AIRD

ASSOCIATES FOR INTERNATIONAL RESOURCES AND DEVELOPMENT

353 Alewife Brook Parkway
Somerville, Massachusetts 02144, USA
(617) 625-1840

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COMPARATIVE RETURNS TO IRRIGATED VS. DRYLAND AGRICULTURE IN THE SENEGAL RIVER BASIN

Model Results

by

Lynn Salinger and J. Dirck Stryker

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PREFACE AND SUMMARY CONCLUSIONS

Over the past fifteen years, the food situation in the OMVS countries of Mali, Mauritania, and Senegal has seriously deteriorated. The ratio today of domestic grain production to total grain consumption is .83 in Mali, .19 in Mauritania, and .62 in Senegal -- much lower than during the 1960s and approaching the levels of the 1972-74 drought years (Clark G. Ross, "The Deteriorating Food Grain Situation in the Sahel and A Program for Grain Self-Sufficiency by the Year 2000", AID, December 1982). In addition to the decline in per capita production there are also large year to year fluctuations due principally to variations in rainfall. This induces great concern among farmers as to whether they will be able to feed themselves and introduces uncertainty into government planning for the allocation of scarce foreign exchange to food imports.

The problems of increasing food production have not proved to be particularly amenable to solution. Although constraints on the availability of investment funds may have accounted for some of the difficulty (Ross, p. 13), more fundamental causes have been (1) the lack of a viable technical package for rainfed foodcrop cultivation in the zone with less than 800 mm of rainfall and (2) the extreme difficulties experienced in trying to develop irrigation along the Senegal River without the flow of that river being regulated. A soluton to the first problem will require much more investment in agricultural research, though this is unlikely to produce substantial results for at least a decade (Carl K. Eicher, "Facing Up to Africa's Food Crisis," Foreign Affairs, Fall 1982). The solution to the second problem, however, is at hand.

With construction of the Manantali dam scheduled for completion by the end of the 1980s, the situation regarding irrigation in the Senegal River Basin will be substantially changed. This will permit relatively secure double-crop irrigated cultivation to take place over an area of 250,000 hectares. The ability to grow two crops per year will substantially increase the profitability of irrigated cultivation and enable resources to be more fully utilized, thus creating the potential for increased food production. In addition, the availability of a technical package for irrigated production using high yielding seed varieties and fertilizer will further increase production of foodgrains. Equally if not more important, this production will be much more secure than that resulting from rainfed cultivation in this area of highly variable rainfall.

In planning for the expansion of irrigation, it is important to consider the alternatives that are available at any moment in time. In particular, there is need for a long-term comparative economic analysis of the returns to investment in irrigation versus rainfed agriculture when investment is envisioned to take

place over a period of decades. This is the subject of this report.

The analysis was carried out using a computer simulation model described in the text of the report. The model is based principally on the economic and financial analysis in the Project Paper for AID's OMVS Integrated Development Project (IDP). Use was also made of other project reports, such as the World Bank's appraisal of its Groundnut and Foodcrop Project in Mali. These reports were evaluated and the results were extrapolated over the Middle and Upper Valley of the Senegal River. The Lower Valley and Delta were excluded since there is as of yet no concrete example of an economically viable irrigation scheme in that zone, and it is impossible just now to say what such a scheme would look like if it were to be developed.

Both rainfed and irrigated cultivation were projected to the year 2010 in terms of hectares, number of farms, production benefits, and costs. Rates of expansion were hypothesized based on anticipated maximum rates of training and supervision of extension agents. Investment capital was left unconstrained. Costs and benefits of the stream of investment were then calculated and internal rates of return were obtained.

The results of this analysis suggest that internal rates of return are substantially higher for irrigated cultivation than for rainfed production. The rates for irrigation vary from 8 percent in Bakel to 23 percent in Podor using manual techniques, and from 18 percent in Gorgol to 31 percent in Guidimaka using animal traction. Rates of return for rainfed cultivation are negative everywhere except Guidimaka in Mauritania and in Mali, where they rise to a maximum of 21 percent using animal traction.

The internal rates of return for irrigated cultivation include the effect of improved security of production as estimated in the Project Paper for IDP. Without this effect, rates of return vary from -7 percent to 15 percent for manual cultivation, and from 11 percent to 23 percent for animal traction. Overall rates of return will, of course, vary between those for manual cultivation and those for animal traction, depending upon the pace at which animal traction is adopted. In any event, rates of return for irrigation are almost everywhere superior to those for rainfed production except in Mali, where only the rates of return for rainfed cultivation have been calculated. This is because the opportunities for improving rainfed cultivation in Mali are relatively good and the possibilities for extending irrigation there are limited and its costs unknown.

If irrigation is pushed vigorously in the years to come, the model projects the development of between 68,000 and 153,000 hectares by the year 2010, depending upon what combination of manual and animal traction techniques is used. This will absorb the existing population of the region, as well as its growth, but will only begin to require immigration from outside the basin.

Under a program of improvement in rainfed agriculture alone, only Mali will be able to meet the consumption needs of the region. If the major thrust is towards irrigation in Mauritania and Senegal, on the other hand, the region will be able to satisfy its own needs and contribute to demand outside the basin by as early as 1990 with animal traction in Senegal or as late as 2005 with manual cultivation in Mauritania. By the year 2010, between 189 and 890 million tons of grain could be exported from the region under some combination of manual and animal traction irrigated cultivation.

Total development costs of such increased production (excluding incremental farm costs) are estimated at $105 million for improved rainfed agriculture and $470 to $950 million for irrigated agriculture, depending on whether manual or animal traction techniques are employed. These costs include outlays for commodities, construction, operation, local staff and extension. Specifically excluded from the model were technical assistance and regional organization support costs.

The rates of return are especially sensitive to two factors. One is the timing of investment expenditures. Were development costs are not assumed to rise gradually with increasing farm involvement over time, returns would be much lower. Second, returns are calculated to incremental net benefits in the model. Thus they depend critically on what assumptions are made about production levels under the existing traditional farm system.

Reliability of the data is also an issue. In particular, the improved rainfed package is more of an idea than a proven, field-tested innovation. While the yields assumed for irrigated cultivation are based on actual experience, those for rainfed agriculture could be seriously in error. There are also important data uncertainties with respect to project costs and rates of expansion to be expected in the future, especially when the period of analysis spans two and one-half decades.

It is also important to point out that the analysis is confined to the Senegal River Basin and does not compare rates of return in that region with those elsewhere in Mali and Senegal. It should be possible, however, to employ the same methodology in higher rainfall areas, where the data base may be somewhat firmer than for rainfed cultivation in the Basin. Finally, the model is regional in nature and is not used to deal with the broader issue of national food self-sufficiency, as does the Club du Sahel report by Clark Ross referred to earlier.

COMPARTIVE RETURNS TO IRRIGATED VS. DRYLAND AGRICULTURE IN THE SENEGAL RIVER BASIN: MODEL RESULTS

1. INTRODUCTION

1.1. Purpose

The purpose of this study is to present to policymakers projections of net returns to alternative investments in the Senegal River Valley. Specifically, AID/RBDO charged the study "to compare the investments for irrigated development planned within the OMVS development plan to year 2010 with possible alternative investments for the development of rainfed agriculture during the same period." (RBDO-DR-83-017) The model developed will serve as a companion piece to the USAID/OMVS Integrated Development Project Paper (625-0621) published by the USAID River Basin Development Office in Dakar.

1.2. Development of Model Scale

Although the model draws extensively on economic, financial, agricultural and sociological data presented in the IDP supporting analyses, it does not apply directly the number of hectares proposed for development by the project in each of the five specific project sites. Nor does it take into consideration the number of already existing irrigation perimeters. Rather, it develops a rate of expansion of project interventions which is independent of specific donor proposals.

In this way, the model is somewhat unique. Instead of accepting a given level of investment and extrapolating from it to levels of benefits, it projects a realistic rate of involvement of farmers in new agricultural development schemes and then calculates the residual capital investment necessary to support such an expansion. The results of the model can therefore be analyzed independently of specific donor activity levels.

