, training, finances, and/or interest to check exports in the airports. Most of the species exported are common or pest species. The export of these birds has a double income-generating value (it saves crops, and supports trappers and exporters). On the other hand, certain birds should not be exported by GOS law (e.g., the Brown-necked parrot) but slip through the controls quite easily. The industry has a reported income of about $500,000 per year. The commercial tax to the GOS could not be determined as a separate line item. Table 6.4 lists birds and other animals involved in the exposed commercial economy.

The major WILDLIFE OPPORTUNITIES AND CONSTRAINTS that can be gleaned by a short-term consultant appear to be:

-- The need for hunt-free zones to allow the recovery of game devastated by the last fifteen years.

-- Close attention to the conservation as well as the exploitive actions of lessees in the leased hunting grounds. Greater attempts to lease to village groups (hunting groups) rather than individuals.

-- Tighter control over the reptile skin market if Senegal is to have a sustained market and not a short-term crash. Limits within the market place might be desirable.

-- Particular attention to the Faleme Hunting Reserve, as this area has broad conservation and high-priced hunting values.

-- Increased attention to the actions necessary to increase attendance of both Senegalese and foreigners to the park system (e.g., package tours, reduced Senegalese entrance rates). This may be possible with the recent merger of the National Parks Department with the Ministry of Tourism.

-- Creation of additional protected waterfowl and wader areas among the new irrigation districts in the Senegal River Basin, especially the Ndiael, the middle valley and Mauritanian wetlands. (These refuges have double or triple economic benefits: reduce crop losses, increase huntable game in Africa and Europe, and provide for the tourist and birdwatching community (Warshall, 1989; Treca,

1988).

-- A market analysis of game ranching potential. (Populations of Senegalese game are too low for any game cropping scheme in the near future.) This would include antelopes, ostrich, and crocodiles. Perhaps as profitable is the culture of beautiful butterflies and beetles for export. This has become a profitable business in Latin America.

In conclusion, the distinction between consumptive and non-consumptive management of the wildlife resource is crucial. The GOS has been ineffective in managing the consumptive uses of wildlife and have presented a contradictory image to its citizens: good laws, lax or no policy and implementation. The informal sector (including the black markets) are having a greater impact on wildlife numbers and species. This is completely out of government control. Certain species that could have been commercially important (ostrich, elephants) are headed for near-term extinction.

There appears to be little hope that Senegal can maintain a renewable wildlife resource for consumption and income generation. Only the non-consumptive use area, especially the protected bird areas, appear hopeful as both a source of income and a viable conservation activity.

C. FISH AND SHELLFISH RESOURCES.

Fish and shellfish are a crucial part of the Senegalese economy. Average consumption of fish is higher in Senegal than in any other West African nation (total of 26 kg per person per year). There are two main fisheries (marine and freshwater), but these categories become blurred because of the dependence of some fish on both fresh and saltwater. In addition, there is a "fishery" for sea turtles, exotic shells, sport fish like marlin, and the early stages of oyster and shrimp cultures. Fish culture projects have either been disbanded or proved uneconomical at this point.

From the natural resource point of view, Senegal has one of the best marine fisheries in Africa because of its littoral zone of 718 kilometers and with a continental shelf area of 23,800 km2. Total bottom surface of fishable marine waters is about 196,000 km2 (12% of Senegal's land surface). In addition, the ocean area is the convergence zone for two great currents causing an upwelling of nutrients that is the base of the fisheries food chain. Both the Gambia and Senegal Rivers once created access for estuary fish, migrating fish, shrimp and crabs that formed at major aspect of the coastal fishery. The Sine Saloum and the Casamance and its bolons are additional "saltwater" fisheries with only occasional seasonal freshwater fishing.

In addition, there was traditionally a freshwater fishery within the niayes' interdunal marshes, the lower and mid-valley floodplains of the Senegal River, Lake Guiers, and a few closed basins fed by substantial rain. The fish fauna is predominantly Sudano-Sahelian with a substantial influence (even in freshwater) from oceanic species. Only in the southeast uplands do forest-type freshwater fish associated with the Guinean fauna exist.

The total inland or FRESHWATER catch in Senegal was not available. The knowledge of the Senegal River -- Senegal's most important inland fishery -- is the lowest of all major African Rivers. The continental or freshwater fishery is regulated under Eaux et Forets' Code de la Peche. This code sets out seasons and mesh sizes for the fishery. As stated by Eaux et Forets (Bosh, Dieng, Dia, mns), the problem has been enforcement which does not really exist.

Before Manantali and Diama dams and the construction of riverside dikes, the SENEGAL RIVER FISHERY produced about 28,000 tons per year (some experts say 30,000 tons) and supported 10,000 full-time fishermen. In addition, it supported many part-time fishermen, providing supplemental protein for their families. During droughts, agro-fishermen and pastoralist-fishermen relied heavily on the Senegal for food.

With the drastic change in the Senegal River, it is known that the floodplain fisheries will no longer support the diversity of fish and the quantity of catch it once produced. The situation is complex and not well studied. For instance, the mid-valley floodplain varied naturally from 20,000 ha inundated for 20 days to 600,000 ha inundated for 120 days. Manantali dam and irrigation projects will reduce both area-flooded, flood duration, and flood depth toward the situation of an artificial permanent drought. Reizer (1983) estimates the loss of 400,000 ha of fish breeding and fingerling growth habitat from on-going waterworks. The reduction in standing stocks will increase unemployment, raise the price of fish, increase imports from Manatali Dam or marine fisheries to the inland towns and villages. In the "worst case" scenario, it will cause protein malnutrition during difficult years, requiring increased food aid.

In addition, the estuarine fish of freshwater origin, euryhaline (salt-tolerant species such as Tilapia) freshwater fish, and marine fish that feed in freshwater will suffer from reduced numbers and species. Since the larval stages of shrimp (Panaeus duorarum) have a freshwater stage, there will be a general collapse of the shrimp industry (a process exacerbated by overfishing). The impacts on crabs (especially, the commercially important "blue crab" Callinectus sapidus) is not known. Increased diking of floodplains, conversion of floodplain soils into irrigated crops, and navigation dredging will further collapse the industry. Since the ecology and behavior of tropical riverine fish

is linked primarily to changes in water level, the unnatural releases for hydropower will further confuse and reduce reproductive potential within the basin. In Mali, aseasonal releases from Selingue dam stimulated a false lateral migration of Alestes into the floodplains. The annual reproductive season failed when the waters retreated abruptly.

Basically, the total water regime of the Senegal River was changed before a clear natural resource assessment was made. We will never know (1) changes in biomass with different water regimes (dry, very dry, wet, and very wet "type-years"); (2) the significance and extent of fish and shrimp migration; (3) accurate estimates of standing yield; (4) the seasonality of feeding and reproduction of most of the fish species; and (5) niche selection by fish in the dry vs. wet season. The Senegal River waterworks have had a major negative impact on the fisheries resource of Senegal's largest river. No mitigation measures (e.g., an artificial estuary, reproductive sanctuaries for floodplain fish, the twenty-year plan to establish aquaculture) have been implemented.

The Marine fishery includes four basic ecological sectors and fisheries:(1) pelagic or open ocean fish (sardines, tuna); (2) coastal fish; (3) bottom-dwelling coastal fish; (4) bottom-dwelling deepwater fish and shrimp. There are about 530 km of coastline (exclusive of estuaries, bays, inlets); 12 nautical miles of territorial seas; and about 200 nautical miles called the Exclusive Economic Zone. The natural limit to exploitable resources is about 200 m at the edge of the continental shelf. So far, no offshore oil or gas has been found to complicate the maintenace of the fishery resource.

There are many good sources for an understanding of the industry and marine resources (Seret, 1986; GOS, 1986; Diouf, 1986). Here, we simply emphasize its crucial importance to Senegal. The statistics are, as with wildlife, for the "formal" sector. The "informal" sector may be vast, including under reporting of oceanic catches by foreign drag-net and open-ocean fishing fleets. In the 1980's, sixty to seventy per cent of the marine catch came from small business fishermen (called "artisanal" fisheries by FAO). The artisanal fishery earns about 35 to 50% of the total formal sector income from marine fisheries. The artisanal fishermen supply 85% of all the fish eaten in Senegal. A full nine per cent of the population is employed in this fishery with many more part-time workers. Because of its low capital investment and high return, this is the one industry that has moved Senegal torward self-sufficiency. In fact, it makes a significant yearly contribution to lowering foreign debt by exporting fish.

The average annual marine catch dropped drastically between about 1974 to 1984. The drop of 30% is not adequately explained but includes over-exploitation of the resource (predominantly the bottom-dwelling coastal fishery), price changes, antiquated fishing

fleets, and above-quota skimming by foreign industrial fish operators. In 1986, the GOS reported a spectacular recovery with increases of 5% in tonnage each year. In 1983-85, the total tonnage of small and industrial fishermen was estimated at about 235,000 tons; in 1986, about 270,000 tons. It is not clear how the increased catch relates to the stocks available. The increase may be due more to increased fishing intensity and efficiency than revival of stocks. Senegal would like to believe that there is a sustainable yield of 420,000 tons.

The management (vs. the increased exploitation) of the saltwater fisheries resources has rested with CRDOT (Centre de Recherche Oceanographique et Technique) which tries to determine stock levels and FAO with small projects for both freshwater and saltwater fisheries. France has been helping finance a project in shrimp culture. The main donor and technical support comes from Canada. Scientific understanding of stocks, fishing intensity and efficiency as well as appropriate technology must be translated into regulations, tax incentives, withdrawal or additions of project subsidies. This complex process includes many Senegalese and expatriate organizations, especially the EEC which negotiates major exploitive aspects of the coastal and deep-water fisheries for European industries.

The major natural resource opportunities and constriants in the FISHERIES area include:

-- Over-exploitation of the bottom-dwelling coastal fisheries and unknown impacts on the other fisheries with a need for better stock assessments, monitoring capability within the Exclusive Economic Zone, ability to designate and enforce protected areas, and ability to turn the industry into a value-added industry rather than simply a raw material industry exploited by foreign fleets.

-- Revival of the estuary and inland fisheries of the Senegalese portions of the Senegal River Basin. This includes creation of the artificial estuary (shrimp and fish) and protection of particular floodplains for fish breeding and livestock use (e.g., bourgoutieres) rather than conversion to irrigated agriculture.

-- Mitigation for over-exploitation and destruction of fisheries with substantial investments in shrimp farms, oyster culture, and, perhaps, fish farming.

-- Inclusion of fishery resources (and grazing resources) in all models concerned with hydro-power releases from Manantali. Study of the possibility of stocking Diama's dry season reservoir with cultured fingerlings.

-- Long-term study of pesticide, drainage and pollution impacts on the new water regime of the Senegal River to determine

at what level and location impacts become significant.

-- A need to protect certain marine species (e.g., marine turtles) and coastal species (e.g., West African manatee) from destructive impacts of fishing. This includes the protected Cypree mollusc that is sold to tourists and collectors and is endemic to the Cap Vert coast.

In 1990, the inland fishery is totally focussed on exploitation with no regulations or projects for protection, regeneration or sustainable yields. The marine fisheries are just starting to combine monitoring of the resource with regulations. Senegal's major estuarine fishery has been destroyed.

In conclusion, the inland fishery has been damaged by drought and non-mitigated river basin development. A crucial GOS policy for food security has been ignored in the general enthusiasm for highly subsidized waterworks. Especially in the Senegal River basin of Senegal, protein self-sufficiency and a reliable resource have been harmed. The marine fishery has started its first attempts to regulate catches for long-term sustainable yields. It is a highly profitable industry that requires attention, especially to bottom-dwelling coastal fish. The shrimp industry dependent on the Langue du Barbarie and Senegal River estuary will collapse unless an artificial estuary is built. Senegal has just begun to substitute for natural regeneration of its fishery by substituting commercial aquaculture.

D. LIVESTOCK RESOURCES.

This section is concerned only with the management of the animals, not the management of the vegetation eaten by them. This chapter focusses on numbers, mix of sexes and species, distribution, and management of seasonal grazing. Because this is a general overview, detailed discussions of fencing, water supply, salting, bedding-grounds for sheep, herding patterns that sustain the grazed and browsed resource as well as herd separation to reduce disease transmission will receive only passing mention. A more detailed review of natural resource management and the livestock sector should include a "regional" discussion of each activity. This section focuses predominantly on cattle. Research lags far behind on sheep and goats. In addition, in Senegal, cattle form the greater part of the livestock biomass.

According to FAO statistics, there were about 2.2 million cattle in Senegal in 1984-86. The change since 1974-76 has been a loss of about 5% of the herd. The latest count estimates 2.5 million cattle so the population has probably fluctuated between 2.2 and 2.5 during two major consecutive droughts. There are about 0.3 cattle per capita in Senegal. There were about 3.2 million goats and sheep in 84-86. This is a 28% increase since the 1970's

and represents an adaptation to drought and an increase in browsing species. There are about 417,000 horses in Senegal which is a 5% increase since the 1970's. Asses numbered about 240,000 in 1983 with no more recent counts available. There were about 6,000 camels in 1984-86, but a huge increase took place immediately after with 23,000 camels censused in 1988. The Mauritanian conflict forced the camels back across the border and the number of camels is believed to be back at 6,000.

The counting of livestock is done by both ground-truthing through the vaccination program and by aerial survey by CSE (1989). Aerial surveys have focussed on the northern half with the first country-wide survey in 1990. An excellent overview of aerial surveys in the Ferlo can be found in LeHouerou (1989) and Centre de Suivi Ecologique (CSE) documents (1990). There have been significant differences between ground-truthed and aerial counts. These populations are only now under careful analysis. The aerial surveys have added two important pieces of knowledge to livestock resources: movements stimulated by fires and movements stimulated by the patchiness of rainfall. These two additions, in themselves, have made the effort worthwhile.

This consultant could not find as interesting or complete data on the Kaolack region nor the Casamance. Perhaps, I just missed the sources or perhaps there are only a few (Boudet, Ellenberger, 1971; Piot, Diatie, 1983; Valenza, 1975). There is a long and detailed history of the northern sector (see LeHouerou, ibid.) with a good but spotty coverage of the Senegal River area, including cross-border migrations (Jacobs, per comm).

Comparing 1950 statistics to recent counts reveals important understandings of the importance of cattle to the social and investment life of the Senegalese. The annual population increase of all livestock and people has been approximately equal(about 2.7% per year). As with humans, population increases can be traced to a drastic reduction in mortality from the introduction of modern medicine. For cattle, the control of rinderpest and bovine pleuro-pneumonia has been particularly important. In a bit more than a quarter century (1950 to 1985), cattle have increased over 200%; sheep 315%; goats over 40%; and asses over 200 percent. In 1983, the density of livestock in Tropical Livestock Units (TLU) per km2 was the densest in all of West Africa with concentrations higher in the more sedentary agropastoral areas near Kaolack than in the more pastoralist and short-range agropastoralist Ferlo. Senegal (along with Burkina Faso) had the highest percentage of cattle in its livestock resource (about 73%).

The breeds of livestock in Senegal are predominantly the long, lyrate-horned zebu (Gobras) in the north and the small Ndama cattle in tsetse territory. The sheep are the hair-type (vs. wool-type). The asses, goats, camels, and horses show no particular breed variants compared to other Sahelian groups.

There are no data that pertain only to Senegal on herd structure but work in various parts of the Sahel provides a "typical" picture: 43% breeding cows, 17% heifers, 9% adult males, 9% young bulls, and 23% calves of both sexes. The data on sheep are poorer but northern Sahel groups had about 22% males and 78% females of which 58% were breeding females. Similarly, goat surveys give "typical" herd structures of 21% males; 79% females of which 56% were in breeding condition.

When considering management; production, consumption, and numbers cannot be easily separated. In quick terms, productivity is not specialized into dairy, skin, or meat components. In Senegal, farmers and pastoralists raise livestock for a great variety of goals: dung and manure, draft power, transport, hides and skins, hair, milk, and, perhaps, most important socio-political and monetary investment. Productivity indexes from industrialized nations are not comparable and should not be used. Production of items such as manure and dung are costs in feedlot operations. In farmers fields, the cost-savings or profits from manuring has been difficult to quantify. Wilson (1984) estimates increased yields of three to five times over unmanured, periodically fallowed fields in one area of Mali. Finally, since land is not privately owned, livestock raisers have relatively little control over production. Instead, they mix herd composition to insure a small reliable profit, not to maximize annual profit.

Production of sheep in Senegal is, to a large extent, aimed at the ram festival which occurs on a different date each year. Thus, stocking rates of sheep (about one-third of Senegalese livestock by numbers, less by weight) are dramatically removed from the herds (with a great relief in grazing pressure) at a different, non-flexible date each year. This limits the ability to harmonize stock numbers with grazing resources.

Production performance and high mortality of Sahelian livestock can be traced to poor nutrition and poor health conditions. Donors have opted for the easy areas of poor health and contributed to overstocking in the 1960's and 1970's with subsidized vaccination programs. They tried to resolve the poor nutrition aspects by better watering and spreading out grazing pressure but this backfired and simply led to more livestock in more pastures and no improvement of nutrition. Predators are not a problem in Senegal.

Managing livestock numbers is further complicated by the four production "systems" and "herd management" styles. These are: sedentary agropastoral in irrigated areas, along the Senegal River, or flooded depressions; short-range transhumant agropastoral which has artificially evolved in the Ferlo with increased boreholes; long-range pastoral which is particularly common between Senegal

and Mauritania; and agro-sylvo-pastoral which is found in southern Senegal associated with groundnuts, Acacia albida, and millet. Each "system" has differing grazing, ruminating, resting and walking times. This is too much detail for the present report. From a natural resource management point of view, stocking rates vary with range type, seasonal market demand, and distance from water. Highest quality range is the bourgoutieres, now threatened by Senegal River basin waterworks. Other rangeland has been converted to farmland forcing overstocking even at current levels. Stocking rates near boreholes have reduced carrying capacities by 20 to 33% around boreholes compared to "pristine" conditions. In short, reduction of stocking rates (offtake) and seasonal management of stocking rates are the central issues in any discussion of sustainable rangelands.

Senegal has been the location of one of the most interesting long-term studies of stocking rate, species mix, and age structure adjustments in West Africa. The West German project in the Ferlo has tried adjusting stocking-rates to long-term carrying capacity; testing fencing, firebreak networks and protecting herds from trespassing by alien herds; water development in strategic places; and application of sensible prophylaxis, culling, stratification, and marketing. The strategy included limiting stocking to 12 ha per TLU in 14,000 ha paddocks. The results, in oversimplified statements, were increased productivity and improved range quality, quantity and browse.

The results of this project and the SODESP project in the present groundnut growing areas are similar. Despite highly beneficial combinations of production and resource conservation, they have difficulties expanding because of:

-- land tenure and ownership problems;

-- marketing and credit problems;

-- authority and enforcement ambiguities (who has responsibility for stock levels? and who has the power of persuasion or policing to control trespassing or stock numbers);

-- pricing policies which run contrary to environmentally sound offtake;

-- and because livestock are a better investment of excess income than banks.

For example, the West German-Senegal project occurs in the government owned sylvo-pastoral zone of the Ferlo. Tenants do not even own their own fences, though they are paying back the West Germans for them. They can lose the land at any time. Conflict over land and usufruct rights has been avoided because of the continual

presence of the German project that would leave if land usufruct rights changed. But this has wedded donor to pastoralist in a manner that is not transferable outside the project nor to Senegal in general.

Similarly, the extra calves that came from the paddocks had no market. They were sold to herders outside the paddock in order to please the West Germans. But, these calves just added to the overgrazing literally on the other side of the fence. The donors have responded by creating the first "high quality" butcher shop in St. Louis. This butcher shop is known for calf meat which is a first attempt to stratify the meat market. The donors are providing start-up capital and credit that would otherwise be impossible to obtain.

In conclusion, management of stock numbers is the central issue to maintain a long-term sustainable range. But, management appears impossible without long-term donor presence because of crucial unresolved questions of authority, power, and control over land, water, investment banking, and marketing networks. The problems are not technical, but sociopolitical. This is the central reason that over $1 billion US spent in arid land Africa over the past 30 years can show no positive large-scale success. Possible interventions include alternative forms of investment; writing long-term leases for pasture-lands; fencing with long-term leasing; tough policing of outsider intrusions (e.g., Moorish camel herds); and creating markets to increase offtake profits.

FAUNAL MAPS

Maps that reconstruct historical locales of various fauna are fascinating but of little use in managing these resources. No map of existing populations of Senegal's fauna exists. In this light, CTFT's map of faunal distribution and hunting areas should proabably be ignored.

CTFT has the only continental (freshwater) fisheries map which again, with years of recent saltwater intrusion and waterworks, is more of historical interest than a practical guide to the fisheries. General resource maps of coastal and offshore fisheries can be found in the Atlases.

Livestock distribution and numbers have been recently monitored by aerial photography in the northern parts of Senegal and were in the process of being monitored for all of Senegal during the 1989-1990 season.

CHAPTER 6

BIOLOGICAL DIVERSITY IN SENEGAL

A. INTRODUCTION.

Biological diversity is a new concept to governments, administrators and donors. Biological diversity is essentially concerned with the preservation and management of genetic resources. These resources are expressed as species, subspecies, races, cultivars, and clusters of species into natural biological communities. There are three values of biological diversity that are important to distinguish (McNeely, 1988):

-- First, many species and communities possess an "existence" value that cannot be judged by monetary accounting. The existence of the species or community is important to the religious or cultural heritage of the planet, nation or peoples. The existence value of various species and natural communities is widespread in Senegal. The government is a signatory of RAMSAR (wetland protection), CITES (endangered species protection), the Bonn Convention on migratory species, the World Heritage Convention and UNESCO's Man and the Biosphere Program among others. Locally, ethnic groups of the Basse Casamance have protected many groves or small forest areas as sacred sites.

Some of these species and communities also have a high economic value -- a non-consumption use from, for example, attracting income paid by humans just to see or photograph the species. For instance, the economic value of a lion in Kenya's Amboselli National Park is estimated to be $25,000 per year from tourist income.

-- Second, some species or communities have an "option" value -- their genetic resources can contribute to human welfare now or in the future. There are innumerable African examples. Recently, a Madagascar plant was found to have a chemical ingredient that cures a form of childhood leukemia. This complex molecule, provided by the plant, would have taken millions of dollars of research and trials before discovery through synthetic fabrication. This option would not have occurred if the species had disappeared by thoughtless destruction of Madagascar habitat. It is impossible for current economics to place a monetary value on future benefits of plant and animal species. Nevertheless, current usages of species in medicine generate $3 to 5 billion per year.

-- Third, some species and communities have a production/consumption value as defined by classical economics. In current sub-Saharan Africa, these include short-season, drought-

resistant cultivars; trypanosome-resistant livestock; VA mychorrhizal and rhizobium bacteria that increase rates of plant growth; plant species for browse, grazing and agro-forestry; animal species for trophy, commercial bushmeat, and subsistence consumption; wild plants involved in crafts, home construction, cooking, and local medicinal uses; and enough diversity of reservoir, lake and river fish species to maintain production despite natural and human-caused fluctuations in water quantity and quality.

This Chapter provides a limited introduction to Senegal's concerns with biological diversity. It expands on previous work done by the consultant in 1987 (Warshall, 1988). It combines some of the unpublished work done by Mark Bosh, Ndiawar Dieng, and Omar Dia for FAO who kindly shared their research with me. It does not fulfill Section 118/119 of the Foreign Assistance Act as the scope and focus is limited. In order to maintain a continuity between chapters, I have focussed on the protection, maintenance and regeneration of Senegal's most unique biotic communities and individual species of animals and plants. As requested by the mission, there are no suggested projects. The chapter is more a "state of the nation" report.

B. BIOTIC COMMUNITIES OF SENEGAL.

1. Status of Knowledge.

There are many ways to slice up a piece of geography. For the purposes of protection, the divisions have been made according to the evolutionary history of the planet (unique combinations of species), terrestrial vs. aquatic communities, and relatively pristine or natural conditions. Because of the extreme fluctuations of climate which periodically kill off many "communities" of animals and plants and the extremely long history of human occupation (since the neolithic), clear division of Senegalese geography into biotic communities is impossible.

From the evolutionary point of view, Senegal contains the Sudano-Zamian Domain and a northern relict area of the Congo-Guinean Domain. The Sudano-Zambian Domain is, in turn, divided in the Sahelian and Sudanian zones. The Sahelian Zone extends across Africa. Senegal is the northwestern edge of the Sahel which continues eastward to the Red Sea. Its flora is linked to species that extend all the way to South Africa and, to a lesser degree, to Asia and the Somalia-Masai Domain (aka Oriental Domain) of the Horn of Africa. There are about 1200 plant species (about 500 to 1,500 per 10,000 km2) of which only about 40 are truly endemic to the region. Senegal has not, in recent geological times, contained plant life and animal life from the Sahelo-Saharan transition. Climatic change may change this situation. At the moment, Senegal shares the Acacia woodland and Combretum/Guiera deciduous steppe savanna with Mali, Niger, Mauritania, Chad and Sudan. During the

process by which donors concerned with conservation of protected areas make financial commitments, Senegal must compete with these other nations on questions of will and ability to manage and enforce protection.

