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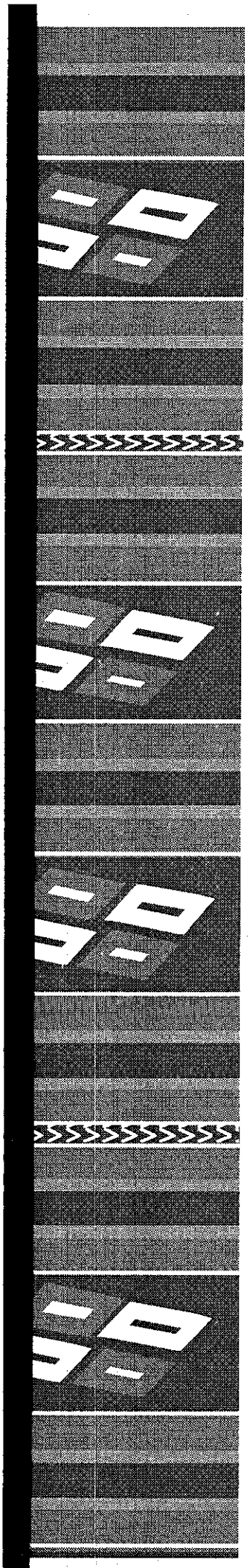

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A Programmatic Environmental Review for The Southern Zone Water Management Project (Projet de Gestion de l'Eau dans la Zone Sud) in Senegal

Lessons Learned

Jon C. Cooper
Louis Berger International, Inc.

November 1997

USAID

Productive Sector Growth and Environment Division
Office of Sustainable Development
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Foreword

This report, a summary of LBII 1993, represents two important features of the work of the U.S. Agency for International Development (USAID). First, as an example of how an environmental impact assessment can be conducted for a project in West Africa, it provides comprehensive methodologies and technical sections for future programs. Specifically, it is a solid example of a Programmatic Environmental Assessment (in a modified form, because a public scoping process could not be carried out under the compromised security conditions at the time) used under the U.S. National Environmental Policy Act (NEPA). Second, this is one of the first examples of an approach that requires significant environmental monitoring of a program during implementation and after completion. The cooperative research program with the Senegalese Institute of Agricultural Research (ISRA) provided an important experience and lessons learned for a research program in West Africa.

The monitoring program is still operational as of 1997 because it is critical to the success of the rehabilitation program. Rice yields in the 22 valleys under the Southern Zone Water Management (SZWM) activity have increased (by 50.5% in 1996 over 1995) due to the expanded use of anti-salt dikes and other NRM techniques. The success of the SZWM interventions is evidenced by the rapid rate of adoption and expansion of the contour berm techniques by PVOs and villages. Significant increases in villagers' participation is a positive indication of ownership of these mitigation technologies.

A full summary of the engineering, agricultural and administrative aspects of this large program has been prepared in a separate report (LBII 1995).

David A. Atwood, Chief
Productive Sector Growth and Environment Division
Office of Sustainable Development
Bureau for Africa
U.S. Agency for International Development

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Glossary of Abbreviations and Acronyms

BOD	Biochemical Oxygen Demand
DFA	Development Fund for Africa
EMEMP	Environmental Monitoring, Evaluation, and Mitigation Plan
IEE	Initial Environmental Examination
ISRA	Senegalese Institute of Agricultural Research
LBII	Louis Berger International, Inc.
MA	Ministry of Agriculture
MEFP	Ministry of Economics and Finance (Senegal)
MRDH	Ministry of Rural Development and Hydraulics (Senegal)
NGO	nongovernmental organization
PER	Programmatic Environmental Review
PROGES	Projet de Gestion de l'Eau dans la Zone Sud
SOP	Standard Operating Procedure
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture

1. Environmental Assessment

1.1. INTRODUCTION AND PROPOSED PROJECT

An environmental assessment for the *Projet de Gestion de l'Eau dans la Zone Sud* (PROGES) was prepared outside of Senegal, because of security considerations, by experts who had previously worked in the project area. They coordinated with and were assisted by several local experts in Senegal. Because of this situation, USAID entitled the report a Programmatic Environmental Review (PER LBII 1993).

PROGES, ongoing since 1989, is designed to help farmers recover productive farmland that has been lost to salinization and improve their water utilization options in existing areas to increase crop production throughout the Casamance River Valley, southern Senegal (Figure 1). The project consists of four components: institution building, water management infrastructure, applied research and operational functions, and monitoring and evaluation. The project operates under the titular head of the Ministry of Rural Development and Hydraulics (MRDH). A Coordinating National Committee, with representatives from MRDH, the Ministry of Economics and Finance (MEFP), and USAID, provides general oversight of project activities. The Ministry of Agriculture also coordinates with the program.

This PER considered specific aspects and cumulative impacts of the project infrastructure components not considered earlier in Initial Environmental Examinations (IEEs) of two valleys (Nguindir and Mayor) in Program I of the project. The main infrastructure components are anti-salt dikes, water retention dikes, contour berms and dikes, and associated elements.

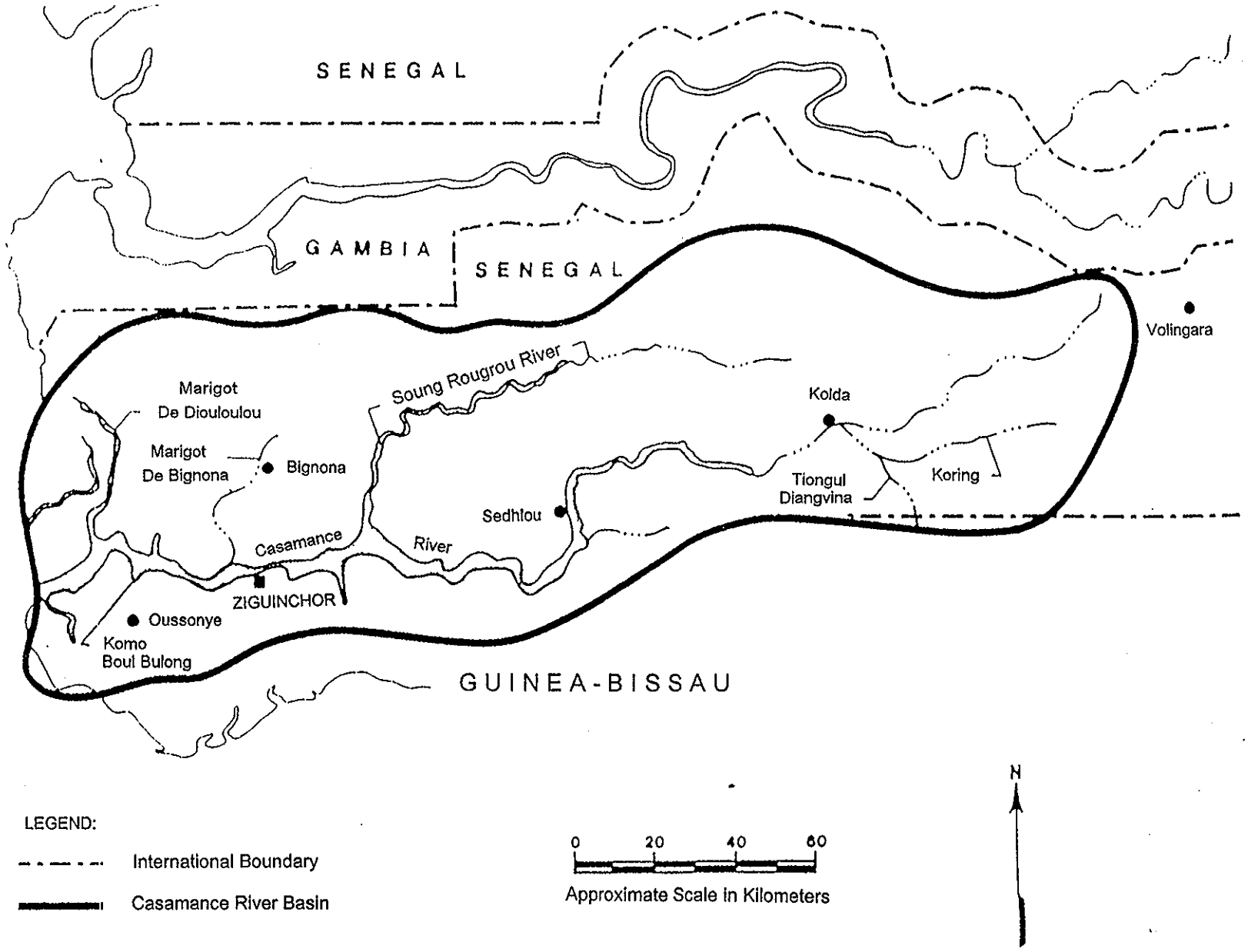
Anti-salt dikes were sited near the mouth of major tributaries of the Casamance River to optimize the areas which should be reclaimed from salinization while minimizing exposure to potential soil acidification. Approximately 150 ha were protected by each dike (although 500 ha areas will be considered). They had top widths of 3 meters, heights of 1.5 meters, and lengths up to 1 km (depending on the width of the valley in question).

Water retention dikes were constructed in mid-valley areas in order to protect an area of about 150 ha at a cost of approximately $1,000/ha. They were generally the same height as anti-salt dikes, but were much narrower because of smaller tributary widths in the placement areas.

Contour berms and dikes associated with these structures protected areas of approximately 150 ha and had heights of 0.6 meters and widths of 2.7 meters.

Associated elements of the program included village assistance programs, institutional strengthening and training programs, termite control with pesticide, and a comprehensive monitoring and applied research program.

In Program I, PROGES constructed projects at Mayor and Nguindir. In Program II, construction is in progress in the Kolda Region (Kandion/Mangana, Kounounding Djoie, and Badobar) and in the Ziguinchor Region (Balingor, Djimande, and Diatang). In Program III, at the preparation stage of the PER, five valleys in the Kolda Region have been selected (Bona, Kambounda/Tilito, Sambali/Taniataba, Badounga/Madinfindife and Mangroongou/Segafoula) and three other valleys in the Ziguinchor Region were to be identified. Overall, the project paper specifies a target of increasing cereal production, mainly rice, by 50 percent (1.8 T/ha) in approximately 60 valleys and on 15,000 ha by 1999 (USAID 1988).



Source: University of Michigan, Gambia River Basin Studies, 1985

Figure 1. Casamance River Valley, Southern Senegal

In evaluating the environmental impacts of PROGES, five project alternatives were considered:

- No action (USAID would not provide any assistance program),
- Conduct interventions only in areas with existing impoundments, such as roads and earlier dams (construction in previously impacted areas),
- Conduct interventions only in the Affiniam Dam area (a major dam on the Bignona River, one of the largest tributaries of the Casamance),
- Plan interventions in all river valleys of the Casamance River, taking into account soil, water, and socioeconomic considerations (construction in any areas where this kind of work can be effective in increasing rice production, etc.)
- Plan interventions in all river valleys of the Casamance River using only water retention dikes (under this alternative no anti-salt dikes would be constructed).