1.3. Marginal Benefit/Cost Methodology

Analysis of possible production scenarios has been performed both for improved rainfed agriculture and for irrigated cultivation using an incremental approach. In each case, an existing level of traditional agricultural activity is used as a benchmark against which to measure increased production and costs. Only marginal returns and costs above and beyond those of the traditional system are analyzed here. Such an approach differs from the IDP Economic and Financial Analysis which treats irrigation as a new activity in the project area, and does not subtract out the net returns to traditional agriculture.

1.4. Walo Production

A second important characteristic of the model presented in this paper is the treatment of the effect of dam construction in the Senegal River Valley on walo, or flood recession, production. Flood recession agriculture, which historically has been an important component of the traditional farming system (See Gannett Fleming Corddry and Carpenter, Inc., "Organisation pour la Mise en Valeur du Fleuve Sénégal -- Assessment of Environmental Effects of Proposed Developments in the Senegal River Basin: Partial Report for Socioeconomics, p. 90), is due to be phased out over the next ten years. Under existing proposals, artificial flooding will permit recession agriculture to continue during this ten-year transition period as farmers are assisted in the switch to irrigation. In the model, the transition period stretches from 1990 to 2000. Were walo cultivated after project intervention using unimproved techniques on the same area of land as before project intervention, it would not figure at all in the present analysis. Since lost walo production is not a direct result of downstream agricultural development but rather is a "fait accompli" resulting from earlier investment decisions, only incremental changes in walo production are phased out in this model. This approach is to be distinguished from that employed in the IDP Economic and Financial Analysis which included the full value of walo production throughout the thirty-year cash flow stream.

1.5. Organization of Report

The remaining sections of this report present the model of comparative returns in detail. Section 2 describes the ecological divisions observed in its construction. Section 3 presents the model's definition of absorptive capacity and explains how this key independent variable affects the model's results. Sections 4, 5 and 6 describe the traditional, improved rainfed and irrigated agricultural systems, and the returns which can be expected from investing in alternative scenarios. Section 7 compares the outcome of the model to projections of such parameters as land availability, population growth and farm-level consumption in order both to confirm model feasibility and to predict the impact of investments on the wider national and regional economies. Section 8 varies certain parameters and describes the sensitivity of internal rates of return to such changes. Finally, Section 9 indicates areas of critial data lacunae, suggesting where future research should be focused.

2. MODEL DESIGN

2.1. Ecological Divisions

Given the high degree of ecological diversity in the Senegal River Basin, both parallel and perpendicular to the river, the model of the basin is divided into relatively

homogenous zones. One of the most critical factors to affect agriculture, rainfall, varies from 300 mm per year in the Delta to 900 mm per year in the Malian Upper Valley. Resource endowments, patterns of social organization, cost projections and ensuing calculations of rates of return all follow similar degrees of variation. Therefore, the trade-offs between improved rainfed and irrigated agriculture must be analyzed separately for each zone.

2.2. Ten Administrative Zones

Following the methodology employed in the Gannett Fleming report, "OMVS: Assessment of Environmental Effects of Proposed Developments in the Senegal River Basin," this model breaks the basin into ten zones corresponding to the ten administrative units contiguous to the river. They are: in Senegal, the departments of Dagana, Podor, Matam and Bakel, in Mauritania, the regions of Trarza, Brakna, Gorgol and Guidimaka, and in Mali, the circles of Kayes and Bafoulabe. Dagana and Trarza are defined to comprise the Lower Valley, Podor, Matam, Brakna and Gorgol make up the Lower Middle Valley, Bakel and Guidimaka are in the Upper Middle Valley; Kayes and Bafoulabe comprise the Upper Valley. Though not a perfect reflection of reality, the Mauritanian and Senegalese zones are paired up in order to permit simplified application of farming systems data when available on one side of the river but not necessarily the other. Accordingly, Dagana and Trarza are seen as counterparts, as are Podor and Brakna, Matam and Gorgol, and Bakel and Guidimaka.

2.3. Restriction of Model Scope

The two zones of the Lower Valley were excluded from consideration for two reasons. First, since the potential for improvement of rainfed agriculture is clearly lacking, it makes no sense to perform a comparative exercise in that region. Clearly, with annual rainfall of 250-350 mm, the only possible investment alternative to expand agricultural potential in this region is through irrigation. Second, due to the extremely low rural population density (compare the 1976 figures calculated from SONED, "Modelisation des Prix Agricoles, Rapport de Fin de 1ère Phase" -- Dagana 9.2 rural population/km^2 vs. Matam 51.0; population density is even lower in Trarza), such expansion would most likely involve heavy mechanization. Though complete data on costs and returns to mechanized, irrigated agriculture are currently unavailable, there is fairly clear indication that such a technique would be economically unprofitable. (Hasan Tuluy's calculations of net social profitability of mechanized rice production techniques in Senegal in Pearson, Stryker and Humphreys, Rice in West Africa, p. 283). Thus, the model focuses only on the remaining three river regions: Lower Middle, Upper Middle and Upper Valleys, and seven zones: Podor, Matam, Bakel, Brakna, Gorgol, Guidimaka and Kayes/Bafoulabe.

2.4. Riverine vs. Nonriverine Population Breakdown

Consideration was also made of the difference in farming systems between riverine and nonriverine populations in Mauritania and Senegal. Access to walo, fonde and hollaldé soils for flood recession agriculture means that farmers along the river can support themselves relying primarily on cultivation. For farmers residing away from the river, the lack of access to this land implies that mixed farming/livestock must be undertaken in order to support the household. Proportions for riverine and nonriverine populations are taken from an ORSTOM study by Lericollais (as reported in Bailhache and Funel, Ministère des Relations Exterieures, Coopération et Développement (France), "Evaluation Economique de l'Amenagement de la Rive Gauche du Fleuve Sénégal" 1983, p. 42), for Senegal and from the Rural Assessment and Manpower Surveys reports for Mauritania. Initially, it is assumed that these proportions will not change over time.

2.5 Carrying Capacity of the Land

In order to get a sense of how the land is to support future increases in population (i.e., whether by expanded agricultural or expanded livestock activities), rough calculations were made to estimate the livestock carrying capacity of each zone. When these estimates were compared with approximate herd sizes, expansion of livestock production through the exploitation of natural pasture no longer appeared to be possible in the Fleuve region (departments of Dagana, Podor and Matam) of Senegal, but would still be possible in Bakel, as well as in all riverine regions of Mauritania and circles of Mali. Ths implies, among other things, that the development of animal traction in Senegal will have to be based to a large extent on cultivated feed and fodder.

2.6 Demographic Module

Table A.1 presents the demographic module for the entire Senegal River Basin. Data culled from 1976 national censuses is reported in a variety of secondary sources (Gannett Fleming, RAMS, SONED) and presented here. Populations are disaggregated into rural and urban sectors, and differential effective growth rates are applied to each. Initially, it is assumed that those rates do not change over time. In most of Mauritania, there is no significant migration into urban areas along the river. In fact, rates are generally quite low, owing to the significant flux of population into Nouakchott.

Population is then divided into numbers of households assuming the same household sizes in each region as in the IDP Economic and Financial Analysis. Again, the number of members per household does not change over time. The evolution of household growth along the river is presented in Table A.2. These figures are later be used as a baseline data against which to compare household consumption, agricultural labor, etc.

3. ABSORPTIVE CAPACITY

3.1. Extension Agent Training as Proxy for Absorptive Capacity

Absorptive capacity is the key factor limiting expansion of any project intervention. For the purposes of this model, the training and installation in the field of extension agents is treated as a proxy for absorptive capacity. This means that regardless of population growth, availability of agricultural labor, or demand of farmers for access to irrigated land or improved techniques, the expansion of the number of farms in a given development intervention is a direct function of how quickly and efficiently new extension agents can be put in the field. Resources to cover the cost of such training, plus recurrent salary and commodity costs, are assumed for the purposes of this model to be unconstrained.