The Sudanian zone envelops the Congo-Guinean forests north of the equator, tapering out in Sudan and Uganda. It nurtures 1,000 to 2,000 species every 10,000 km^2. There are over 2,750 plant species with about 900 endemics. The Sudanian zone extends across fourteen African nations from Senegal on the western to Ethiopia on the eastern edge. Senegal's western location within the Sudanian zone gives it a special place in world biogeography because its populations had adapted to a coastal climate and the populations were furthest removed from eastern species.

Finally, there are northern pockets of the Congo-Guinean zone in southern Senegal. The most unique is the Basse Casamance National Park which nurtures "rainforest" species that survive because of shallow groundwater (not abundant rainfall). Other Guinean-type forests also exist.

From the aquatic point of view, Senegal has two main rivers (the Senegal and the Gambia) which held close biological connections to the Niger River Basin and the Fouta Djalon coastal rivers. The Senegal River is the third largest wetland in West Africa. It is on par with Lake Chad and the inner delta of the Niger River as one of Africa's top ten wetland ecosystems. An exceptional gonakie forest (Acacia nilotica) in the immediate floodplain of the Senegal River served as a great sanctuary for savanna birds and wildlife during the recent sixteen year drought. The Walos floodplain areas of the Senegal, the flood pools and lakes (marigots), the isolated islands and flooded tree islands of the gonakie forests support the major reproductive area for cormorants, flamingos, pelicans, herons and egrets in West Africa as well as the winter feeding grounds for intra-African migrant ibis, ducks, geese and Eurasian waterfowl and shorebirds. The most important parts of the delta complex are Trois Marigots, Ndiael, Lampsar, and Djeuss as well as areas in Mauratania. These same floodplains form the major inland fishery of northern Senegal. The bourgoutieres (the floodplain grasslands of Echinichloa stagnina) are an exceptional community for both fish and livestock. Finally, an old bed of the Senegal River is now a controlled lake (Lac de Guiers) which is both an important breeding ground for the West African manatee, fish resource and feeding, roosting and nesting area for wetland birds.

The Senegal COAST contains unique "anti-estuaries" -- relict deltas that once functioned as estuaries but now, in this era of lower rainfall, actually contain salinities higher than the ocean. These coastal watersheds contain unique communities such as tannes and bolons. The northernmost mangroves in West Africa can be found in Senegal estuaries with significant remaining groves in Casamance and the Sine Saloum delta. The Senegal River delta is also a unique

coastal form -- a combination of relict delta reshaped by the long sand spit of Langue de Barbarie. The interdunal marshes of the Grand Coast (Dakar to St Louis) called niayes nurture another unique community of plants including oil palms (Elaeis guineenis).

The coastal and OFFSHORE biological communities comprise the last complex of Senegal's unique attributes. The fish, squid, and mollusc fauna comprise a unique complex of Temperate, Mediterranean, and Gulf of Guinea species. The coastal islands are major breeding grounds for many sea birds -- again combining southern and northern species into a richness not found elsewhere (see Table A8.1 in Annex 8). Like the inland wetlands, the coastal and offshore areas are critical for migratory species of sea birds, whales, dolphins and sea turtles. The natural history of these islands is poorly known and needs more attention (see Species).

In summary, Senegal has the following important biological communities:

-- Inland wetlands, especially marigots, floodplains and Walos, and Lake Guiers that support nesting colonies, Palearctic bird migrations and intra-African bird migrations, fish reproduction, and a safe breeding area for the manatee.

-- Coastal estuaries, sand spits, and islands (especially mangrove forests and tidal flats) that support migratory and breeding sea birds, sea turtles, whales, dolphins, and a major fish and shellfish industry.

-- Unique communities, especially the niayes, the gonakie forests, one or two relatively pristine borassus palm mixed forests, and the relict Guinean humid forests.

-- A flora and fauna in Niokolokoba National Park that includes some of the most pristine Sudanian zone flora and fauna left on the planet.

-- A Sahelian region important to dry season African raptors.

-- The Faleme Hunting Reserve (Chapter 5).

2. Protected Areas of Senegal.

Tables A8.2 to A8.4 in Annex 8 (prepared by Bosh, Ndieng and Warshall) list our best understanding of GOS legislative acts that authorized protected areas. Essentially, Table A8.2 lists "zone integralement proteges" which have about the same protection level as American National parks. Both flora and fauna are protected. Table 8.3 lists areas protected by virtue of Senegal signing international conventions and treaties. Table 8.4 lists zones of partial protection where certain uses such as grazing can

occur. These differ from American multiple-use lands in that hunting is prohibited. They are game reserves. The most important is Ndiael which is also part of the RAMSAR international protection program.

In addition, there are hunting areas of Senegal (zones d'interet cynegetique et zone amodiees) that have been discussed under Animal Resources. The connection of large game populations between the Faleme, Niokolokoba National Park, Mali, and Guinea need immediate attention as this is the last location in Senegal where seasonal migrations of large mammals are possible.

There are about 184 classified forests and sylvopastoral reserves covering about 2,773,595 ha with paper protection of forest and grazing resources. The consultant did not have time to review how completely the legally protected areas covered the biological communities of Senegal.

From a legal point of view, there is no "national park level" protection within the Sahelian zone, the niayes, and the gonakie forests. IUCN (the International Union for the Conservation of Nature) has suggested the Niaye de Sangalkam as a candidate for Niaye protection (IUCN, 1989). They suggest the Classified Forest of N'Dioum Walo (near Podor) for gonakie protection by, perhaps, upgrading its legal status to Botanical Preserve.

The inland wetlands are in a huge, somewhat chaotic state of flux in terms of legal protection. Nevertheless, from a legal point of view, Senegal has made a praiseworthy and significant effort to protect wetlands (Djoudj, Sine Saloum, Kalisaye, Kassel, Popenguine, Ndiael, Guembeul). The actual states of protection of walos, floodplains, bourgoutieres, sloughs, bolons, and marigots need a much better review than presently exists.

The coastal biological resources also have significant legal protection (Basse Casamance, Sine Saloum, Iles de Madeliene, Popenguine, Kalisaye, Kassel, Langue de Barbarie). No review of coastal islands (especially those near Gambia) and pristine coastal strand communities is known to exist.

The Sudanian Zone has significant legal protection in Niokolokoba National Park. But, not all Sudanian woodland types can be found within the park. For instance, the Classified Forest of Patako-East (Kaolack) has been suggested as a site for upgrading and increased protection because it has an extraordinary variety of tree and Combretum species. Similarly, the relict Guinean forests need review with only the tiny Basse Casamance National Park providing adequate protection for a few of the existing "Guinean" vegetation types. The Classified Forests of Dianteme and Essikene have received attention from IUCN and the Sweden. Biological status of the forests is unknown.

These protected areas link to Senegal's and the world economy in the following ways: (1) They provide a safe place for reproduction of hunted species that then disperse into hunting areas -- providing the animal resource for commercial, subsistence and trophy hunting. This includes the sale of hunting licenses in Europe for migrant waterfowl and shorebirds. (2) They provide a safe place for the regeneration of wildlife after the devastating losses from drought and poaching (especially, Gueumbeul and fish spawing areas in estuaries). (3) They provide for a non-consumptive use industry (tourism) which, because it is non-consumptive, has a very high return value. (4) They protect option values for future industrial and pharmaceutical uses of select plant species. (5) To the extent that they are managed to provide village produce, they support local economies. They can provide value-added income to local communities that become involved in crafts or guide services.

3. Effectiveness of Protection; Opportunities and Constraints for Managing Biotic Communities.

Senegal has made a serious legislative effort to protect areas of significant interest to Senegal, the world, and its peoples. They spend internal tax dollars to subsidize the protection of various parks and reserves. On the other hand, the amount of Senegalese state financing available is small and salaries for park and forest guards are low, equipment is sorely absent, and living conditions are dreadful. Donors have not been interested in long-term or substantial aid to protect most of Senegal's legislated areas. For instance, mitigation measures to protect fish and wildlife in the Djoudj National Park and Senegal River estuary were studied under USAID contracts. But USAID did not implement any of the recommendations nor use its influence in a "round table" discussion to encourage the donors constructing waterworks to take partial responsibility for harms done. Similarly, World Wildlife Fund helped set up two national parks but essentially abandoned them financially from the point of view of tourist development, park management, and operations and maintenance assistance.

Effectiveness of protection has been hampered by the "paper parks" syndrome -- protection looks good on paper but the reality is quite different. For instance, the upper levels of the Government of Senegal have, in some cases, ignored their own legislation. The most notable example is the complete disappearance of Ndiael Faunal Reserve by SAED's dams and drainage project. The destruction of this reserve violated Senegal's own laws as well as RAMSAR to which Senegal is a signatory.

EFFECTIVENESS OF PROTECTION IS HEAVILY DEPENDENT ON A COMBINATION OF ATTRACTING INTERNATIONAL INTEREST AND THE SERIOUSNESS OF THE COMMITMENT OF THE GOS. For instance, with the demise of Boucle de Baoule National Park in Mali, Niokolokoba has become

among the last Sudanian areas with legislated protection in Africa. In terms of financing, Niokolokoba must compete with other Sudanian parks in Benin, Burkina Faso, Cameroon, Niger, and Nigeria for both tourists and international aid. Both Burkina Faso and Niger have better management programs and Sudanian woodland of equal "pristine" condition. As time goes by, Niokolokoba could compete with these parks given a strong commitment to protection by the GOS. But, the park suffers from development of a major road, the possibility of a dam within or upstream from the park, a rapidly diminishing elephant population; poor park equipment and living facilities; inadequate tourist and education materials. This low interest on the part of the highest levels of the GOS is encouraging international aid to help these other nations.

In addition, Senegal suffers from biological constraints typical of many protected areas around the world, including the United States. The most salient are undersizing and the isolation of protected areas from each other. Undersized and isolated protected areas such as Basse Casamance become "island habitats." During periods of drought, terrestrial mammals in search of water or food, leave the protected island and enter the harsh world of farms, roads and urban development. While in search of better habitat, they are shot; some of the larger mammals (similar to American bison) require an annual migration. During migration, they leave protected areas and are shot. The extinction of the giraffe and korrigum hartebeeste in Senegal is, at least, partially due to these wandering habits.

ISOLATION IN UNDERSIZED PARKS, in almost all the Senegalese National Parks, has caused the population of large mammals to drop below a viable level. When populations of large mammals drop below 500 to 1,000 adults, genetic inbreeding occurs with increased abortion, smaller litters, and increased vulnerability to disease. Without safe corridors to maintain genetic variability, the population suffers from what biologists call "genetic depression." Genetic depression can lead to extinction even in protected areas. The populations of reintroduced Damas and Dorcas gazelle in north Senegal; Sitatunga and African Buffalo at Basse Casamance; wild dog, elephants and chimpanzees in the Niokolokoba/Faleme complex and ostrich in the Ferlo are probably below genetically viable levels with little opportunity to outbreed. The situation appears impossible to solve in Basse Casamance and Djoudj without artificial introductions but could be solved at Niokolokoba. Niokolokoba needs to be linked by safe passage corridors to the Faleme Hunting Reserve, Mali, and Guinea's Bandiar National Park.

This "extensive" approach to habitat islands, safe passage corridors, adequate sizing, and assured outbreeding opportunities has not been incorporated in GOS policies nor NGO policies for terrestrial mammals, aquatic species, or flightless birds (ostrich). It is a high priority for any long-term protection of intact biotic communities.

The effectiveness of protection has also suffered from lack of INTEGRATION OF LOCAL POPULATIONS into the management of the protected area. The Djoudj National Park is just now writing its first management plan. As far as this consultant could determine, none of the other protected areas have a management plan but decide on a year-by-year basis what has priority. As opposed to legislative dicta, Djoudj now allows livestock grazing, fishing, and planting of exotic species within the National Park. Villages have settled within the "buffer zone" which is contrary to protected zone laws and regulations but seems to be an accepted policy of GOS, despite its own laws. Introduction of the Asiatic water buffalo has been suggested.

It is surely necessary to build a consensus of how the areas within the park and within the buffer zones around each park will be managed. Limited access agreements may be one initiative to reduce poaching and create a feeling of responsibility for the protected area. But, at the moment, these modifications of "zones integralement proteges" are chipping away at the protected areas in a piecemeal and ultimately non-constructive fashion. Similar compromises with protection within national park areas can be found at Sine Saloum, Niokolokoba, and Basse Casamance. (For more details, see the now somewhat out-of-date but still useful description of each park in Lariviere and Dupay, 1978 and Warshall, 1988 and the brief sketches by IUCN, 1989).

Outside the "integrated protected" areas, effectiveness of enforcement and management of legislation have been minimal. The Ferlo Faunal Reserve has been devastated of wildlife and flora. Only the unlikely possibility of electric fencing, range riders, and the concentration of remaining Sahelian wildlife into part of the Ferlo could allow recovery. The Classified Forests and Sylvo-pastoral zones as well as the two Botanical reserves, have not been surveyed but general discussions with Eaux et Forets leaves the impression that they have suffered greatly from drought, charcoal dealers, lack of management, firewood and construction pole "poaching," etc.

4. Conclusions.

In summary, it is useful to review the inland and coastal wetlands as they are unique development and conservation assets of Senegal. From the development and financial point of view, the wetlands provide for hunting in both Africa and Europe. The shoreline provides for both beaches, marine sport fisheries, protein self-sufficiency, industrial secondary sectors, drought-resistant food supply, and nature-oriented tourist income. The conservation of these resources will in the long-term yield a more reliable (not erratically maximal but more consistently predictable) income than export crops such as rice or cotton which need

subsidies, extract and diminish soil resources, have huge operation and maintenance costs, and participate in a fickle international commodities market. Both marine fishing and interesting birds are increasingly scarce resources that appreciate in value with each passing year. At the moment, there are no competing birding areas in all of West Africa. There is no opposition here between conservation and development. In fact, European bird protection and hunting groups as well as ORSTOM provide the most solid constituency for foreign aid and technical assistance for these protected areas.

Major problems remain. Lack of appreciation of this resource is high in both donor and GOS circles (see below). Irrigation works are devouring floodplains and waterfowl areas at the same time as consultants such as Gibbs and associates leave tourism, hunting and protein self-sufficiency out of their cost/benefit analysis. Development with conservation actions such as the artificial estuary which would restore the shrimp industry are not included in land/water development trade-offs and financial analysis. Irrigation engineering works take precedence over laws such as the RAMSAR Convention and the Code Forestier which, for instance, should have protected Ndiael. Manatali dam releases are not scheduled to maximize floodplain reproduction of the fisheries and bourgoutieres.

In short, Senegal suffers from the following:

-- ecological problems of undersized and scattered protected zones with no safe passage corridors;

-- from lack of appreciation for the contribution fish and wildlife resources make to both protein nutrition and long-term economic development by both the upper levels of the GOS and donors;

-- from the impacts of the drought and non-mitigated river basin development;

-- from a lack of personnel and financing to manage protected areas, resolve conflicts with neighboring villages, and build a consensus on the use of buffer zones, sylvo-pastoral reserves, and classified forests.

Financing and hope for Senegal's protected areas seems remote, except for the commitment of European bird conservation and hunting groups, the Netherlands, and the Peace Corps. Foreign aid for conservation is minimal, relative to money spent on non-mitigated development.

C. PLANT SPECIES CONCERNS FOR BIOLOGICAL DIVERSITY.

1. Status of Knowledge.

The consultant did not have time to review existing literature, herbarium collections, nor talk to experts on various Families of the Senegalese Flora. The basic references consulted are Davis(1986), IUCN(1989), Berhaut(1975), and Adam(1968). According to these sources, there are about 2,100 macrophytes (many celled plants) within Senegal. Rare and threatened plants are listed in Table A8.5. Non-threatened endemic plants (plants found only in Senegal) are listed in Table A8.6.

In addition, work on the important medicinal, veterinary, pharmaceutical plants of Senegal has not been investigated (Kerharo, 1968; Kerhar, 1974; Busson, 1965; von-Mayhall, 1983). It is known that the plants of Senegaleis Sahelian and Sudanian zones have been hammered by the drought, the charcoal market, the fuelwood market, and overbrowsing (Chapter 4). The species -- beside the gum acacias -- that have been particularly hurt in the last fifteen years need investigation. No survey of the incorporation of native plants nor the maintenance of natives within agroforestry or women's gardens was made(e.g., Irvine, 1956). These are important actions to conserve biological diversity. Finally, no survey of any cultigens (such as specially ancient or drought-adapted millets) has been made (ICRISAT, AGP).

2. Protection of Plant Species.

If plants are protected at all, they are protected by local custom. This has been difficult after the nationalization of all plant resources. One species particularly over-exploited has been Echinochloa stagnina (Bourgu) which is a favored livestock feed and provides shelter for fingerling fish. It is losing ground with the advent of waterworks along the Senegal River and, because of its outstanding economic value (perhaps the highest in the Sahel), should be surveyed and protected or restored.

D. PROTECTION OF ANIMAL SPECIES.

1. Status of Knowledge.

There have been no recent field reports on the size, distribution or even existence of the birds, mammals and reptiles of Senegal. Literature is extensive on birds (Morel, 1972; Brown, et al, 1982; Morel, 1968; Morel and Morel, 1978; Morel and Roux, 1966; Roux, et al, 1976; Dupuy, n.d; Baillon, 1986; Cramp, 1983; - Versuchen and Dupuy, 1987; Naurois, 1969); and mammals (Dupuy, 1980; Dorst, 1970; Bourliere, 1976; Deyesor, 1955). Less material is available on snakes (Cansdale, 1981; Villiers, 1963) and other reptiles. Insects and butterflies (Boorman, 1971) have not been

studied extensively. On the other hand, there is an extensive literature on freshwater fish (Holden and Reed, 1972; Reizer, 1971, 1984; Sissoko, n.d; Diouf, 1988; Leveque, et al; Daget and Durand, 1981; Pandare, 1987) and saltwater fish (Cadenta, 1950; Serret, 1981) and shellfish (Crosnier, et al, 1967).

There are probably about 92 genera and about 175 species of mammals, not including cetaceans (whales, dolphins) and pinnipeds (seals). About 542 birds have been recorded though many are rare or only cited by experts as vagrants or offshore passage migrants. The consultant could not find enough references to summarize the numbers of reptiles and amphibians. The number of insects by Family or Order has not been determined. There are about 240 species of freshwater and estuary fish in Senegal's inland waters that come from 22 Families. Because the Senegal is the northernmost of the Sudano-Sahelian rivers, its fish fauna is slightly depauperate (Gambia: 25 Families; Niger, 31 Families; overall, 30 Families).

Many species reach their northern or southern limit in Senegal and adjacent waters. Table A8.1 gives some examples. Despite this extensive research, good estimates of the major species of concern are lacking, and a summary of races and subspecies unique to Senegal is unknown. The consultant did not have time to talk to University of Dakar professors who might have been able to supply more information.

2. Status of Protection.

Table A8.8 (Annex 8) lists extinct species, endangered species, threatened species, and rare/vulnerable animal species in Senegal. We have used IUCN criteria in most cases. But, a "viable" population (a population that can survive for many generations) usually requires 500 to 1,000 adults for large mammals and birds. In addition, the population should be in contact with other populations in order to avoid genetic depression. Isolated populations tend to be in greater danger of extinction than small populations in erratic contact. Further complications occur because some adults may not participate in reproduction because of the social structure of the group, skewed adult sex-ratios, post-reproductive adults, etc. By this definition, there is almost no large mammal nor flightless bird (ostrich) that is not endangered in Senegal. For instance, because the last Senegalese population of 50 elephants appears to be without contact with other groups, it has a high probability of extinction even without poaching.

There are a long series of laws that protect wildlife and limit takes on certain partially protected species, including fish (Bosh, Dieng, Dia, mns). The protected species in Senegal were presented in Tables 5.1 and 5.2. There is no reason to review the law as it has been completely ineffective in stopping the rapid decline in all major populations of menaced species. In particular, almost all Sahelian species (Damas and Dorcas gazelle,

oryx, ostrich, lion, cheetah, spotted hyena, hunting dog, elephant, even red-fronted gazelle) are extinct or below viable levels. The Sudanian and wetland species have been reduced to isolated, pocket populations (e.g., Sitatunga in Basse Casamance, manatees between Lake Guiers and Diama dam, hippos in Manatali and Niokolokoba, elephants and chimpanzees in Niokolokoba). Similarly, populations of the largest reptiles such as the monitor lizards, the pythons, the crocodiles, and sea turtles are probably diminishing with little or no control over hunting. Although surveys are not available, at least five species of estuary fish and lateral migrant fish of the Senegal will probably disappear over the next twenty years. It is not known if the white shrimp can survive without the Senegal estuary migration. An endemic snail of the Cape Vert region is already close to extinction from overcollecting and habitat destruction.

T. picture is indeed bleak for all major groups of vertebrates except flying (vs. flightless) birds. Certain rare birds with small habitats (eg, Criniger olivareous, a kind of bulbul) may have disappeared from Senegal without anyone noticing.

It is difficult to know how to proceed. Perhaps, from a financial, management and enforcement point of view, what is needed is an overview of "best locations" to preserve particular species for all of West Africa. All other areas should simply be written off.

CHAPTER 7

SOCIOECONOMIC AND SOCIOPOLITICAL ASPECTS OF NATURAL RESOURCE MANAGEMENT

A. INTRODUCTION.

Chapters 2 through 6 of this report have discussed the biophysical aspects of natural resources and natural resource management. As important as these aspects are, an assessment of natural resource management would be incomplete if it did not include a discussion of the socioeconomic and policy environment in which that management was to occur.

This chapter will provide a synthesis of the socioeconomic aspects of natural resource management problems mentioned in Senegal's development literature. The discussion begins with a presentation of the organizations involved in natural resource management and their role. The following section then discusses certain policies of the government which create an atmosphere which either encourages or discourages proper natural resource management. Land tenure is one of the legal and policy areas which is held to be very important in Senegal. Because of the importance accorded land tenure, as judged by the number of documents covering the subject, it is discussed in a separate section. Finally, the development and natural resource management strategies of several major donors are presented.

B. INSTITUTIONS.

This section considers some of the institutions having responsibilities for natural resource management in Senegal. Here, the term "institution" is taken in the limited sense of an organization rather than the more global sense of sets of rules governing behavior. The organizations discussed here are the technical ministries, the government administrative hierarchy, programs and projects financed by outside donors, and non-governmental organizations.

1. Technical ministries.

Before March, 1990 there were four government ministries which had direct responsibility for the management of the countries natural resources. These were the Ministère du Développement Rural (MDR), the Ministère de la Protection de la Nature et de l'Environement (MPNE), the Ministère des Ressources Animales (MRA), and the Ministère de l'Hydraulique (MH). There were a number of

changes in responsibility which came with the ministerial reorganization of March, 1990.

Two ministries were eliminated entirely, the Ministère de l'Hydraulique and the Ministère de la Protection de la Nature et de l'Environement. The responsibilities of the first, MH, were assigned to the Ministère du Développement Rural which then was renamed the Ministère du Développement Rural et de l'Hydraulique (MDRH). The responsibilities of the second, MPNE, were divided. Prior to reorganization, MPNE had four Directions: national parks; environment; forestry, fisheries, and wildlife; and reforestation and soil conservation. The two Directions for national parks and the environment were transferred to the Ministère du Tourisme which was then renamed the Ministère du Tourisme et de l'Environnement. The Direction for reforestation and soil conservation was divided into two Divisions, both of which were placed in the Direction for forestry, fisheries, and wildlife. This enlarged Direction was then transferred to the Ministère du Développement Rural et de l'Hydraulique. The reader can have a quick overview of the responsibilities of each of the new ministries by examining the organigrams (See Figure 7.1).

Normally when there is this sort of government reorganization in West Africa it is due to one or more of three reasons. First, it may be felt that government services are not performing efficiently due to lack of proper organization. Secondly, a change in priorities may call for a realignment of associations and dependencies of different technical services. Thirdly, the President may be attempting to keep ministers from acquiring too much power. When such reorganizations occur, observers speculate as to what impact it was meant to have on this or that service. The March, 1990 reorganization in Senegal was different in that it had an entirely different reason. As part of Senegal's structural adjustment, the government had agreed to reduce the number of ministries and Directions. However, even though the reorganization was not strictly for reasons of efficiency, the reorganization was done in a way which may improve the efficiency of natural resource management.

Below are several thoughts on how the recent reorganization may enhance natural resource management. First, it may be good for forestry not to be associated with national parks or "the environment." National parks, by their very nature, require protection since they are meant to remain more or less as they are. The environment Direction also has certain responsibilities to protect the environment by monitoring and in some instances regulating development. The Senegalese forest service has long been criticized, as have the forest services of other West African countries, for being too protective. That is, traditionally the forestry agents have seen their role as one of protector of the forest against the malicious actions of the population. It is only in the past five to ten years that forestry agents have begun

working with the rural populations. Although some change has taken place, institutional attitudes change slowly so progress will take time. Many authors have said that forestry extension services should shift from control and policing to a service with a development orientation (Deneve-Steverlynck, 1982; Catterson, 1984). In general, reports call for a greater degree of people's participation (Catterson, 1984).

Figure 7.1. Organization of Senegalese ministries responsible for natural resource management. April, 1990.

Ministère du Développement Rural et de l'Hydraulique.