1.2. EXISTING CONDITIONS

The Casamance River valley in southern Senegal is generally bounded on the north by the Republic of The Gambia, on the east by the Tambacounda (Senegal)-Koudara (Guinea–Bissau) road, on the south by Guinea–Bissau, and on the west by the Atlantic Ocean. To perform an environmental impact analysis of physical features, the number of first-, second- and third- order streams was counted. The Casamance River itself, the only first-order stream in the basin, flows directly into the Atlantic. Second-order streams, of which there were 136, flow directly into the Casamance. Third-order streams, which flow directly into the second-order streams (including the Bignona, Soungrougrou, and other rivers), number approximately 385. Of these, 47 appeared to have existing blockages of less than 50 percent, and 277 had blockages greater than 50 percent. Multiple blockages were found in 211 streams. Thus, nearly 75 percent of the streams contained preexisting blockages (road crossings, etc.), and nearly half had multiple blockages.

The region shows seasonal precipitation from July through December, which results in freshwater ponding, aquifer recharge, and floodwater volumes to the Casamance. Tidal amplitude of up to 1 meter is found as far upstream as Kolda. Volumetric discharge of the river tends to increase slowly but exponentially as one moves downstream, approximately 3-5 x 10 6 m 3/sec, increasing to 37-69 x 10 6 m 3/sec at Ziguinchor.

Salinity patterns are among the most unique features of the Casamance River system, in that the highest salinity waters are now found in inland areas (up to 150 ppt at points 200 km inland), rather than the usual pattern of highest salinity near the outlet to the ocean. At the present time, a situation of severe drought has resulted in an accumulation of salt in many adjacent areas. Precipitation in the past 20 years has dropped dramatically. The effect has been so severe that, in effect, climatic regions throughout Senegal have shifted southward, so that areas that once had ample precipitation in the south now exhibit the relatively low precipitation of the north.

Soils have been affected in two ways. First, a lack of moisture has resulted in a drop in agricultural productivity. This drying of the soils has resulted in an accumulation of saline materials in the upper layers of the soil. Apparently, before the drought, these areas received sufficient precipitation to prevent this phenomenon through the leaching of salts during the rainy season. Second, and independently, the drying of the soils has resulted in exposure of acid minerals in the soil (mainly aluminum sulphate) to oxygen in the air. This results in an irreversible formation of sulfuric acid, which is manifested as a high acidic content of these soils. Associated with this effect, at low pH values, the aluminum in the soil becomes toxic. To prevent this secondary effect, the general approach has been to flood the areas with freshwater, when available, or with saline water. In the latter case, the saline waters are then leached from the soils during the beginning of the rainy season.

A wide variety of terrestrial and aquatic organisms are found in the river system. The historic range, in isolated or protected locations, includes more than nine species of threatened or endangered species. The Casamance provides nursery and feeding areas for more than forty

species of fish. It is at the southern range of major bird migrations, and a variety of birds are typically found in the region (LBII 1993). Mangrove resources, now concentrated in the lower portions of the Casamance, have been on a continuous decline since 1973. This decline is generally attributed to a drop in rainfall levels, although it has been estimated that 50 percent of all charcoal used in Ziguinchor derives from mangrove.

The Casamance is a site of major diseases associated with water, including malaria and schistosomiasis. The Diola and the Manding are the largest and most influential ethnic groups in the southern zone, although the Casamance is also a traditional area for other groups, including the Balante, Manjak, Bainounk, Bayot, Mancagne, and Peul.

1.3. POTENTIAL ENVIRONMENTAL IMPACTS

The major potential environmental impacts of the project infrastructure components were assessed in light of the environmental scoping document (LBII 1993). This document identified 12 major concerns: 1) malaria incidence increase, 2) schistosomiasis incidence increase, 3) aquatic habitat/wetland loss, 4) effects on birds, 5) threatened and endangered species, 6) surface water quality, 7) groundwater quality, 8) soil quality (particularly soil acidification), 9) reduction of mangroves, 10) use of chemical fertilizers and pesticides, 11) forest resource loss, and 12) crop diversity loss.

Discussions of these individual issues featured, when relevant, the potential cumulative impact of a project element on the Casamance River as a whole. In many cases, although the impacts of a component are believed to be small, there is little empirical evidence on the issue. Therefore, scientific and engineering judgments were verified in a subsequent monitoring and research stage of the program. In short, the PER evaluated impacts based on present information, and was used to plan a monitoring and research program to collect additional information as needed to verify estimates and make changes where appropriate.

The overall impact assessment of each of these concerns is summarized in Table 1.1. The relevant issues in each case are summarized below.

1.3.1. Soil Acidification

Anti-salt dikes are designed to control saltwater intrusion, reverse the salinization process, and keep potentially acid sulphate soils moist enough to avoid acidification and mineral toxicity. The beneficial effects of such dikes on upslope vegetation and crops are well established. Because a minor potential exists, however, for mismanagement of such dikes to result in some degree of upslope acidification after the end of the project, PROGES did not fund construction of such dikes where a significant potential for upslope acidification under mismanagement exists.

It was originally envisioned that a simple quantitative cutoff point for potential soil acidity as measured by sulfide concentration or by total acidity could be used to site anti-salt dikes above areas of potential acidification, and thereby avoid any potential for acidification under a mismanagement scenario following project completion. Subsequent soil sampling and survey work showed, however, that exclusion of all potentially acid sulfate soils from above potential anti-salt dikes was not a practicable approach. This was because potentially acid soils, as well as already acidified soils, occur in thin strips along water courses in virtually all of the basin valleys. The potentially acid soils have remained at or near saturation moisture content during the last 15 years of drought but, in areas where anti-salt dikes have been constructed and operated, salt concentrations have diminished and mangrove vegetation has begun to naturally reestablish. In areas where significantly acidified soils already occur, salt content and residual acidity prevent their use for agricultural purposes. Reduction in salt concentration through construction and operation of anti-salt dikes may, however, allow revegetation and eventual reclamation to occur.

Table 1.1. Potential Impacts Matrix

Activity/Resource	Malaria	Schisto-somiasis	Aquatic Habitat/ Wetland Loss	Bird Life	Threatened and Endangered Species	Surface Water Quality	Ground-water Quality	Soil Quality	Man-groves	Chemical Fertilizer and Pesticide Impacts	Forests	Crop Diversity
Anti-salt dikes, properly installed and maintained	-1/0	-1/0	-1/0	-1/0	-1/0	-1/0	+1/0	+1/0	-1/0	-1/0	-1/0	-1/0
Anti-salt dikes, improperly installed and maintained	-2/-1	-2/-1	-2/-1	-3/-1	-3/-2	-2/-1	-3/-2	-3/-2	-2/-1	-3/-2	-2/-1	-1/0
Freshwater retention dikes, properly installed and maintained	-1/0	-1/0	0	0	-1/0	0	+1/+2	+1/+2	0	-1/0	-1/+1	-1/0
Freshwater retention dikes, improperly installed and maintained	-2/-1	-2/-1	-1/0	-1/0	-2/-1	-1/0	-2/-1	-2/-1	-1/0	-2/-1	-1/0	-1/0
Contour berms, properly installed and maintained	0	0	+1/+2	+1/+2	0/+1	+1/+2	+1/+2	+3/+2	0/+1	+1/0	+1/+2	+1/0
Contour berms, improperly installed and maintained	-1/0	-1/0	-1/0	0	0	-1/0	-1/0	-1/0	0	-1/0	0	0

Key - 3: Significant adverse impact, -2: moderate adverse impact, -1: minor adverse impact, 0: no impact
+3: Significant beneficial impact, +2: moderate beneficial impact, +1: minor beneficial impact

The effect of the anti-salt dikes proposed by the project would be to maintain these soils in their saturated condition, but at reduced salt concentrations favoring mangroves. Even under a worst- case scenario in which the reclamation process proves unsuccessful, the hydraulic regime can be expected to return to a pre-dike pattern of alternating freshwater and saltwater flows. These soils will not, therefore, be any drier than before anti-salt dike construction. If rainfall and runoff are insufficient for reclamation, then the dikes will still allow water (regardless of its salinity) to move upstream of the dike during high tides and maintain maximum or pre-dike construction soil saturation levels. Therefore, the moisture content of the soils (and thus the potential for acidification of those soils) will remain the same whether or not a dike is constructed. It should be reiterated that drainage of these soils is neither a project objective nor an objective of farmers who recognize that these soils are susceptible to sterilization if they dry out. Construction of anti-salt dikes is therefore essentially a "minimum risk" activity from the soil acidification perspective. However, further minimization of any potential risk during project implementation will be ensured by establishment of the criterion of siting anti-salt dikes so that the total area of high potential soil acidification or pre-existing acidified soils, as defined by occurrence of the taxonomic subgroup of soils described as typic sulfaquents in the USDA Soil Taxonomy system, does not exceed 15 percent (plus or minus 2 percent) of the service area upstream of the anti-salt dikes.

It is important to reiterate two points. First, none of the anti-salt dike sites selected required reclamation of high potential soil acidification. Second, the project helped protect against soil acidification by maintaining low-lying land at saturated or near-saturated conditions and/or improving saturation conditions. The monitoring program will provide additional assurance to avoid adverse environmental impacts.

Properly operated and maintained freshwater retention dikes will keep upland soils moist, either with saline waters during the dry season or freshwater during the wet season. Therefore they should reduce the potential for soil acidification because of the chemistry described above. However, when saline water is not allowed to flood areas during the dry season, these soils will dry out and the potential for the production of acid soils will increase. The monitoring program will include elements to record dates for opening the dikes to allow flooding of saline water, as well as the collection of data to monitor changes in soil acidity.

The impacts from the freshwater retention dikes are expected to be less significant than from the anti-salt dikes.

Contour berms are expected to keep upland soils moister than they would be without this intervention and therefore will have a positive effect in avoiding acidification. These berms will also serve as erosion control devices. No significant adverse environmental impacts are expected from these activities.

1.3.2 Surface Water Quality

The chemical and physical characteristics of project-area water resources may also be affected by project activities. The construction of dikes and berms by the project will arrest the runoff of surface waters. This ponding will result in a decrease in the dissolved oxygen content, an increase in the thermal gradient in the water, an increase in the nutrient content, an increase in evaporation, an increase in groundwater recharge, an increase in the salinity, an increase in the concentration of dissolved solids, an increase in the Biochemical Oxygen Demand (BOD), and a change in the pH. The initial water quality conditions, the dilution potential of the Casamance River, the rate of water change, and the collective water management practices used on farms in the basin are all factors related to potentially adverse project impact on water quality. The degree of groundwater degradation likely to occur as a direct result of the proposed project activities, particularly to the Casamance River, is information important to decision makers. These changes in the water quality could effect the types of crops which can be grown in the project area,

reduce crop yields, promote the growth of algae, and increase waterlogging.

Potential impacts to surface water quality would be greatest for the anti-salt dikes, intermediate for the freshwater retention dikes, and minor for the contour berms. The monitoring program will determine the actual magnitude of the impacts and allow for mitigation to avoid significant impacts.