3.2. Schedule of Extension Agent Training

Accordingly, an algorithm was developed to determine how many farms could be developed in each country, either under improved rainfed or under irrigated techniques. Mauritania, it was assumed, can only train extension agents half as quickly as can Senegal and Mali, which seems reasonable given historical rates of project expansion. In Senegal and Mauritania the training schedule projects ten new agents being turned out every year for the first five years; every five years thereafter, an additional ten new agents per year can be launched. Thus, after thirty years, Senegal and Mali will each have 1050 additional extension agents in the field, whereas Mauritania will have trained and installed 525. Table A.3. shows the schedule of extension agent training. Such a rate of expansion is cautious in the early years and more ambitious in later years. The algorithm is varied in the sensitivity analysis section of this report.

3.3. Development of Farm Involvement in Project Interventions

It was felt that an individual agent, during his first five years after training, can effectively work with fifty farmers. As the farmers' experience grows, it is expected that extension agent productivity will be doubled. The implication is that as each new agent comes "on line", the fifty farmers with whom he or she deals during years 1 through 5 increases to one hundred farmers per extension agent after five years. This calculation was applied to each new graduating class of extension agents, in Senegal and Mali as well as in Mauritania. As shown in Table A.4., this means that by the year 2010, 68,000 farms in both Senegal and Mali and 34,000 farms in Mauritania could be involved in downstream development initiatives in the Senegal River Valley. A total of 170,000 farm families would therefore benefit directly from investments. Table A.5 translates this rate of expansion of absorptive capacity into a rate of development of land area, given assumptions of average farm size.

In Table A.4 the total number of farms which can be handled by the extension staff is allocated to each zone according to the geographic distribution of the riverine population across zones as shown in the demographic component of the model. This distribution is initially assumed not to change over time.

The rate of expansion of involvement of farms in development interventions is within the projected expansion of population in the project zones. An adequate supply of labor should thus be available to support the investments.

4. TRADITIONAL FARMING SYSTEM

4.1. Sources of Data/Riverine Farms

Data on the traditional farming system is adopted from the IDP paper Volume III, Section 3.2., "Technical Analysis of the Agricultural Component". This report presents highly aggregated information drawn from IBRD, FAO and local government sources. Given the wide range of microclimates in all of the zones considered here, the usual cautions about representativeness of data apply.

Table A.6 presents a summation of the farm budgets for riverine farms in each of the zones of the model. Technical coefficients for inputs, wages and prices are taken from the IDP Economic and Financial Analysis. According to the IDP Agricultural Analysis, the use of animal traction is found in insignificant amounts except in Mali; thus, the base case used in the model only considers a manual technique in Senegal and Mauritania. The picture of the traditional farm is critical to the outcome of returns later in the analysis. Since this paper evaluates the level of incremental net returns stemming from a given project intervention, the base level of agricultural activity bears directly on internal rates of return. This is as it should be. The decision whether or not to alter an existing system should be based on the level of projected economic improvements over the existing system.

4.2. Effect of Intercropping

As shown, the intercropping of sorghum and niebe in dieri, or rainfed, production from Matam/Gorgol to Bakel/Guidimaka greatly increases the riverine farm's value of production and income above those of sorghum monoculture. The inclusion of the value of niebe, a higher yielding and higher value crop, increases value of farm production 30 to 50%. Income is increased somewhat less due to the increase in seed costs. To maintain consistency with the IDP Agricultural Analysis of the traditional farming system, niebe was not specifically included in the budgets of Podor and Brakna. It will be seen later what affect this exclusion has on the analysis of incremental returns

to project investment.

4.3. Returns to Traditional Farming

Depending on assumptions of household size and per capita consumption rates, the existing farms survive at a subsistence level with potential net revenue barely covering the value of household labor, evaluated at the market wage rate. It is arguable that the subsistence farmer does not value his or her labor at the same rate as hired labor. Still, it is clear that the margin of error available to the farmer working under traditional techniques is very slim.

5. IMPROVED RAINFED AGRICULTURE

5.1. Scope of Improved Rainfed Agricultural Development

Informed opinions are that there still is not a viable rainfed agricultural development package for the Senegal River Basin. Much research has been done to improve crop varieties, to select those which are area-adapted, to determine the appropriate level of improved input application, and to develop new manual and animal traction technique recommendations. Experience in other geographical areas, however, has shown that the research-farmer link often fails to bear the positive fruit indicated as feasible at the research station level. Bearing this in mind, the improved rainfed model presented here is a cautious estimate of the kinds of benefits foreseeable from such a project intervention. Furthermore, returns have only been calculated to improvements in Matam, Bakel, Gorgol, Guidimaka and Kayes/Bafoulabé; the potential for improvements in rainfed agriculture in Podor and Brakna is too poor to warrant the exercise.

5.2. Technical Coefficients for Improved Rainfed Agriculture

Yields rise with an improved rainfed package because of two factors: improved seed varieties and improved cultivation techniques. The following kilogram per hectare increases are assumed:

	Manual	Animal Traction
Cereals	200/300	200/400
Niébé	75/100	75/150

The initial yield improvement occurs during the first five years; as farmers adjust their practices, there is an additional improvement in the sixth year of participation in the program. The package does not include fertilizer or chemical application, although in Mali there may be sufficient rainfall to warrant them. Assumptions about improved seed costs and increased labor times are taken directly from the IDP Economic and Financial

Analysis, page A.7. The model assumes that the amount of land devoted to a given crop does not change under the proposed improved farming system.

5.3. Crops Included in the Improved Rainfed Agriculture Package

The model initially includes all crops from the traditional budget in the projection of improvement: that is, millet/sorghum as well as niébé. Niébé is a high-value crop; its inclusion in calculations of returns may therefore raise profitability. However, though the potential for such improvement is there (see USAID/Semi-Arid Foodgrain Research and Development Project documentation on cowpeas research, for example), there may, in the case of niébé, be a considerable time delay in the application of research results to extension efforts. Therefore, the rates of return to an improved rainfed package are presented including and excluding incremental improvements to niébé. Since peanuts were only included in the Malian traditional farm system, their improvement is not included in the package in order to remain consistent with the other zones. Table A.7 summarizes the budgets of improved traditional farms. It is the difference in returns and costs between Tables A.7 and A.6 which are used to calculate returns to project investment.

5.4. Cost of the Improved Rainfed Agriculture Package

The most critical factor to affect returns is cost. The calculation of discounted values of cash streams is highly sensitive to level and timing of project investments. A variety of earlier USAID and IBRD projects for the development of rainfed agriculture were analyzed, and project costs from an IBRD project in Mali (see IBRD Report No. 340a-MLT, "Appraisal of Integrated Rural Development Project Mali," May 13, 1974) were deemed most similar in scope to those of this study. Excluded from consideration, however, were expenses related to head office operation, technical assistance and supplementary project components since these are unlikely to have to be incurred repeatedly in the future. The remaining line items (commodities, local staff salaries, operation and vehicle maintenance) were converted to per farm costs and updated for 9% annual inflation from 1973 to 1983 prices. These constant costs were then applied to the scale of intervention proposed here.

The only cost item not taken from the IBRD project paper is the cost of extension. The level of investment in extension <u>per hectare</u> was calculated from project cost tables 89-93 of the Economic and Financial Analysis (pp. 147-151) and applied to the number of farms in the model, assuming that real extension costs per hectare will drop 50% after the first five years reflecting the 50% relative improvement in extension agent productivity.

5.5. Timing of Project Costs

The project cost summary for improved rainfed agriculture is to be found in Table A.8. Initial timing of investment in

commodities is planned over five years. Subsequent commodity replacement costs are lumped every five years thereafter. Operating costs are calculated on a per farm basis and expand continuously throughout the envisioned thirty years as farm involvement increases. Total extension costs are timed in the same manner, that is directly linked to the rate of expansion of farm involvement, and thus are continuously expanding. In the extension of farm returns in years 2011-2040, commodity costs are no longer included; operation, extension and farm costs are fixed at their 2010 levels.