- o Direction de l'Agriculture.
  - Division des actions et programmes.
  - Division des statistiques agricoles.
  - Les stations agricoles et fruitières.
- o Direction de la Protection des Végétaux.
  - Division de l'avertissement agricole et de la défens des cultures.
  - Station de désinfection et de contrôle phytosanitaire du Port autonome de Dakar.
  - Groupe de lutte anti-acridienne de St-Louis.
  - Centre de Formation du Km 15.
  - Laboratoire d'analyse de pesticides et de résidus de pesticides de km 15.
- o Direction du Génie rural et de l'Hydraulique.
  - Division de l'Hydraulique rurale et des Etudes.
  - Division des travaux hydrauliques de l'entretien et de la maintenance.
  - Divisions regionales de l'hydraulique.
- o Direction des Eaux et Forêts, des chasses et de la protection des sols.
  - Division de la Chasse.
  - Division de la protection de la forêt et de la lutte contre les feux de brousse.
  - Division du reboisement.
  - Division de la pèche continentale et de la pisciculture.
  - Division de la conservation et de la restauration des sols.
- o Direction de l'Administration générale et de l'Equipement.
- o Inspection du Dévelopement rural.
- o Bureau de Presse et de Documentation.

SAED	Société d'Aménagement et d'Exploitation des Terres du Delta et de la Vallee du Fleuve Senegal. (1)
SOMIVAC	Société pour la Mise en Valeur de la Casamance. (1)
ISRA	Institut sénégalais de recherches agricoles. (1)
SONACOS	Société nationale de commercialisation des oléagineux du Sénégal. (2)
SEPFA	Société d'Etudes et de promotion financière pour l'agro-alimentaire. (2)
SODEVA	Société de Développement et de Vulgarisation agricole. (2)
SODAGRI	Société de Développement agricole et industriel. (2)
SNTI	Société nationale de la tomate industrielle. (2)
SNSS	Société nouvelle des Salins du Sine-Saloum. (2)
SODEFITEX	Société de Développement des Fibres textiles. (2)
SONFOR	Société nationale des forages. (2)

(1) Establissement public à caractère industriel et commercial.
(2) Société nationale ou société d'économie mixte.

Ministère du Tourisme et de la Protection de la Nature.

- Direction des investissements et de la Promotion touristique.
- Direction des Professions et des activités touristiques.
- Direction des Parcs nationaux.
- Direction de l'Environement.
- Service de l'Administration générale et de l'Equipement.
- Services régionaux.
- Inspection des affaires administratives, financières et techniques.
- Conseil supérieur de la chasse et de la Protection de la Faune.

Ministère des Ressources Animales.

- Direction de l'Océanographie et des pèches maritimes.
- Direction de l'Elevage.
- Service de l'Administration générale et de l'Equipement.
- Inspection des affaires administratives et financières.

SODESP Société de Développement de l'Elevage dans la zone sylvo-pastorale. (1)

SERAS Société d'Exploitation des Ressources animales (2)

(1) Etablissement public à caractère industriel et commercial.
(2) Société nationale ou société d'économie mixte.

Secondly, it may be advantageous for the Direction for reforestation and soil conservation to have become subsidiary to the Direction of forests, fisheries, and wildlife. The majority of donor assisted forestry projects in Senegal are reforestation projects and were therefore in the Direction for reforestation and soil conservation. Project personnel implement the project more or less independently of the traditional forest service responsible for activities in the area. In some cases, there is very little communication. Forestry agents in the traditional forest service have been heard to complain that they are not involved and do not feel responsible for the continuation of or follow-up activities for any project activities after the "project" is over. The reorganization may not resolve this problem but now the projects are administratively more closely associated with the forest service.

A third possible improvement may be due to the fact that forestry is now part of the ministry for rural development, at the same level as agriculture. Now forestry is part of "development" and no longer part of "protection." In addition, the forest service is now more closely associated with agriculture. Since most forestry activities in Senegal are agroforestry or are at least on agricultural land, this closer association may bring about a greater degree of collaboration between forestry and agricultural agents.

2. The government administrative hierarchy.

Prior to 1972, the lowest level of government was the arrondissement, administered by a sous-préfet. As a result of the 1972 administrative reform, Communautés Rurales were created as subdivisions of the arrondissements. This additional level of local government was to increase local participation in government. Communautés Rurales were first mentioned in the 1964 Loi sur le Domaine National. This law made Communautés Rurales responsible for land allocation. However, the Communautés Rurales were not officially created until 1972 under the Loi Relative aux Communautés Rurales.

Even this later law did not automatically create the Communautés Rurales, however. Application decrees were issued, region by region, so that between 1972 and 1984, Communautés Rurales were created in all regions of the country (Vengroff and Johnston, 1989). The Communauté Rurale is governed by a Conseil Rural, a council of officials elected by the local population. Conseils Ruraux have the authority to:

- regulate exercise of use rights to land within its territory, except for hunting, fishing, commercial forestry, and mining rights;

- distribute and expropriate National Domaine lands within its territory;
- encourage local projects, and community participation in such projects;
- plan projects involving communal labor (Colvin, 1982).

The Conseil is also to serve in an advisory capacity when an outside agency wishes to initiate a development project within the Communauté Rurale. The Conseil forwards its decisions to the Sous-Préfet who prepares the necessary documents and transmits them to the Préfet. If the Préfet does not reverse this decision, it becomes effective three months after transmittal (Colvin, 1982). Despite the legal standing of the Conseil Rural, these elected officials play a small role in the local administration. In many cases the Sous-Préfet has not delegated the authority as it may have been supposed he would.

3. Donor-funded projects.

Many development projects financed by foreign assistance funds create new and autonomous organizations. It is not infrequent that a development project will create forestry or agricultural extension service entirely separate from the government extension service which normally would have responsibility for that same geographical area. This is true for almost all of the reforestation projects operating in Senegal.

4. Non-governmental and private voluntary organizations.

There are literally hundreds of non-governmental and private voluntary organizations (NGO's and PVO's) in Senegal. ENDA (Envrionement, Développement et Action) reported that it works with over 300 NGO's in the Thiès Region (NDIAYE, per comm). However, most of these NGO's are rather informal village level organizations. In 1988, there were 126 NGO's registered with the Ministère du Développement Social. CONGAD, the Conseil des Organisations Non-Gouvernementales d'Appui au Développement, reported in 1989 that it had a membership of 65 NGO's.

Many, but not all, of these NGO's are involved in natural resource management activities. Annex 5 gives a list of the legally registered NGO's, or those which are members of CONGAD, which are involved in natural resource management of some kind. For each, there is an indication of the type of activities in which each is active and the geographical regions in which each is active.

In a 1987 study for USAID/Washington, Ross mentions some of the qualities of NGO's which make them particularly well suited for certain development activities. NGO's are generally able to organize and motivate local communities better than extension services because the NGO personnel are usually residents of the

community. They are also more able to react quickly to logistical, technical, and social constraints. Finally, these organizations are skilled at acquiring funding from a variety of sources.

NGO's do have their problems though. Because they are generally small, they do not always have expertise in the technical fields in which they wish to operate. Because they do not, they must rely on the transfer of technologies from other organizations. Unfortunately this transfer of technology is not always as efficient as it could be (Ross, 1987).

5. Institutional problems.

Vengroff and Johnson (1984) conducted a very interesting survey of extension agent attitudes and perceptions. Among the important problems listed by the agents in this study were the lack of coordination in the interventions of different technical services; the lack of coordination between development projects; the failure of the administration to consider the needs of the local population; the lack of collaboration between government agents and traditional authorities; and the lack of collaboration between territorial administration and technical services.

a. The lack of coordination between technical services.

Many authors indicate that there is insufficient coordination between the various ministries or, for that matter, between different Directions within the same ministry. One of the unfortunate consequences of this lack of coordination is that the farmer, the one who is ultimately responsible for resource management, sometimes receives conflicting messages. Catterson (1984) states that there is a need for a multidisciplinary extension approach rather than three separate extension services which compete for the attention and resources of the farmer.

For example, it is held by many that one of the most beneficial components of traditional farming systems in the Peanut Basin is the Acacia albida (see Chapter 4). For over twenty years, various forestry and agricultural researchers have been acclaiming the benefits of maintaining a certain number of these acacias on cultivated fields. Fifty trees per hectare is the density often recommended. For years, foresters have been encouraging farmers to plant acacia or to protect spontaneously regenerated seedlings. At the same time, other government agricultural agents have encouraged farmers to uproot all trees in their field in order to make farming more efficient. According to Seyler (per comm) Les Dix Commmandements de SODEVA includes such instructions to its extension agents. Deneve-Steverlynck (1982) reports that SODEVA (the Société de Développement et de Vulgarisation Agricole) once paid farmers for removing all trees to facilitate animal traction. Now, they are paying the same farmers to protect Acacia albida.

However, this is more than an argument for an integrated extension service, agriculture, forestry, and animal husbandry activities must be integrated. The yet-to-be-financed Projet Intégré de Conservation et de Gestion des Ressources Naturelles (PICOGERNA) will address this problem by having a special extension service within the project area. Each area will be served by a three-man team composed of an agronomist, an animal husbandryman, and a forester (Bathily, per comm). This project will attempt to integrate forestry, animal husbandry, and field crop production. The whole will be integrated by means of a planning process which will involve the local residents.

We mentioned above the problems associated with the lack of coordination between government services. One related problem is the lack of coordination between independent projects and the government services for which they work, and between the various independent projects. For example, the Direction des Eaux et Forêts has many reforestation projects. However, almost all of these projects are autonomous, having very weak links with the traditional forest service. It is this traditional forest service which is expected to take over project activities after the foreign assistance agreement expires.

b. The lack of coordination between development projects.

Donor designed and financed projects are not as well coordinated as they could be. According to the minutes of a USAID/Dakar-sponsored meeting of donors in the forestry sector, the representatives of all donors attending the meeting recommended that more coordinating meetings be held (USAID/Dakar, 1988). Despite this initial effort in April of 1988, it seems that no other coordination meetings of donors in the forestry sector have been held. There were two meetings of donors in the forestry sector in early 1990. The first was sponsored by Germany to present their project in the Ferlo. The second was sponsored by the French to discuss the upcoming PICOGERNA. Both of these meetings, it seems, were technical meetings, not meant to discuss the possibility of donor coordination.

Grosenick, in his 1989 nursery study, found a lack of communication between projects. In general, personnel in any given project, say those who were responsible for nursery production of promotion of private nurseries, were unaware of what their counterparts in other, similar projects were doing. The lack of communication was as evident for project policies as it was for technical information. Some project personnel held that they could not sell seedlings, for instance, because peasant farmers could not afford to pay for them. Meanwhile, a nearby project had been selling seedlings for years.

USAID's Senegal Reforestation Project has suffered slightly from the communication barriers that seem to exist. This project uses television and radio as well as the traditional forest service extension service to explain its matching grant program. This program is operational in virtually every corner of the country. That is, peasant farmers all over Senegal have learned of the program and taken advantage of it. Still, there are many people working on donor-financed reforestation projects who do not understand what the program is, how it works, or what its purpose is. This example shows the difficulty one confronts when communicating with others. Despite the project's best efforts to publicize its program, and its success in reaching the rural populations, it seems to have missed the rest of the development community. This is not a criticism of the Senegal Reforestation Project's ability to transfer information. It is a reflection of the narrow view taken by many development professionals. Many feel they do not need to know what others have done or are doing.

One last example of conflicting efforts, this time between development projects and the forest service. In some areas, even when small private nurseries are promoted, the forest service continues to produce its own supply of seedlings which it distributes at no cost. This makes it difficult for a private nursery to be able to sell its seedlings, even though people may have been willing to pay for seedlings.

Catterson (1984) calls for better donor coordination, including communication, better cooperation between the government and donors, and better long-term planning.

c. <u>The failure of the administration to consider the needs of the local population.</u>

This section will present a number of examples, cited in the literature, in which government or project technicians do not work closely enough with local populations. In some of the cases cited, technicians seem to have a paternalistic view, feeling that they must take care of the peasant because he cannot take care of himself. In other cases, it seems that the technicians maintain control for the pleasure of being in charge. In any event, one of the most basic needs of the local population is being ignored: the need of every man to feel that he has some control over his destiny. Without this feeling, it is unlikely that the person will be motivated to participate in the given activity.

There are numerous examples of extension agents hesitant to turn control of a development activity to farmers. Grosenick, in his 1989 study on the promotion of private sector nurseries, gives two examples. First, many foresters are hesitant to encourage private nurseries because they feel that then they will have no control over production. There are concerns that the private nurseries will not produce enough seedlings or that they will produce poor quality seedlings. Secondly, when private nurseries

are started the number is limited, it is said, by the ability of the extension agent to supervise production. Each agent can handle only a certain number of nurseries. However, even nurseries which have been producing seedlings for eight years still receive the same intensity of supervision as those which are just beginning production. Thus the extension service of the forest service or of the project effectively maintains control of the development activity.

Foresters often state that cutting permits are a necessary part of production. If the farmer was not required to ask for a cutting permit, the forester would not be able to advise him. The farmer might, for example, want to cut his trees a year earlier than he should, or at the wrong time of the year, or at a time when the market price was not advantageous. By requiring the farmer to obtain a cutting permit, the forest service believes it can save the farmer from making these mistakes. All these examples indicate a somewhat paternalistic attitude on the part of the forestry extension agent. However, this problem is not limited to the forest service.

Bloch (1986) argues that rice farmers must have much more input in the management of irrigated perimeters. Many irrigation perimeters in the Senegal River Valley are operated by professional managers working for SAED (Société d'Aménagement et d'Exploitation des Terres du Delta du Fleuve). These managers believe that the small rice farmers are not capable of organizing themselves so as to take over either the technical or administrative management of the irrigated areas.

Gradually, however, many of the regional development authorities and other parastatal organizations with extension responsibilities are being forced into playing a smaller role. Since the mid-1980's, the government has been reducing the budgets and personnel ceilings of these organizations. According to the government's new strategy, producers and producer groups are to take on more responsibility for many of the development activities. According to the New Agricultural Policy:

> "Le producteur agricole à acquis un certain niveau de technicité. Il a assimilé la plupart des méthodes améliorés qui lui sont proposées de sorte qu'il a moins besoin d'être entouré d'un encadrement dense, du type actuel ... il apparaît raisonnable de se fixer un délai de cinq ans pour le dépérissement effectif de l'encadrement...."

Although the process has begun, many technical and administrative personnel are still reluctant to change their ways of conducting business. This is not to say that there are no examples of extension services turning the operation of certain activities over to the producers. In 1986, the government turned the

management of a number of wells in the north Ferlo over to management committees organized by herders (Juul, et al, 1989). In 1989, these committees were still operating the wells, even though some of them were having trouble collecting user fees from certain of their members.

C. GOVERNMENT POLICIES.

This section discusses two government policy statements which affect the management of natural resources. They are the Nouvelle Politique Agricole, the New Agricultural Policy (NAP), introduced in 1984 and the 8th Plan for Economic and Social Development. Land tenure policies are treated separately in the following section.

1. The New Agricultural Policy.

The government's New Agricultural Policy was introduced in 1984. This policy attempted to create the conditions which would allow new growth in production. This was to be done with a system which encourages the active participation of rural populations and gives them an increased degree of responsibility in each step in the development process. As a result, the role of the State was to be reduced to that of catalyst. The main orientations of the NAP are presented in Figure 7.2.

The NAP does not address the problems of the livestock, fisheries, or forestry sectors. It is primarily concerned with agronomic production. Nonetheless, there are several features of the policy which do have or could have an effect on natural resource management.

a. Producer groups to take on more responsibility.

Firstly, the NAP reiterates the government's intention to increase the degree to which user groups become responsible for all aspects of production. This turning over of responsibility is to be done by authorizing the formation of officially sanctioned user groups and by gradually reducing the role played by the regional development agencies and other parastatal organizations.

Figure 7.2. The New Agricultural Policy of 1984.

The New Agricultural Policy (NAP) is aimed at the production of field crops; it does not address the problems of the livestock, fisheries, or forestry sectors. The four global objectives or orientations of the NAP are:

1. Encourage economically viable, village level institutions. These cooperative institutions should be capable of helping the producer in managing production, consumption, savings, credit.

   Within each Communauté Ruralé a new multifunction, multisectoral cooperative is to be formed. Each village within the Communauté Rurale will have a section villageoise which is a multifunction and multisectoral. There will also be, within this section villageoise, multifunction but sectoral groupements for fishing, forestry, animal fattening, for instance. These cooperative structures will be capable of helping the individual producer with the acquiring inputs, production, transportation, transformation, credit, and marketing.

2. Extension methods will be adapted to the needs of the newly developed cooperatives. This will necessitate a reorganization of the regional development organizations and a redefinition of their role.

   STN will be eliminated within one year. SODAGRI will be combined with SOMIVAC. This new organization will have a 60% reduction in personnel within the first five years. SODEVA will have a 75% reduction in personnel within the same period of time.

3. The supply of agricultural inputs will be improved by assuring better management of these inputs and better financing. The agricultural inputs which will be supplied are seed, agricultural implements, and fertilizer. Farmers will have to acquire fertilizer in one of three ways: agree to have a certain amount deducted from the sales price of the product so as to be available the following year; pay cash; get credit at CNCA. Fertilizer price will be held down by controlling margins, and eliminating taxes. Use of organic fertilizer will be encouraged.

4. Losses to pests and post harvest losses will be reduced. Cereals losses are to be reduced from 30% of harvest to 15%. Actions to be implemented are a monitoring program for integrated pest control; seed treatment; storage protection for cereals and cowpeas; treatment of peanut mills; nematicide treatment of soils; border control; and pesticide legislation, approval process of pesticides.

b. Fertilizer policy.

For more than 150 years, the colonial and then the Senegalese government has promoted peanut production. One of the

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Ministère du Développement Rural, 1984.

measures used to encourage farmers to cultivate peanuts was to subsidize fertilizer. After harvest, farmers sold both the peanuts and the peanut fronds, thereby exporting the entire production of the field. Naturally, this quickly reduced the nutrient levels in the soil. Traditionally, farmers would put fields into fallow for several years so the natural vegetation which would take over the fallow field would increase the fertility of the soil. As fertilizers became more widely available, and at relatively low prices, farmers had an alternative to fallow. Farmers no longer relied exclusively on fallow and the organic production of trees, shrubs, and grasses to fertilize their fields. Trees began to disappear and fallows were shortened.

Admittedly, there are other reasons for trees disappearing from fields and for fallow being shortened. Increased population pressure being one major reason. However, in 1984, the government announced the New Agricultural Policy. One aspect of this new policy was the elimination of fertilizer subsidies. This in itself made fertilizer less attractive. In addition, credit programs were eliminated so that those farmers who still wanted to purchase unsubsidized fertilizer had to pay cash. At this point, one would think that farmers would again need to have acacias on their fields. According to observations made by Seyler (per comm), and based on preliminary analysis only, it seems that farmers may be encouraging acacias to once again play a part in the farming system. That is, those farmers who do have acacias in their fields seem to have trees older than 30 years and younger than five years. This can only have happened if these farmers allowed acacia seedlings to remain in the field before fertilizers were subsidized, more than 30 years ago, and after fertilizer subsidies were eliminated, five years ago. (A more complete analysis of these findings will be forthcoming. Consult J. Seyler.)

According to Commander, et al (1987), fertilizer use is uneconomical, even at subsidized prices. "The returns to fertilizer use may be presently so low that the actual decline in consumption may not merely be a reflection of recent price shifts but in addition a recognition among farmers of this more binding constraint."

c. The cereals policy.

In the mid-1980's, Senegal produced just over half of its domestic food requirements. Imports accounted for 40% and food aid for 8%. One objective of the NAP was to produce 75% of the nation's cereals requirements by the year 2000. When the Plan

Céréalier, or Cereals Plan was introduced, this goal was raised to 80% of domestic cereals needs by 2000 (Commander, et al, 1987).

In order to increase the production of cereals, the NAP calls for an increase in the area cultivated. The 6th Development Plan called for an annual increase of 3,000 ha of irrigated land from 1983 to 2000. The NAP increased this objective to 5,000 ha per year: 3,500 ha on the Senegal River, 1,000 ha in the Casamance, and 500 ha around deep wells. There should also be an increase of 10,000 ha rainfed cereals production per year. This increase should be in areas with more than 800 mm of rainfall and a rainy season of at least three months duration. In addition, there should be an increase in production in areas with more than 700 mm and a decrease in cereals production in areas with less than 400 mm.

d. Reduction in losses to pests and post harvest losses.

This objective calls for a 50% reduction of crop losses, from 30% of harvest to 15 percent. Two aspects of this effort are relevant to this study. First, the government wished to create a program to monitor pest infestations. This early warning system would allow a higher degree of control of pests and allow integrated pest management techniques to be used rather than automatic use of chemical treatment.

Secondly, the government proposed to draft and enact pesticide legislation and to create a process through which chemicals would be accorded or denied approval for use in Senegal.

2. VIIIe Plan de Développement Economique et Social.

The 8th Development Plan (Ministère du Plan et de la Coopération, 1989) is a planning document which lays out the course the government would like to follow during the period from 1989 to 1993. The Plan is published without having the budgetary resources necessary to implement the various elements of the Plan. It is likely, therefore, that some parts of the Plan will not be carried out. This section discusses some of those aspects of the 8th Plan which concern the natural resources sector. The philosophy of the government is clear. There is a definite recognition of the importance of protecting the natural resource base. It calls for

> "... une transformation qualitative des systèmes de production dans le sens d'une amélioration de la gestion des ressources naturelles. L'incitation pour une meilleure protection des sols et des forêts par le biais d'une sécurisation du droit d'usage et des possibilités de jouissance des fruits des investissements réalisés."

One of the major blocks to this increased security is the land tenure system which does not permit a more liberalized economy, privatization, and security of productive activity (Ministère du Plan et de la Coopération, 1989). Land tenure will be discussed in the next section of this chapter.

The overall strategy for rural development during the five-year period covered by the Plan calls for the satisfaction of food needs, a decrease in the rate of desertification, and the assurance that producers are able to earn an adequate livelihood. By themselves, these strategy elements seem very much like earlier statements made by the government. However, now, the desire to satisfy food needs will rely on a food policy which integrates sylvo-pastoral activities. The fight against desertification is based on improved natural resource management and the protection of soils and forests is based on establishing more secure use rights. Finally, improving the producers chance of earning an adequate income is based on the belief that farms should be made more viable by increasing tenure security and by making investments such as in water conservation and erosion control measures.

a Strategies by sector.

1. Agricultural sector.

Agricultural production will increase. As mentioned above in the Cereals Plan, this will be done mainly by increasing the area under irrigated agriculture by 5,000 ha and the area under rainfed agriculture by 10,000 hectares. It seems that increasing rainfed agriculture by 100,000 ha over the next ten years is feasible. At least, there is sufficient land available which can be put under cultivation without fear of short-term destruction of the soil base.

2. Livestock sector.

The main objective in the livestock sector is to maintain meat consumption at the 1989 levels of 5.7 kg of beef, 2.3 kg of goat and mutton, and 3.0 kg of poultry per person per year. Production will therefore have to increase at the same rate as the population. To accomplish this objective one must rehabilitate rangelands; encourage intensification by stabilizing herd size; increase weight gain not number of animals; and increase the offtake rate.

Strategies for livestock are: 1) To improve knowledge of production systems. Identify different production systems and their relationship with other production systems. 2) Rationalize use of food stuffs according to animal type and in an agro-sylvo-pastoral integration. Reduce and eliminate sources of competition between subsectors; protect herders from uncontrolled expansion of agriculture; rationalize pasture exploitation to insure

regeneration; and increase food sources. 3) Support organization of herder groups. They should manage pasture, their animals, and water, guaranteeing regeneration, and participate in adopting an agro-sylvo-pastoral code.

3. Protection de la nature.

The government's objectives over the five-year planning period are to manage the country's natural resources, to make producers responsible for the management of natural resources by organizing producer groups; and to integrate natural resource management, especially silviculture, and agricultural production. The tenure rights to investments are to be guaranteed.

A variety of activities are designed to help achieve these goals. Dunes will be reforested and salty soils will be restored. Private and communal tree planting will be encouraged. Rangeland and forests will be protected to insure natural regeneration of the vegetation. Popular participation in the management of forêts classées will be encouraged. Forests will be managed not only for fuelwood but for timber. Certain problems in the charcoal industry will be corrected. These current problems include the quota system, seasonal shortages, a price structure which does not encourage the use of substitute fuels, lack of management of forests and woodland. Rangeland and woodland will be protected from overgrazing and fire. Soils will be protected and restored. Air and water quality will be protected. Wildlife management will be improved.

3. Conclusions.

The policy statements discussed above give an indication that the government's view of natural resource management is changing. Even though these policy statements have not yet all been translated into policy, that is, action, it is clear that the government recognizes the relationship between natural resource management and agricultural production.

In 1984, Senegal began a program to reduce the degree to which parastatal organizations are involved in the productive sectors. The areas of responsibility, personnel ceilings, and budgets of many parastatals have been reduced significantly. There has already been a ministerial reorganization which is to be a precursor to a reduction in civil service personnel. However, even though the government is withdrawing from the productive sectors, it is not at all clear that the any significant degree management and control of these sectors has been transferred to producer or user groups as intended.

The 8th Development Plan, which was adopted in late 1989, often mentions the need to integrate more closely the various productive sectors: agriculture, animal husbandry, and forestry.

This is perhaps in recognition of the problems resulting from a lack of coordination between the various technical institutions. Or it may be recognition of the possibility of increased productivity integration seems to offer. Land tenure is also mentioned in the 8th Plan as a factor which must change in order to encourage security and productivity.