1.3.3. Groundwater Quality

The ponding and retention of surface water will increase the degree of groundwater recharge and change the hydraulic gradients in the area aquifers. The intrusion into the aquifer/groundwater reservoirs of surface water contaminated with fertilizers or pesticides, with low pH, with high temperatures, and with low dissolved oxygen will be direct and indirect impacts of the project. Fertilizer or pesticide contamination could impact drinking water supplies and lead to health problems and birth defects.

Similar to the impacts on surface water quality, potential groundwater impacts from the anti-salt dikes will be greater than from freshwater retention dikes, which are in turn greater than from the contour berms. Groundwater monitoring will be conducted within the areas protected by the dikes and berms to determine the actual magnitude of the impacts and to allow for mitigation to avoid any significant adverse impacts.

1.3.4. Aquatic Resources

1.3.4.1. Barrage Impacts and Aquatic Ecology

Barrage impacts on aquatic ecology in the southern zone region have been described by a number of authors. The Guidel barrage, enclosing an area of approximately 745 km^2, has been described as having had the effect of decreasing salinity variability and decreasing nutrient levels and fish recruitment below the barrage (LBII 1993). Above the barrage, the effects have been to maintain the fish biomass at about pre-closure levels, to change the species composition of the fish community and apparently to generally improve the regenerative capacity of the area for mangrove reestablishment. Overall, however, the effects of the barrage have been described as "practically nil."

The aquatic impacts in the Bignona Valley, site of the Affiniam Dam, have been somewhat more intensively studied. Data from eight stations monitored monthly and located both above and below the dam provide an indication of the variability prevailing there (Diaw 1986). This bolon has a watershed of approximately 800 km^2, and a length of about 88 km of which about 68 km was originally under tidal influence. In 1971, the bed of the river was about 150 m wide and 10 m deep at Elora, just above the confluence of the Bignona with the Casamance River, but by the mid 1980s (after the building of the Affiniam Dam), the bed was no deeper than about 6m at this point. Farther upstream, the channel narrows to about 20 m wide and 1.5 m deep at the town of Bignona.

The proposed freshwater retention dikes are of substantially smaller scale, and further removed from aquatic ecosystems than the anti-salt dikes. As such, they will have fewer impacts. The contour berms will be constructed on uplands and should have no adverse impacts to aquatic ecosystems. Monitoring will be conducted to determine the nature and extent of any changes in the aquatic environment.

1.3.4.2. Aquatic Habitat/Wetland Loss

This project intends to construct up to 60 barriers to the entry of saltwater in up to 120 of the approximately 442 second- and third-order stream valleys in the Casamance watershed that currently are inundated during periods of high water and seasonal flooding (the number of second and third order streams is discussed in chapter 4 of the PER). Thus, in a very crude measure of overall impact on unperturbed valleys, an impact on 27 percent of the habitats would be expected. The degree to which each valley is impacted would vary, but is estimated at approximately 50 percent of the valley within which it is placed (the Mayor and Nguindir barrages fell into this range). Thus, once again on a crude

measure, approximately half of the 27 percent — or 13.5 percent — of habitat in the Casamance may be lost.

However, a review of existing mapping indicates that nearly 75 percent of the stream valleys are currently blocked to some degree. Thus if a valley has already lost some of its habitat because of the existing blockages, the proposed interventions would have little or no impact beyond the existing conditions. To the extent that existing blockages do *not* completely block the streams (for instance, if there are bridge openings, etc.), all new interventions will lead to a loss of the remaining (i.e. existing) opening between upstream and downstream areas. For the project as a whole, if it is assumed that all of the new interventions are in already-blocked valleys, then no additional cumulative impact from the project would be expected. On the other hand, if all new barrages are in valleys with no existing blockages or with some existing opening, then the total cumulative impact on habitats would be as great as 13.5 percent. These two numbers — 0 to 13.5 percent — represent the potential impact of the project.

Some explanation of the concept of blockage is necessary in order to define mitigation measures. An unblocked stream allows physical and chemical mixing between the two areas. Once a stream has been blocked to any extent, there begins to be a loss of tidal mixing and of the tidal energy which had been supplied to the stream system. Ecologically speaking, the system has begun to lose some of its productivity.

In addition, the lack of mixing can mean the loss of areas of intermediate salinity that are formed when saltwater and freshwater mix. These areas are also important ecologically, because many species require specific salinity ranges for feeding, reproduction, or survival. In the case of the Casamance, which has become hypersaline, the mixing of freshwater during the rainy season may be the only time when salinity ranges are satisfactory for these biological functions. On the other hand, project interventions may have beneficial effects, at least over the short term, when they maintain a freshwater area and provide this habitat for species that have had to try to exist under the hypersaline conditions of the Casamance for the past decades.

Tidal mixing also provides a means of transport for many organisms that have little or no mobility on their own. For instance invertebrate food species, fish eggs, and small fish larvae ride tidal currents selectively to move within a stream area. In general, they are not able to move against strong currents, but instead change their buoyancy to take advantage of currents moving in the direction they are trying to go.

Thus, if a stream has already been mostly blocked by a berm or road, many of these "interchange" functions have already been lost to the system. There may be some residual interchange, depending on the size of the opening, the characteristics of the steam, and the types of organisms utilizing the area. For some of the streams in the Casamance, there does appear to be some mixing under bridge areas, as evidenced by changes in hydrological characteristics. However, only the monitoring and research program planned for the Casamance will help to determine quantitatively the size of the residual interchange.

Cumulative impacts, if they occur, will adversely impact reproduction areas, nursery areas, and supplemental feeding areas vital to fish and other aquatic organisms. Anti-salt dikes could reduce the number of species, the number of individuals within a species, local populations, and the richness of the ecosystem food chain. Artisanal fishermen have traditionally fished in the valley areas during the times that the tide and flooding inundated these areas. The project interventions will result in the loss of habitat which could impact migratory and residential commercial species, as well as other aquatic species. Anti-salt dikes will block tidal motion (and therefore tidal energy), which is important to the productivity of an estuarine area. This cumulative impact of habitat loss on the aquatic resources of the Casamance River ecosystem due to project activities in relation to the entire resource base and the impacts of interventions funded by other donors and

organizations must be considered.

The freshwater retention dikes have impacts similar to the anti-salt dikes, but to a lesser degree since they are further removed from the aquatic habitats and wetlands. The contour berms should have no adverse impact on aquatic habitat or wetlands. On-site monitoring will determine the actual type and extent of fisheries impacts.

1.3.5. Terrestrial Resources

1.3.5.1. Birds

The project has the potential to have an impact on birds by contributing to the loss in tidal productivity and the resulting loss of food organisms for the birds. This impact would be in proportion to the cumulative habitat loss, as discussed above. The project may also contribute to a reduction in the available habitat, feeding, breeding, and nesting areas for shorebirds and palearctic species. Rice paddy and pond areas will also provide attractive feeding areas for some birds that could be trapped or shot as pests, or affected by pesticides (see below). On the other hand, increased areas of rice paddy could result in an increase in the number of pest bird species or populations. The Casamance region is a known area for the termination of some bird migration patterns. Therefore the attraction of birds to project sites is of some concern.

The project did not plan to promote or finance the use of pesticides. However, there are some plans for farmers to use fenitrothion as a termiticide in new intervention areas. Bird nesting and aquatic wetland habitats have been identified as habitats to be avoided when using this termiticide. Alternative termiticides and integrated pest management practices will be explored where such habitats exist. This will be a greater concern for the anti-salt dikes, and a progressively lesser concern for the freshwater retention dikes and contour dikes respectively.

Project impacts to birds are expected to be greatest in vegetated or undisturbed sites. As such, site selection will focus on relatively open areas and previously disturbed sites which offer marginal bird habitat, especially for nesting. Phragmite stands have been identified as valuable waterbird habitat. The anti-salt dikes pose the greatest potential impact to waterfowl. The location of such sites will avoid waterfowl nesting habitat. The freshwater retention dikes, contour dikes, and pilot irrigation system should pose no significant impact to birds or their habitats if constructed in open areas. Freshwater impoundments may actually enhance habitat for some species of waterfowl.

These improvements to existing open areas to increase rice production would reduce the pressure to clear other areas for farming which may have offered high-quality bird habitat. As such, this project may offer significant benefits to birds and their habitats by reducing these pressures.

1.3.5.2. Impact of Chemical Pesticides

The use of chemical pesticides by villagers may have an impact on ecological components. Presently, there are plans to use limited quantities of fenethrethion on termite mounds located in newly reclaimed areas. While visiting the Nguindir sites, many birds were seen feeding in the vicinity of these newly reclaimed areas. Fenethrethion has been evaluated in a separate study by USAID's Locust and Grasshopper Control Programs (TAMS 1986). Unlike many other pesticides, it is listed for use by USAID with a precaution that it not be used near bird feeding or nesting areas. Therefore, acephate and other pesticides, if they need to be used at all, should be considered in these situations. The potential for adverse environmental impacts from pesticide use would be greater for the anti-salt dikes than the freshwater retention dikes. This is due to the relative proximity of the anti-salt structures to sensitive habitats. The contour berm projects could actually serve to prevent pesticide dispersion outside of the agricultural area, thus yielding positive impacts. The appropriate level of monitoring will be implemented if pesticides are to be used.

1.3.5.3. Mangroves

The most critical processes involved in the perpetuation of mangrove ecosystems depend upon an adequate supply of water, an adequate supply of nutrients, and stability of the substrate.

The proposed project has the potential to impact water supply and nutrient supply. The availability of water depends upon the frequency and volume of tidal exchange and freshwater supply, as well as upon the evaporative demand of the atmosphere. The greatest potential impact of the proposed project is on freshwater supply volume and frequency. The project area has many places where mangroves have historically been grown, at least prior to the current drought. The project area will potentially reduce the habitat available to this important and increasingly threatened plant.

The anti-salt dikes will have the greatest potential for mangrove habitat reduction as they will be located in zones where mangroves historically grew. As previously mentioned however, mangroves have been in decline, primarily due to natural conditions. Natural hypersalinity of the soil prevents reestablishment. If the anti-salt dikes are placed in these areas of natural mangrove reduction, adverse impacts resulting from the anti-salt dikes would not be significant. Dike placement should occur in places where a minimal amount of mangrove plants are needed to be removed.

The freshwater retention dikes and contour dikes will most likely be located outside (upslope) of the historical range of the mangrove. Although direct impacts from these dikes may not exist, the indirect impact of reduced freshwater flow to the mangroves may be detectable. Any increase in salt content below these dikes can be monitored to assure that potential salinization does not exceed the tolerance limits of the mangroves. The freshwater retention dikes and contour berms, if properly installed and maintained, may actually yield beneficial impacts to mangrove communities by reducing soil erosion and flash flooding.

Monitoring will be established to detect any changes in the mangrove ecosystem resulting from the installation and operation of the projects.