5.6. Returns to Improved Rainfed Agriculture Project

The result of such incremental benefit and cost calculations are rates of return to improvements in rainfed agriculture which are negative in all zones except Guidimaka and Mali.

	Including Improvements to Niebé	Excluding Improvements to Niebé
Matam, manual	negative	negative
Bakel, manual	negative	negative
Gorgol, manual	negative	negative
Guidimaka, manual	28.2	12.5
Kayes/B, manual	20.8	8.6
Kayes/B, animal traction	28.5	22.9

The number of farms involved in the project expands until the year 2010, after which time returns are calculated with farms at full productivity. For the first five years of each farm's involvement in the project, the yield increments achieved are less than shown on Table A.7.

If niebé improvements are included in the analysis, rates of return improve dramatically. Higher grain prices in Mauritania improve Guidimaka's internal rate of return to 28.2% with the assumption of improvements in niebé production compared to 12.5% without. In Mali an improved rainfed agricultural package makes economic sense, with an internal rate of return of 8.6% using manual techniques and an internal rate of return of 22.9% using animal traction techniques. If Niebé is intercropped with millet/sorghum and is included in the improvements package, rates of return increase to 20.8% and 28.5% for manual and animal traction techniques respectively. Tables A.9 through A.14 present the calculations for each of the six cases.

6. IRRIGATED AGRICULTURE

6.1. Scope of Irrigated Agricultural Development

The model, as developed and presented in this paper, depicts several polar cases of alternative investment scenarios. One of these, improvement in rainfed agriculture, is outlined in

Section 5. The other two scenarios are presented in this section. Both concern the development of irrigated agriculture: one assumes continuation of manual techniques and the other hypothesizes immediate adoption of animal traction. An intermediate scenario beginning with manual cultivation and gradually shifting to animal traction can be devised as appropriate, given the pace of farmer learning.

6.2. Technical Coefficients for Irrigated Agriculture

All technical coefficients which describe the irrigated farming system in the various zones of the Senegal River Basin are taken from the IDP Economic and Financial Analysis. In this scheme, yields improve initially somewhat, and then further after six years of an individual farmer's involvement in the project.

In most cases, the proposed irrigated farming system for each zone in the model is applied directly from the IDP. However, assumptions regarding the limit to the amount of land available for development in small perimeters sometimes affect how the IDP proposals are adapted. In the case of Brakna, Podor cropping patterns and level of development costs appropriate for intermediate perimeters are applied. Output is evaluated using Kaédi market prices. Development and input costs are applied at an exchange rate of 5 CFA = 1 UM. In addition, since small perimeter land is close to exhaustion in Matam, the analysis foresees all future development of irrigation there at the higher, Podor level of investment, and therefore applies the Podor cropping system as well as development and input costs levels. In Gorgol, the expansion of irrigation follows the pattern proposed in the IDP Project Paper for Kaédi until 1990 after which the system and costs of development in Brakna apply. In Bakel, costs of development of the Collenga perimeter envisioned by IDP are as high as Podor, which indicates that the amount of land available for less expensive development will be quickly depleted. Thus, though the farming system proposed under irrigation does not change, the costs of development are assumed to be on a par with those at Podor by 1996. Guidimaka development is envisioned as it is in the Gouraye section of the IDP. The lack of a viable irrigation development package for the Malian Upper Valley at the present time led to its exclusion from this analysis. Tables A.15. and A.15.a summarize irrigated farm budgets. Yield figures reflect higher productivity as of the seventh year of a farm's involvement. It is the differences in returns and costs between A.15 /A.15 a and A.6. which are used to calculate returns to project investment.

6.3. Cost of the Irrigated Agriculture Package

Project costs are all adapted from the IDP Project Paper's financial tables. Consistent with the improved rainfed scenario, the costs of regional organization support, technical assistance and supplementary project components are excluded, as well as as the contingency and inflation line items. Commodity and operating costs (vehicles, office and technical equipment,

project staff salaries, vehicle maintenance and office operation) are applied from the proposed USAID contribution levels, as calculated per hectare, to the number of farms involved in the interventions in this model in the same way as was done in the improved rainfed model (see Section 5.4.). In Mauritania the proposed level of investment is significantly higher than in Senegal. Extension costs per hectare in all three countries are the same as those under an improved rainfed package. The project cost summary for improved irrigated agriculture is to be found in Table A.16.

6.4. Timing of Project Costs

The timing of investments follows the same pattern as for the improved rainfed package. That is, commodity replacement costs are lumpy expenditures occuring once every five years. Operating expenses expand after the first four years according to the rate of expansion of farm involvement in the project. Construction, irrigation equipment and extension costs are directly linked to the level of farm involvement, continuously expanding over time.

6.5. Security Benefits and the Irrigated Agriculture Project

Included in the irrigated agriculture analysis is an evaluation of the benefits to improved farmer security as a result of the intervention. Using the same methodology as employed in the IDP Economic and Financial Analysis, the value of the reduction in variance of average net income is added to the original net income stream. In this way, the frequency and severity of drought occurances and their effect on incomes from rainfed agriculture are accounted for and reflected in the relative difference in internal rates of return between irrigated and rainfed agriculture.

6.6. Returns to Irrigated Agriculture Project

The results of the incremental benefit and cost calculations are rates of return to irrigated agricultural development which are substantially higher than those found with improved rainfed agriculture. Though the number of farms expands at exactly the same rate in each polar case, and though the investment costs are much higher under irrigation than under improved rainfed, the net returns to investment yield the following internal rates of return, <u>including</u> increases to farmer security:

	Manual Technique	Animal Traction Technique
Podor	23.3	25.5
Matam	18.2	22.5
Bakel	7.9	22.8
Brakna	14.2	25.9
Gorgol	12.5	17.8
Guidimaka	11.8	30.9

Tables A.17 through A.28 present the calculations for all twelve cases.

If the value of the increased benefits to security are not added to the net returns stream, the following internal rates of return are obtained:

	Manual Technique	Animal Traction Technique
Podor	15.3	18.1
Matam	11.0	15.7
Bakel	-7.7	16.0
Brakna	9.6	19.5
Gorgol	7.7	11.1
Guidimaka	5.6	22.9

Although these rates are below those in which the benefits from increased security are included, they are still higher than returns to rainfed cultivation in every case except for Guidimaka using the manual (but not animal traction) technique.

7 MODEL VALIDITY

7.1 Land

The model predicts that by the year 2010 Senegal will have developed 50,000 hectares of irrigated perimeters, assuming .75 hectares per farm in Podor and Matam and .50 in Bakel using manual techniques, or 102,000 hectares, assuming 1.50 hectares per farm using animal traction. Mauritania, with a lower absorptive capacity and slightly smaller irrigated area per farm (see Table A.5.), will have developed nearly 18,000 hectares under manual cultivation or 51,000 hectares if animal traction is used. Such projections are well within the 204,000 hectares deemed easily irrigable by the technical report issued in 1978 by the United Nations Development Programme and the Food and Agricultural Organization, "OMVS: Etude Agro-Pedologique de la Vallee et du Delta du Fleuve Senégal" (Rome, AG:DR/RAF/73/060).

This implies the following annual rate of expansion of irrigated area, by country:

Years	Senegal/manual hectares	Senegal/animal traction hectares
1-5	365	750
6-11	1095	2250
11-15	1825	3750
16-20	2555	5250
21-25	3285	6750
26-30	4015	8250

Years	Mauritania/manual hectares	Mauritania/animal traction hectares
1-5	129	357
6-10	387	1071
11-15	644	1875
16-20	902	2625
21-25	1160	3375
26-30	1418	4125

The rates of expansion implied here assume a significant increase in managerial capacity on the part of national administrative bodies.