The government has mentioned certain intentions which may improve the management of natural resources. In the future, more attention is to be given to the rate at which livestock put on weight rather than the number of animals in a herd. The government would like to begin to control the use of chemical pesticides. The charcoal production and distribution network is recognized as a problem area which needs attention.

D. LAND TENURE.

Before beginning the discussion of tenure policies and their effects on natural resource management, it is informative to review briefly the legal status of land in Senegal.

1. The legal status of land in Senegal.

Caverivière and Debene (1988a, 1988b) discuss in detail the land tenure laws in Senegal. However, these authors are professors of law and have a narrowly defined field of interest. Although these documents may be valuable contributions to the legal field, they are of little value to the development community.

Hardy (1987, 1989) gives a brief discussion of the evolution of Senegalese land law through the colonial period and on through the years since independence. After independence, Senegalese lawmakers were faced with a number of problems related to land tenure. It was their intention to draft a new law which would resolve four major difficulties. First, France's attempts to introduce private property laws were futile. Second, it was felt that the traditional tenure systems, which were seen as backward, would stand in the way of development. Third, lawmakers feared that the traditional land tenure system was being transformed into a feudal system by certain Islamic brotherhoods. Any new system would have to protect the average peasant from this type of abuse. Fourthly, one land tenure system for the entire country was bound to fail since the existing traditional tenure systems reflected a wide range of ethnic and agro-ecological diversity. In 1964, the Loi sur le Domaine National was enacted in response to these concerns.

The 1964 Loi sur le Domaine National defined a number of categories into which all land would fit. These categories are: the Domaine de l'Etat (3% of total), the Domaine des Particuliers (2% of total), and the Domaine National (95% of total). The Domaine National was divided into four classes: zones urbaines,

zones classées, zones des terroirs, and zones pionnières. The zones urbaines include all land located in towns and cities. The zones classées include all national forests and national parks. The zones des terroirs were comprised of all land which was used for agriculture, pasture, or rural housing. Finally, the zone pionnières were made up of all remaining land.

a. Zones urbaines.

This class of land includes all land located in towns and cities. This class of land will not be discussed further in this report. It is only mentioned here for completeness.

b. Zones classées.

In 1972, Senegal had 205 separate national forests and national parks covering an area of almost 4.9 million hectares (Giffard, 1974). Since then, the number of forests has been reduced somewhat but the overall area has not been reduced significantly. All this land has traditionally been under the control of the Senegalese forest service and park service.

The Forestry Code describes the use rights for the nation's forests. Within the forestry domain, local residents or those who traditionally used the forests, have the right to collect dead wood, wild fruit, food or medicinal plants, gums and resins, straw, and honey. There may be additional use rights described in the individual classification documents, the legal documents which officially create the National Forest. All these use rights may be exercised without authorization of any kind. However, certain use rights do require prior approval. When wood of protected species is to be used for the construction or repair of houses, a free permit must be obtained from the Forest Service. All of these use rights are non-commercial use rights. None of the products collected or harvested under this section of the Forest Code may be sold. Any of these rights may be temporarily suspended by the Forest Service if necessary for proper management.

Grazing is permitted except in areas being regenerated either naturally or artificially. Protected species may not be cut for fodder. The traditional useright holders are expected to contribute to the maintenance of the forests they use. Parcs Nationaux and Reserves Naturelles have no use rights.

The Forest Service may, according to Article D.10, turn forestland over to local groups for management.

> "Article D. 10 Certaines parties du domaine forestier peuvent être affectées à des collectivités ou à des cooperatives en vue d'un aménagement sylvicole ou de reboisements sous le contrôle technique du service des Eaux et Forêts."

c. Zones des terroirs.

The National Land Law has several major provisions covering agricultural land. According to the law, anyone who cultivates any land in these zones has the use rights to that land. Thus, land would not be taken away from those who were cultivating it. Traditionally token payments had been made to local authorities for the use of land. In the years just after independence, these payments were seen to have grown to significant amounts. With the passage of the new law, sharecropping, renting, lending, and selling of land were prohibited. That is, one who controlled more land than he could cultivate himself could not retain control of the excess. If a use right holder does not cultivate his or her land, the use rights to that land could be given to someone else. Any redistribution of land resulting from the above situation is to be handled by the local Conseil Rural, the duly elected leadership of the Communauté Rurale in which the land was located. The Conseil Rural is also to redistribute the use rights at the death of any use right holder, as these rights are not heritable. As mentioned above these Communautés Rurales and Conseils Ruraux were eventually established between 1972 and 1984.

These Communautés Rurals were created as part of the government's decentralization policy. The Conseil Rural is to manage rural land in a way that reflected local priorities and conditions (Bloch, 1987). This was the solution to one of the problems recognized by Senegalese lawmakers. As explained earlier, they realized they could not enact a law which would be able to recognize and take into consideration the tremendous variety of traditional land tenure systems which arose under a variety of ethnic and agroclimatic situations. Instead they enacted a law with general provisions which would be interpreted and enforced by local people, the Conseil Rural, with knowledge of local conditions (Hardy, 1989).

Some writers feel that the National Land Law has made land tenure less secure. They feel that once the government declared that it now owned all land in the country, the peasant had less secure tenure. However, according to Hardy, the lawmakers' intention was to give peasants more secure tenure. Indeed, some consider this to be the case. For example, "Farmland is almost all held under customary tenure arrangements guaranteed under the Loi sur la Domaine National... (Economic Intelligence Unit, 1986). The law states that any redistribution of land, if any is ever to be redistributed, will be done by the local Conseil Rural. It was felt that the Conseil Rural, composed of elected officials for the area, would make recommendations for land tenure in accordance with local traditions.

d. Zones pionnières.

This class of land includes all land that is nonagricultural land not included in National Forests or Parks. Any land which was part of a zone pionnière could be ceded to an organization willing to develop it. As an example, SAED was allocated the Senegal River Delta and later the entire Senegalese portion of the Senegal River Basin. In 1971, the government ceded control of approximately 6,000 ha near Richard Toll to the parastatal Compagnie Sucrière Sénégalaise (Colvin, 1982).

2. Resource Management Problems Related to Land Tenure.

Shaikh (no date) points out that "to bring about increased productivity on a sustained basis, farmers must invest in the land by improving the specific parcels they farm." That is, they must make capital investments in their land. Based on the discussions in previous chapters, it seems that the farmers must invest improvements such as establishing windbreaks, Acacia albida, hedgerows green manure, water conservation structures, or rock phosphate applications. It is held by most authors that secure land tenure is necessary before farmers will be willing to invest in what are essentially capital improvements.

While not specific to Senegal, Lawry (1989) gave three general goals for policy dialogue: greater management control by local user groups is a broadly desirable policy goal; states should support policies which recognize clearer and less ambiguous individual rights for farmers; and disincentive effects on farmer investment in farm forestry should be reduced. Lawry then identified three models for innovation: law reform, action research to develop and test packages which combine legal change with incentive creation, and participatory land system planning allowing villagers to establish land management rules.

Lawry (1989), in his discussion of tenure policy and natural resource management in the Sahel, considers the tenure systems which cover three basic resource types: agricultural land, common property resources, and trees. The present report will use these three categories as a starting point. Agricultural land, however, will be divided into two separate categories to distinguish between rainfed agriculture and irrigated agriculture. This distinction is made since establishment of irrigation systems often entails redistribution of rights to land. Another special case is also considered, tenure rights on National Forest land.

a. Rainfed agricultural land.

Many documents which discuss natural resource management state that long-term land rights of farmers need to be clear and unambiguous if farmers are to invest in technologies and management practices which contribute to sustainable management.

In most cases, this assertion is not backed up by examples or discussion of any kind. However, a number of studies have been conducted on land tenure on rainfed land. Hardy (1987, 1988, 1989) spent a year studying land tenure in representative villages near Kaolack. Her reports make several interesting points.

According to Hardy, students of land tenure often infer that the male head of the family retains all the tenure rights in the family's land. The author demonstrates that this is an oversimplification of reality in the area of the Peanut Basin studied. In many cases, wives, sons, brothers, and other family members have secure tenure rights. That is, although the head of the family may represent the family to the outside world, the members of his family do have certain rights which he must respect. Assuming that one person holds all tenure rights and makes all production decisions could lead to incorrect policy decisions.

Land registration is sometimes recommended as a method of privatizing land ownership and thus allowing mortgaging of land for investment funds. Hardy holds that registering the family's land in the name of the head of the family would reduce the security of tenure of the other family members, thereby discouraging them from investing in their land. If, on the other hand, land were registered in the names of each person having tenure rights, the system would be unwieldy. This argument implies that registering land in the names of each individual would be unwieldy whereas registering land in the name of the male head of the family only would not be. However, the examples given by the author show that registration would not be possible in any event. The 13,000 applications for land registration made in between 1964 and 1966 had not yet been processed in 1988.

Hardy wanted to test whether more secure tenure does indeed have an effect on the farmer's willingness to invest in his or her land. Interviews were conducted to determine which respondents felt more or less secure in their control of land considering their family, the village, and national law. Hardy was unable to find any record of land ever having been redistributed by a Conseil Rural, either at the death of an useright holder or for not cultivating the land. However, she contends that the peasants know the law permits such redistribution and thus there is an element of insecurity of tenure. Unfortunately, investments in land have always been rare in the Peanut Basin so the hypothesis could not be tested.

Thus, it seems that although the author was concerned about registration and the National Domain Law, the first is an administrative impossibility and the second has been ignored by both peasants and rural councils alike for 24 years. Thus, Hardy's study was not able to substantiate the hypothesis that the new law led to less secure tenure and therefore to less investment in land maintenance or improvement.

The Senegal Reforestation Project's social soundness analysis (USAID/Dakar, no date) points out that the Code Pastoral prohibits a farmer from excluding livestock from his fields once he has harvested his crop. This provision may discourage farmers from planting trees on their land if they feel that there is a danger of the trees being damaged by grazing or browsing animals. According to Bathily (per comm) Senegal has not yet enacted a Code Pastorale.

b. Irrigated land.

In 1986, the Land Tenure Center (LTC) issued a report which attempts to assess the role of land tenure in river basin development in general, and in irrigation schemes in particular (Bloch, et al, 1986). The LTC report concentrates on three dimensions of land tenure: security; size of holding and qualifications of holders; individual and collective responsibilities of farmers. Information was drawn from seven case studies from Kenya, Madagascar, Mali, Sudan, Zimbabwe, Mauritania, as well as Senegal.

Bloch points out that there are various reasons for differential success of irrigation projects: faulty design of the works, inappropriate economic incentives given to participants, insensitive or incompetent management, uncertainty of input supply and markets, and various forms of land conflict. Land tenure problems should not be blamed each time farmers demonstrate a lack of interest in participating in project activities. Sometimes, the suggested technology or organization is faulty but tenure is blamed.

There is no single set of land tenure guidelines that is best for every irrigation project at all times. 1) Cultural traditions of farmers from different ethnic groups and the legal institutional traditions of the country vary. 2) Irrigation projects are undertaken for different, sometimes contradictory purposes. 3) Tenure arrangements instituted at the onset of the project may not be appropriate after the project has matured.

National objectives may be conflicting at the project level. Some agents at some facility may be expected to perform several functions at once. Project objectives may conflict with farmer objectives. National objectives can be grouped into three large production strategies: 1) Cash crops for export. 2) Cash crops or food crops for domestic use - national self-sufficiency. 3) Cash crops or food for farmers themselves - local self-sufficiency. Indeed, conflicting national policies are the rule in any country. In Senegal, for instance, there are policies to not interfere in agricultural markets. However, rice is subsidized. There are policies to support peanut production yet cereals production is to increase.

Most irrigation projects have established a system of professional management under the presumption that farmers are incapable of organizing and operating irrigation systems by themselves. Reasons for centralized control: 1) Infrastructure and its maintenance require new skills and make significant demands on the farmers time and resources. 2) Timing of crop calendar and water distribution are crucial. 3) There are potential economies and diseconomies of scale different from traditional systems. 4) Farmers may not be aware of some cropping options. 5) Farmers may have to master new techniques of production and marketing arrangements. Block held that, while it is true in many cases that some degree of supervision and training is necessary in the early stages of a project, a gradual phase out of rural development authorities is necessary. This is related to the reluctance extension services have to allow producers to manage their own resources as mentioned in an earlier section.

Block also discusses the Senegal River. Emphasis is given to the legal-institutional context; pre-existing land use and claims; conflicts arising as projects are implanted; and security, plot size, and other tenure dimensions of ongoing projects.

The Delta of the Senegal River was relatively unused so SAED had little trouble appropriating this area. The middle and upper valleys were under traditional tenure systems. The main difference between the two areas is that the upper valley has a rainfall high enough to justify rainfed agriculture. Flood recession agriculture thus plays a relatively smaller role in the upper valley.

Insecurity of tenure is disastrous for maintenance. Both smaller plots and smaller perimeters tend to have higher yields per hectare than to larger plots and perimeters.

Between 1987 and 1989 the Land Tenure Center conducted a research program to assist USAID in determining the role of land tenure in its Bakel Small Irrigated Perimeters Project. The research program was to test four hypotheses:

1. Access to irrigated land may change over time.
2. Social stratification may determine access to irrigated land.
3. Women's access to land may be affected by the creation of irrigated perimeters.
4. The success if irrigation may be influenced by constraints to access.

While these are very interesting questions, and their answers can influence the design of irrigation projects, they are not clearly related to the present study. The LTC research program focussed on access to land rather than the management of it. The final report (Bloch, 1989) summarizes and discusses each of the 14 Discussion Papers which the research program issued as well as the

final report of a long-term researcher. Nowhere in these summaries or in the report itself is there a discussion of or even reference to the effect of management decisions on the resource base. This is not a weakness of the program. The program was designed to study the specific issues of access to parcels in irrigated perimeters and did that very well.

In an earlier paper, Colvin (1982) examines traditional rules for allocating land rights used by each of the major ethnic groups in the valley. In the Delta, the Wolof are the predominant ethnic group. In the Middle Valley the Tokolor predominate, while the Soninke are most common in the Upper Valley. The approaches to land tenure adopted by SAED are discussed also. The author suggests other long-term issues which must also be considered: the choice of land to be irrigated, the allocation of land to individuals, the transfer of plots, and plot size. The relevance of all these factors is considered at each of the 43 proposed sites along the valley.

When SAED conducted large scale production schemes, productivity was generally low and always lower than productivity in neighboring land which was privately operated. This demonstrates that farmers are willing to work harder for themselves than when working for a salary. It says nothing, however, about the sustainability of the management practices used.

Finally, Colvin points out, as many authors have, that the National Land Law is never 100% effective. It is always subordinated, partially or totally, to traditional tenure. This is an unusual statement because the National Land Law is and was always meant to be based on traditional tenure (Hardy, 1989).

c. Common property lands.

Sahelian states claim ownership of common property resources. This approach has led to a free-for-all and has probably contributed to accelerating degradation (Lawry, 1989). In all the literature consulted, there was only one other reference made to common property lands. Colvin (1982) mentions that, traditionally, there was no control of rangeland. Instead, control was over water. The person who dug a well controlled who had access to its water. In this way the well's owner could, in effect, say who could use the surrounding rangeland since the only way a herder could use the rangeland was to have access to water. When the government, both colonial and post-independence governments, decided to install deep borehole wells in the Ferlo, they effectively stopped the control over grazing since anyone could use the government wells.

d. National forests.

The Government of Senegal clearly owns the land occupied by national forests. The control of the management of these forests is given to the forest service. However, the forest service has found it very difficult, for a variety of reasons, to manage or even protect these forests as they would like. The new PICOGERNA project will experiment with local management of forests, woodlands and rangelands (DIOP, per comm).

e. Tree tenure.

Deneve-Steverlynck (1982) states that current legislation in Senegal discourages farmers from planting or protecting trees on their land. The argument is that if the farmer cannot receive the fruits of his labor, he will not attempt to cultivate trees on his land.

West African states seek to regulate farmer management of trees on the farm. This desire of the forest service to protect trees may even be counter-productive (Deneve-Steverlynck, 1982). According to her logic, the forest service notices that the number of trees on farmland is falling. In order to stop this decline, the forest service increases its actions to protect the remaining trees. The farmer then decides not to protect his trees because, due to forest service protection, he cannot use them. Since these trees are not being protected by the farmer, they begin to disappear. The result is that the forest service feels it must step up enforcement to protect the trees even more. Forest Codes need to be reformed to give greater control to farmers over tree management practices on the farm.

Elbow (1988) provides an overview of the forestry laws in Senegal as well as Niger and Mali. This paper describes the forestry laws of the three countries. It is straightforward, not interpreting or judging the laws. Its main usefulness is that is saves the reader the time and trouble of reading the original texts in French and it points out what the author considers the most important portions of the law.

The social soundness analysis for the USAID Senegal Reforestation Project (USAID/Dakar, no date)

> "points out several aspects of tenure which affect tree planting. One important point is that customary law often prevails in the countryside, even when in conflicts with national law. ... According to customary law, useful trees that are deliberately planted (or saplings protected) by an individual are his property. ... Planting trees on land is an easy way to establish ownership. This is one of the

strongest motivations that land-owning families have for planting windbreaks around their fields."

Elbow and Lawry (1989), in their study of forestry legislation in Senegal, emphasize the necessity of changing the tree tenure laws and regulations in order to encourage private investment in tree planting. They state their concern that "farmers will not plant trees on their farms if use of their trees is subject to the administrative control of the forest service." (Emphasis by Elbow and Lawry) Again, "individuals will require clearer rights to trees and tree products if they are to undertake the investments and bear the risks associated with tree production." These two statements, and others in their report, lead a reader to conclude that farmers are not planting trees and will not until the current laws are changed. To draw this conclusion would be wrong.

In fact, there are approximately 15 projects in Senegal which encourage farmers to plant trees on their own land. These projects are successful in encouraging farmers to plant trees, despite the warnings given in the above paragraph. That is, farmers are more than willing to plant trees under current tenure conditions. The limiting factors in most of the reforestation projects seems to be the inabilility of the extension system to grow at a faster pace, the inability to increase nursery production at a faster pace, or the limitations in funding.

3. Conclusions.

The most important conclusion which can be made after this review of land tenure literature is that there are many different points of view. This is not to say that different authors disagree with one another. In general, it is a reflection of the fact that different authors look at different aspects of "the problem." If there is one universal truth accepted by all authors it is that land tenure could be a limiting factor in the farmer's willingness to invest in improving or maintaining the productive potential of his land.

However, saying that land tenure is an important factor and should be examined is like saying that rainfall is important to agriculture and should always be examined. The degree to which either of these factors is really limiting varies from place to place and over time. Thus, although one should always consider land tenure, one need not think that, a priori, it is a more important factor than any other in the success or failure of any development effort. Indeed, Bloch, in his introduction to land tenure issues in river basin development, says that land tenure should not always be blamed for project failures. Technicians, it seems, are often wont to blame some "social issue" for project

failure instead of examining the possibility that their technology is inappropriate.

The National Land Law has been variously credited with increasing tenure security and decreasing tenure security. According to Hardy (1989) the original intent of the law was to make tenure more secure by guaranteeing the use rights of anyone who cultivated land; by prohibiting sharecropping, renting, or lending of land; and by guaranteeing that any redistribution of land would be done by local representatives implementing customary laws. As quoted earlier from the EIU (1986) "Farmland is almost all held under customary tenure arrangements guaranteed under the Loi sur la Domaine Nationale...." But some writers reason that since the Conseil Rural has the right to redistribute land, tenure is less secure. However, the Conseil Rural has the right to redistribute land only under certain well-defined situations. From a practical standpoint, Hardy (1989) was unable to find a single instance where a single piece of land had been redistributed by a Conseil Rural between 1964, when the National Land Law was enacted, to 1986 when she conducted her study. Other authors maintain that this same law reduced tenure security by giving "ownership" of all land to the government. According to the various documents, the only right the government seems to have with this "ownership" is the right of eminent domain, and then only in the case of public utility.

It seems then that one could conclude that the law is misunderstood by at least some authors. There is no clear agreement. There are indications that it is also misunderstood by the nation's farmers. Hardy seems to be one of the few authors to have conducted long-term research in Senegal on the question of the relationship between tenure security and investments in land. She attempted to determine whether a greater degree of tenure security was correlated with a greater degree of investment in land. Basically, she found that no one was making any investments in land, at least not enough when one considers all the development projects encouraging such investments. Even those with secure tenure were not making such investments. Therefore, tenure security, although it is an important, factor, was not the limiting factor in Hardy's study area.

The last area to examine is tree tenure. As discussed above, Elbow and Lawry maintain that changes in forestry legislation are essential. Indeed, farmers will not plant trees under the present legal system. However, since farmers are planting upwards of 12 million trees per year at present, one must conclude that Elbow and Lawry were wrong. This is not to say that the law should not be changed. But consider that many parts of the forest code are ignored now. One should not assume that the new law would not be ignored also.

E. DONOR STRATEGIES.

"If concessional aid flows were to stabilize at present levels, and in the absence of further adjustment, real per capita gross domestic product would decline by 5% from 1988 to 1995, assuming export growth at historical rates. On the other hand, with rapid adjustment, gross domestic product growth could exceed 4% per annum in the 1990's" (World Bank, 1989).

This quote, from the 1989 World Bank Senegal Country Strategy Paper, is the basis for much of the development strategy for Senegal over the next five years. Indeed, it is felt by some that structural adjustment is so important that Official Development Assistance funds will have to be concentrated in structural adjustment activities rather than in investment activities in agriculture, natural resources, health, and other sectors. This section will discuss the development strategies of several of the major multilateral donors and how these strategies might affect natural resource management in Senegal.

1. World Bank.

The World Bank will be making few investments in natural resource management in the coming years. The Bank's country strategy statement states that the Bank should maintain its emphasis on broad policy reform rather than on specific investment projects. More specifically, the World Bank Programme d'Ajustement à Moyen et Long Terme (PAML) for the period 1985 to 1992 is the basis for Bank investments. The PAML calls for efforts in five major areas.

- Consolidate the base for economic growth.
- Attempt to improve the efficiency of public investments.
- Relieve structural constraints due to size of public and parapublic sector.
- Maintain growth basis in services and infrastructure.
- Continue financial reform in the public sector and improve the countries external position.

These recommended actions would have only indirect effects on the management of natural resources. For example, reducing the expenditures of the civil service and of parastatals will require that the certain agencies withdraw from activities in which they are currently involved and turn responsibility over to producers or producer groups or to the private sector. Producer groups need to be encouraged, both to take up the slack of reduced parastatal involvement and to manage communally used natural resources.

The strategy of the Bank to natural resource management is outlined in a 1989 document (Lewis, 1989). This document does not

address Senegal specifically but outlines overall Bank policy as concerns natural resource management. The author views two quite different dimensions to resource management. First, there are those activities which are both income-increasing and resource-conserving. Such activities include contour bunding, composting, and crop rotations. These are expected to be within the competence of individual families. Secondly, there are other activities which are resource-conserving but which do not generate income in the short term. The activities in this second category include windbreaks and natural forest management. They necessitate some sort of collective management. Lewis's policy paper addresses only this second category.

The main focus of the Bank strategy is on enabling local communities to regain authority and control over the management of their land. Secondary strategies are to improve the efficiency and relevance of government institutions and their support to groups of natural resource users; to improve the collection and use of ecological and geographic information; and to protect key wildlife populations and habitats. In order to implement these strategies within a given country, the individual national program should include development of community-level land and resource use plans and contracts; policies and legislation to improve security of land and resource use; institutional reform; establishment of GIS and monitoring programs; training; and improved management of wildlife and protected areas. PICOGERNA, a project funded jointly by the World Bank International Development Agency (IDA) and the French Caisse Centrale de Coopération Economique (CCCE), incorporates many of these features.

2. European Economic Community (EEC).

During the 1960's and 1970's the EEC has concentrated its efforts on economic and social infrastructure such as construction of roads and bridges, urban water supply and drainage systems, construction of clinics and hospitals, construction of schools. Beginning with the 5th European Development Fund (EDF), there has been a greater emphasis on activities in rural areas, although economic and social infrastructure were still important. The 5th EDF, which is based on the negotiations known as Lomé II, included funding in the following areas: education and training, public health, infrastructure and transport, drainage, rural development and fishing.

According to the 1988 annual report of the EDF in Senegal, the funding allocated to natural resource management during the 6th EDF remains a small proportion of the total. Five million ecu's are budgeted for natural resource management out of a total of 97 million ecu's for programmed assistance. Thus natural resource management represents 5% of programmed assistance. If one includes the 219 million ecu's of non-programmed assistance, natural

resource management will receive 1.6% of total EEC funding during the period 1987 to 1991.

The five million ecu's programmed for natural resources is for a single project in and around Podor. In the floodplain (walo) the project will promote windbreaks, fruit trees, irrigated tree plantations, and semi-intensive plantations in uncultivated portions of irrigated perimeters. Above the floodplains (dieri), the emphasis will be on protection and plantation of Acacia senegal. Two studies are to be conducted in Podor. One to ascertain the fuelwood problems and substitute energy sources and another to determine roundwood problems.

In addition to the country program, the EEC will also finance a regional program to promote the use of butane gas in order to reduce firewood and charcoal use, thereby reducing the pressure of forests and woodlands. Gas consumption in Senegal is expected to increase from 17,000 tons in 1987 to 60,000 tons in 1995. This increase in gas use should reduce annual wood consumption by 450,000 tons. An education project will develop teaching materials for schools. A 30 million ecu watershed management project in the upper Niger, Gambia, and Tinkino river basins will be based on farmer participation. Some part of this project should have beneficial, downstream effects on the Senegal portion of the Gambia River Basin. Actions will include simple erosion control measures.