1.3.5.4. Forest Resource Loss

It is estimated that at least 5 tons of lime will be necessary for this project. The recovery rate after calcining is about 33 percent of shell weight as calcium carbonate. This translates to approximately 15 tonnes of shells per hectare. This substantial amount is constrained by transportation and shell collection efforts as well as by fuelwood supply (USAID 1988).

In the course of producing lime, which will be used to counteract soil acidity, it is necessary to kiln oyster shells (which are heated by wood) or to use wood ash, which is produced by burning wood. The project is therefore expected to cause some loss of forest resources as wood is taken for these purposes.

Alternative methods of de-acidification as well as appropriate site selection to reduce the need for de-acidification must be applied. Alternative fuels, such as groundnut shell pellets, can be explored to reduce dependence on wood for fuel.

The anti-salt dikes, freshwater retention dikes, and contour berms should pose no significant impact to forest resources if located in unforested areas. As described above, the anti-salt dikes have a greater potential to impact mangrove forests due to their relative proximity.

Other impacts from these activities to forest resources can be positive if sites are selected on previously substantially cleared land. Improved rice production on the selected sites will reduce the pressures of slash-and-burn agriculture to convert forest land into farm use.

Section 118 of the Foreign Assistance Act recognizes the importance of tropical forests and tree cover and expresses concern over desertification. This section of the Act denies U.S. assistance to "actions which significantly degrade national parks or similar protected areas which contain tropical forests or introduce exotic plants or

animals into such areas." This section also denies assistance for "the construction of dams or other water control structures which flood relatively undegraded forest lands" or promote "the colonization of forest lands" without an environmental assessment which indicates "that the proposed activity will contribute significantly and directly to improving the livelihood of the rural poor and will be conducted in an environmentally sound manner which supports sustainable development."

In order to avoid the need for detailed environmental assessments of each scheme relative to this section, it is advised that undegraded forests and protected land be avoided to the greatest extent practicable.

1.3.5.5. Crop Diversity Loss and Intensification of Agriculture

There is a danger that the project, by encouraging rice production, will lead to the substitution of rice for other traditional crops such as millet and sorghum. Another concern is that the extension of an improved variety of rice could lead to a monoculture.

Rice is currently the preferred cereal food grain in Senegal. An increase in domestic production will reduce dependency on foreign imports. Since rice is grown on the wetter soils which this project intends to rehabilitate, agricultural land competition with millet and sorghum will be minimal since the latter are upland crops.

The anti-salt dikes and the freshwater retention dikes should pose no significant impacts to crop diversity. The contour berms and dikes may promote crop diversity as they improve the land's capability to sustain an increased variety of crops. It has been noted that the Diola people currently utilize rainfed rice cultivation employing anti-salt dikes and berms. As such, the proposed project may be an improvement to a preexisting cultural practice.

Agricultural monitoring of the rice crop to prevent diseases which may be facilitated by monoculture situations will be conducted. The use of a variety of appropriate rice strains can be encouraged to avoid substantial monoculture situations.

The project is expected to result in the intensification of agriculture in the areas behind the anti-salt barriers and the water retention structures. Intensive cropping and mono-cropping in particular will lead to a reduction in the fertility of the soil, a reduction in the organic content of the soil, a decrease in tilth, and a reduction in productivity. The ponding of water on the soil will increase the acidity, increase the salinity, and increase the anaerobic organisms in the soil. The mechanisms for the separate effects of drought, acidification, and salinization need to be more carefully discussed, interrelated, and assessed for their significance for the project operation.

1.3.5.6. Chemical Fertilizers

Chemical fertilizers may be used after testing in experimental plots; chemical fertilizers as well as manure are being encouraged in the project. Soil and water monitoring will be conducted to assure that the appropriate amount of chemical fertilizers and other soil nutrient amendments are applied. The anti-salt dikes have the greatest potential for permitting adverse environmental impacts from chemical fertilizers to occur due to their relative proximity to more sensitive ecosystems.

1.3.5.7. Threatened and Endangered Species

The effects of project activities on threatened and endangered species or critical habitat is an issue because the status of individual species is unclear. Project activities could conceivably have an impact upon the food chain of certain species such as manatees, turtles, crocodiles, otters, and other aquatic species. Each site can be inspected for the presence of threatened and endangered species through direct observation, observation of evidence (i.e. nests, dens, scat, or tracks), and interviews with local farmers. If clear evidence of the presence of endangered species or their critical habitats within a proposed site location is found, then a

recommendation that an alternative site be selected should be made. It should be noted however, that since one of the objectives of this project is to rehabilitate lands from hypersalinity, it is highly unlikely that prime or critical habitat for threatened and endangered species will be selected for potential sites.

If properly located, the project activities should pose no significant impacts to threatened and endangered species. The anti-salt dikes and water retention dikes may pose a higher potential for adverse impacts than the contour berms if improperly located and maintained.

1.3.6. Effects On Public Health

The project support for anti-salt dikes and freshwater retention dikes that create freshwater ponds will increase the habitat for malaria vectors. Borrow pits for the materials needed to build project dikes and berms could collect standing water and provide additional habitat for the multiplication of disease-carrying mosquitoes. The potential for adverse impact increases with the size of the mosquito habitat created. The contour berms would however, make little to no contribution to malarial incidence increase. Vector control can reduce the potential adverse impacts. Site monitoring will be employed to determine the extent of the problems and solutions.

In general, villages and sleeping quarters are found at a sufficient distance from the standing water created by the infrastructure elements, so there is little or no likelihood that insect vectors will be able to travel these distances. Villagers do not usually swim, bathe, or wash clothes in the river or impoundment areas since these areas are far enough away from the villages. This distance will mean that latrines and sewage systems in villages will not impact standing water associated with new project interventions. Drinking water is usually taken from wells so little or no impacts from project interventions are expected due to disease vectors through this route.

The project goal of increasing rice production could make necessary the employment of more people for work in rice paddy cultivation. This could result in increased exposure of people to schistosomiasis. The potential of this problem would increase in wetter situations, and downslope sites would be more susceptible than upslope ones. It could also increase the time and degree of exposure for individuals who have not previously been in serious risk of contracting the disease. An increase in the hectares of permanently ponded water could result in an increase in the number of snails which can host and spread the disease.

Vector control can be accommodated to limit or eliminate the potential for schistosomiasis. Intermittent drying and/or salt water flushing are two of the most effective physical means of control.

The main impact expected is to farmers and rice planters, who are at risk from both paludisme and bilharziasis because of their contact with standing water. These populations need to be protected by the use of appropriate medication. Since a number of villagers are involved in rice culture, one needs to estimate the increase in exposure associated with the PROGES infrastructure program. This is difficult to estimate at this time because of the variability between valleys. Overall it has been estimated that project interventions will increase rice production by 2 to 25 percent, which would be expected to increase the potential for disease by the corresponding percentage. Impacts will be mitigated as warranted.

1.3.7. Effects on Socioeconomic Aspects of Villagers

With the interventions of the project, one can assume that rice production will increase and rice cultivation activities will intensify. In this case, there will be an overall increase in local rice available for consumption, meaning a higher level of food security as well as a higher standard of living.

For the Diola, the project will likely reinforce the importance of rice in their society. The organizational forms introduced by the project will not threaten the traditional associations. In those cases where the wards decide to utilize the traditional

associations as water management committees, the associations will be expanded and strengthened. When the water management committees are newly created, because their activities are distinct, they will be able to complement the activities of the traditional associations.

Among the Manding, while there will be no widespread participation of men in rice cultivation, there are signs that men are becoming more interested. There have been individual cases of men helping women with a particularly abundant harvest (from a pilot parcel), and men sometimes are willing to use animal traction to plow the rice fields. Increased involvement of Manding men in rice cultivation would be positive for the development of the valleys.

As rice cultivation in the valleys increases in importance, women will probably lessen their upland activities and return to the valley. The major implication is that they will change from possible cash crops to a subsistence crop, reinforcing their dependence on men for cash. Theoretically, rice could become a cash crop once subsistence needs are met, but this is unlikely in the near future.

As production increases, and rice land becomes more valuable, there are risks of increasing conflicts over land use and water distribution. While certain conflicts are unavoidable, the potential for land tenure conflicts were taken into consideration during the selection process in an effort to keep these conflicts to a minimum. Consequently, during pre-organizational meetings with villagers, the possibility of land conflicts was stressed so that they would be sensitized to the issue. Furthermore, it is the policy of the project not to distribute land or to get directly involved in land tenure issues. The traditional village structure will continue to decide on land tenure problems. Conflicts over water distribution can be kept to a minimum by the inter-village committee fulfilling its role, which is to regulate such issues.

In all of the sites where the project has intervened, the project will leave not only dikes, berms, and new technology, but also village committees experienced in dealing with outsiders, in coordinating the work of village laborers with construction contractors, and in dealing with foreign technical assistance as well as Senegalese civil servants and non-governmental organizations. This experience will be an advantage if they decide to take on future projects. They will have developed a sense of responsibility for the water control structures based on interactions with project technicians and participation in the walk-through and construction activities.

The project has introduced the inter-village water management committee, a new form of organization based on the watershed (or valley) as a shared natural resource. This is of crucial importance in the development of the valley because the inter-village committee is responsible for coordinating the activities of the village-level committees.

Since traditional associations tend to be all men or all women, the project has introduced an innovation by having mixed committees. However, men still tend to dominate these committees. For the six Program II valleys, the project gave women the choice of forming their own committees or being part of mixed committees. Only in one case did the women agree to form a women's committee.

1.4. ALTERNATIVES ANALYSIS

Five technical alternatives have been considered:

- *Technical Alternative I:* No action. Under this alternative, USAID would not provide any assistance program in this area.

- *Technical Alternative II:* Conduct interventions only in areas with existing impoundments, such as roads, and earlier dams. Under this alternative, USAID would only undertake construction interventions in valleys that had previously been impacted by construction of roads, dikes, berms or other interventions that transect the valley.

- *Technical Alternative III:* Conduct interventions only in the Affiniam Dam area (on the Bignona River). Under this alternative, USAID would only undertake interventions in the Bignona River valley.

- *Technical Alternative IV:* Interventions planned in all river valleys of the Casamance River, taking into account soil, water, socioeconomic and environmental considerations. Under this alternative, construction interventions would be planned in any areas where this kind of work can be effective in increasing rice production.

- *Technical Alternative V:* Interventions planned in all river valleys of the Casamance River without the use of salt-water detention dikes, taking into account soil, water, socioeconomic and environmental considerations.

An analysis of each of these alternatives is presented below:

1.4.1. Technical Alternative I: No Action or Construction of Project Structures

As discussed in the PER, the overwhelming consensus among technical specialists (engineers, soil scientists, agriculturalists, aquatic ecologists, and fisheries specialists) familiar with the Southern Zone region, its naturally changing environmental characteristics, and the mix of engineering infrastructural interventions which have taken place there to date is that salinization control in the bolons through construction of small anti-salt dikes in the lower valleys and freshwater runoff catchment through construction of water retention structures in the mid- and upper valleys are critical to stabilizing the prevailing deterioration of agricultural land and water quality occurring naturally in the region.