7.2. Population

Comparing the projected expansion of farm involvement in project interventions in Table A 4, with the population-by-farms expansion in Table A 2, it is seen that there will be a sufficient number of farms in the project zone, allowing for natural demographic growth and foreseeable migration, until the year 2005 (see Table A 29, for the comparison of farm numbers). By 2010, the rate of expansion of farms involved in project interventions will exceed the demographic projection in some zones. It is likely, however, that migration into the region will increase as a result of the improved profitability of agriculture in the region and will compensate for the gap.

7.3. Consumption

As stated in the IDP Executive Summary, one of the overriding concerns of the OMVS states has been to invest in irrigation as a means of decreasing the burden of foodgrain imports on trade balances (IDP, Executive Summary, p. 2.). To see what impact irrigation would have on local foodgrain markets, supply and demand figures have been calculated.

Assuming a per capita foodgrain consumption figure of 100 kilograms in urban areas and 150 kilograms in rural areas, Table A.30. estimates that 96 million tons of grain (primarily rice, maize and sorghum) will be consumed on the Senegalese side of the river, 95 million tons will be demanded by consumers in Mauritania and an estimated 93 million tons will be needed in Kayes and Bafoulabe, Mali by the year 2010.

Tables A.31., A.32. and A.33. compare these demand figures with production projections under rainfed and irrigated agriculture scenarios in Senegal, Mauritania and Mali (rainfed only, in Mali). Under an improved rainfed program, only in Mali will the increased production meet consumption needs; the Senegalese and Mauritanian riverine region will not be self-sufficient under such a program.

Alternatively, irrigation in these two countries could lead to an excess of foodgrain production over consumption, thereby contributing to grain needs outside the river basin, by as early as 1990 with animal traction in Senegal or as late as 2005 with manual cultivation only in Mauritania. By 2010, there would be an export out of the region of as much as 890 million tons of grain from farms under animal traction, or as little as 189 million tons from manually cultivated farms in Senegal and Mauritania combined.

8. MODEL SENSITIVITY

8.1. Base Case Assumptions

As stated in Section 4.2., assumptions about the level of traditional farm activity will critically affect rates of return. For example, when intercropping of dieri millet/sorghum with niébé is assumed in the existing farm systems of Podor and Brakna (thereby raising the value of traditional production and decreasing net incremental returns to irrigation), rates of return to manual irrigated cultivation are 10.8% and 17.8% without and with security benefits in Podor, and 5.7% and 10.3% in Brakna. The respective returns to animal traction cultivated irrigation are 13.1%, and 20.3% in Podor and 16.8% and 22.8% in Brakna. Clearly, the level and variability of existing production should be accurately specified in such a model.

8.2. Timing of Project costs

This model allows for project costs to be spread over time, increasing gradually as more farms are developed by the project. Though costs do outweigh the value of incremental benefits to the system during the first few years in any given zone, they are not designed to fall heavily in the first five project years. Were significant costs (such as technical assistance) added to the budgets' early years, the relative profitability of irrigated agriculture over improved rainfed agriculture would be compromised.

However, simply delaying the entire budget by five or ten years does not affect rates of return.

8.3. Rate of Extension Agent Training

Varying the algorithm which determines the pace of extension agent training by the same percent across all zones was found to change absolute, but not relative, rates of return.

9 SUMMARY

9.1. Costs of Development

The interventions described here do not come cheaply. The model estimates that from 1980 to 2010 $105 million (in constant 1983 prices) would be needed to finance a program of improved traditional agriculture in Senegal, Mauritania and Mali versus $472 million for the development of irrigated perimeters cultivated manually or $952 million for the development or irrigation using animal traction techniques in Senegal and Mauritania only. See Tables A.34. to A.36. for the schedules of investment costs. These exclude farm costs, as well as technical assistance, regional organization support, peripheral project components, and recurrent costs after the year 2010.

9.2. Data Weaknesses

Three components of the model should be studied further before model refinements are attempted. First, the assessment of incremental improvements must be based on a more disaggregated view of the existing farm system than that found in the IDP Agricultural Analysis. Second, the tradeoffs betwen manual and animal traction cultivation techniques must be more accurately specified and the process of farm-level adoption of traction better understood. Third, irrigated development obviously is the beneficiary of sunk research costs. More emphasis must be placed on developing a viable rainfed agriculture improvement package for the Middle and Upper Valley before such a package can truly be competitive with irrigation.

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Section 8

A.34. Project Investment Costs: Improved Rainfed Agriculture
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A.36. Project Investment Costs: Irrigated Agriculture/animal traction

A.1. Senegal River Basin Population Projections
('000)

Zone	% Growth Rate	1980	1985	1990	1995	2000	2005	2010
Dagana								
Rural	1.0216	114.10	126.97	141.28	157.22	174.95	194.67	216.63
Urban	1.0384	122.60	148.02	178.71	215.75	260.49	314.49	379.69
Total		236.70	274.98	319.99	372.97	435.43	509.16	596.32
Podor								
Rural	1.0218	137.70	153.38	170.84	190.29	211.96	236.09	262.97
Urban	1.0269	7.80	8.91	10.17	11.61	13.26	15.15	17.30
Total		145.50	162.29	181.01	201.91	225.22	251.24	280.27
Matam								
Rural	1.0216	156.40	174.04	193.66	215.50	239.80	266.84	296.94
Urban	1.0265	10.80	12.31	14.03	15.99	18.22	20.77	23.67
Total		167.20	186.35	207.69	231.49	258.03	287.61	320.61
Bakel								
Rural	1.0215	25.40	28.25	31.42	34.95	38.87	43.23	48.08
Urban	1.0263	3.40	3.87	4.41	5.02	5.71	6.51	7.41
Total		28.80	32.12	35.83	39.97	44.58	49.74	55.49
Total Senegal								
Rural	1.0217	433.60	482.63	537.21	597.96	665.58	740.84	824.62
Urban	1.0368	144.60	173.10	207.31	248.38	297.69	356.91	428.07
TOTAL		578.20	655.74	744.52	846.33	963.26	1097.75	1252.68

Trarza								
Rural	1.01	198.02	208.12	218.74	229.90	241.62	253.95	266.90
Urban	1.01	24.52	25.77	27.09	28.47	29.92	31.45	33.05
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Total		222.55	233.89	245.82	258.36	271.54	285.39	299.95
Brakna								
Rural	1.012	143.24	152.04	161.39	171.31	181.83	193.01	204.87
Urban	1.012	13.68	14.52	15.41	16.36	17.37	18.43	19.57
---		---	---	---	---	---	---	---
Total		156.92	166.56	176.80	187.67	199.20	211.44	224.44
Gorgol								
Rural	1.018	135.88	148.56	162.42	177.57	194.14	212.25	232.05
Urban	1.024	21.84	24.59	27.69	31.17	35.10	39.51	44.49
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Total		157.72	173.15	190.10	208.74	229.23	251.77	276.54
Guidimaka								
Rural	1.02	81.93	90.46	99.87	110.27	121.74	134.41	148.40
Urban	1.02	6.37	7.03	7.76	8.57	9.47	10.45	11.54
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Total		88.29	97.49	107.64	118.84	131.21	144.87	159.94
Total Mauritania								
Rural	1.0142	559.07	599.18	642.41	689.04	739.34	793.62	852.23
Urban	1.0165	66.41	71.91	77.95	84.57	91.85	99.84	108.64
---		---	---	---	---	---	---	---
TOTAL		625.47	671.09	720.36	773.61	831.18	893.47	960.87
Kayes								
Rural	1.0259	153.87	174.86	198.70	225.80	256.60	291.59	331.36
Urban	1.0267	55.03	62.78	71.62	81.71	93.21	106.34	121.31
---		---	---	---	---	---	---	---
Total		208.90	237.63	270.32	307.51	349.81	397.93	452.68
Bafoulabe								
Rural	1.0258	94.26	107.06	121.61	138.12	156.88	178.19	202.40
Urban	1.0269	8.04	9.18	10.48	11.97	13.67	15.61	17.83
---		---	---	---	---	---	---	---
Total		102.30	116.24	132.09	150.10	170.56	193.81	220.23
Total Mali								
Rural	1.0259	248.13	281.92	320.31	363.93	413.48	469.79	533.76
Urban	1.0267	63.07	71.96	82.10	93.68	106.88	121.95	139.14
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TOTAL		311.20	353.88	402.41	457.60	520.37	591.74	672.90
TOTAL SENEGAL RIVER BASIN								
RURAL	1.0194	1240.80	1363.73	1499.93	1650.92	1818.40	2004.25	2210.61
URBAN	1.0305	274.08	316.98	367.37	426.63	496.42	578.70	675.85
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TOTAL		1514.88	1680.71	1867.30	2077.55	2314.81	2582.96	2886.46