3. United Nations Development Program (UNDP).

UNDP allocated 13.3% of its funds from the Third UNDP Plan to anti-desertification and water control projects. These projects included a complete inventory of forests in Casamance and Senegal-Oriental (SEN/82/027); additional professional training for 51% of the foresters and forestry agents in the country (SEN/81/005); Projet de Gestion et de Protection des Eaux Souterraines, a monitoring system for groundwater in the Cap Vert region and along the north coast (SEN/81/003); 5,000 ha of forest plantations to stabilize sand dunes along the north coast (UNSO/SEN/84/X07 Norway and SEN/73/012); plus funding for conferences, the promotion of wood stoves, the Centre de Suivi Ecologique.

In addition, there are projects which, although not designed specifically to improve the management of natural resources, are relevant to this study. Projects dealing with food self-sufficiency include the Agrhymet project, establishing a nationwide system for collecting agrhymet data (SEN/82/030). Projects dealing with energy resources include a feasibility for the use of peat (UNSO/SEN/84/X06 Denmark). Planning and administration projects include the Projet d'Assistance à la Planification to prepare Plans Régionaux de Développement Intégré (SEN/82/023); and assistance for the preparation of the Schéma National d'Aménagement du Territoire and the Plan National d'Aménagement du Territoire (SEN/82/016).

UNDP's Fourth Program for the period 1987 to 1991 is based on five development objectives: to better understand population problems; to preserve natural resources; to reduce the food deficit; to reorient the production system; and to reinforce the state's ability to guide the country. The natural resources sector will receive $8.2 million, or 25.6% of all UNDP funds for the five-year period.

There are three basic objectives for the UNDP natural resources strategy. The first is to preserve forests and reconstitute vegetation cover by elaborating a model for managing national forests which associates local residents. UNDP will elaborate a plan for rural forestry development; integrate various donor activities; and concentrate on forestry activities which require a lot of labor and use food aid (SEN/87/008). A windbreak program will be established to preserve and regenerate soils. This project will also be use highly labor intensive techniques and food aid (SEN/87/008). An integrated agro-sylvo-pastoral program will be established to ensure food and energy self-sufficiency in four Rural Communities and one pastoral zone (SEN/86/008 Phase II). The Centre de Suivi Ecologique will monitor pastoral ecosystems (UNSO/SEN/84/X09). UNSO will also be involved in dune fixation (UNSO/SEN/84/X07).

UNDP also intends to help conserve wood fuel and develop substitute energy sources through use of the Casamance kiln for all charcoal production; widespread use of improved wood stoves; the creation of a market structure for peat; and testing of alternative energies, including wind, solar energy, and biogaz.

The third objective is the preservation and rational management of water resources. The Fourth UNDP Plan recognizes three needs: the planning and management of water resources, assistance to water use projects, and the maintenance of existing water control structures. To help fulfill these needs, UNDP will create a planning and project management office in the Ministry of Hydraulics (SEN/87/006). Another project (SEN/81/003) will make use of information gathered on groundwater monitoring. UNDP will also assist in the formulation of programs to guide development in the sector: a national plan for water development, a master plan for rural water use, a water quality monitoring system in the Ministry of the Protection de la Nature, and a maintenance system for structures.

UNDP will also guarantee the start-up of the après-barrage by financing part of the Left Bank Master Plan (SEN/86/002) and supporting the Cellule Après-Barrage (SEN/86/001).

4. Conclusions.

The examination of the strategy for each of the three largest multi-national donors in Senegal shows that natural resource management is not a priority. The World Bank will be concentrating most of its funds in structural adjustment, making few investment loans in any sector. The EEC has always concentrated its efforts on infrastructural development and will continue to do so in the near future. The UNDP, which has a very small budget in any event, will not be spending more than 15% of its total budget in the natural resources sectors.

F. CONCLUSIONS.

It has been shown in previous chapters that the management of natural resources is confronted with a large number of technical problems. In addition to these technical problems, the resource manager also faces a number of socioeconomic or policy constraints which prevent him or her from managing the resource base as efficiently as he/she might otherwise. These are the problems which have been discussed in this chapter. This section will briefly review those problems.

1. Institutional problems.

A number of institutional problems were discussed in this chapter. All of them were examples of a lack of coordination or communication between various organizations or individuals involved in the development process. First, there was a lack of coordination between technical services. Often technicians give advice or propose technical interventions which are viewed narrowly from their own perspective. Any given specialist attempts to have the farmer adopt his (the specialist's) solution. Thus the development process is oriented toward implementing solutions rather than solving problems.

There is also a lack of coordination between those working in the same technical field. In some cases, projects are autonomous. That is, they are not associated with the government agency which will be responsible for the continuation of project activities once the project is over. Donor financed projects are seldom as well informed as they should be about the activities of other donors. This leads to repeated mistakes and, occasionally, conflicting policies. Opportunities for progress are often foregone when there is a less than optimal transfer of information on technologies. Ross (1986) discussed the problems NGO's face vis-a-vis technology transfer. The lack of communication between researchers and extension personnel is proverbial.

Too often, government and project personnel do not work closely enough with local populations. Foresters are unwilling to allow farmers to decide when to harvest their own trees. SAED

personnel are hesitant to turn management of irrigation perimeters over to farmer groups. However, many of the regional development authorities and other parastatal organizations with extension responsibilities are being forced into playing a smaller role. According to the government's new strategy, producers and producer groups are to take on more responsibility for many of development activities. Although the process has begun, many technical and administrative personnel are still reluctant to change their ways of conducting business.

2. Government policies.

Over the past few years, government policy statements have been paying more and more attention to natural resource management and the integration of agricultural production and natural resource management. Even though these policy statements have not yet all been translated into policy, that is, action, it is clear that the government recognizes the importance of being able to stabilize and protect the resource base.

In 1984, Senegal began a program to reduce the degree to which parastatal organizations are involved in the productive sectors. There has already been a ministerial reorganization which is to be a precursor to a reduction in civil service personnel. The 8th Development Plan mentions the need to integrate more closely the various productive sectors: agriculture, animal husbandry, and forestry. In the future, more attention is to be given to the rate at which livestock put on weight rather than the number of animals in a herd. The government would like to begin to control the use of chemical pesticides. The charcoal production and distribution network is recognized as a problem area which needs attention.

3. Land tenure.

It is generally accepted among those involved in development that land tenure is an important factor influencing the farmer's decisions about natural resource management. However, it should not be assumed to be a problem in every instance. Indeed, there are often issues of technical and financial feasibility which are much more important.

The National Land Law has been variously credited with increasing tenure security and decreasing tenure security. Different authors have different opinions as to its effect on tenure security. As different tenure specialists interpret the law differently, it is entirely logical to expect individual farmers to interpret it differently, as well. Despite what the various writers say about how the farmer ought to act, there have been few studies to examine the actual situation in Senegal. Only one of the authors of land tenure articles did long-term field research in Senegal on the relationship between tenure security and the willingness of farmers to invest in their land, Elise Hardy.

She was unable to show a significant difference in the way different farmers treated their land as a function of tenure security. Nor was she able to find a single instance of how the National Land Law had caused anyone to lose control of land between 1964, when the law was enacted, and 1986.

The last area to examine is tree tenure. As discussed above, Elbow and Lawry maintain that changes in forestry legislation are essential. However, the authors seem to have missed the point that there is little relationship between the legislation and tenure security as viewed by the individual farmer. Thus, although it might be advantageous in the long run to change the law, participation in tree planting programs is not dependent upon such changes.

4. Donor assistance.

The examination of the development strategy for the World Bank, the European Economic Community, and the United Nations Development Program shows that natural resource management is not a priority for any of them. If any significant investments are to be made in the natural resources sectors, they will have to be made by bilateral donors.

CHAPTER 8

ENVIRONMENTAL ASSESSMENT OF PROJECTS IN SENEGAL

A. INTRODUCTION.

In order to have both development and conservation, in order to balance the short-term exploitive aspects of development with a long-term sustainable natural resource base, it has become necessary to investigate and to evaluate projects that affect Senegal's soils, water, air, flora and fauna. The first formal evaluations of projects began in the United States in 1971. Three years later, the first evaluation of a large waterworks project (the Diama/Manatali dam complex) was conducted in Senegal, supported by USAID. By the late 1970's, USAID had also supported an environmental evaluation of the plans for the Gambia River Basin. It had also installed a procedure which is followed for all projects: An Initial Environmental Evaluation (IEE) is conducted, then, if necessary, the IEE can be amended or an Environmental Assessment (EA) is conducted.

This section will briefly look at some of the IEE's and the river basin evaluation of the Senegal River. Other multilateral and bilateral donors contacted could not supply details on their environmental evaluation procedures. The World Bank passed its first environmental evaluation requirements in 1989. It will be put to the test in Senegal in two upcoming projects: the Canal du Cayor Project and the alternative road developments proposed to connect Dakar to Bamako. Similarly, the African Development Bank is in the process of developing an environmental evaluation procedure and the local office had no relevant documents on Senegal from the past. Because of the timing of this study, the French and German Embassy were unable to respond in time for their procedures to be reviewed. West German consultants were not sure that Germany had environmental evaluation procedures. In short, of the limited number of groups that were contacted, only the United States and IUCN appeared to have much experience with environmental assessment.

B. QUESTIONS ASKED IN EVALUATING ENVIRONMENTAL ASSESSMENTS.

Below are the questions that need to be asked to determine the adequacy of an environmental assessment and how well it addresses the question of natural resource management.

PURPOSE AND NEED: Is the purpose of the project exploitation of a resource, increased efficiency of use of a resource, regeneration of a resource, or protection of an existing resource? Is the purpose of the project research, monitoring or development? How

widespread or intense is the need (as opposed to the purpose)? Will the proposed project or program actually address the need or only part of the need? Is the need defined by policies and abstractions such as "desertification" or "self-sufficiency" or by specifics such as "eroding dek soils" or "increased protein consumption of the near-by rural population?"

TIMELINESS AND PARTICIPATION: Has the environmental evaluation been prepared at an early stage so that changes can actually be made in project design or alternatives that accomplish the same goals be considered? Have project alterations or alternatives been suggested in the environmental assessment? Was the prefeasibiliy design circulated among participants in the program or project for suggestions? This includes the village(s) impacted as well as the government bureaucracy and lead agency.

ENVIRONMENTAL BASELINE: How much is known about the location of the project, its environmental background (climate, hydrology, soils, geology, flora, fauna, socio-economic characteristics). Have these been summarized well? Is there a map(s) of sufficient detail so that the reader can see impacted area (especially, a watershed map)? Has the site been visited? At what season and for how long? If the environmental baseline is incomplete, has the environmental assessment listed gaps in knowledge. This is crucial as many impacts may be indeterminate or there may be future-potential-impacts that cannot be determined at an early stage of the project/program.

IMPACTS AND SIGNIFICANCE OF IMPACTS: Have all possible impacts been considered? Direct and indirect? On-site and off-site? Short-term, mid-term and long-term? Cumulative impacts from various actions, including non-project actions in the same area?

Once this list is made, what criteria have been used to determine "significant" impacts? This is crucial. The "significance" of an impact can be evaluated in terms of policies (does it help or go contrary to a policy?) or thresholds (does the impact exceed an acceptable limit in terms of health or damage or pollution?)

Listing and weighing the importance of potentially significant impacts is the test of a good or mediocre consultant. The environmental assessment can only be as good as the persons who determine significance.

MITIGATION AND RESIDUAL IMPACTS: Many negative impacts can be mitigated. Many poorly planned monitoring or research programs can be improved. Significant negative impacts or poor programming usually require another go-round with the lead agency. It is important for the consultant or agency to prioritize the important mitigation measures, put a price tag on them and state which need to be included in the budget in order for the project to be

acceptable. If the proposal requires monitoring or enforcement, the agency responsible for these actions should be suggested and manpower/equipment estimated. The transformation of written impacts into budgetary line items is usually the point at which the process breaks down.

After mitigation measures have been accepted within the budget or project design, some impacts may remain. These are the "unavoidable" or "residual" impacts and they should be clearly listed. In the United States, they are called "irreversible impacts." If the project is large in scale, changes in "long-term productivity" are sometimes used to summarize all impacts. Changes in population growth or distribution should always be noted.

C. SOME EXAMPLES.

Seven environmental evaluations were reviewed. It is a small sample and it would be interesting to have a more complete sampling of the various bilaterals and ONGs.

1. OMVS Agricultural Research II, Phase II (Project 625095).

An IEE was prepared for this research project. The project was subsequently modified with no supplemental IEE made on the change in project structure. The assessment was made by Peter Freeman using a check list of potential impacts and then commenting from the check list on two aspects he felt were significant: land clearing and pesticides.

The IEE section on pesticides is extremely well done with contacts made with experts in the United States. Solid recommendations with person-months required were included. It was impossible to tell from the Logical Framework, if these recommendations had been budgeted. Even a casual questioning of some USAID administrators failed to determine if the mitigation measures appeared in the LOG FRAM. It was also difficult to determine if the Project Evaluation had specifically determined if the mitigation measures had been followed.

The land clearing, water use and waste disposal were probably minor impacts. Nevertheless, from a procedural standpoint, we do not know if the consultant ever visited the site, how much land on what kind of slopes would be cleared nor any cumulative impacts within the watershed. There is no comment on flora or fauna (probably because it was judged insignificant) and no comments on water source, health, or hygiene.

Because this is a research project, questions of purpose and need have great importance. The IEE does not address this question. When addressed, it is seen that the project is for maximizing

productivity. It has no component to see if cultivars or fertilizer/pesticide/intercropping helps regenerate or sustain soil fertility. This is a crucial question for the widescale implementation of the research in the peanut basin. In short, the purpose of the project does not address the need for sustainable soil fertility, especially increased organic matter. Nor does the research program include evaluation of the impacts of various fertilizers/pesticides on the microbial community of the soil. The IEE appears to be so narrowly defined to structures (buildings) and commodities(pesticides/fertilizers) that the renewable natural resource component is completely absent.

Adding the questions from Part A to the IEE checklist or creating a special checklist for research (vs. development) projects, might have improved the understanding of the purposes and needs of this project. The project would also have conformed more with ISRA goals of a broadly defined training program (p. 10, Project Report).

2. <u>USAID/Senegal Reforestation Project (685-0283).</u>

This is a three page IEE with one page of introduction and 1.5 pages of environmental analysis for a seven-year, $10 million project. There is no checklist, no description of watersheds or areas where the project will take place, no maps. In fact, there is no information in the whole IEE.

It is assumed that there can be no negative impacts from a project that "regenerates forests." While this could be true, the author in no way convinces the reader. For instance, does species choice of trees regenerate or degenerate the soil? Do the trees increase, decrease or remain neutral to the biological diversity of the region? Will reforestation techniques run the risks of increased erosion and does the project allocate financing for this aspect? Will the trees use up groundwater that might be important to nearby farmers? Does reforestation take into account women's needs for specialty trees for medicines and household sauces and spices? What kinds of vegetation are cleared to make room for the forests and administrative facilities? If this is a long-term project, how secure are the trees from poaching? What are the increased risks of fire from increasing biomass and has this been mitigated?

These may not be "significant" negative impacts but we will never know from the IEE. In addition, we will never know what are the specific positive impacts to the pieces of land reforested because these are not addressed except to say it fights desertification. (Most of the project is outside the Sahel where desertification is more of an issue.)

3. Southern Zone Water Management Project (Project 6850295).

This is an IEE and an IEE amendment. The IEE amendment by Jeffrey Goodson (REDSO) is one of the best I have seen. The environmental baseline is specific to the area with each watershed type described in enough detail (no map). On-site and cumulative off-site, direct and indirect impacts are described.(A perhaps minor gap was ignoring the project impacts on classified and protected forests in the study area.) The outstanding aspect was listing potential impacts that could not be known at the time of the project paper and describing in detail a monitoring system that would detect any negative changes so that the project could be modified year by year. Goodson lists each mitigation measure, what year it should be included in the budget and program, and how many person months he estimates for the consultancy. He emphasizes that this feedback to the program is the crucial aspect of the project as it is the only way farmers and USAID will learn about a more sustainable agriculture.

Again, the mitigation measures cannot be found as line items in the Logical Framework nor the Project Paper. They may have been included but the way the Logical Framework is presented makes it difficult to know without consulting the actual project director.

4. IUCN's Impact statement on a Road through Niokolokoba National Park.

This preliminary environmental assessment of a road improvement through or around the Niokolokoba National Park (NNP) was financed by the FED and EEC and implemented by IUCN. Seven days were spent in the field and about two weeks talking to administrators and park personnel. For reasons unknown, the Government of Senegal has not accepted the conclusions of the report. The report was both timely and tried to be inclusive of all interested parties. It included maps of the park and alternative routes.

The limited purpose of this assessment was to reduce impacts of a paved road on NNP. The broader issues of whether an alternative road through Kayes would fulfill the needs of the road connection to Mali was not addressed. Nor were off-site (vs. on-site), cumulative, or indirect impacts addressed. This broader sense of alternatives was not part of the terms of reference but might have been a useful addition to the report.

The environmental baseline data were available for only part of the alternative route. Time limitations prevented complete field survey of the rest of the road. Major impacts (e.g., increased access for poachers, increased roadkills, increased opportunites for brush fires within the park) were well addressed as were some

of the construction impacts (e.g, need for water and gravel for road materials). There was not enough time to indicate how wildlife used the area of the alternative road, how the circumferential road might increase poaching and fires compared to the through-park route. Gaps in knowledge could have been more explicitly presented.

The report does an excellent job in setting out the GOS criteria and the EEC criteria for judging significance. It uses existing policy and baseline (e.g., no control on night driving) to evaluate the alternatives. For socio-economic evaluation, it uses the GOS's own goals of increasing ease of contact between rural villages and major town centers. Because of its preliminary nature, it does not quantify impacts (how many roadkills) nor set scientific criteria for "acceptable" losses, and residual impacts are not addressed. It would have been interesting to address the question of how the two alternative road routes might impact park attendance.

Two aspects of the report are striking: (1) This is a major project and should have a still more complete analysis before donor funding. The road has many implications for Senegal outside the project area. For instance, will a paved road through the park encourage Kekreti Dam by changing cost/benefit ratios? (2) There are political agendas operating that have not been (and, perhaps, cannot be) addressed by the consultants. This IUCN EA raises the questions of how environmental assessments can be turned into actions by both the donors and the GOS.

5. <u>OMVS Groundwater Monitoring Project (Project 625-0958).</u>

This IEE points out the different approaches required for a monitoring project with few physical impacts and a development project with large-scale physical impacts. The IEE limits itself to the actual impact of placing monitoring wells which have relatively minor impacts.

The IEE does not address the environmental and natural resource management concerns of the monitoring program, except to be abstract ("integrated water use planning"). It does not address the choice of locations of the wells (no map) and if these locations will accomplish the monitoring goals (especially for changes in salinity and surfacing groundwater tables that may damage crops, alter Djoudj wetlands and feeding areas for birds, pollute the St. Louis water supply). The IEE needs a more specific approach so that maximum use can be made of the monitoring data for natural resource management.

6. <u>The Gannet-Flemming Report on the Senegal River Basin.</u>

This multi-volume environmental and socio-economic assessment contains almost all the problems to be found in river

basin analysis. The report, in a sense, has been up-dated by Euroconsult/RIN (1990). This work is much better organized but still lacks many of the features found in standard environmental assessments. We will simply go through the questions from Part A and give examples that help illustrate what could have been done.

GF never really defines the need for each individual element of the project(irrigation, hydropower, deepwater navigation). It accepts the project and design of the project without any attempt to re-arrange priorities by a cost/benefit or cost/harm analysis. This would have eliminated a lot of paper on the navigation sector which, without major mining, has little chance of being funded for deepwater vessels. GF never reviews existing policies in Senegal, Mali and Mauratania and compares the project's purposes to national needs. For instance, does this project actually encourage or discourage rural exodus to the cities? Were there better alternatives to stabilize the river basin pastoralists, fishermen, and floodplain farmers? In other words, GF accepted the project as given and did not think of alternatives nor modifications that might have helped increase productivity, conform more closely to stated government policies, and conserve more of the natural resource base (e.g., floodplain fisheries and bourgoutieres).

The purposes of the project were never critically analysed. For instance, there already existed a pipe from Lake Guiers to Thies/Dakar. With urban expansion, there was an obvious need to either expand this pipe or find another source of urban water supply. (This is now part of the use of Manatalli waters planned in the Projet du Cayor.) GF never seems to have spotted this obvious need and incorporated it into the evaluation at an early stage where dam design, release scheduling, and seasonal urban needs could be considered. Or, despite many Senegalese policies, GF never includes protection of wetlands and tourism as one of the major goals of the project, thus undercutting the value of its own suggested mitigation measures (see below). In short, it is crucial on large river basin projects that needs and purposes be compared at an early stage. In this case, GF just accepted the moment's political staging.

It is difficult to analyse timeliness and participation. Some of the reports (e.g., Ornithology) have no understanding of the immense and crucial French literature and, it must be assumed, that French ornithologists did not participate. The author does not even mention both the negative and positive value of waders (shorebirds) in the basin. The French had carefully studied the impact of birds on rice growing, especially counter-seasonal rice. Similarly, GF never considered modifications of dam design. For instance, there is no discussion of a dam design for a structure to release an "artificial flood" (by passing hydropower releases) nor an analysis of cost/benefit (fishery, grazing, recessional agriculture) that might have influenced the design at the early stages of the project.

The environmental baseline suffers from organization. There is no summary of "gaps in knowledge" so, for instance, the upper middle valley fishery is ignored. In a river basin project of this scale, "gaps in knowledge" will always exist but the job of the consulting firm is to make clear how they may impact their results ("worst vs. best" case scenarios). GF continually uses "averages" or what it feels are "typical years" without giving worst/best cases.

As mentioned, there are no criteria for "signifcance" of impacts. The impacts are never summarized in terms of short, mid and long-term so that budgeting mitigation measures can be appropriately scheduled. The on-site/off-site and cumulative impacts are particularly weak. The relationships of Ndiael, Trois Marigots, Lake Guiers, the Ferlo, Dakar water supply, locations of irrigation development, dikes plus Diama, water scheduling and secondary dams are never addressed.

Although OMVS had promoted the floodplains as gaining in value from the waterworks, there is no understanding that this promotion might rekindle the tensions between Toucouleurs and Maures that have existed for centuries. No mitigation measure (such as assuring clear title to land) was suggested. On the Senegalese side, many farmers may not be able to make a living in the mid-term (between dam completion and irrigation perimeter development) because of the lack of an adequate floodpulse. Without the pulse, their land is temporarily worthless and "speculators" are buying title rights, causing increased out-migration. This is directly contrary to Senegalese Government policy. The mid-term and long-term impacts are not well separated and, in the case of fishermen out-migration, not addressed.

The mitigation measures address some of the potential impacts (e.g., the artificial estuary and fish productivity) but the major mitigation measure (release scheduling) is not addressed. Both the Diama and Manatali will release water at various times of year but the GF report does not set out criteria to maximize either economic output or a sustainable yield. Because of the complicated sequence of events (twenty years to "completion" of irrigation development), it was necessary to separate out mitigation measures for the "mid-term." GF did not do this and this has caused many of the improvised measures that now exist. Nor did it use standard "California" hydrological-type management framework (very dry, dry, normal, wet, very wet, consecutively dry years) to discuss mitigation measures. This is an astounding omission for a Sahelian river.

There is, as usual, a politics of river basin management. In the Gambia Basin, despite results of an assessment of Balingho Dam that showed it to be unnecessary, non-economical and environmentally damaging, the Gambian government still pursues financing.

There is in Africa (and all over the world) a politics of monument building in which funds are predominantly recycled to engineering firms in the donor country. This would have occurred on the Senegal River even if GF had been more able to perform its contractual duties. It has been suggested that the company or administration that profits from waterworks construction be contractually separated from both the designers, the assessors, and the managers of the project (modified from Scudder, mns). If possible, this would reduce "conflicts of interest." USAID and American firms, by dropping from the dam construction business, have essentially taken this step. But, making donors take socio-economic and environmental responsibility for their loans or donations and internalizing mitigation costs into project development failed in the Senegal River basin waterworks. Now, more expensive "mitigation" measures have difficulty finding sponsors and two nations, formally at peace, have closed borders.

D. COMMENTS ON THE PROCESS.

The USAID/Senegal Mission request to review the environmental assessment process itself as performed by the Mission and donors is unique and resulted, given the very limited time, in a fruitful understanding of some needed improvements to the process. It stimulated questions. One USAID reader of the draft noticed that there had been no discussion of USAID funded projects of IBRD, ADB, IFAD and the UN from the point of view of the environment. This consultant highly recommends pursuing a process to accomplish this monitoring.

To improve the ENVIRONMENTAL ASSESSMENT process, the USAID IEE could use additional forms, especially a separate form for research and monitoring projects. Research and monitoring projects appeared to confuse evaluators.

The mitigation measures in the USAID process should be included as a separate line item (LOG FRAM) so that it is easier to discover if mitigation has been budgeted or included in project papers.

All EAs reviewed need to pay more attention to criteria for "significant" impacts; to referene policies or thresholds used to judge significance; to greater detail on off-site vs. on-site impacts; to better presentation of cumulative impacts; as well as to more precise discussion of the actual natural resource management needs of the project.