Without the new program, areas with existing berms will continue to have high maintenance demands, and areas that have no interventions will be left almost completely non-productive because of the present drought. Thus, the no-action alternative would lead to a continuation of the food deficit in the area.

Environmentally, the no-action alternative would remove some of the need to mitigate cumulative impacts in the system. However, as discussed in the following alternatives, appropriate adjustment of selection criteria can avoid much of the cumulative impact programs anyway. Until the monitoring plan is completed, it is simply unclear whether in fact there are any soil or water quality impacts. If there are any, then the no-action alternative would avoid them.

Thus, on balance, the no-action alternative would lead to loss of many benefits, with the prevention of very few impacts.

1.4.2. Technical Alternative II: Construction of Dikes Only in Areas Presently Impacted by Berms, Roads, and Other Impoundments

This is the preferred alternative environmentally. As discussed in chapter 5 of the PER, on a very crude measure of overall impact on unperturbed valleys, an impact on 27 percent of the habitats would be expected. The degree to which each valley is impacted would vary, but is estimated at approximately 50 percent of the valley within which it is placed (the Mayor and Nguindir barrages fell into this range). Thus, once again on a crude measure, approximately half of the 27 percent — or 13.5 percent — of habitat in the Casamance may be lost.

However, a review of existing mapping indicates that nearly 75 percent of the stream valleys are currently blocked to some degree. Thus if a valley has already lost some of its habitat to the existing blockages, the proposed interventions would have little or no impact beyond the existing conditions. If we assume that all of the new interventions will be in valleys that are already blocked by 50 percent or more, then no additional cumulative impact from the project would be expected. This is why this is a preferred alternative.

1.4.3. Technical Alternative III: Construction of Dikes Only Above the Affiniam Dam

The Affiniam Dam area is already severely impacted

because of the presence of the dam. Therefore, little cumulative impact in this area would be expected. Thus, this is an acceptable alternative with respect to environmental impacts. However, this alternative would not meet economic and sociological goals and therefore does not appear to be acceptable.

1.4.4. Technical Alternative IV: Construction of Project as Described in Technical Alternative II and Mitigation Measures

If we assume that all new barrages will be in valleys with no existing blockages, then the total cumulative impact on habitats would be 13.5 percent for this alternative. The true cumulative impact will depend on the mix of valleys that have existing blockages compared to those with no blockages. Thus under this option, cumulative impact will be between 0 and 13.5 percent. These two numbers — 0 to 13.5 percent — represent the potential impact for the project. This alternative becomes the same as alternative III, if in the selection criteria one avoids unblocked valleys.

1.4.5. Technical Alternative V: Construction of Project as Described in Alternative IV without the Use of Anti-Salt Dikes

If all new interventions are limited to freshwater retention dikes and contour berms, then most of the environmental impacts of the program would be reduced. This is because the anti-salt dikes are larger, impact a larger area of the second- or third-order streams, and are located in a more highly productive area of the estuary. While it is assumed that freshwater retention dikes would have some minimal impact by reducing at least seasonal connections to habitats in the upper stream areas, the cumulative impacts is not expected to exceed 1 percent of all the habitats in the Casamance system.

1.5. PLANNED MITIGATION

The PER also considered the use of measures to mitigate the impact of loss of aquatic habitat, such as the construction of aquaculture ponds. These ponds could be associated with existing rice culture, or be independent sources of fish or shellfish protein for villagers.

It should also be noted that a separate summary of the mitigation and monitoring report has also been prepared under the title of *Implementation of Programmatic Environmental Review for the Southern Zone Water Management Project, Senegal* (USAID 1994).

1.6. TRANSITION FROM ENVIRONMENTAL ASSESSMENT TO IMPLEMENTATION PROCESS

After the Programmatic Environmental Review was completed and approved for the Southern Zone Water Management Project, then Initial Environmental Examinations were prepared for project activities as provided for below. As expected most, if not all, project activities have been analyzed in detail in the PER, and the IEEs checked that these relevant topics had been considered. (Project activities that had not been covered in the PER would have been analyzed in the IEE, but none occurred.)

IEEs were briefed and refered to the environmental assessment completed in the PER. Valleys and project activities were grouped into two IEEs. An IEE may make a negative environmental determination after reviewing the following points:

- Name and location of new activities (e.g. anti-salt dikes at Bona or Badobar) and rational for grouping as necessary.
- Does the activity fall within the range of activities analyzed in the PER? Specifically,
    - If it is an anti-salt dike, does it fall within a valley of the size analyzed in the PER and is the dike within the size analyzed in the PER? If not, a positive determination will be made and an environmental evaluation of that component performed.
    - Similarly, if it is a freshwater retention dike,

does it fall within the parameters analyzed in the PER? If not, a positive determination will be made and an environmental evaluation of that component performed.

- If anti-salt or freshwater dikes are planned, do they fall within the restrictions of the preferred alternative, i.e. has the valley selected been previously blocked by other activities? If the valley is unblocked, then an environmental assessment must be performed for this activity.

- Is it an activity utilizing pesticides (which are not supported by the project)? If so, a full environmental assessment under AID regulations must be performed.

- Is it any other kind of activity not specified or analyzed in the PER? If so, a positive determination will be made and an environmental evaluation of that component performed.

- Have all mitigation activities required for this activity (as specified in the PER, chapters 6 and 7) and summarized in this report been initiated? If so, the activities must described in the IEE.

All IEEs had approval sheets at the end, signed by the Mission/regional environmental officer and USAID/Senegal and forwarded to USAID/W for approval of the Bureau Environmental Officer and General Counsel. Until otherwise authorized, projects may not proceed without these approvals.

2. Mitigation and Monitoring Activities

2.1. INTRODUCTION

As discussed in chapters 6 and 7 of the PER (LBII 1993), the major mitigation concern is the loss of aquatic habitat. Technical Alternative II (Conduct interventions only in areas with existing impoundments, such as roads, and earlier dams) was selected to minimize environmental impacts. This alternative was seen as the least restrictive to achieving the aims of the program, while still avoiding as many environmental consequences as possible. The implication of this alternative is that only valleys with previous blockages will be considered for future sites. While in all cases the need for mitigation must be considered, it is expected little or no mitigation will be necessary in new valley sites. This is because it is expected that little or no new loss of habitat will occur (as discussed in Section 1).

However, in the case of Program I and Program II valleys, some sites had been selected for dike construction in areas that had not been previously blocked (in some cases there had been previous blockages, but these were gone at the time of the PROGES intervention). In these areas it will still be necessary to do significant mitigation to make up for loss of aquatic habitat. It is hoped by picking valleys under the new more restrictive rules, these will be the last of the valleys that will require mitigation for this purpose.

Finally, as discussed in chapter 4 of the PER, a monitoring program has been established to ensure that additional environmental consequences that may not be foreseen are discovered and measures taken to modify PROGES to avoid these new effects, if any are found.

Environmental monitoring of USAID development activities is required by Regulation 22 CFR 216, usually called Reg 16. This regulation requires environmental reviews, as well as environmental monitoring and provides in its chapter 216.3(a)(8):

> To the extent feasible and relevant, project and programs for which Environmental Impact Statements or Environmental Assessments have been prepared should be designed to include measurement of any changes in environmental quality, positive or negative during their implementation. This will require recording of baseline data at the start. To the extent that available data permit, originating offices of AID will formulate systems in collaboration with recipient nations to monitor such impacts during the life of AID's involvement. Monitoring implementation of projects, programs and activities shall take into account environmental impacts to the same extent as other aspects of such project, program or activity, whether or not an environmental assessment or environmental impact statement was originally required. If it appears to the Mission Director or officer responsible for the project, program or activity that is having or will have a significant effect on the environment that was not previously studied in an Environmental Assessment or Environmental Impact Statement, the procedures contained in this part shall be followed including as appropriate, a Threshold Decision, Scoping and an Environmental Assessment or Environmental Impact Statement.

Section 496 of the Foreign Assistance Act, which sets out the terms of the Development Fund for Africa (DFA) specially requires that "policy reforms shall also include provision to protect . . . long term environmental interests from possible negative consequences of the reforms."

The basic approach to the entire program is, first, to conduct a scoring system (section 7.2 of the PER) that ensures that environmental impacts are minimized. Second, for the present program it is expected in the future that there will be little or no environmental impacts because of the adoption of

the preferred alternative. That alternative specifies that interventions will only be considered in areas that have previously had blockages of the river valleys. However, some valleys in Program I and Program II interventions have been located in areas that are expected to have environmental impacts. Therefore, a mitigation plan for aquatic habitat destruction is discussed in chapter 4 of the PER. Third, in accordance with Reg 16, a monitoring program has been established in order to determine if further impacts of the programs occur during its implementation stage. This is described in section 7.4. For PROGES, a cooperative agreement with the Senegalese Institute for Agricultural Research (ISRA) is designed to have ISRA serve as the contractor responsible for the monitoring program (with proper oversight from USAID's contractor, Louis Berger International, Inc.).

Based on the scoping sessions and the PER, twelve factors were considered of environmental concern to the program (see page 3).

The PER reviewed these possible impacts and identified item 3 — aquatic habitat/wetland loss — as the major area requiring mitigation. For other items, project impacts were seen as either nonexistent or minimal. However, because of considerable uncertainty in the data available, these other items were included in the long-term monitoring program. Therefore, aquatic habitat loss is discussed in detail in the mitigation section, while the other items are addressed in the applied research/ environmental monitoring programs being conducted with ISRA.

2.2. AVOIDANCE OF IMPACTS

As discussed in detail in the PER, a series of scoring systems for PROGES have been designed to ensure that environmental concerns are given the same attention as other matters. The scoring system is divided into four areas: sociology, engineering, agriculture/soils, and environment. Each of these areas considers factors important to successful completion of that part of the program. In the environmental area, factors considered include forests, endangered species, fisheries and aquatic habitats, and critical or pristine ecosystems. This scoring system, in combination with restrictions due to the preferred project alternative (avoiding use of unblocked valleys), avoided major anticipated environmental impacts

2.3. MITIGATION

2.3.1. Non-Aquaculture Mitigation Measures

Mitigation measures for the project will include providing sufficient drainage from borrow pits in order to eliminate the accumulation of standing water, avoidance of soils with high acid mineral content, and the introduction of covenants to assure avoidance of environmental impacts. Certain covenants are required in association with deferral of environmental review for infrastructure activities pursuant to the provisions of 22 C.F.R. 216. 3(a)(7)(iii). Environmental review for infrastructural activities under this project shall consist of the findings of the project IEE, as amended, and the findings of the assessments of the five issues retained in the IEE amendment. The Project Grant Agreement shall, therefore, contain the following covenants:

> (1) USAID and the Grantee agree that the issues of a) anti-salt barrage effectiveness in controlling upstream salinity; b) the effects of infrastructure on groundwater quantity, quality and distribution; c) the cumulative effects of regional barrage construction on estuarine and other aquatic ecosystem resources; d) the effects of regional infrastructural development on water-associated disease incidence rates; and e) the effects of infrastructural development on terrestrial ecosystems and endangered, protected or commercially important species, as described in the Project IEE Amendment, shall be addressed as described except insofar as those issues or approaches may be amended or modified by the mutual agreement of both parties.