A.2. Number of Farms, Riverine Population
('000)

Zone	1980	1985	1990	1995	2000	2005	2010
Podor pop	129.44	144.16	160.59	178.87	199.24	221.92	247.19
(# farms = pop/10)	12.94	14.42	16.06	17.89	19.92	22.19	24.72
Matam pop	145.92	162.38	180.68	201.06	223.73	248.96	277.05
(# farms = pop/6)	24.32	27.06	30.11	33.51	37.29	41.49	46.17
Bakel pop	22.76	25.31	28.15	31.32	34.83	38.73	43.08
(# farms = pop/8)	2.84	3.16	3.52	3.91	4.35	4.84	5.38
Brakna pop	70.47	74.80	79.40	84.28	89.46	94.96	100.80
(# farms = pop/10)	7.05	7.48	7.94	8.43	8.95	9.50	10.08
Gorgol pop	73.24	80.07	87.54	95.71	104.64	114.40	125.07
(# farms = pop/6)	12.21	13.35	14.59	15.95	17.44	19.07	20.85
Guidim pop	58.99	65.13	71.91	79.39	87.65	96.78	106.85
(# farms = pop/8)	7.37	8.14	8.99	9.92	10.96	12.10	13.36
Kayes pop	153.87	174.86	198.70	225.80	256.60	291.59	331.36
(# farms = pop/13)	11.84	13.45	15.28	17.37	19.74	22.43	25.49
Bafoul pop	94.26	107.06	121.61	138.12	156.88	178.19	202.40
(# farms = pop/13)	7.25	8.24	9.35	10.62	12.07	13.71	15.57
Total Farms							
Senegal	48.47	53.95	60.05	66.84	74.39	82.80	92.16
Mauritania	36.21	39.04	42.11	45.43	49.04	52.95	57.20
Mali	19.09	21.69	24.64	27.99	31.81	36.14	41.06
Total	103.77	114.68	126.79	140.26	155.23	171.89	190.42

A.3. Training Schedule of Extension Agents

Yearly Training Capacity (total number of agents)

Year:	1	2	3	4	5	6	7	8	9	10	11
Senegal	-	10	20	30	40	50	70	90	110	130	150
Mauritania	-	5	10	15	20	25	35	45	55	65	75
Mali	-	10	20	30	40	50	70	90	110	130	150

A.4. Expansion of Farm Involvement Year by Year (total number of farms)

Zone	% Total	2	3	4	5	6	7	8	9	10	11
SENEGAL		500	1000	1500	2000	2500	4000	5500	7000	8500	10000
Podor	.43	215	430	645	860	1075	1720	2365	3010	3655	4300
Matam	.49	245	490	735	980	1225	1960	2695	3430	4165	4900
Bakel	.08	40	80	120	160	200	320	440	560	680	800
MAURITANIA		250	500	750	1000	1250	2000	2750	3500	4250	5000
Brakna	.35	88	175	263	350	438	700	963	1225	1488	1750
Gorgol	.36	90	180	270	360	450	720	990	1260	1530	1800
Guidimaka	.29	73	145	218	290	363	580	798	1015	1233	1450
MALI											
Kayes/ Bafoulabe		500	1000	1500	2000	2500	4000	5500	7000	8500	10000

A.3. Training Schedule of Extension Agents, cont.

Yearly Training Capacity

Year:	12	13	14	15	16	17	18	19	20	21
Senegal	180	210	240	270	300	340	380	420	460	500
Mauritania	90	105	120	135	150	170	190	210	230	250
Mali	180	210	240	270	300	340	380	420	460	500

A.4. Expansion of Farm Involvement Year by Year (total number of farms), cont

Zone	12	13	14	15	16	17	18	19	20	21
SENEGAL	12500	15000	17500	20000	22500	26000	29500	33000	36500	40000
Podor	5375	6450	7525	8600	9675	11180	12685	14190	15695	17200
Matam	6125	7350	8575	9800	11025	12740	14455	16170	17885	19600
Bakel	1000	1200	1400	1600	1800	2080	2360	2640	2920	3200
MAURITANIA	6250	7500	8750	10000	11250	13000	14750	16500	18250	20000
Brakna	2188	2625	3063	3500	3938	4550	5163	5775	6388	7000
Gorgol	2250	2700	3150	3600	4050	4680	5310	5940	6570	7200
Guidimaka	1813	2175	2538	2900	3263	3770	4278	4785	5293	5800
MALI										
Kayes/ Bafoulabe	12500	15000	17500	20000	22500	26000	29500	33000	36500	40000

A.3. Training Schedule of Extension Agents, cont.

Yearly Training Capacity

Year:	21	22	23	24	25	26	27	28	29	30	31
Senegal	500	550	600	650	700	750	810	870	930	990	1050
Mauritania	250	275	300	325	350	375	405	435	465	495	525
Mali	500	550	600	650	700	750	810	870	930	990	1050

A.4. Expansion of Farm Involvement Year by Year (total number of farms), cont

Zone	21	22	23	24	25	26	27	28	29	30	31
SENEGAL	40000	44500	49000	53500	58000	62500	68000	73500	79000	84500	90000
Podor	17200	19135	21070	23005	24940	26875	29240	31605	33970	36335	38700
Matam	19600	21805	24010	26215	28420	30625	33320	36015	38710	41405	44100
Bakel	3200	3560	3920	4280	4640	5000	5440	5880	6320	6760	7200
MAURITANIA	20000	22250	24500	26750	29000	31250	34000	36750	39500	42250	45000
Brakna	7000	7788	8575	9363	10150	10938	11900	12863	13825	14788	15750
Gorgol	7200	8010	8820	9630	10440	11250	12240	13230	14220	15210	16200
Guidimaka	5800	6453	7105	7758	8410	9063	9860	10658	11455	12253	13050
MALI											
Kayes/ Bafoulabe	40000	44500	49000	53500	58000	62500	68000	73500	79000	84500	90000

A.5. Expansion of Irrigated Land Area (hectares)

MANUAL TECHNIQUE		2	3	4	5	6	7	8	9	10	11	12	13
SENEGAL Area per farm													
Podor	.75	161	323	484	645	806	1290	1774	2258	2741	3225	4031	4838
Matam	.75	184	368	551	735	919	1470	2021	2573	3124	3675	4594	5513
Bakel	.50	20	40	60	80	100	160	220	260	340	400	500	600
Total		365	730	1095	1460	1825	2920	4015	5110	6205	7300	9125	10950
MAURITANIA													
Brakna	.75	66	131	197	263	328	525	722	919	1116	1313	1641	1969
Gorgol	.30/.75	27	54	81	108	135	216	297	378	459	540	675	810
Guidima	.50	36	73	109	145	181	290	399	508	616	725	906	1088
Total		129	258	387	516	644	1031	1418	1804	2191	2578	3222	3866
MALI													
Kayes/B	.75	375	750	1125	1500	1875	3000	4125	5250	6375	7500	9375	11250
ANIMAL TRACTION TECHNIQUE													
SENEGAL													
Podor	1.50	323	645	968	1290	1613	2580	3548	4515	5483	6450	8063	9675
Matam	1.50	368	735	1103	1470	1838	2940	4043	5145	6248	7350	9188	11025
Bakel	1.50	60	120	180	240	300	480	660	840	1020	1200	1500	1800
Total		750	1500	2250	3000	3750	6000	8250	10500	12750	15000	18750	22500
MAURITANIA													
Brakna	1.50	131	263	394	525	656	1050	1444	1838	2231	2625	3281	3938
Gorgol	1.30/1.50	117	234	351	468	585	936	1341	1746	2151	2556	3231	3906
Guidima	1.50	109	218	326	435	544	870	1196	1523	1849	2175	2719	3263
Total		357	714	1071	1428	1785	2856	3981	5106	6231	7356	9231	11106
MALI													
Kayes/B	1.50	750	1500	2250	3000	3750	6000	8250	10500	12750	15000	18750	22500