The quality of environmental assessments can be no better than the commitment, the ability, the experience and the wisdom of the consultants involved. The process is wide-ranging and covers multiple disciplines. The US AID IEE's ranged from the excellent work by Jeffrey Goodson (REDSO) and Peter Freeman (US AID) to sophomoric pleasantries by unnamed consultants. There is a need to

train "environmental officers" at each embassy or agency on how to go about searching for significant impacts, to ask for help when there are gaps in knowledge, and to find consultants in environmental analysis.

The EA should also address the purpose of the project from a natural resources point of view: Is the project for exploitation, increased efficiency, regeneration and/or protection?

There appears to be little concern for impacts on flora and fauna and biodiversity with the exception of Goodson's IEE.

Inadequate maps of the area of the proposed project was a specific and major gap in most environmental assessments reviewed. It should be stated whether the consultant visited the sites and for how long.

In Africa, the environmental evaluation process is very political. It is important to have a sociologist or economist partake in the environmental assessment at the earliest stages. The "purpose" and "need" for the project should address WHO will benefit and WHO may suffer from the project. Natural resource management is by humans and they must be identified as early as possible because they may have useful things to say about impacts that consultants missed or ways to improve the project. This applies to research, especially agricultural research, as well as development projects.

Many of the environmental assessments have been made very late in the program/project process. In these cases, the environmental assessment becomes more of a commentary than an "action" document.

All over the world, the environmental assessment process tends to be "pro forma." The document is written, consultants paid, and the project goes on as if nothing was ever written. For instance, in USAID "logical frameworks," the mitigation measures proposed by the IEE were not broken out as a line item or designated cost. This meant that in project and budgetary evaluation, it was near impossible to determine whether the mitigation measures had been incorporated into the project. When possible, mitigation budgeting should be a separate line item. Where possible, a commitment to mitigation measures should be made before starting to spend money on the project. In large projects, a "round table" meeting with donors on internalizing costs of harmful impacts appears necessary.

EAs tend to require a "holistic" approach. Because environmental assessments appear to be done by engineers, there is an overemphasis on structures. Impacts that are less obvious (downstream impacts, cumulative impacts of many small projects, impacts outside the study area, gaps in knowledge or indeterminate impacts) receive less attention.

CHAPTER 9

CONCLUSIONS

Senegal has been battered by a series of droughts, a major change in its international terms of trade, and a burgeoning population. Although there has been some amount of industrial development since independence, Senegal relies heavily on its agricultural sector for employment, generation of foreign exchange, and value added. Because Senegal relies so heavily on agriculture, any decline in agricultural productivity, whether slow or rapid, will affect the country's economy.

The basis for the productivity of the country's agriculture is its natural resource base. If this resource base becomes less productive or if parts of it are irreversibly destroyed, the agricultural sector will suffer, the economy will suffer, and the Senegalese people will suffer. In addition to the strictly agronomic production which relies on the natural resource base, livestock, forestry, fisheries, and tourism also rely on these same resources.

The population is still predominantly rural and agricultural. As the population has grown over the last decades, more and more pressure has been placed on the land to produce enough food to feed the country and to generate enough export earnings to satisfy the country's need for consumer goods. This increased pressure on the resource base has not been without effect. In many areas the soils are much less productive than they were 20 years ago. Vegetation has less dense, less varied, less protective, and less productive. The animal resources of Senegal have also suffered, both directly from fishing and hunting, and indirectly from destruction of the habitat necessary for their survival. One resource seems to have escaped serious deterioration of productive potential. Water.

Senegal is fortunate to have access to such large quantities of high quality water. Over the past decades these sources of water have been tapped through an evergrowing system of dams, dikes, pipes, and wells. This infrastructure assures an adequate supply of water for urban and household needs, allows irrigation of agricultural land, and permits the watering of livestock herds.

Each of the chapters 3 through 9 discussed one major natural resource sector or one major aspect of natural resources management in Senegal. The bulk of the information in this report was gathered from numerous project-related documents and technical reports (see Annex 2, Bibliography). Additional information and insight was obtained during interviews with officials from government services, projects, and donor agencies. Members of the team were also able to visit a number of field sites to better

understand the resource management problems addressed by the literature or our informants (see Annex 3, List of Persons Met and Schedule of Field Visits).

In addition to the synthesis of available information, each chapter also contains an assessment of the information found in the available documents. First some general problems will be presented. These are the aspects of natural resource management which need to be considered on a strategic level rather than on a project level or even a sector level. Many of the conclusions drawn are not sector specific but transcend any boundaries which may exist between the various resources. Then the technical conclusions are presented in two different ways. First, the conclusions from the various chapters are brought together on a regional basis. This may give a more complete picture of the natural resource problems faced by a given region. Secondly, certain technical problems which are not necessarily related to any specific region are pointed out as sectoral problems. This method of presentation will lead to some amount of redundancy.

A. GENERAL NON-TECHNICAL PROBLEMS.

1. In project management and implementation, many technicians place more emphasis on implementing solutions than on solving the specific problems.

The team received instructions from the USAID Mission to concentrate on defining problems. Specifically, the team was not to propose solutions to the problems. At first, the team did not consider this an appropriate approach. However ...

As part of the review process, the team examined how various development projects addressed specific natural resource management problems. In doing so, one aspect of project implementation became evident. In numerous cases, it seems that those who are responsible for implementing a project have taken the role of solution implementers rather than problem solvers. That is, problems are defined during the design phase of the project cycle and solutions are proposed for those problems. Once the proper solutions have been chosen, the project execution is aimed at installing the proper number of solutions or involving the proper number of project beneficiaries. When this approach is taken, those responsible for the project tend to lose sight of the real purpose for having financed the project. Their objective is to implement the proposed solution whether or not it really helps eliminate the problem.

2. There is very little coordination between the various participants in development assistance.

This is a general problem which can be attributed to every participant in natural resource management: government

agencies, donor offices, project managers, NGO's, research organizations, and extension services. Often one group is not aware of the activities of other groups. This is a very general conclusion which covers a multitude of specifics. For example, donors do not coordinate activities. While USAID is attempting to encourage the development of private nurseries, Japan is designing a project which could finance the modernization of as many as 15 major government run nurseries around the country. While foresters were encouraging farmers to protect Acacia albida trees in their fields, SODEVA agricultural agents were encouraging the same farmers to uproot all trees on their fields. The low levels of coordination between research units and extension services is well know.

One project repeats the mistakes others have made and learned from. A corollary to this is that these projects do not advance as rapidly as they might, i.e., time is lost. One may ask local producers to take responsibility for management of local resources while another allows outsiders to exploit the resource without consideration of local residents.

3. Government policy statements are showing more concern for the management of natural resources. Some observers do not adequately distinguish between policy statements, policies, and laws.

Over the past few years, government policy statements have been paying more and more attention to natural resource management and the integration of agricultural production and natural resource management. Even though these policy statements have not yet all been translated into policy, that is, action, it is clear that the government recognizes the importance of being able to stabilize and protect the resource base.

In 1984, Senegal began a program to reduce the degree to which parastatal organizations are involved in the productive sectors. There has already been a ministerial reorganization which is to be a precursor to a reduction in civil service personnel. The 8th Development Plan mentions the need to integrate more closely the various productive sectors: agriculture, animal husbandry, and forestry. In the future, more attention is to be given to the rate at which livestock put on weight rather than the number of animals in a herd. The government would like to begin to control the use of chemical pesticides. The charcoal production and distribution network are recognized as problem areas which need attention.

Some analyses of laws and regulations use the terms law and policy interchangeably. Very simply, a policy is something that everyone, or at least most people, have decided to do. As an example, say there is a law against cutting trees. Also consider that people are cutting trees everyday and the government knows that this is happening but does nothing about it. The law says

trees should not be cut. Policy says that cutting of trees will be tolerated. In the same sense, strategy statements are generally indications of activities or policies one would like to have, not necessarily those which one expects to carry out. A strategy is not a policy just because someone says it is. Action is required.

4. Extension agents are hesitant to turn management over to producers.

Despite the policy statements of the government, many of the representatives of the extension services or the regional development agencies are not turning management of productive resources over to producers and user groups. As farmers learn that they have less and less control over the natural resources around them, they stop caring for them.

5. The resource user is not allowed to make resource management decisions.

Responsibility for many management desicions has been given to extension services or other government agencies. These government officials have the authority to make or approve a number of what would normally be considered routine management decisions. This means that the individuals who are most familiar with the resource and who are responsible for the day-to-day management of that resource do not have this authority. As is typical of human nature, when an individual has no authority he tends not to take any responsibility. Thus, this situation leads to a double problem: The resource management decisions are being made by those who are not as familiar with the resource as the resource user and the resource user who is in daily contact with the resource has abdicated responsibility for its care.

6. Planning is often monosectorial.

Despite the good intentions of many agencies, they still have a narrow technical view of the proposed activity. Projects which are to drill wells for livestock do not consider the impact of increased concentrations of animals on vegetation. Irrigation projects often do not consider the effect of changing hydrological regimes on flood recession agriculture, fisheries, forestry, or national parks. Foresters who want to protect a valuable heritage often neglect the vital needs of the populations surrounding the forests. The result of this limited view leads to a situation where confrontation is the norm. There are as many or more constituencies against the project or action as there are in favor of it.

In addition to the negative impacts that this monosectoral view of the world causes, there are also lost opportunities. By considering protection only, foresters miss the opportunity to contribute to agricultural production. By concentrating on

agronomic technologies only, extension services miss the opportunity to integrate livestock management in the overall management of the farm enterprise, often to the benefit of the field crops.

7. Land tenure, like many other issues, must be considered in any strategy or design. However, it will not be a crucial issue in all cases.

It is generally accepted among those involved in development that land tenure is an important factor influencing the farmer's decisions about natural resource management. However, it should not be assumed to be a problem in every instance. Indeed, there are often issues of technical and financial feasibility which are much more important.

The National Land Law has been variously credited with increasing tenure security and decreasing tenure security. Different authors have different opinions as to its effect on tenure security. As different tenure specialists interpret the law differently, it is entirely logical to expect individual farmers to interpret it differently as well. Despite what the various writers say about how the farmer ought to act, there have been few studies to examine the actual situation in Senegal. Only one of the authors of land tenure articles did long-term field research in Senegal on the relationship between tenure security and the willingness of farmers to invest in their land, Elise Hardy. She was unable to show a significant difference in the way different farmers treated their land as a function of tenure security. Nor was she able to find a single instance of how the National Land Law had caused anyone to lose control of land between 1964, when the law was enacted, and 1986.

On open access resouces, such as rangeland, the situation is slightly different. All herders tend to have very secure tenure. Anyone can use the rangelands. What is needed, according to some, is the possibility to exclude some herders so that only the "proper" number of animals uses the rangeland.

Tenure is always an issue in irrigated perimeters if there is to be redistribution of land. The issues generally concern who has access to irrigated land, how large the parcels should be, and what types of land transfer should be allowed.

The last area to examine is tree tenure. As discussed above, Elbow and Lawry maintain that changes in forestry legislation are essential. However, the authors seem to have missed the point that there is little relationship between the legislation and tenure security as viewed by the individual farmer. Thus, although it might be advantageous in the long run to change the law, participation in tree planting programs does not seem to be dependent upon such changes.

8. The multilateral donors are not investing in natural resources management.

The examination of the development strategy for the World Bank, the European Economic Community, and the United Nations Development Program shows that natural resource management will not be a priority for any of them for the next few years. The World Bank has decided to concentrate its limited funds on structural adjustment. The EEC has always invested most of its funds in economic and social infrastructure and will continue to do so. The UNDP will allocate about one-quarter of its budget to natural resources. However, the UNDP budget is very limited, so this amounts to only $8 million. Any major investments in natural resource management in Senegal will have to come from bilateral donors.

B. SPECIFIC TECHNICAL PROBLEMS.

This section presents certain technical problems which do not fit conveniently into a regional analysis. The following section will discuss the six regions and the natural resource problems specific to each. There is obviously some redundancy in this method but it has been kept to a mimimum.

1. Soils.

- Chronic erosion and degradation on upland soils which are resilient but not responsive to management.
- An apptitude classification of Senegal River Valley soils which gives an excessively optimistic and narrow interpretation of their potential.
- The threat of salinization of soils with poor internal drainage in the Senegal River Valley.
- Localized acute problems with water erosion.
- Localized acute problems with dune encroachment on farms and roads.
- Chronic salinization and acidification of rice soils in Casamance resulting from the ongoing reduced rainfall conditions.

Relevant USAID projects may incidently deal with soil resource problems as is the case with the Southern Zone Water Management project but their general orientation does not relate to specific soil resource management problems.

2. Vegetation.

The harvest of wood from the nation's forests and woodlands is considerably greater than the sustainable yield. The primary use of wood fiber in Senegal is as fuelwood. The demand for and harvest of fuelwood is generally distributed as the population is distributed. However, there is also the demand of the urban centers and especially of Dakar. The fuelwood harvested and converted to charcoal for Dakar is equal to the volume of fuelwood harvested for all of the rest of the country. Two basic problems exist. First, the forests are expected to satisfy a demand they cannot possibly satisfy continuously. Secondly, while is would be possible, technically, to increase the productivity of the country's forests, it would be very difficult to do because of a lack of administrative ability.

In order to manage the country's rangeland, one must be able, on a year-to-year basis, to control the number of animals which use any given area. This is because rainfall is the prime determinant of biomass production. In years of low rainfall, herds should be reduced. However, this is difficult because there is open access to rangelands in Senegal, because the livestock markets are not well developed, and because there are few alternative investments available to the herder who finds himself with extra cash.

There are opportunities for addressing the soil fertility problem in the agricultural areas by use of agroforestry techniques which are now being adapted to Senegalese conditions. USAID through the reforestation project has experience at the national level of farm forestry through Eaux et Forêts agents. The accent of this program has been to get the farmer to plant trees. This has been a successful program but much of the planting has not been multi-use or agroforestry applications but income generation of trees as a crop. The next logical step with these farmers is to work with them to protect their Acacia albida and other field trees and bushes, and to develop management of natural forests and plantations which have been created by village action.

3. Water.

Although there seems to be some potential for using groundwater resources in much of the country, special studies are needed to quantify any proposed use of groundwater.

This study shows that there is great potential for surface water in the Senegal River for multipurpose development of the Valley, including recharge of the aquifer. This potential depends on the hydrology of the Faleme River, mainly on water released from Manantali dam. The dam is expected to release 200 m3/s during transition period and 300 m3/s at full operation. This potential is estimated to be from 6.4 to 9.5 billion m3/yr (transition to full stage). An additional runoff of 6.4 billion/yr can also be

obtained from Faleme River alone. At present operation stage of the dam, a monthly average of 122 million m3 was released from December 1989 to April 1990.

4. Animal Resources.

a. Wildlife.

Commercial bushmeat, subsistence game, trophy and craft hunting, trapping birds for the pet trade are all consumptive uses of Senegalese wildlife. Tourism, research, and birdwatching are potentially profitable non-consumptive uses.

The government has been ineffective in controlling trade, trapping, sales, and hunting of wildlife. The most dramatic example is that ivory poaching is sending Senegalese elephants to rapid extinction. There appears to be little hope that Senegal can maintain a renewable wildlife resource for consumption purposes and, even, in Niokolo Koba for non-consumptive income generation. The recent merging of National Parks and Tourism may be a hope for the protection of wildlife for tourism. Otherwise, the next twenty years will see hunting, trapping, game-based crafts, and drought fallback protein from bushmeat disappear or diminish far beyond its already degraded condition.

b. Fish and shellfish.

The fish and shellfish resources have great importance to the economy and protein nutrition of Senegal. The freshwater fisheries have no management for long-term sustained yields. The government is beginning to monitor and regulate the fisheries for sustainable yields.

The main source of freshwater fish in Senegal -- the River Basin -- has been utterly destroyed from the point of view of shrimp, migratory, and riverine fisheries. In order for this resource to continue to contribute to the economy corrective measures must be taken to create an artificial estuary. The Manatalli Dam release schedules will have an important effect on floodplain fish production. Considerations for the future fish production could be included in the water release program.

c. Livestock.

There are several problems which are predominant in the livestock sector. First, is that objectives of livestock owners are not strictly production oriented. Animals are kept as a form of investment as much as for the production of milk and meat. A prime reason for not selling animals is that owners do not have alternative investment opportunities. In many cultures, the size of one's herds are still important social status symbols.

Most cattle, sheep, and goats are fed on open rangeland or on common lands. Traditional control of commonlands has broken down and has not been replaced with other adequate control mechanisms. The result is an overuse of the vegetative resource unaccompanied by any investment in its management.

5. Biodiversity.

Senegal has the following unique and biologically signifcant communities: inland wetlands; coastal landforms; niayes; gonakie forests; relict Guinean forests; Niokolokoba National Park/Faleme Hunting Reserve complex; and a Sahelian region important to dry season raptors.

Areas are protected by Senegalese laws and international conventions. But "paper" protection suffers from: undersized areas, with no buffer zones, too isolated from other protected areas, and with no safe passage corridors between "habitat islands;" from lack of appreciate by both donors and the upper levels of the GOS of the value of protected areas; from the impacts of the drought and non-mitigated river basin development; and from inadequate financing of all aspects of support for personnel, local villagers in buffer zones and equipment needed for effective protection.

The situation for protected animal and plant species is similar. There is good paper protection but ineffective implementation of the law. The giraffe, Dorcas and Damas gazelle, and a species of hartebeest are already extinct. Every major large mammal appears to have populations too small or too scattered to be viable over the next twenty years. For instance, the elephant, wild dog, Ferlo ostrich, and cheetah will probably go extinct in the near future.

There does not appear to be much that can be done. Probably, donors will help those nations in which good species management is more reliable. Senegal will remain a center for wetland and bird protection. All other species will simply be written off.

6. Environmental assessments.

Among the limited number of donors contacted, only USAID and IUCN have well founded environmental assessment procedures. The World Bank has just recently adopted assessment procedures and the African Development Bank is in the process of revising theirs. ADB will also develop procedures.

The USAID IEE could use additions, especially a separate form for research and monitoring projects. These type projects caused confusion. The mitigation measures should be included as separate line items (LOG FRAM) so that it is easy to discover if mitigation has been budgeted or included in the project papers. The EAs need more attention to the criteria for "significant" impacts; on-site vs. off-site impacts; cumulative impacts; as well as the natural resource management need for the project.

In Senegal, the process is very political. Environmental assessments are considered problems caused by special interest groups within the donor community. They are not yet understood or appreciated by the current administration or non-interested donors. There is no binding commitment to environmental assessment recommendations, no matter what the conclusions.

The assessments were very sensitive to individual abilities and thoroughness. In some cases, the assessments may be biased. Engineering firms, for example, tend to evaluate structures, not indirect consequences of the structures (e.g., a dam but not its impact on fish breeding by changing the flood pulse).

C. REGIONAL PROBLEMS.

1. Peanut Basin.

The Peanut Basin, as its name suggests, is dominated by peanut production. Usually peanuts are alternated with millet or sorghum on a more or less regular basis. Fallow fields are becoming less and less common due to population pressure.

There are too many people attempting to earn a livelihood on a poor resource. It is true that there is what could be called overpopulation in the Peanut Basin. However, this should not be equatd with a surplus of labor. Labor is in shortage due to the migration, primarily of able-bodied men. Soil degradation is important because it is extensive and affects a large population. Dealing with soil degradation, that is, soil of low fertility, is probably the only way of dealing with wind erosion. Erosion is not currently a big problem but could become serious. However, this may be a difficult problem to solve because solutions are complex and the innate fertility of these soils is low so the increases in yield will not be high. Fortunately, these soils can take a lot

of abuse as they are not prone to erosion, laterization, or other processes which are irreversible.

The Peanut Basin is predominantly an agricultural area. However, the concentration of animals is greater in the Peanut Basin than in the Ferlo or in Senegal-Oriental, areas normally considered as livestock areas. Because of this high concentration of animals, there is a great demand for animal feed. Yet, because the area is used predominantly for cultivated crops, there is little pasture or rangeland for the herds. A large portion of the livestock diet in the Peanut Basin is what are sometimes called crop residues. The term seems inappropriate in this situation. Because of the pressure these animals place on the vegetation, establishing any type of vegetative cover in association with agriculture becomes more difficult.

2. Senegal-Oriental.

This region is an area where cotton and millet and sorghum are produced. Because the region receives slightly better rainfall than the Peanut Basin, maize has been becoming more important in recent years.

Senegal-Oriental has areas which have steeper slopes than the Peanut Basin. The soils are gravelly and sandy like the light soils of the Peanut Basin. However, they have more slope so are more prone to water erosion. Soils are also shallower in this area so a given amount of soil loss is more serious. Senegal-Oriental receives more rainfall than the area to its west. More rainfall will mean increased erosion if the soil is bare, as it is likely to be on agricultural land. However, more rainfall will mean increased vegetative cover on non-agricultural land and thus less erosion.

As mentioned above, vegetation is slightly more dense in Senegal-Oriental than in the Peanut Basin because of the higher rainfall. Livestock populations are probably least dense here than in any other part of the country. Wild animals, on the other hand, are most dense here. Low human populations and the existence of large reserved areas such as Niokolo Koba National Park have permitted the wildlife in this region to hold on.

3. The Ferlo.

The Ferlo has mostly sandy soils. However, the soils in the southern Ferlo, while predominantly sandy, have a greater amount of clay than the northern area. The Ferlo is considered rangeland due to its low rainfall. However, in the eastern Ferlo, for example around Bakel, there is more rain, and therefore more agriculture.

The vegetation in the Ferlo is highly dependent on rainfall. The Centre de Suivi Ecologique has been monitoring biomass production in various parts of the Ferlo since the early 1980's. The most striking aspect of vegetation is the tremendous annual variation in production. The 1983 and 1984 production is seen to have been virtually nil. However, two years later, biomass production was again at relatively high levels. A vegetation survey is just being completed. This survey will show the changes in species composition over the years. It is likely that the more desirable species are slowly being replaced by less desirable species but this cannot be confirmed.

The Ferlo is considered the silvo-pastoral region of the country. Because of this denomination, many think that livestock populations are high. As mentioned above, this region has what are probably the lowest concentrations of animals in the country. However, livestock remains the most important production opportunity. The vaccination and borehole programs of the 1950's led to overstocking. How to manage the area and how to deal with overstocking is most crucial for the Ferlo. The question is sociopolitical rather than not technical.

4. The Niayes.

The major problem in the Niayes is the moving sand dunes which must be stabilized to protect areas of vegetable and fruit cultivation.

This very narrow area along the coast is dominated by casuarina windbreaks, fruit orchards, and vegetable gardens. Litle can be said about natural vegetation or livestock production.

5. The Casamance.

The main crop in the Casamance is rainfed rice. This rice is produced in the low-lying areas. Cultivation of the upland areas has only recently become common. Millet, maize, and peanuts are the most important crops in these areas.

The Casamance still has some limited fallow. The tidal surges carry salty seawater onto agricultural land. The soils are higher elevations have much the same problems as in other areas. Mangrove swamps are susceptible to acidification because the soils have a high sulphur content. If the soil is drained, the sulphur oxidizes to form sulphuric acid.

The Casamance is the region of the country which receives the highest amount of rainfall. It is therefore the area with the most natural vegetation. Population pressure is relatively low, compared to the Peanut Basin and many farmers still put their fields into fallow.

6. The Senegal River Valley.

The management of natural resources in the Senegal River Basin depends almost entirely on the management of water. There do not seem to be any abusive management practices at this time, with the exception of overcutting in the regions' forests. Also, there do not seem to be any important problems attached to the management of the irrigated perimeters which are planned. The major issue is whether the streamflow should change to a completely regulated flow, should have a modified flow with an artificial flood, or should not have been changed at all.

No one seems to think that irrigated agriculture is harmful or detrimental. It is seen by all as a good thing. However, many feel that there are negative impacts associated with the change in streamflow which should be mitigated.

ANNEXES

ARTICLE I - TITLE

Natural Resources Management
(PROJECT NUMBER: 685-0294)

ARTICLE II - OBJECTIVE

The USAID/Dakar Mission is currently preparing its CDSS for 1991-1996 and intends to incorporate Natural resources Management analysis as one of the several major analytical foundations for this strategic document. It plans to build upon the work done in the regional NRM assessment, numerous studies that have already been completed in Senegal, and other existing analyses to develop substantive inputs into the strategic thinking of the Mission.

Therefore, the objective of this consultancy is to rigorously review the existing NRM analyses relating to Senegal, identify NRM constraints and potentials, and provide analysis and guidance on NRM for the Mission's consideration in developing the CDSS. Given the strategic nature of this consultancy, emphasis should be placed on reasonable NRM approaches and, if time permits suggested interventions that will significantly reinforce the Mission's major objective of preserving and protecting the Natural Resource base of Senegal for the present and the future particularly as it relates to Agricultural production and food security.

ARTICLE III - STATEMENT OF WORK

Task 1:
Synthesis of Existing Information

The purpose is to identify all available information regarding Senegal NRM concerns. Information will include studies, reports and any and all documents directly and indirectly related to NRM concerns in Senegal.

Much information on NRM already exists, but documents are dispersed in offices and storage places with limited access and cross-transference capability. Information sources will be identified and their NRM materials evaluated and synthesized. Information gaps will be identified from the synthesized data.