(2) USAID and the Grantee agree that implementation plans for infrastructural development will be modified in accordance with the findings of the five issue assessments listed in (1) above, as appropriate and practicable.

(3) USAID and the Grantee agree:

a) that anti-salt dikes shall only be constructed where the area of high potential acid sulfate soils or already acidified soils of the taxonomic subgroup of typic sulfaquents (USDA Soil Taxonomy) does not exceed 15 percent plus or minus 2 percent of the service area upstream of the dike.

b) that siting of water retention dikes will be undertaken with the full knowledge, advice and consent of the affected village populations; and

c) that any irrigation system funded under this project shall have had sufficient technical analysis performed to indicate that salinization and waterlogging potential in the affected area will be minimal; that measures will be available to the target population to mitigate any salinization or water logging which may occur in the future; and that sedimentation rates upslope of the primary structure are sufficiently low to permit use of the reservoir for irrigation throughout a reasonably long facility target life.

2.3.2. Design and Operational Mitigation

After scoring systems (section 2.3.1 above) have determined the best areas for operational success of the program, and the environmental component of the scoring system has attempted to avoid the building of interventions in areas which have particular environmental sensitivity (including valleys that have not had previous blockage), then the second step is to seek to mitigate these impacts. The need for mitigation becomes greater as the size of the expected impacts increases. As discussed in earlier sections, the size of the impacts will be a function of the size of the stream impacted, the extent to which the new interventions block areas previously unblocked (or partially blocked), and the sensitivity of the resources affected.

Since infrastructure components are expected to completely block specific river valleys, the project needs to consider the use of operational mitigation measures that can provide some connection between upriver and downriver areas of the affected valley. Of primary concern, are the salt-water detention dikes. These mitigation measures fall into two categories: design mitigation and operational mitigation.

In design mitigation, features such as the use of fish passages (which are generally 0.5 m wide) at several locations in the structures in order to allow tidal flow and biological movements between the two areas can be introduced. Fish ladders are used when there is a significant difference in water height behind the dam structure. By-pass spillways may also be employed for this purpose.

However, because of the low volume behind the saltwater impoundments there may not be sufficient water in storage in order to allow releases of water to downstream areas. Therefore design structures may not be warranted. In these cases operational mitigation measures can be considered, such as the opening and closing of gates and other structures in order to allow water and biological movement between the two areas (PROGES 1992). For instance, if it is known that a particular species migrates upstream during a certain season, then one would plan to open the water gates periodically during this period. Unfortunately, not enough is known about these movements in the Casamance River. Since fish breeding and bird feeding (indicative of the presence of food species) activities were both observed during the dry and rainy seasons, operational measures would appear to be warranted throughout the year. It was also observed that there appeared to greater impacts in areas with larger water impoundments. For instance there appeared to be greater impacts at Badobar than at Mayor or Nguindir. Therefore there is a greater need to consider mitigation measures at Badobar (and any larger sites) than at Mayor and Nguindir.

2.3.3 Aquaculture and Related Mitigation Measures under the EMEMP

The studies on aquaculture farming are summarized and based on those conducted on small projects in lower Casamance in the PER. The suggestions made to complete some data helped achieve a more thorough economic and socioeconomic study on aquaculture in the mid-Casamance.

If this mitigation plan, which comes from the Environmental Monitoring, Evaluation, and Mitigation Plan (EMEMP), is successfully implemented, it is expected that major loss of aquatic habitat will be properly mitigated. To summarize the elements:

1) Louis Berger International, Inc. (LBII), with assistance and approval from USAID/Senegal has prepared a cooperative agreement with ISRA to perform the mitigation activities;

2) ISRA, with oversight from LBII, conducted a series of pilot aquaculture ponds during the 1994 rainy season. The activities for performing this research are based on the above section. In accordance with the cooperative agreement, ISRA is to make monthly progress reports, as well as quarterly analyses of results, and an annual report summarizing progress in this activity. LBII will provide the necessary support for construction of the ponds. LBII will provide copies of all ISRA reports to USAID. Further details of the cooperative agreement are contained in the Terms of Reference for the ISRA program (available only in French).

3) It is expected that the research program of 1994 will form the basis of a permanent aquaculture mitigation program under the EMEMP in the valleys of Nguindir, Mayor, and Badobar during 1995. In addition to monitoring and reporting requirements for this season (identical to those in 2) above), a program of village participation, as well as training in use of the ponds, will be started prior to 1995. As long as LBII is involved in the program, it is expected that a cooperative agreement with ISRA will form the basis for mitigation monitoring, as well as necessary reporting. It is expected that the training program will allow these ponds to be self-sustaining with proper maintenance and operation by local villagers. USAID will need to make arrangements with the Government of Senegal to ensure that these ponds are maintained after formal contractor participation ends (as it did in 1996).

Specific technical details for the experimental mitigation program are included in the PER. In summary, a series of net enclosures approximately 1000 cubic meters were constructed in valley areas that are planned for mitigation. The enclosures were stocked at the beginning of the wet season with fingerlings obtained at the lower part of each valley, usually just below the dikes. Species considered included fish in the tilapia family, which are resistant to saline conditions. Species of shrimp (*Paneaus*) were also considered for stocking. Fish were fed a variety of agricultural by-products.

After the second season, it was planned that the program would have sufficient data to determine the productivity of these enclosures. At the same time, the ISRA research program planned to conduct primary and secondary productivity studies on the corresponding river valleys to estimate any loss of productivity that has occurred as a result of the interventions. It was planned that the number of ponds needed to make up for this loss of productivity will be constructed and maintained during the length of the program.

2.4. MONITORING PROGRAM AND ISRA RESEARCH

As discussed in the PER, there are several factors that cannot be adequately evaluated at this time, or factors which appear to be not significant in their impact, but which warrant additional attention because of their potential importance. The comprehensive plan for integrated research and monitoring will serve this role and is described in the next section.

3. Progress on Research in the Post-Construction Monitoring Program with ISRA

3.1. OVERVIEW

A cooperative agreement was made between LBII (under contract with USAID) and the Senegalese Institute for Agricultural Research (ISRA) in August 1993. The objective of the research was to conduct studies related to expected or potential environmental effects associated with the addition of one or more water control dikes in valleys of the Casamance River system. The environmental effects had been identified earlier under the PER.

Impacts identified included: 1) impacts on soil salinity, pH, nutrients and aluminum toxicity, 2) impacts on crop diversity, forest destruction (due to potential liming of the newly reclaimed acid soils by the project), changes in village structure, and the effect on the management of the new dikes, 3) impacts on surface and groundwater, particularly the potential for reverse flow of saline waters under the dike structures, 4) loss of aquatic habitat and associated fisheries production, and 5) impacts on birds (through the use of fertilizers and pesticides in the new farming areas) and on public health (by providing new aquatic habitats for insect disease vectors).

The ISRA research was organized around six teams:

Team 1–Soils and vegetation
Team 2–Sociology and agricultural production
Team 3–Hydrology
Team 4–Fisheries
Team 5–Ornithology and public health (consultation)
Team 6–Coordination and administration

The work of each team was organized around a series of standard operating procedures (SOPs) to collect the data, as well as store them for further use. The SOPs, contained in a written volume, include the details of when, where, and how samples are taken, and standard data sheets for data entry. These SOPs proved consistency in sampling methods between years and between researchers, as well as provide quality assurance. The SOPs were linked to a series of workplans and bar charts, which were to plan activities at least six months in advance. ISRA was to report progress on the tasks in each chart monthly. Each quarter, it was planned that ISRA would provide summaries of the data collected, as well as further commentary. Each year, ISRA was scheduled to prepare two annual reports. The first would summarize all data collected during the year. The second would addresses progress on the major objectives for the studies, e.g. what is known about groundwater effects of the program or the potential increase in rice productivity.

During the first and second quarters of the programs, ISRA refined and finalized the SOPs (including badly needed coordination between the SOPs and the teams) and identified equipment needs. The teams made a selection of intervention valleys to be studied (Mayor, Nguindir, and Badobar), as well as a selection of control valleys (Silinkene and Birkama). In theory, control valleys were areas that were not presently diked and did not have major blockages, such as roads.

The equipment purchased included:

- Computer equipment.
  - 4 "486" computer systems (CPU and monitor)
  - Backup power supplies
  - 2 printers
  - 1 digitizing pad

1 large plotter for printing maps, etc.
Software, such as word processing and statistical packages

- Chemical Autoanalyzer, complete with replacement parts and computer software
- Laboratory chemicals
- Laboratory supplies, such as glassware, thermometers, weighing balances
- Field supplies, such as measuring tapes, coring equipment, weighing scales, theatolyte for surveys, marking paints, and field paper
- Transportation including 2 cars and 10 motorcycles

During the third quarter, team accomplishments included setting up of the analytical laboratory (including a one-week training session by the manufacturer), setting up of the computer laboratory (including training on the Information Management System and Paradox software and training sessions on the use of Autocad graphical assistance programs), coordinating preliminary reconnaissance of the research valleys (with special emphasis on Badobar), and placing piezeometers in research valleys.

During the fourth quarter, teams began to collect information in the five valleys in accordance with the SOPs. Information was collected for the studies on soils, sociology, hydrology and ornithology. Fish enclosures were constructed at Nguindir and Badobar to start the fisheries mitigation program. ISRA also began to prepare the annual reports.

The fifth quarter was the height of the research activities because it coincided with the rainy season. Activities included data collection, data entry into the information management system, and preparation of the annual reports. Data were collected in soils, vegetation distribution, sociology, agricultural production, hydrology, and the operation of the fish enclosures. Limited data were also collected on fisheries diversity in the valleys.

During the sixth and seventh quarters, ISRA research began to wind down, due both to the end of the research season and apparent financial management problems. There were limited data collected on soils, sociology, agricultural production, hydrology, and fisheries. The technical annual report was actually delivered during these quarters and plans were made for a final report, since no decisions about continuing this component of PROGES were to be made before the eighth quarter

The significance of the research is two fold. It was the first effort to have an advanced scientific study on the Casamance River system. There were solid accomplishments in the setting up of infrastructure (laboratories, equipment, transportation, etc.) and the beginning of an organization of the research scientists. Understanding of the use of SOPs, organizing into research teams, using information management systems and designing research to fit within budgets and workplans are some of the successes of the program. Thus there was a very strong and important element of training for both the technical work and the administration of technical work. Despite the training, the ISRA team does not yet appear to be capable of successfully managing its administration at the present time, but there does appear to have been progress in this area

In addition, the program collected solid baseline scientific data in the fields of soils, vegetation, sociology, agricultural production, hydrology, fisheries mitigation, and ornithology. These data have contributed to a better understanding of the impacts of the program on soil pH and salinity, water management systems for the villagers, surface water movement and water quality in the valleys, and avian diversity. Unfortunately, the data are not at all sufficient to answer major research issues concerning the impacts of the impoundments on each valley. Additional research seasons (only one has occurred during this program) are needed in order to identify trends and describe changes in the valleys that may occur subtly, over a period of years, or which may take time to stabilize. The processes in the valleys are complex and can only be understood by a series of data over several years. Several years of information are also needed in order to adjust for natural variations in the systems

due to changes in weather and other natural processes. Of course, the key to that analysis is to collect data correctly each year, with appropriate number of samples, appropriate quality control, and controlled and repeatable locations of samples (both within the valley geographically and also with respect to depth and appropriate timing of samples).