A.5. Expansion of Irrigated Land Area (hectares)

MANUAL TECHNIQUE

14	15	16	17	18	19	20	21	22	23	24	25	26	27
5644	6450	7256	8385	9514	10643	11771	12900	14351	15803	17254	18705	20156	21930
6431	7350	8269	9555	10841	12128	13414	14700	16351	18008	19661	21315	22969	24190
700	800	900	1040	1180	1320	1460	1600	1780	1960	2140	2320	2500	2720
12775	14600	16425	18980	21535	24090	26645	29200	32485	35770	39055	42340	45625	49640
2297	2625	2953	3413	3872	4331	4791	5250	5841	6431	7022	7613	8203	8925
945	1080	1215	1404	1593	1782	1971	2160	2403	2646	2889	3132	3375	3672
1269	1450	1631	1885	2139	2393	2646	2900	3226	3553	3879	4205	4531	4930
4511	5155	5799	6702	7604	8506	9408	10310	11470	12630	13790	14950	16109	17527
13125	15000	16875	19500	22125	24750	27375	30000	30000	30000	30000	30000	30000	30000

ANIMAL TRACTION TECHNIQUE

11288	12900	14513	16770	19028	21285	23543	25800	28703	31605	34508	37410	40313	43860
12863	14700	16538	19110	21683	24255	26828	29400	32708	36015	39323	42630	45938	49980
2100	2400	2700	3120	3540	3960	4380	4800	5340	5880	6420	6960	7500	8160
26250	30000	33750	39000	44250	49500	54750	60000	66750	73500	80250	87000	93750	102000
4594	5250	5906	6825	7744	8663	9581	10500	11681	12863	14044	15225	16406	17850
4581	5256	5931	6876	7821	8766	9711	10656	11871	13086	14301	15516	16731	18216
3806	4350	4894	5655	6416	7178	7939	8700	9679	10658	11636	12615	13594	14790
12981	14856	16731	19356	21981	24606	27231	29856	33231	36606	39981	43356	46731	50856
26250	26250	26250	26250	26250	26250	26250	26250	26250	26250	26250	26250	26250	26250

A.6. Traditional Riverine Farm Budgets

Zone	Crop	Area (ha)	Yield (kg/ha)	Price (local P)	Value of Prod (local P)	Seed Cost	Sm Tools Cost	Farm Transport Cost	Income	# Labor Days	Value of Household Labor
Podor	Dieri/sorg	2.00	150	71.3	21390						
	Walo/sorgh	3.00	450	71.3	96255						
	Total	5.00			117645	5350	7018	2000	103277	290	145000
Matam	Dieri/sorg	1.25	150	68.3	12806						
	Dieri/nieb	1.25	300	85	31875						
	Walo/sorgh	1.90	450	68.3	58397						
	Total	3.15			103078	5570	7018	2000	88490	183	91500
Bakel	Dieri/sorg	1.60	400	68.3	43712						
	Dieri/nieb	1.60	150	85	20400						
	Dieri/mill	.40	250	68.3	6830						
	Dieri/nieb	.40	150	85	5100						
	Walo/sorgh	1.36	450	68.3	41800						
	Total	3.36			117842	7692	7018	2000	101132	208	104000
Brakna	Dieri/sorg	2.00	150	16.2	4860						
	Walo/sorgh	3.00	450	16.2	21870						
	Total	5.00			26730	1200	1490	400	23640	290	29000
Gorgol	Dieri/sorg	1.25	150	16.2	3038						
	Dieri/nieb	1.25	300	22	8250						
	Walo/sorgh	1.90	450	16.2	13851						
	Total	3.15			25146	1381	1490	400	21875	183	16300
Guidimaka	Dieri/sorg	1.60	400	17	10880						
	Dieri/nieb	1.60	150	22	5280						
	Dieri/mill	.40	250	17	1700						
	Dieri/nieb	.40	150	22	1320						
	Walo/sorgh	1.36	450	17	10404						
	Total	3.36			29584	1806	1490	400	25888	208	20800
Kayes/Bafmanual	Dieri/sorg	1.45	800	139.4	161704						
	Maize	.44	950	141.8	59272						
	Peanuts	.57	750	270	115425						
	Rice	.08	850	149.9	10193						
	Walo	.05	800	139.4	5576						
	Total	2.59			352305	8348	12300	6000	325657	406	304500
Kayes/Baf animal traction	Dieri/sorg	1.16	880	139.4	142300						
	Maize	.35	1045	141.8	51863						
	Peanuts	.57	825	270	126968						
	Rice	1.80	935	149.9	252282						
	Total	3.88			573408	22760	12300	8000 (also: 80717 oxen care)	449631	523	392250

A.7. Improved Traditional Riverine Farm Budgets: Years 7-plus

Zone	Crop	Area (ha)	Yield (kg/ha)	Price (local P)	Value of Prod (local P)	Seed Cost	Sm Tools Cost	Farm Transport Cost	Income	# Labor Days	Value of Household Labor
Podor											
Matam	Dieri/sorg	1.25	450	68.3	38419						
	Dieri/nieb	1.25	400	85	42500						
	Walo/sorgh	1.90	750	68.3	97328						
	Total	3.15			178246	6988	7018	3000	161240	218	108825
Bakel	Dieri/sorg	1.60	700	68.3	76496						
	Dieri/nieb	1.60	250	85	34000						
	Dieri/mill	.40	550	68.3	15026						
	Dieri/nieb	.40	250	85	8500						
	Walo/sorgh	1.36	750	68.3	69666						
	Total	3.36			203688	9204	7018	4000	183466	245	122480
Brakna											
Gorgol	Dieri/sorg	1.25	450	16.2	9113						
	Dieri/nieb	1.25	400	22	11000						
	Walo/sorgh	1.90	750	16.2	23085						
	Total	3.15			43198	1665	1490	600	39443	218	21765
Guidimaka	Dieri/sorg	1.60	700	17	19040						
	Dieri/nieb	1.60	250	22	8800						
	Dieri/mill	.40	550	17	3740						
	Dieri/nieb	.40	250	22	2200						
	Walo/sorgh	1.36	750	17	17340						
	Total	3.36			51120	2108	1490	1200	46322	245	24496
Kayes/Bafi manual	Dieri/sorg	1.45	1100	139.4	222343						
	Maize	.44	1250	141.8	77990						
	Rice	.08	1150	149.9	13791						
	Walo	.05	1100	139.4	7667						
	Total	2.02			321791	10810	12300	10000	288681	434	325668
Kayes/Bafi animal	Dieri/sorg	1.16	1280	139.4	206981						
	Maize	.35	1445	141.8	71715						
	Rice	1.80	1335	149.9	360210						
	Total	3.31			638906	31454	12300	22000 (also: 80717 oxen care)	642488	554	415530

A.8. Project Costs, Improved Rainfed Agriculture

Mali IBRD Project Paper: Per farm expenditures (US 1983 $)