Key source documents are available in the Mission and are listed at the end of the statement of work.

The contractor will review available NRM documents wherever they exist in document centers, libraries, localized collections, laboratories, offices, etc., to obtain information about:

(1) scope and significance of natural resources management problems in Senegal including problems which may have as a cause activities outside of Senegal, e.g. the respective watersheds of the Senegal and Gambia River Basins.

(2) current activity in NRM in Senegal by the GOS or other donors, by type, place and organization, agency, or institution responsible;

(3) traditional land-use management systems that show promise for having favorable economic and ecological impacts if extended to a substantial portion of Senegal;

(4) gaps if any between existing problems and activities to resolve those problems;

(5) recommended approaches to take in order to fill information gaps of a technical, organizational, institutional, and social nature, including:

- approaches to identify social and institutional factors in villages or local communities that can contribute to successful implementation of environmentally sound projects;

- examples of other projects such as agroforestry, soil and water conservation natural forest, brush land, and small-scale renewable energy management, and describe the reasons for their success;

- techniques to train people with no previous experience in technical matters to apply NRM technology;

- techniques to predict potential environmental consequences of development activities;

- effective practices which will work with villagers' identification of environment/natural resource management problems and recommended solutions to them, including reorientation of public institutions to support and encourage farmers and local urban and rural groups to invest in land;

examples of technologies that have short, mid, and long-term impacts on NRM including soil and water conservation, vegetation management and soil fertility.

<u>Task 2: Detailed Natural Resources Management Assessment</u>

The purpose is to prepare a detailed assessment of natural resources management problems in Senegal. The assessment will include data collection and analysis, recommendations for actions, and programs or projects that might be financed by GOS and donors.

The team will work with GOS professionals in conducting the assessment. It is vital that the team keep in mind that the assessment is part of a process and not an end product in itself.

The assessment will provide basic information and direction to identify and achieve NRM objectives by the GOS and the limitations/conditions under which USAID/Dakar as well as other donors can carry out a NRM program. The assessment will use information obtained from the synthesis and identify projects, programs and actions to respond to Senegalese (public and private), USAID, and other donor NRM concerns in Senegal. It will provide a common working base between the GOS and donors about long-range NRM in Senegal.

The contractor will list and describe all the components of the assessment, including but not necessarily limited to:

(1) Policy, Legal and Institutional Framework

(a) Including a review of administrative, legislative and institutional components specifically relevant to NRM problems and programs bearing on environmental rehabilitation and stability of the natural resource base.

(b) From the above review, the contractor will identify key limitations to environmental rehabilitation and maintenance of the stability of the natural resource base, including land tenure and land use, laws, practices and policies.

(2) Base-Line Data on Ecosystems

(a) Review and synthesize the state of base-line information relevant to environmental rehabilitation and natural resource base stability, including tree planting, agroforestry, soil and water conservation, water resources management and watershed management.

(b) From this review, identify fundamental gaps in knowledge preventing a clear understanding of how to go about environmental rehabilitation, and promotion of activities that will stabilize the natural resources base.

(c) Review the status of NRM baseline monitoring activities in the upper river watersheds in Guinea (Fouta Djallon). Describe the status of information on quality of the data base, facilities, programs for monitoring and analysis, including lab facilities.

(3) Identify Examples of Successful Interventions in NRM Activities

(a) Identify on-going examples of NRM activities in the USAID/Senegal portfolio that demonstrate how village and community level socio-economic-cultural characteristics were accounted for in establishing and sustaining the activity.

(b) Analyze the examples and identify basic and potentially replicable characteristics of each.

(c) Identify, in these examples, the specific contribution made by women in the activity.

(4) Biodiversity

(a) Identify institutions and organizations especially interested or responsible for maintaining biodiversity areas and assess their objectives and capabilities.

(b) Identify, from agroforestry literature and discussions with agroforestry experts, possibilities for encouraging biological diversity in agroforestry projects.

(c) Identify plant species that could be used to maintain biological systems and biological diversity, and new locations where these plants could be introduced with a reasonably high potential for sustainability.

(d) Develop an outline for a plan to introduce these species in on-going and planned projects.

(e) Review existing available literature in Senegal which relates to plant and animal diversity, look for common demoninators, logical groups etc, record them and describe any major biodiversity areas.

(5) Training in Environmental Assessment

(a) Identify the state of practices in environmental assessment, donor, and indigenous institutions engaged in training programs or conducting assessments.

(b) Identify GOS and donor agency requirements for environmental assessments of NRM projects, such as water resources management, forestry, energy, or water supply and sanitation.

(c) Recommend, in conjunction with the policy, legal and institutional assessment above, improvements for conducting assessments that will lead to positive interventions that promote resource stability, including design of training programs and identification of resource requirements and potential institutions.

(6) NRM Oriented PVOs/NGOs (much of this information should be available in the survey by the U.N.)

(a) Identify PVO/NGOs having programs in NRM.

(b) Categorize these groups, if possible, to identify areas in which they have experience in NRM at the national and local level.

(c) Identify those with special experience or expertise in NRM and in what areas.

(d) Identify major strengths, limitations and weaknesses in PVO/NGO ability to contribute to NRM programs.

(7) Data Analysis and Project Identification

The contractor will review if time limitations permit the data, synthesis and other materials to (a) identify short- and long-term programs and projects for a coherent and coordinated national NRM strategy; and (b) identify programs that must be continued over the long term to assure resource base sustainability, such as institutional strengthening, development of incentives for local NRM, monitoring of changes in the resource base and coordination among GOS ministries and services, donors and PVO/NGOs.

At the national and local levels the strategy will include the estimated costs of establishing conditions that increase the incentive for farmers to adopt natural resource management. These conditions will be based on the findings of the synthesis, the assessment and other data sources and include:

- Resource tenure and land use, laws, practices and policies that confer the products of responsible management to the managers.

- Inputs of training and extension form the GOS, donors, and local organizations (this includes the costs of assisting local resource managers to establish and implement management plans).

- Provision of financial inputs for credit, cost-sharing, market development and strategies to reduce risks and increase returns from NRM investments.

- Strengthen the capacity of public institutions to support NRM actions.

- Strengthen the capacity of local private institutions to manage capital for assisting farmers to invest in land.

During the course of contractor's work performance period mutual decision will be made regarding the timing or necessity of this task.

Task 3: Briefing on Work Progress

At the end of week 6, the work order team will give an oral briefing (2-3 hours) to USAID/Dakar in Dakar. The briefing will provide progress to date, recommend any changes, discuss/resolve issues, etc. The results of the briefing will be incorporated in the final report outline and in the final report. The precise date of the briefing will be established by USAID/Dakar.

ARTICLE IV - REPORTS

1. Work Plan: The team leader will submit a time-phased work plan of major task components for USAID/Dakar approval not later than seven work days after arrival in Senegal. The work plan will contain, inter alia, the six-week oral briefing, the submission of the outline, the review stated at Task 1, the draft and final report described below.

2. Outline of Final Report: Team Leader will submit 30 days prior to completion of the work order a brief annotated outline of topics which will be covered in the final report. The outline will follow tasks 1-2 above. USAID Dakar will approve of the outline in five working days.

3. Draft Final Report: The contractor will submit three copies of a draft final report to USAID Dakar two weeks prior to the end of the work order. The report will be of sufficient length to cover all points in tasks 1 and 2. Estimated number of pages for each task is 100. Form and content will respond to, and follow the tasks as described.

Contractor will present the report orally to USAID/Dakar at a meeting (to be established approximately one week prior to departure) and appropriately incorporate all comments in the final report stated below.

4. Final Report: Contractor will submit the final report in form and substance satisfactory to USAID/Dakar not later than 30 days after departure from Senegal. All references utilized will be listed.

The final report will be in English 15 copies and in French 15 copies. Draft reports will be in English only.

ARTICLE V - TECHNICAL DIRECTIONS

Technical directions during the performance of this delivery order will be provided by IWME Deputy Chief or his designee pursuant to Section F. 3 of the IQC contract.

ANNEX 2

LIBRARIES IN SENEGAL CONTAINING INFORMATION ON NATURAL RESOURCE MANAGEMENT.

ENDA

The ENDA library is very well organized. Documents are on the shelves by subject matter. Shelf labels include: forestry, agroforestry, energy, firewood and charcoal, water, hydrology, wells and groundwater, agriculture crops, rural development, and a variety of others including urban development, housing, health, etc. Most of the documents are how-to books, as compared to textbooks found at the University. Most are documents from other African countries, reports on how such and such a problem was addressed. There are few books in each category, 1 to 4 feet of shelf space. It may not be of great value to most specialists but it is convenient, well organized, and easy to use. It is worth visiting.

IFAN

I used the card catalog to look up several subject areas: sols, soils, regime, foncier, tenure, forêts, forests, vegetation. Their collection has an amazing variety of documents dating from the colonial period. I often saw 1935, 1950, 1908, 1888. However, there were almost no recent documents. This library would give one a tremendous historical perspective but is of little use in describing recent phenomena.

IUCN, Dakar

Basically oriented to its own programs. Good for contemporary issues of Senegal and West Africa. Produces Nature and Resources which is the only updated newsletter on events in West Africa. Not scholarly. But always something useful and surprising for wildlife, environmental impacts, biological diversity, forestry, infrastructure development, networking and education.

FAO

FAO has no document center or library. They are beginning to establish one, however.

National Park of Djoudj

Rare items of interest on park and related subjects. These local libraries should be updated and helped with basic field guides.

ORSTOM, Dakar

This library is one of the best libraries on natural resource related subjects. However, it is not a general library. Well arranged and cared for so that items are rarely missing. Soils, geology, water, weather and climate, vegetation, and sociological studies. It is very complete, easy to use, and the ORSTOM staff is very helpful. You can also purchase recent publications. Has a complete set on major science magazines on hydrobiology, pedology, Science, Sciences Humaines, etc.

UNDP

UNDP's document center is located in a very small room. The only documents visible were a number of magazines and journals.

UNESCO, Dakar

For natural resources, this is a totally inadequate library. Does not even have UNESCO publications on West Africa in natural resources related areas. Poorly arranged.

UNIVERSITY OF DAKAR

I looked up the same subject areas in the University library as I had at the IFAN library. Most of their documents were either textbook type documents or general studies such as the soils of Africa. This library has little to offer of practical value which is Senegal specific.

WORLD BANK

The World Bank does not have a documentation center which is open to the public, although representatives of other donors may have access. Not having spent more than two minutes in the room where the documents are physically stored, it is difficult to say exactly what type of documents are kept. It seems that most of the documents they have are project documents.

OTHER LIBRARIES NOT VISITED

CENTRE DE SUIVI ECOLOGIQUE

ISRA, Bambey.

ORSTOM ORNITHOLOGICAL FIELD STATION, Richard Toll.

Not visited but one of the oldest field stations in Africa. Should have good documentation.

ANNEX 3

LIST OF PERSONS MET AND

SCHEDULE OF FIELD VISITS.

Friday, March 16.

Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
Balago KEMO, IWME Section, USAID/Dakar.
Jean LeBLOAS, IWME Section, USAID/Dakar.
James BONNER, ADO, USAID/Dakar.
Mame Coumba DIOP, ADO Section, USAID/Dakar.

Monday, March 19.

Phil JONES, ADO Section, USAID/Dakar.
Ron KITE, ADO Section, USAID/Dakar.
Mame Coumba DIOP, ADO Section, USAID/Dakar.
M. BARETTO, pedologist at ORSTOM.
Bassirou DJEDJOU, Chef de Divison de la Production.
Forestière, Ministère de la Protection de la Nature et de l'Environement.

Tuesday, March 20.

Papa Assane DIOUF, Canal de Cayor.
Julius COLES, Mission Director, USAID/Dakar.
James FICKES, Chief of Party, Senegal Reforestation Project.
Louis VERCHOT, forestry advisor.
Geoffrey LIVINGSTON, private sector advisor.
Salif GAYE, private sector.
Ministry for the Protection of Nature and Environment.
A. LERICOLLAIS, ORSTOM.

Wednesday, March 21.

Abdou DIOP, Conseiller du Ministre, Ministry of Rural Development.
John BERMAN, Ecnomist, AFRICARE.
Abdou FALL, pedologist, Min. of Rural Development.
Bakary KANTE, Directeur de l'Environement, Ministère de la Protection de la Nature et de l'Environement.

Thursday, March 22.

M. Jacques PIOT, conseiller technique du Ministre de la Protection de la Nature et de l'Environement.
M. Seni DIEMI, Protection des Vegetaux.

Friday, March 23.

Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
James BONNER, ADO, USAID/Dakar.
Mame Coumba DIOP, ADO Section, USAID/Dakar.
Dave ROBINSON.
Bob GILSON, Program Office, USAID/Dakar.
Alassane Kéba DIAWARA, Operations Officer, World Bank.
M.T. MUKENDI, Représentant de la FAO, FAO.

Saturday, March 24.

Tidiane WANE, President's advisor on natural resource matters.

Monday, March 26

Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
Balago KEMO, IWME Section, USAID/Dakar.
Raphael NDIAYE, ENDA.

Tuesday, March 27

Raphael N'DIAYE, ENDA.
Jean-Luc SAOS. Hydrogeologist, ORSTOM/Hann.
Abdoulaye Sega SOW, Director of Cabinet, Ministry of Hydraulics, Dakar.
Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
Wayne NILESTUEN, Head of ADO Section, USAID/Dakar.
Ron KITE, ADO Section, USAID/Dakar.
Phil JONES, ADO Section, USAID/Dakar.
Mame Coumba DIOP, ADO Section, USAID/Dakar.
Mark BOSCH, wildlife specialist, USDA Forest Service, Tropical Forestry Action Plan team.

Wednesday, March 28

Jean-Luc SAOS, Hydrogeologist, ORSTOM/Hann.
Jean-Pierre LAMAGAT, Hydrologist, Director of Research, ORSTOM/Hann.
Jean ALBERGEL, Hydrologist, ORSTOM/Hann.

Arona FALL, Hydraulic Engineer, UNDP/Dakar.
Eric T. FERGUSON, member of energy study team, Tropical Forestry Action Plan team.
Babacar NDIAYE, Direction des Eaux et Forêts.
Soulemane GUEYE, Direction des Eaux et Forêts.
Geoffrey LIVINGSTON, Direction des Eaux et Forêts.
Lucie Colvin PHILLIPS.
Robert B. KAGBO, Agronomist.
Dames and Moore, Upper Senegal River Valley Master Plan.

Thursday, March 29

Arona FALL, Hydraulic Engineer, UNDP/Dakar.
Michel GAGEONNET, Hydrogeologist, Regional Director, BRGM/Dakar.
Samba Tening BARRY, Hydraulic Engineer, Deputy Director, "Direction d'Etudes Hydrauliques," Ministry of Hydraulics, Dakar.
Julius COLES, Mission Director, USAID/Dakar.
Abobacar KOUROUMA, Ingénieur Agronome, Directeur Adjoint de l'Agriculture.
Mme. BA Rokhaya Daba Fall, Bureau Pedologique, Direction de l'Agriculture.

Friday, March 30

Pierre Pol VINCKE, Expert Environnementaliste.
Waly SECK, Ingénieur de Planification.
Cellule Après Barrage, Ministère du Plan et de la Coopération.
Yves MARLIERE, Technical Assistant, Canal du Cayor, Dakar.
Matar FALL, Hydraulic Engineer, Canal du CAYOR, Dakar.
Madior FALL, Hydraulic Engineer, "Direction Hydraulique Rurale" Ministry of Hydraulics, Dakar.
Djibril SALL, Hydraulic Engineer, "Direction Amenagement.
Hydro-Agricole, Ministry of Hydraulics, Dakar.

Saturday, March 31.

Adama M'BAYE, Hydraulic Engineer, "Direction Hydraulique Rurale," Ministry of Hydraulics, Dakar.

Tuesday, April 3.

Samba Tening BARRY, Hydraulic Engineer, "Direction Etudes Hydrauliques", Ministry of Hydraulics, Dakar.
Arona FALL, Hydraulic Engineer, UNDP/Dakar.
M. DIOP, Rodale, Thiès.
Mamadou Pamin SOUKO, Directeur, ISRA, Bambay.

Thursday, April 5

Don BROUSSARD.
Doudou Soce DIOP, Director of Southern Zone Water Management Project.
Thiaka DIOUF, plant physiologist, Chef du Centre de Djibelu.
Dr. Yamai M'BODJE, plant pathologist, coordinator of rice project.
Samba SALL, agroeconomist.
Mabeye SYLLA, soil scientist.
Ibrahima THOMAS, forester, Chef de la Station Forestière de Djibelu.
ISRA, Ziguinchor.
Field Trip to: Guidel and Katoure Anti-salt dams.

Friday, April 6

Jean-Pierre MONTOROI, Soil Scientist, ORSTOM/Dakar.
Field Trip to Djiguinoum Valley, Djilakoum Anti-salt dam.
Field Trip to Affiniam Anti-salt dam (Chinese Project).
Mabeye SYLLA, soil scientist, ISRA, Ziguinchor.
Ibrahima THOMAS, forester, ISRA, Ziguinchor.
Doudou Socé DIOP, Director, Southern Zone Water Management Project, Ziguinchor.

Monday, April 9

M. DIOP, Director.
CTL-Nord project (CIDA), Saint-Louis.
Julius COLES, Mission Director, USAID/Dakar.
Gary NELSON, Deputy Mission Director, USAID/Dakar.
Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
Kemo BALAJO, IWME Section, USAID/Dakar.
James BONNER, ADO Section, USAID/Dakar.
Rod KITE, ADO Section, USAID/Dakar.
Phil JONES, ADO Section, USAID/Dakar.
Mame Coumba DIOP, ADO Section, USAID/Dakar.
Dave ROBINSON.
Robert GILSON, Program Office, USAID/Dakar.

Tuesday, April 10

Songthara OMKAR, Hydraulic Engineer, OMVG.
Nassirou DIALLO, Secretaire General, OMVG.
Adolf TOUSSAINT.
M. BAMBA.
PREMINA (FED), Podor.
M. Martin, FED. (by telephone)
Gorën Bjorkdahl, PROBOVIL (Sweden). (by telephone)

Wednesday, April 11

Tim ROSCHE, OMVS/USAID Project, Saint Louis.
Denis RICHARD, Hydrogeologist, OMVS/USAID Project, Saint Louis.
Ousmane N'GOM, Hydraulic Engineer/Hydrogeologist, OMVS/USAID Project, Saint Louis.
Field Trip to Diama Dam and Area.
M. DIOUF.
Dr. Ulf BAUM.
Dr. Georg KASBERGER, Projet Zone Nord (RFA), Saint-Louis.
Mme. Werber, Dutch Embassy, Assistant to M. Fred van de KRAAY.

Thursday, April 12

Mamadou THIAM, Conseiller Technique Agricole, SAED, Dagana.
Field Trip Dagana Irrigation Perimeter.
Gem. Eraldo BIASETTI, Project Manager, ITALTEKNA MATAM IRRIGATION PROJECT (ITALY).
Sora FALL, Hydraulic Engineer, MATAM PROJECT.
Papa Bakary BATHILY, Director, PDESO (PICOGERNA), Tambacounda.
Abdul Aziz THIOUNE.
Emmanuel HOUNZANGBE, CIDA, Canadian Embassy.

Friday, April 13

Papa Bakary BATHILY, Director, PDESO (PICOGERNA), Tambacounda.
Abdul Aziz THIOUNE.
PDESO (PICOGERNA), Tambacounda.
Geom. Eraldo BIASETTI, Project Manager, ITALTEKNA MATAM IRRIGATION PROJECT (ITALY).
Sora FALL, Hydraulic Engineer, MATAM PROJECT.
Field Trip Irrigation Project under construction.
BAKEL PROJECT: Ronald J. GADDIS, Project Manager.
Field Trip to Collangal site.

Saturday, April 14.

BAKEL PROJECT: Ronald J. GADDIS, Project Manager.
Mamadou KANE, Hydraulic Engineer SAED, Bakel.
Bureau du Groupement de Collengal:
- Yougoukhasse CAMARA, President.
- Abdoulaye DIALLO, Secretaire General.
- Malal BARRY, Chef Groupe 3, GIE.
- Mamadou N'DIAYE, Chef Groupe 4, GIE.
- Dialel DIALLO, Chef Groupe 2, GIE.
- Malick CAMARA, Secretaire du Groupe 3, GIE.

Field Trip to Collangal.
U.P. HOLGERSSON, Chef des Operations, PRO.BO.VIL, Bakel.

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Field Trip to Vallee de Fondale (Erosion/watershed management).

Tuesday, April 17

Malcolm MARKS.
M. DIALLO.
Centre de Suivi Ecologique, Hann.

Wednesday, April 18

Jean-Pierre MONTOROI, Soil Scientist, ORSTOM/Dakar.
Jean-Luc SAOS, Hydrogeologist, ORSTOM/Dakar.

Thursday, April 19.

Jean ALBERGEL, Hydrologist, ORSTOM/Dakar.
James FICKES, Chief of Party, Senegal Reforestation Project.
Louis VERCHOT, forestry advisor.
Geoffrey LIVINGSTON, private sector advisor.
James SEYLER, forester, Michigan State University.

Friday, April 20.

Julius COLES, Mission Director, USAID/Dakar.
Gary NELSON, Deputy Mission Director, USAID/Dakar.
Gil HAYCOCK, Head of IWME Section, USAID/Dakar.
Charles SHORTER, IWME Section, USAID/Dakar.
Rod KITE, ADO Section, USAID/Dakar.
Phil JONES, ADO Section, USAID/Dakar.
Robert GILSON, Program Office, USAID/Dakar.

Saturday, April 21.

Dr. Papa Bakary BATHILY, Director, PDESO (PICOGERNA).

Tuesday, April 24.

James SEYLER, forester, Michigan State University.
Momar WADE, forester, ISRA, Tienaba.
M. SIDIBE. Conseiller Technique, Ministere du Developpement Rural et de l'Hydraulique.

Thursday, April 26.

Dieye FAYE, Ingenieur Genie Civil, Chef de la Division Programmation, Ministere du Developpement Rural et de l'Hydraulique.

Wednesday, May 2 and Friday, May 11.

Babacar DIENG, Directeur Technique, SONEES.
Wolfgang ROHRBACH, Ingenieur, Conseiller Technique, OMVS.
Bouba CAMARA, Chef de la Cellule d'Exploitation, OMVS.
Antoine DIOKEL, Ingenieur, Division Hydro-Agricole, Ministere du Developpement Rural et de l'Hydraulique.

ANNEX 4

PVO's AND NGO's INVOLVED IN NATURAL RESOURCE MANAGEMENT

ABACED	Asso. des Bacheliers pour l'Emploi et le Developpement
ACAPES	Asso. Culturelle d'Aide a la Promotion Educatif et Sociale
ACT	Asso des Centres Tara
ADMUR	Asso. Aide au Developpement en Milieu Urbain et Rural
ADRA	Agence Adventiste d'Aide et de Developpement
AEFAR	Association d'Entraide Franco-Arabe
AFARD	Asso. des Femmes Africaines pour la Recherche sur le Developpement
AFOTEC	Serv. Internat'l d'Appui a la Formation at aux Technologies
AFRICARE	AFRICARE
AFVP	Asso. Francaise des Volontaires du Progres
AISA	Agence Islamique de Secours en Afrique
AJED	Asso. des Jeunes pour l'Education et le Developpement
AJUPENS	Asso. des Jeunes Urbains pour la Promotion de l'Emploi Non Salarie
ANAAS	Asso. Nat'l des Amis de l'Arbre du Senegal
ANMFR	Asso. Nat'l pour la Formation des Jeunes Ruraux en Maisons Familiales Rurales
APROSOR	Asso. pour la Promotion Sociale en Milieu Rural et Urbain
ARP	Asso. pour la Reneaissance du Pulaar
ASAFIN	Asso. Senegalaise d'Aide a la Formation et a l'Insertion des Necessiteux
ASESCAW	Amicale Socio-Economique Sportive et Culturelle des Agriculteurs du Walo
ASNAV/S	Asso. "Aide Sociale Normande aux Villages du Senegal"
ASPR	Asso. Senegalaise pour la Promotion Rurale
ASRADEC	Asso. Senegalaise de Recherche et d'Assistance pour le Developpement Communautaire
CARITAS	CARITAS
CCF	Christian Children's Fund, Inc.
CEADS	Conseil des Eglises des Assemblees de Dieu du Senegal
CECI	Centre Canadien d'Etudes et de Cooperation Internat'l
CIEPAC	Centre Internat'l pour l'Education Permanente et l'Amenagement Concerte

COMI	Cooperation pour le Monde en Voie de Developpement
COSPE	Copperazione Allo Sviluppo dei Paesi Emergenti
CRS	Catholic Relief Services
CWS	Church World Service
DAHW	Asso. Allemande d'Aide aux Lepreux
DELIPRO	Developpement, Liberte, Progres
DEVSOL	Developpement Solidaire
EDS	Eclaireurs du Senegal
EELS	Eglise Evangelique Lutherienne du Senegal
ENDA-TM	Environment, Developpement et Action Tiers-Monde
FAFD	Fed. des Asso. du Fouta pour le Developement
FAFS	Fed. des Asso. Feminines du Senegal
FDEA	Femmes Developpement Entreprise en Afrique
FID	Fondation Internat'l pour le Developpement
FISA	Foundation Internat'l de Secours et d'Amitie
FONGS	Fed. des ONG de Senegal
FSCU	Fed. Senegalaise des Clubs UNESCO
GADEC	Groupe d'Action pour le Developpement Communautaire
GRDR	Groupe de Recherche et de Realisations pour le developpement Rural
GRED	Groupe de Recherches et de Realisations pour l'Eco-Developpement
IARA	Islamic African Relief Agency
IIA	Inst. Islamique Agricole
INODEP	Inst. Internat'l pour le Developpement des Peuples
JCLT	Jeunesse, Culture, Loisirs et Technique la Kora
LVIA	Asso. des Volontaires Laics Italiens
LWR	Lutheran World Relief
MB-SBC	Mission Baptiste SBC
MENTM	Mission Evangelique NTM
MLS	Mission Lutherienne du Senegal
NCNW	Nat'l Council of Negro Women
OEF-I	Overseas Education Fund Internat'l
OFADEC	Office Africain pour le Developpement et la Cooperation
OMS	Overseas Mission Secretariat
OSVD	Org. Senegalaise de Volontaires pour le Developpement
OXFAM	Oxford Committee for Famine Relief
PADEC	Asso. Panafricaine pour le Developpement Communautaire
PASDA	Pour Autres Strategies de Developpement en Afrique
PLAN	Foster Parents Plan Internat'l
PSDS/COE	Conseil Oeucumenique des Eglise - Programme de Solidarite pour le Developpement au Sahel
RADI	Reseau Africain pour le Developpement Integre
RI	Rodale Internat'l
SOS	SOS Sahel Internat'l
Six "S"	Se Servir de la Saison Seche en Savanne et au

TDHF	Terres Des Hommes France Sahel
Thil BURAL	Thilogne "BURAL"
UCJGS/YMCA	Union Chretienne de Jeunes Gens du Senegal
USE	Union pour la Solidarite et l'Entraide
WFD	Weltfriedendienst
Winrock	Winrock Internat'l
WRI	World Relief Internat'l
WVI	World Vision Internat'l

Sources:

Ministere du Development Social, Diretion du Developpement Communautaire and UNDP. 1988.