3.2. OBJECTIVES AND SIGNIFICANCE OF RESEARCH FINDINGS

The following sections summarize the objectives of each research team and the significance of their findings.

3.2.1. Soils and Vegetation

The major objectives of the soils and vegetation studies were as follows.

3.2.1.1. Soils

The three objectives of the study were: 1) to follow changes in soil and groundwater in area and determine rates of change in salinity, pH and other soil/water chemistry; 2) to determine whether placing dikes in the valley induced lower salinity while avoiding highly acidic soils; and 3) to determine whether there were other unexpected consequences of dam placement on soils and water — including seepage of saline waters under the dikes into freshwater impoundments, induction of aluminum toxicity in lower acid soils, etc.

3.2.1.2. Vegetation

The objective of the study is to evaluate changes in vegetation in the three valleys with dikes and the one valley without a dike and relate these changes to the presence or absence of the dikes. Thus, the major objectives of these SOPs were to address ecological questions raised in the PER. Specifically under the first major category, listed above, the presence of threatened and endangered species (in this case of plants), reduction of mangroves, changes due to the use of chemical fertilizers and pesticides, and possible forest resource loss due to the activities of PROGES were to be examined.

These efforts established a solid database in soils and vegetation for the five valleys studied. The primary characteristic of most soils in the five valleys of Birkama , Badobar, Nguindir, Silinkene and Balingor are of low pH (frequently less than 4) and moderate to high salinity (up to 50 mmhos/cm). Salinity regimes decrease during the rainy season. For instance, at Nguindir salinities are as high as 50 mmhos/cm in May at the beginning of the rainy season and drop to less than 4 mmhos/cm in August at the height of the rains. The presence of highways and other structures all significantly affect salinities, so that, for instance, at Silinkene the salinities can vary from 34 to 18 mmhos/cm near the national highway to 18 to 8 mmhos/cm near the higher valley areas. By contrast, in the control valley of Birkama (which has no dams or major roads), salinities do not appear to drop below 20 mmhos/cm. Acid soils persist through the depth profile — from surface areas to areas at a depth of greater than 40-60 cm.

The collection of data for one season is not sufficient to answer any of the major questions concerning effects of the interventions on the soils of the three intervention valleys or for changes in the two control valleys. However, the researchers have begun to collect the information that can eventually address these questions through the database. There do not appear to be any major differences in soil characteristics in the intervention and control valleys. The long history of previous blockages to all of the valleys, and the presence today of the national highway in the control valley of Birkama, lead to the not unreasonable finding that the salinity and hydrology patterns for both the control valleys and the intervention valleys are similar. Therefore, at the present time, there is little evidence of a difference caused by the interventions beyond that which might be expected from blockages caused by other structure such as roads.

The significance of this finding is that the environmental impacts of the new interventions (as viewed by soils data) might not be significantly

greater than other previous or existing impacts in the valleys. For Program III valleys (where dikes were constructed after the PER requirement that only valleys where previous blockage occurred were to be selected) this is a confirmation that there is no need for mitigation programs. For Program I and II valleys (where some dikes were built in unblocked or partially blocked valleys), there would still be expected to be a need for mitigation.

In addition, this finding also means that the impacts of the interventions on agriculture may also be more subtle, because of the need to compare the present situation, in which there is one or more dike structures, with a previous situation, where there may have been some blockage. Changes in agricultural production may have occurred on areas that were small compared to the total size of each valley. Therefore while production changes may be important, they have relatively low impacts on the total soil and hydrologic picture for each valley.

The vegetation database provided useful baseline studies in each of the five valleys. There appear not to be sufficient samples (at different time periods) to address any changes in vegetation over seasons or for documenting changes in vegetation due to the impact of the dikes. There is no information on changes to the presence of threatened and endangered species (for plants), reduction of mangroves, changes due to the use of chemical fertilizers and pesticides, and possible forest resource loss due to the PROGES activities.

No analysis on the vegetation surveys is provided by ISRA, but a quick inspection reveals that there appear to be little differences in vegetation between the valleys.

3.2.2. Sociology and Agronomy

The objectives of sociology and agronomy studies were:

- *Group 1–Sociology.* The objective is to show any changes in villages, valleys, and regions due to the dike construction. It is also intended to form a framework for sociological issues related to control and maintenance of dikes after PROGES ends.

- *Group 2– Operation of the Dams.* The objective is to consider agricultural and sociological aspects of dam management (lower field farmers vs. upper field farmers, etc.). This satisfies the need for operational research for PROGES. This group must work closely with Team 3–hydrology, which is considering soils and hydrological aspects of dike operation.

- *Group 3–Economics.* The objective is to measure changes in farmer income and changes in crop productivity. It is also intended that in a discussion of these issues, this section will compare results to the studies conducted in other valleys by Seneci.

- *Group 4–Agronomy.* The objective is to look at agronomy questions related to the dikes, including plots to look at rice varieties in different areas of salinity/water height behind the dikes and surveys on entomological changes in the area. The latter section is also designed to assess ecological changes. These relate to the objective of showing changes in ecology due to the dike operations. This section needs to assess changes in fauna over time between the valleys.

The database documents village structures for each valley. As such, it appears to be useful data. However, none of the analyses have been conducted in relation to the objectives discussed above. Detailed database information is contained in the ISRA Annual and Final Reports.

The surveys revealed a bipolarization in interest between the villagers based on 1) internal interest based on cultural interests, and 2) external interests based on their relationship to the water regimes for the new interventions.

The village committees have attempted to sort out the interests between the farmers with plots near the dikes and those with plots further away. Additional background information has been collected. It does not appear to have resulted in any

recommendations for future dike operations. The database documents village structures for each valley that have some importance to farmer income. As such, it appears to be useful data. However, none of the analyses have been conducted in relation to the objectives discussed above.

There have been a variety of agricultural trials and ISRA is in the process of reporting this information (their data and analysis are not presently available). As such, it appears to be useful data. However, none of the analyses have been conducted in relation to the objectives discussed above.

3.2.3. Hydrology

The objective of the hydrology studies was to document pH and salinity changes in groundwater and surface water due to the construction of dikes in three valleys and to compare these changes to two control valleys. The reason for these studies is because of environmental concerns about these changes and because of the importance of these changes for success of the project. An additional objective was to prepare a plan for the most efficient operation of the dikes in three valleys. It needed to be coordinated with the sociology studies and the water quality studies, but this was not done.

The hydrology studies appear to have provided carefully prepared survey maps for the five valleys over four time periods. As with the soil surveys, they do not appear have addressed the major objectives, again apparently because of a lack of information over a sufficient time period. This section was intended to coordinate with work of Team 2 (presented above in sociology). At present, neither team has prepared recommendations for dike operations.

3.2.4. Fisheries and Mitigation

The objectives of the fisheries and mitigation studies were to document changes in fish abundance and variety due to the dike operations by conducting fish market surveys in each of the regions of the five valleys and to estimate changes in productivity of estuary and estimate of net gain or loss of biomass in valleys with dikes. Both objectives were needed to estimate losses in aquatic habitat due to the building of dikes in these valleys.

An additional important objective was to provide mitigation for impacts on aquatic habitats in the three valleys. The reason for this is to address environmental concerns about the loss of fisheries. This study conducted mitigation studies in aquaculture to replace fisheries production lost due to presence of dikes.

In the control valley of Birkama, there is higher diversity of fish species than those found in valleys where dikes are present. In contrast to the soil or hydrology studies, there do appear to be major differences in fish composition between these valleys. The significance of this is unknown. One may hypothesize that the presence of impoundment structures has resulted in smaller area or more limited access to habitats for reproduction and/or feeding.

The mitigation programs got off to a slow start. However, ISRA included the innovation of establishing fish mitigation through a series of bamboo enclosures located in the areas and in areas of seasonal freshwater above the anti-salt dikes. The monitoring of conditions in enclosures appears to be useful. The placement of enclosures at Badobar in an area between the anti-salt dike and the upstream freshwater retention dike appears to be a very cost-effective approach to fish mitigation. Instead of expending large funds on digging fish ponds in these areas, it is possible to construct bamboo enclosures at a lower cost. The enclosures are flooded constantly by water in the areas, allowing removal of harmful waste materials from the enclosures and maintenance of adequate oxygen and lower temperatures for the growing fish. The inconvenience of reaching the ponds on plank bridges apparently is not a major concern to the villages. The structures appear to be sturdy enough to withstand several seasons of operation and repair is with inexpensive materials. Fish appear to triple in weight during the four-month growing season.

Major questions to be addressed include the

optimal species and growing regimes (food, etc.), who would be paid to maintain the structures, and how to conduct training programs and coordinate them with village committees.

3.2.5. Ornithology and Public Health

The objectives of the ornithology and human health studies were to document changes in bird species due to the presence of dike structures, as well as to document any effect due to pesticides and fertilizers used in the newly reclaimed areas. An additional objective was to assess changes in the incidence of malaria and schistosomiasis due to the presence of additional aquatic habitats for insect disease vectors.

The avian survey revealed a large diversity of birds in all valleys, as well as the presence of some species of storks and cormorants that are considered to be endangered in Senegal. A comparison between the numbers of species between the dikes valleys and the control valleys, reveals that there has been a reduction in bird species in the diked areas. No information has been provided on the effects of pesticides or fertilizers on birds.

No data have been collected on human health.

The report appears to have collected good secondary information on the impacts of the Affiniam Dam on the Bignona River.

All data collected by the program were contained in a collection of databases. The database was organized around a software program designed to enter data. This system used was a standardized, computer-based information management system. The system assured that the data would not be lost and gave some quality control to the data by assuring that needed data were included and that the data appeared to fit into normal ranges.

3.3. NEED FOR PROGRAM IMPROVEMENTS

ISRA made a serious effort to change the very independent operations of the scientists and to organize research teams. This area involved major problems with communication, administration and use of budgets, as well as supervision that must be improved for major success in these programs to occur. Groups attempted to garner resources in excess of their expected share of the equipment and labor budgets. There also appeared to be little success in coordinating research trips to the valleys in order to economize on transportation expenses (especially given the relatively few number of vehicles available). There are conflicting stories as to what extent the laboratories were functioning properly and the reasons for the problems.

Administration and supervision — both technical and budgetary — must be improved in order to have a future program of any type. Despite major accomplishments in setting up better scientific infrastructure (labs and field equipment), the major roadblock to success in the research in ISRA appear to be supervision, administrative control, and budgetary control. Despite a sizable "coordination" budget, teams did not seem to focus their efforts on research objectives as directed by PROGES, and most reports were late.