Repertoire des ONG's Agrees au Senegal. CONGAD. 1989.

Repertoire des ONG Membres.

Natural resource management activities of NGO's working in Senegal, by sector. Page 1.

NGO	Ag[1]	Lstk	Hydr	Env	Soil	For	Veg	Irr
ABACED	x	x		x			x	
ACAPES	x	x	x	x				
ACT	x							
ADMUR	x	x				x		
ADRA			x			x		
AEFAR	x	x	x	x		x		
AFARD	x			x				
AFOTEC	x	x	x	x		x		
AFRICARE		x				x	x	
AFVP	x		x	x	x		x	x
AISA	x	x						
AJED	x		x	x		x	x	
AJUPENS	x	x	x				x	
ANAAS						x		x
ANMFR	x						x	
APROSOR	x	x		x		x		
ARP	x		x	x		x	x	

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[1]Ag - Agriculture, agricultural production, foodcrop production
Lstk - Livestock production, including poultry.
Hydr - Hydraulics, village hydraulics, rural hydraulics, rangeland hydraulics.
Env - Environment, anti-drought measures, anti-desertification measures.
Soil - Soil restauration, soil conservation.
For - Agro-forestry, reforestation.
Veg - Vegetable gardening.
Irr - Irrigation, rice production.

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NGO	Ag[2]	Lstk	Hydr	Env	Soil	For	Veg	Irr
ASAFIN	x		x					
ASESCAW	x		x			x		
ASNAC/S			x					
ASPR		x				x		x
ASRADEC	x	x	x	x		x		
CARITAS	x	x	x	x		x	x	x
CCF	x			x		x		
CEADS	x	x	x					
CECI	x	x	x	x				
CIEPAC	x		x	x	x	x		
COMI	x		x				x	
COSPE	x							
CRS	x	x	x	x		x		
CWS	x	x	x	x		x	x	
DAHW	x	x	x					
DELIPRO	x							
DEVSOL	x	x	x	x		x		
EDS	x	x	x	x				
EELS	x			x				
ENDA-TM	x			x				
FAFD	x	x		x		x	x	
FAFS	x	x						
FDEA	x							
FID		x				x	x	
FISA	x	x		x				x
FONGS	x	x	x	x		x		
FSCU	x						x	x
GADEC	x	x	x				x	
GRDR	x	x						
GRED	x		x	x	x		x	
IARA	x	x	x	x		x	x	
IIA	x	x	x					
INODEP				x				
JCLT	x	x					x	
LVIA			x	x				
LWR	x	x		x	x	x		
MB-SBC	x		x					
MENTM	x	x						
MLS			x					
NCNW	x	x	x	x		x	x	
OEF-I	x	x						
OFADEC	x		x	x		x	x	x
OMS	x		x					
OSVD	x	x						
OXFAM	x	x	x	x			x	x
PADEC	x	x	x	x				
PASDA	x	x	x					

[2]See footnote 1 for explanation.

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NGO	Ag[3]	Lstk	Hydr	Env	Soil	For	Veg	Irr
PLAN	x	x	x	x		x	x	
PSDS/COE	x	x	x	x				
RADI	x	x	x	x				x
RI	x	x		x	x			
SOS	x		x	x	x	x		
Six "S"	x	x						
TDHF	x							
Thil BURAL	x	X	x	x		x	x	
UCJGS/YMCA	x	x						
USE	x	x	x	x				
WFD							x	
Winrock	x							
WRI	x	x	x	x		x		
WVI	x	x	x	x	x	x	x	

Sources:

Ministere du Development Social, Diretion du Developpement Communautaire and UNDP. 1988.

Repertoire des ONG's Agrees au Senegal. CONGAD. 1989.

Repertoire des ONG Membres.

[3]See footnote 1 for explanation.

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Location of NGO's natural resource management activities in Senegal, by region.

NGO	Louis	Saint-Louga	Dakar	Thies	bel	Diour-Fatick	Kaolack	counda	Tamba-Kolda	chor	Ziguin-
BACED			x			x	x		x	x	
ACAPES	x		x						x	x	
ACT										x	
ADMUR					x					x	
ADRA			x							x	
AEFAR			x						x		
AFARD	x	x	x	x	x	x	x	x	x	x	
AFOTEC	x		x	x		x	x	x	x	x	
AFRICARE	x	x	x	x			x			x	
AFVP	x		x	x			x	x	x	x	
AISA			x	x		x					
AJED	x		x	x		x		x		x	
AJUPENS			x	x	x						
ANAAS	x										
ANMFR	x	x		x	x	x	x	x	x	x	
APROSOR			x	x							
ARP	x	x	x	x	x	x	x	x	x	x	
ASAFIN			x	x		x					
ASESCAW	x	x									
ASNAV/S		x								x	
ASPR	x			x			x				
ASRADEC	x				x			x		x	
CARITAS	x	x	x	x	x	x	x	x	x	x	
CCF			x	x							
CEADS						x					
CECI	x		x	x				x		x	
CIEPAC	x		x			x				x	
COMI							x				
COSPE		x			x					x	
CRS	x	x	x	x	x	x	x	x	x	x	
CWS		x								x	
DAHW	x	x	x	x	x	x	x	x	x	x	
DELIPRO	x	x	x	x	x	x	x	x	x	x	
DEVSOL	x		x	x			x				
EDS	x			x			x		x	x	
EELS	x	x	x								
ENDA-TM	x		x	x						x	
FAFD	x										
FAFS	x	x	x	x	x	x	x	x	x	x	
FDEA	x	x	x				x				
FID		x									
FISA			x				x				
FONGS	x	x	x	x	x	x	x	x	x	x	
FSCU	x			x		x			x	x	
GADEC								x			
GRDR	x							x		x	
GRED								x			
IARA			x	x	x	x					
IIA			x				x	x			
INODEP					x	x	x				
JCLT			x	x							
LVIA				x	x						
LWR				x		x		x			
MB-SBC	x	x	x	x			x		x	x	
MENTM								x	x	x	
MLS	x			x		x					
NCNW			x	x						x	
OEF-I			x		x	x	x		x	x	

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NGO	Louis	Saint-Louga	Dakar	Thies	bel	Diour-Fatick	Kaolack	counda	Tamba-Kolda	chor	Ziguin-
OFADEC	x							x			
OMS			x	x					x	x	
OSVD		x	x	x	x						
OXFAM	x	x	x	x				x			
PADEC	x						x	x	x		
PASDA	data missing										
PLAN	x	x		x							
PSDS/COE	x	x	x	x	x	x	x	x	x	x	
RADI	x			x	x			x		x	
RI	x	x	x	x	x	x	x	x	x	x	
SOS	x	x	x	x	x	x	x	x	x	x	
Six 'S'	x			x		x		x	x	x	
TP[illegible]			x						x	x	
Thil BURA	x										
UCJGS/YMCA			x	x		x	x		x	x	
USE	x	x	x				x				
WFD									x	x	
Winrock			x	x		x	x	x	x	x	
WRI					x	x		x			
WVI		x									

ANNEX 5

WATER ANNEXES

Explanation of Figure 2-3

- Zone 1: Continental Terminal.
- Zone 2: Maestrichtian Aquifer.
- Zones 3, 4, 5, and 6: Continental Terminal (and Oligo-Miocene) and Maestrichtian Aquifer with lithological or tectonic variations.
- Zones 7 and 8: Shallow aquifer, Continential Terminal or Quaternary in the Coastal zone, with a deep captive Maestrichtian aquifer containing high concentraticn of salt.
- Zones 9 and 10: Shallow aquifer in the Limestones or sandstones Eocene with presence of subjacent aquifer containing variables concentration of salt.
- Zones 11 and 12: Shallow Paleocene aquifer with or without subjacent potential aquifer.

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Explanation of Figure 2-4

Senegal River Valley Basin.

3: Free Maestrichtian aquifer in the sand and river alluvium at about 30 m depth near the river. Its depth increases with the distance from the river (see also Fig-2, section C).

5: Aquifer extending from Podor to Matam in the limestones or sandstones Eocene with a continuous hydraulic gradient between the quaternary alluvium sand and the gradient between the quaternary alluvium sand and the subjacent Eocene and Paleocene. The aquifer is located at a depth of about 20 meters. The depth rapidly increases toward West. Podor forms the frontier of problem area in salt concentration which exceeds 2 grams per liter in shallow aquifer between podor and Bogue (see also Fig. 5-2, section C).

16: Shallow aquifer between Podor and Saint Louis, in the alluvium and quaternary sand has limited potential. Deeper aquifer in the Eocene and Maestrichtian is highly mineralized with a content in mineral of about 3 gr/1. Downstream of Dagana, the aquifer is brackish and salty.

Sylvo-Pastoral Zone.

2: Aquifer with lesser information to assess its potential.

6: Potential aquifer with variable hydraulic gradient in the Continential Terminal and the Oligo-Milocene. The depth of groundwater can exceed more than 60 meters, almost on the entire zone. Water is slightly mineralized with pH of 6. Also presence of Maestrichtian aquifer with possible potential West of Linguere at the depth from 200 to 350 meters.

9: Captive Maestrichtian aquifer with possible high probability of groundwater development between Koki and Linguere, and it extends to region of Ferlo, Kaolack, Fatick, Diourbel, Thies, and the Horst de Ndiass. However, the distribution of the aquifer in the Continental Terminal and the limestone eocene and paleocene is not well known.

10: Mineralized Shallow and Maestrichtian aquifers (3g/1).

Peanut Basin

11: Aquifer with good potential in the limestone karstified eocene, in particular between Louga and Bambey.

12: Aquifer in the quaternary sand, and/or the Continental Terminal contain with a very low potential, in particular between Kaolack, Fatick, and Thies. Subjacent aquifers have a better potentiality, but mineralized (from 2 to 3g/1)/, in particular northern of Fatick (see also, Fig. 5-2, section D).

13 Aquifer with high potential in the paleocene formation between Sebikotane, and north and south of Pout (more than 100 m3/hr/m), but subject to salinisation (see also Fig. 5-2, Section D).

17: Deeper mineralized Maestrichtian aquifer with a content in mineral of more than 2 g/1, in the Sine-Saloum Delta.

Casamance

4: Shallow aquifer at less than 100 m in the sand of the Continental Terminal and Oligo-Miocene (see also Fig. 5-1).

7: Maestrichtian aquifer with good potential south and east of Kolda in the Continental Terminal, and Oligo-Miocene, but often contains a higher iron-content. In the oriental boundary, the maestrictian is shallow, but with lower potentiality, in particular south of Velingara in Casamance (see also Fig. 5-1).

8: Two aquifer separated by fellow clay in the quaternary alluvium of Continental Terminal and the Oligo-miocene sand, but with higher iron-content on certain locations (see also Fig. 5-1).

15: Mineralized aquifer west of Oligo-Miocene (see also Fig. 5-1).

Senegal-Oriental

1: Aquifers with lesser information to assess their potential.

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Les Niayes

14: Shallow aquifer in the Continental Terminal or Quaternary. Also deep captive Maestrichtian with high concentration of salt (see also Fig. 5-2, Section A and B).

SENEGAL WATER CODE (Law No 81-13 of March 4, 1981).

Development of water resources and their management constitute one of the major preoccupations of the Government of Senegal.

In order to take into account the various socioeconomic and sanitary aspects, the Water Code was drawn up in collaboration with all the ministries concerned.

The following are some extracts from the Code as they relate to ground and surface water development and management.

Preamble:

"The most important principal of all is the public property status of water which makes it a common utility for all.

It is on this basis that a good planning of the resources is made, consisting of their good management and equitable sharing among

General Presentation

Article 1

The regulation on non-maritime water including water from delta, estuaries and mangroves and the regulation on hydraulic works shall both be defined by the provisions of the present Code.

Article 2

The hydraulic resources shall constitute an integral part of the public domain. These resources shall constitute a collective property and their exploitation on the national territory shall be subject to a prior authorization and inspection.

Article 3

The artificial utilization or accumulation of rain water falling into a private basin shall be authorized on condition that such water shall remain in the basin.

Groundwater

Article 6

All forms of utilization of water and hydraulic works shall come under hydrologic cycle and can be declared as public utility, much in the preservation of the quantity of the water as of the quality.

Article 9

On the date of coming into force of present Code, any person desirous to:

carry out underground water harnessing work by drilling wells or using drainage gallery consisting of drawing more than 5 metric cubes per hour or to equip existing work or to draw water from a layer classified in zone,

undertake in the bed or above a water-course a fixed or mobile water harnessing work must seek authorization from the Ministers responsible for Hydraulics and Drainage.

Article 30

Underground water is classified in zones I and II.

Zone I is made up of the following:

1. basin where the utilization of underground water sheets gets closer to the limits of their resources;

2. basins from which water is provided for local communities through a public water supply service;

3. basins where exists areal danger of salt water intrusion.

Zone II is made up of all the other basins.

Article 33

No underground water harnessing shall be carried out in zone I without the authorization of the ministries responsible for Hydraulics and drainage.

This authorization shall be granted after a survey shall have been carried out and in cases of absolute necessity, particularly, in such cases as extending water supply to local communities which do not have public water supply, providing drinking water for animals and crop irrigation.

Article 34

The authorization of water harnessing in zone I must fix the limits of the animal, daily and hourly extraction volumes.

Article 36

The exploitation, in the same area, of several water sheets each supplying less than 5 metric cubes per hour but whose global supply is higher than 5 metric cubes per hour shall also be subject to authorization.

Surface Water

Article 40

No surface water harnessing through fixed or mobile installation or for derivation works shall be carried out without authorization with the exception of the provisions made under Article 3.

Article 41

The authorization for harnessing water destined for irrigation shall define the maximum surface area to be irrigated, the maximum annual and daily water volume to be utilized.

Article 43

Surface water harnessing without fixed or mobile installation shall be free, unless otherwise provided for under the regulation applicable to the water sheet in question.

Order of priority in water utilization

Article 75

The attribution of water resources should, at all times, take into consideration the social and economic needs of the populations.

Water supply to populations shall remain the priority elements in the attribution of water resources.

Article 76

After human water needs shall have been met, priority shall then be given to animal rearing, agriculture, forestry, fish farming and afforestation projects followed by industrial and agro-industrial complexes.

Article 77

In the case of exception events such as drought, inundations, natural calamities, the order of priority can be temporarily modified.

ANNEX 6

SOILS ANNEXES.

TECHNICAL DESCRIPTIONS OF SENEGAL'S SOILS

Senegal's soils are very uniform when considered on the basis of their fertility and adaptation to agricultural production. Basically there are two classes of soils in Senegal. By far the most extensive soils and most important agriculturally are light textured, low-organic matter, inactive, low-fertility soils. In the northern and central part of the country these are called "sols bruns et brun rouge" in the French system of soil classification (FR) and would be Entisols, probably Psamments, in the United States Department of Agriculture SOIL TAXONOMY (USDA). In many cases stabilized dunes (Psamments) would be common in these regions. At about the 500 mm isohyte there is a transition to "sols ferrugineux non lessives" (FR) or Alfisols (USDA). Especially in the northwestern part of this region stabilized dunes would be common. At roughly the 700 mm isohyet there is a transition to "sols ferrugineux lessives" or Ultisols (USDA). Because of the low cation exchange capacity of these soils the percent base saturation is easily modified. Consequently, boundaries between regions of Alfisol and Ultisol domination are not well defined. In the southwestern part of Senegal where rainfall varies from 900 to 1800 mm the dominant soils are "sols ferrallitiques rouges" or Oxisols "USDA". In the eastern and southeastern regions of Senegal, the topography is more varied and parent materials are laterite or sandstone. On the laterite one finds "sols caillouteux et sols peu evolues" (FR) or Entisols (USDA) and Inceptisols (USDA). On the sandstone parent materials one finds (sols caillouteux et sols ferrugineux" (FR) or Entisols (USDA), Inceptisols (USDA), and Oxisols (USDA)

The other grouping of important agricultural soils in Senegal are heavier soils which are usually found in basins or along water courses. These are the Vertisols (FR, USDA) and "sols hydromorphes" (FR) or Alfisols (USDA) of the Senegal River Valley. Closer to the Atlantic Ocean they are the "Sols de mangrove et sols sales" (FR) or Entisols (USDA) of the Senegal River Delta and adjacent to the Casamence, Sine, and Saloum rivers. These are the soils which tend to have salinity problems.

One basic problem in soil management is that there are several soil classification systems which are used in Senegal. There is the French system, the USDA system, and the FAO system. The

differences between the systems makes it difficult, in some instances, to make direct comparisons between the ....

Another problem is that there is no direct correlation between the systems mentioned above and the various local classification systems used by farmers. In many cases farmers make important distinctions between soils, especially rainfed soils, that may not be made by European or American classification systems.

Table 2.2 lists some of the available soil maps for Senegal. The map that provides the best "first cut" on Senegalese soils is the US AID/RSI map at 1: 500 000 which uses the French Classification system.

US AID/RSI has the most useable guide to areas with erosion, degradation, and salt problems (1: 100 000). CTFT/SCET have produced maps at a scale of 1: 500 000. CTFT categorizes soils as irreversibly eroded, possible to restore, and peri-urban zones which would require exceptional actions.

ANNEX 7

BIODIVERSITY ANNEXES.

Table A7.1. Biogeographical Uniqueness of Senegal.

ENDEMICS OF SENEGAL:

For plants, see Table 8.6.
Cypree

FISH AND SHELLFISH: NORTHERNMOST DISTRIBUTION

White Shrimp (P.duorarum)
Cyprinids of forest-types in Niokolakoba
Heterotis niloticus (SR)
Tilapia heudelotii (SR)

FISH AND SHELLFISH: SOUTHERNMOST DISTRIBUTION

Sardinia pilchardus
Trachurus trachurus
Lichus vadigo
Pomatomas salatrix

BIRDS: NORTHERNMOST DISTRIBUTION

Halcyon senegalensis senegalensis
Alcedo quadribrachys
Corythornis leucogaster
Royal Tern (nesting)

BIRDS: SOUTHERNMOST DISTRIBUTION

Red-billed Tropic Bird (nesting)
Numida melagris
Guttera edouardi
Gull-billed Tern (nesting)
Little Tern (nesting)

MAMMALS: NORTHERNMOST DISTRIBUTION

Colubus badius temmincki (Patako)
Chimpanzee (with Mali)
River River Hog
Nandinies
Duikers

MAMMALS: NORTHERNMOST DISTRIBUTION (continued)

Cepahlophus sylvicultor (Basse Casamance)
Smutsia gigantea (Giant Pangolin) NK
Cercopithecus aethiops
Cercopithicus mona campbelli(BC)
Papio papio doguera
Sylvicarpa grimmia
Redunca redunca
Oribi

MAMMALS: SOUTHERNMOST DISTRIBUTION

Canis aureus (Sine Saloum)
Acinoyx jubatus
Hyena hyena

REPTILES/AMPHIBIANS: NORTHERNMOST DISTRIBUTION

Naja nigricolis
Naja melanolueca
Python regis

REPTILES/AMPHIBIANS: SOUTHERNMOST DISTRIBUTION

INSECTS AND OTHERS: NORTHERNMOST

INSECTS AND OTHERS: SOUTHERNMOST

Table 7.2. Zones Intégralement Protégées in Senegal.

NAME	Hectares
Niokolokoba national Park	913 000
Basse Casamance National Park	5 000
Djoudj National Bird Park	16 000
Langue de barbarie National Park	1 000
Iles de Mdeleine National Park	450
Sine Saloum National Park	73 000
Kalissaye Bird Preserve	200
Kassel Bird Preserve (proposed)	90
Gueumbeul Special Faunal Preserve	720
Popenguine Nature Preserve	1 009
Noflaye Botanical Preserve	16
Djoval (Botanical) Preserve	3
TOTAL	1 011 507

(Prepared by Bosh, Dieng, Dia and Warshall, 1990)

Table 7.3. Areas with International Standing Protected in Senegal.

AREA	WORLD HERITAGE	MAN AND BIOSPHERE	RAMSAR
Djoudj National Park	yes	no	yes
Samba Dia Classified Forest	no	yes	no
Sine Saloum National Park (Delta)	no	yes	yes
Niokolokoba NP	yes	yes	no
Ile de Goree	yes	no	no
Ndiael Special Reserve	no	no	yes

Table 7.4. Legislated Wildlife Reserves.
No Hunting. Other Compatible Activities Allowed.

NAME OF RESERVE	HECTARES
Ndiael Special Faunal Reserve	46 550
North Ferlo Faunal Reserve	487 000
South Ferlo Faunal Reserve	663 700
TOTAL	1 197 250

Table 7.5 Plants Endemic to Senegal.

Acalypha senegalensis Pax & K. Hoffm.
Alectra basserei Berhaut
Andropogon gambiensis A. Chev.
Cissus okoutensis Berhaut
Crotalaria sphaerocarpa Perrote
ex DC ssp polycarpa
Ficus dicraonstyla Mildbr.
Nesaea dodecandra (DC.) Koehne
Spermacoce phyllocephala DC.
Urginea salmonea Berhaut

ANNEX 8

GLOSSARY.

The following terms are used in this report. They are described here for those wanting or needing further information on how the term is used.

Captive aquifer. An insulated aquifer without flowing direction.

Eocene. Refers to an epoch of the Tertiary period with dominance of marly-clay and presence of limestone.

Fallow. Fallow contrasts with continuous cropping and refers to taking land out of production for a season or more. When fallowing consists of plowing land and then leaving it unseeded for one or more growing seasons, it is referred to as a "clear" fallow. In Senegal a "wooded fallow" was used to restore fertility to soils. Fields were left uncultivated until trees and bushes were growing on the land. Sometimes reference is made to a "grass fallow" which means that a field was left uncultivated only long enough for grass to grow before it was returned to production.

Free aquifer. Aquifer which flows in a given direction.

Heavy soils. Heavy and light are useful but inexact terms used to describe and compare soils. In absolute terms, heavy soils are compact soils which are dominated by clay and silt. Light soils are loose, open soils which are dominated by sand. These terms are also often used in a relative sense e.g., one soil is described as being heavier than another soil when in fact both soils are light, sandy soils.

Hydraulic gradient. With regard to an aquifer, it represents the slope of free water surface in a given direction.

Light soils. See "Heavy soils."

Maestrichtian. European stage of geologic time upper cretaceous consisting of the largest aquifer identified in Senegal.

Miocene. Relates to an epoch of the Tertiary with presence of some basaltic, ankaratrite and turf formation.

Paleocene. A major worldwide epoch of the Tertiary period extending from the end of the Cretaceous period to the Eocene epoch which presence of limestone and marly-argillaceaous.

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Phreatic aquifer. Groundwater in the zone of saturation.

Soil erosion. Erosion refers to the removal or transport of soil. In its most accute forms erosion destroys soil resources. Erosion can be a factor in soil degradation.

Soil degradation. Soil degradation refers to an in place reduction of the value or yield potential of soil. Soil acidity, soil salinity and the loss of soil organic matter are examples of soil degradation. Severe soil degradation can also destroy a soil but generally soil degradation is reversible. Erosion can be a factor in soil degradation. E.g., wind erosion removes silt and clay from upland soils.

Soil structure. "Soil structure refers to the aggregation of primary soil particles into natural, more or less porous compounds or aggregates.... A structureless soil is often characterized by compactness, poor aeration, low hydraulic conductivity and poor root penetration." The only exception to this is "soils with a (coarse) sandy texture, for which a poor moisture retention is their only main shortcoming." The importance of soil structure is directly related to the increase in clay content.