The sources of the problems seem to have occurred at many levels. First, the program objectives were too broad and long-term for an emerging research institution. While it is important to involve the research scientists in defining program objectives and methodologies (as well as analysis of the data), it appears that none of the researchers focused very carefully on the objectives needed by PROGES. In the future, programs must be much more narrowly defined and limited in objectives, so as to allow a realistic completion of the program. While such directed research is only desirable in the short run, it is a necessary building block in building a strong scientific community in Senegal.

Second, and related to the issues above, there was a need to recognize the difference between long-term objectives and short-term objectives. The program perhaps had unrealistic expectations that a one-year program could answer significant

questions on the Casamance (especially considering the need to dedicate program resources to training). As has been the case in studies of other large river systems, many years may be necessary to answer the questions successfully. Of course, the key to that research is that the data be taken in an appropriate manner each year. In the future, there must be a recognition by USAID of what work they will find acceptable for short-term needs and where there must be investments over a period of years to achieve necessary results.

Third, there is continued disappointment that more was not achieved in the research program, thereby failing to recognize that there was a strong training component in this program. If only the research results were wanted, then it might have been more cost-effective to bring in an established university group. Such a study would have been expected to cost at least ten times the established budget. However, that investment might have guaranteed studies as complete as those done, for instance, for the Gambia and Senegal Rivers. The present program must recognize the inherent inefficiency of establishing a new program with a need for strong training.

Fourth, there was a major problem of supervision. Because of the complex nature of the work, ISRA must be given frequent supervisory assistance to assure that work is progressing satisfactorily and that problems are being addressed. ISRA has almost no ability to make timely requests for assistance if there is a need for additional materials, etc. and staff most often deal with problems by blaming them on some other activity or person. They must learn to think through solutions to the problems and, if the solutions involve materials beyond their control, make timely requests for action. In the future, there must be major supervision to ensure that the program progresses fully. For instance, stories conflicted about the chemical laboratory: in quarterly reports, the laboratory was reported to be functioning, but individuals reported that it was not. If the laboratory was not functioning properly, attributed to parts that needed fixing and the lack of some laboratory chemicals, then laboratory personnel should have addressed the matter by reporting it to the research supervisor at ISRA, who could then discuss it with the PROGES Research Director (who could have arranged to have the materials provided). Instead, an expensive laboratory may have been non-functional due to the lack of a few fairly inexpensive items.

Also in the future there is a need for a local supervisor who is familiar with scientific research and someone who has training and experience in technical issues that are being supervised. In practice this means someone with a master's degree who is familiar with research in soils, hydrology, and fisheries, as well as familiarity with scientific methods. Further use of interim objectives might help to focus the research efforts. This is yet another reason that local supervision needs to be improved.

Another aspect of supervision was that few of the teams had the senior personnel assigned to the tasks. During the program, several senior researchers (in sociology and hydrology) went for overseas training. They were replaced by more junior personnel, who appear to have needed additional supervision in the overall direction of the research. Another senior researcher (in soils) was so occupied with administrative duties that he appears to have had little time for supervision of the research program. Yet another of the teams (fisheries) was lead by a senior researcher not present at the Djibulor (southern Senegal) station. It does not appear that the researcher spent enough time at the station to provide for the administrative and technical direction needed for the work.

Fifth, the use of an external director has benefits and problems. It provides the program with services of scientists with long experience in this type of research and familiar with many of the training aspects. However, because those visits are at best only every six months, the supervision is discontinuous. This form of supervision is also expensive and leads to communication problems.

Sixth, ISRA appears to have had little control over cash flow and other budgetary issues, so that there were continual issues about needing extra advances, salary disbursement, etc. This problems

must be addressed by administrative changes.

Seventh, ISRA administrative systems are poorly coordinated with ISRA-Dakar and there is a lack of coordination between ISRA units. ISRA-Dakar needs to show a real interest in supporting the work of the station or little progress in solving this problems can be expected.

3.4. RECOMMENDATIONS TO ISRA

In light of the seven sets of problems identified in the program, the following recommendations for improvement in the future for ISRA are made:

1) In Cooperative Agreements, ISRA needs to ensure proper supervision of the research efforts by assuring the on-site presence of senior researchers to direct their teams, by holding regular team meetings, and by making specific plans for accomplishments and status reports.

2) Researchers need training in problem solving. For instance, administrative structures need to be in place to address problems that require resources or actions beyond that group (for instance, the purchase of replacement parts). Researchers and research supervisors need to use this mechanism. They need to learn to change their approach by asking how and what needs to be done to keep the work moving forward, rather than blaming other people or circumstances. There are usually many ways to approach a problem and they need to be flexible in their thinking. On the other hand, in cases where there appears to be only one solution, they need to push hard at least within the supervisory structure. If a researcher has a record of a request that is not acted upon, then a supervisor should also be made accountable. This is not a search for blame, but an approach that seeks ways to get the work accomplished. Many of the researchers appeared to have the attitude that they would have a job whether or not they finished their work appropriately. While people should not be punished for not succeeding if a situation is beyond their control, there should be an effort to get solid, directed effort from all the researchers.

3) Researchers and the organization need to learn how to design research efforts to fit into budgets available. It is not realistic to plan a SOP or sampling plan in five valleys, when there will only be resources available (for instance, transportation) to get to three valleys on a regular basis.

4) Research stations need to have a mission and a plan for coordination of activities. Supervisors need to set priorities for station needs (setting up labs, computer support, presence of soil labs, etc.). It should be determined whether Djibulor will be an agricultural station only, or function to examine major issues related to soils, hydrology, and fisheries. There did not appear to be any coordinated effort to set up an operational unit that truly functioned (such as a laboratory, although the computer laboratory appeared to be highly used and needed). Also maintenance of the equipment (even a small effort such as keeping the laboratory clean and orderly) is also essential.

5) The research station appears to have poor infrastructure support (electricity, water, telephone, fax, photocopy, etc.) that seems to be holding up the entire operation. There appeared to be little or no support from ISRA-Dakar. There needs to be a strong effort made to support the research efforts.

6) Many of the researchers need training in a variety of skills. Some need additional technical training, but basically all of them need training in organization, communication, and scientific analysis (including planning research efforts, whether small or large). While some overseas training may be appropriate, much of the training with respect to research can be accomplished within the present resources if the training is properly planned and objectives identified.

7) With respect to technical skill training,

researchers need training in scientific method presentation. The normal order of presentation of materials is objectives, materials, data, and discussion of the data with respect to the objectives. Almost none of the materials prepared by ISRA had all of these elements. In particular, data were almost never presented correctly. In most cases, they wrote about the data, rather than presenting the data itself. For example, a table on salinities for each valley might not include an explanation of how, when, and where the samples were taken. The presentation of one number or one series of numbers in time shows a serious lack of training (data presented in that way have no significance and do not tell one anything about the situation). Scientists at ISRA need to make much greater use of graphs, maps, and materials to display their information. For instance, a series of maps on salinities and pH for each valley would have been very helpful. Similarly, a presentation of the vegetation data in this way would have been much better than the table included in the report.

8) Financial systems and record keeping need to be completely reformed. There does not appear to be control over cash flow or payments to researchers.

9) Researchers and the institution should be told how to handle contract research. They must listen to the objectives of the client(s), and, if they accept the work, try to meet those objectives. If they have a better idea, it should be discussed with the client, as it is still the client that is supporting the research. Researchers should realize that if they fail in their work, there may not be additional research opportunities in the future.

3.5. RECOMMENDATIONS FOR FUTURE RESEARCH

Finally, the report contains recommendations for continuing the research program for another year. Studies on fisheries, soils, and hydrology are highly recommended because of the legal requirement for mitigation studies and because of the usefulness of having several years of data with which to perform analyses that help to explain the natural processes in the Casamance and the continuing human efforts in that river system. Priority must be given to the fisheries efforts (because of the legal requirements). Soils studies should have the second greatest priority because of their need to complement other aspects of the ongoing program. Finally, hydrology studies would provide a useful in-depth aspect of studies on a few valleys, as opposed to the PROGES studies, which will address limited sampling in many valleys.

The report contains a detailed Terms of Reference for each research effort. These are summarized below:

3.5.1. Fish Mitigation Studies

The objectives of fish mitigation studies are: 1) to quantify changes in fish abundance and variety due to the dike operations by conducting fish market surveys in each of the regions of the four valleys (three valleys with impoundments and one valley without a dike), 2) to quantify changes in abundance and productivity by conducting physical/chemical surveys in the affected valleys, and 3) to provide mitigation for impacts on aquatic habitats in the valleys.

This will be accomplished by a workplan that includes four tasks: 1) Standard Operating Procedure preparation and other planning, 2) Construction of enclosures, 3)Research and training program, and 4) Revisions to the SOP and final report.

Changes in aquatic habitat will be assessed through a market survey and a physical/chemical survey. In the market survey, the objective is to measure changes or losses in fish abundance to the affected valleys as seen in fish market surveys. This workplan will include three tasks: 1) Planning for a survey of fish markets where any effects of the dikes are expected, 2) Performance of the surveys, and 3) Analysis and final report.

In the studies on changes in productivity due to

loss of aquatic habitat, the objective is to measure the extent of loss of primary and secondary productivity to the affected valleys as seen in physical/chemical surveys. Once this estimate is obtained, an appropriate number of mitigation ponds/enclosures for each valley can be planned. Without this measurement, worst-case scenarios based on theoretical loss of habitat may have to be used. The workplan includes three tasks: 1) Planning, 2) Performance of surveys, and 3) Analysis and final report.

3.5.2. Soils

A second set of research efforts includes the soils survey. The objective is to test the hypothesis that there is the possibility of saline intrusion into soils by leakage or hydraulic pressure around the dikes. Alternatively, there is the hypothesis that the dike operations do not improve the salinity profile in deeper soils, or do not represent a permanent improvement.

3.5.3. Hydrology

The third set of research efforts includes the hydrology survey. The objective of this research is to document changes in salinity and pH of the surface and groundwater hydrology due to the presence of dikes in the intervention valleys.

3.5.4. Monographs

The last research efforts proposed is to have a series of monographs prepared on the five research valleys. Data accumulated over both this project, as well as through earlier efforts, would be collected at one location and analyzed in order to better understand the operation of hydrology and soils in these valleys.

3.6. RELATIONSHIP TO OTHER ONGOING PROGES RESEARCH

The projects recommended above can cooperate with and complement other ongoing projects in progress at PROGES. In particular the hydrology programs should help each other through the use of shared databases, use of the same grids for organizing sampling programs (including pizeometers in place and labeled as to grid location) and use of common laboratories. The proposed program would provide in-depth studies of five valleys that would help in the analysis of the information from the PROGES valleys (22 valleys), which will have much more limited information for each valley.

In addition, the operations manual will require water quality sampling that can be tied to the research program.

Finally, the monitoring program of PROGES is planning to use a computer-based information management system. It is recommended that the computer programs developed for the ISRA program be adapted as necessary for the needs of PROGES.

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