	PY1	PY2	PY3	PY4	PY5
COMMODITIES					
Furniture and equipment	.25	2.74	2.69	.15	
Vehicles, Field(no expat)	.96	3.92	.98	1.09	3.92
Lorries	2.38	1.18			
SUBTOTAL, COMMODITIES	3.59	7.85	3.67	1.24	3.92
OPERATING					
Local Staff, Field	4.29	5.84	6.53	6.7	6.83
Gar & Wkshop staff, Field	.23	.28	.43	.46	.47
Operatg Exp, Field Office	.11	.17	.26	.31	.34
Operatg Exp, GenGarage	.15	.26	.39	.47	.53
Vehicles M&O,Field&Garage	2.8	3.51	4.03	4.1	4.1
Motor-& Bicycles, M&O	.38	.44	.59	.63	.67
Lorries, M&O	1.12	1.19	1.09	.96	.91
SUBTOTAL, OPERATING	9.07	11.69	13.32	13.64	13.85
Total in US $$	12.66	19.54	16.99	14.88	17.78
Senegal total in CFA	3798	5861	5097	4464	5333
Sub, Commodities	1076	2354	1102	372	1177
Sub, Operating Costs	2722	3507	3995	4092	4156
Mali Total in MF	7596	11722	10195	8928	10666
Sub, Commodities	2151	4707	2205	744	2354
Sub, Operating Costs	5445	7015	7990	8184	8313
Mauritania, Total in UM	760	1172	1019	893	1067
Sub, Commodities	215	471	220	74	235
Sub, Operating Costs	544	701	799	818	831

A.9. Rates of Return, Improved Rainfed, Matam

(million CFA)

	1983	1984	1985	1986	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				245	1225	4900	11025	19600	30625	30625
Incremental Value of Production				12.49	58.90	142.14	165.60	350.33	604.77	871.25
Project costs			36.29	76.39	6.36	75.46	57.27	101.82	159.10	159.10
Extension costs				4.33	70.72	141.43	318.22	565.72	883.94	883.94
Incremental Farm Costs										
Seeds				.35	1.63	4.42	6.15	10.94	17.09	
Transport				.25	1.23	4.90	11.03	19.60	30.63	
Subtotal				.59	2.86	9.32	17.18	30.54	47.71	47.71
Incremental Labor Costs				4.24	19.94	54.17	75.80	134.75	210.55	210.55
Total Costs			36.29	85.56	99.88	230.38	468.47	832.83	1301.30	
Net returns			-36.29	-73.06	-40.98	-88.23	-302.87	-482.50	-696.54	-430.05

Net present value @ 15% -534.932

Internal rate of return negative

A.10. Rates of Return, Improved Rainfed Agriculture/manual, Bakel

(million CFA)

	1983	1984	1985	1986	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				40	200	800	1800	3200	5000	5000
Incremental Value of Production				2.35	11.31	36.31	67.13	129.12	213.08	262.03
Project costs			5.92	12.47	1.04	4.16	9.35	16.62	25.98	25.98
Extension costs				.75	12.32	24.63	55.42	98.52	153.94	153.94
Incremental Farm Costs										
Seeds				.06	.29	.92	1.62	2.89	4.51	
Transport				.08	.40	1.60	3.60	6.40	10.00	
Subtotal				.14	.69	2.52	5.22	9.29	14.51	14.51
Incremental Labor Costs				.74	3.55	11.19	19.80	35.20	55.00	55.00
Total Costs			5.92	14.11	17.59	42.50	89.79	159.63	249.42	
Net returns			-5.92	-11.76	-6.28	-6.19	-22.66	-30.01	-36.35	12.61

Net present value @ 15% -44.9263
Internal rate of return negative

A.11. Rates of Return, Improved Rainfed Agriculture/manual, Gorgol

(million UM)

	1983	1984	1985	1986	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				90	450	1800	4050	7200	11250	11250
Incremental Value of Production				1.10	5.21	12.72	15.24	32 01	55.06	78.51
Project costs			2.66	5.61	.47	1.87	4.21	7.48	11.69	11.69
Extension costs				.38	6.19	12.38	27.85	49.51	77.36	77.36
Incremental Farm Costs										
Seeds				.03	.12	.33	.46	.82	1.28	
Transport				.02	.09	.36	.81	1.44	2.25	
Subtotal				.04	.21	.69	1.27	2.26	3.53	3.53
Incremental Labor Costs				.31	1.47	3.98	5.57	9.90	15.47	15.47
Total Costs			2.66	6.35	8.33	18.91	38.90	69.15	108.05	
Net returns			-2.66	-5.24	-3.12	-6.19	-23.66	-37.14	-52.98	-29.53

Net present value @ 15% -40.6397
Internal rate of return negative

A.12. Rates of Return, Improved Rainfed Agriculture/manual, Guidimaka

(million UM)

	1983	1984	1985	1986	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				73	363	1450	3263	5800	9063	9063
Incremental Value of Production				1.07	5.16	16.58	30.77	59.37	97.55	119.78
Project costs			2.15	4.52	.38	1.51	3.39	6.03	9.43	9.43
Extension costs				.05	2.22	4.43	9.98	17.73	27.71	27.71
Incremental Farm Costs										
Seeds				02	.11	.33	.59	1.06	1.65	
Transport				.06	.29	1.16	2.61	4.64	7.25	
Subtotal				.08	.40	1.49	3.20	5.70	8.90	8.90
Incremental Labor Costs				.27	1.29	4.05	7.17	12.74	19.90	19.90
Total Costs			2.15	4.92	4.28	11.49	23.74	42.20	65.94	
Net returns			-2.15	-3.85	.88	5.09	7.03	17.17	31.61	53.84

Net present value @ 15% 17.24411
Internal rate of return 28.2

A.13. Rates of Return, Improved Rainfed Agriculture/manual, Kayes/Bafoulabe

(million MF)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				2500	10000	22500	40000	62500	62500
Incremental Value of Production				141.05	611.08	1458.81	2727.31	4398.73	5036.56
Project costs			148.05	25.98	103.91	233.80	415.65	649.45	649.45
Extension costs				147.85	295.70	665.33	1182.80	1848.13	1848.13
Incremental Farm Costs									
Seeds				6.04	21.92	45.27	80.48	125.75	
Transport				10.00	40.00	90.00	160.00	250.00	
Subtotal				16.04	61.92	135.27	240.48	375.75	375.75
Incremental Labor Costs				53.32	211.22	471.56	838.32	1309.88	1309.88
Total Costs			148.05	243.19	672.75	1505.95	2677.25	4183.21	
Net returns			-148.05	-102.14	-61.67	-47.14	50.06	215.53	653.36
Net present value @ 15%	-518.306								
Internal rate of return	8.6								

A.14. Rates of Return, Improved Rainfed Agriculture/animal traction, Kayes/Bafoulabe

(million MF)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Improved Rainfed Farms				2500	10000	22500	40000	62500	62500
Incremental Value of Production				240.58	1202.89	3127.51	6014.44	9863.68	12028.88
Project costs			148.05	25.98	103.91	233.80	415.65	649.45	649.4531
Extension costs				221.49	442.98	996.70	1771.92	2768.62	2768.623
Incremental Farm Costs									
Seeds				21.74	86.94	195.62	347.76	543.38	
Transport				35.00	140.00	315.00	560.00	875.00	
Subtotal				56.74	226.94	510.62	907.76	1418.38	1418.375
Incremental Labor Costs				58.20	232.80	523.80	931.20	1455.00	1455
Total Costs			148.05	362.40	1006.63	2264.92	4026.53	6291.45	
Net returns			-148.05	-121.83	196.26	862.59	1987.91	3572.23	5737.424
Net present value @ 15%	1366.869								
Internal rate of return	22.9								

A.15. Irrigated Farm Budgets (manual technique) Years 7-plus

Zone	Crop	Area (ha)	Yield (kg/ha)	Price (local P)	Value of Prod (local P)	Farm Costs	Income	# Labor Days	Value of Household Labor
Podor	Rice	.25	9500	76.7	182163				
	Corn	.25	3500	72.5	63438				
	Sorghum	.25	3250	71.5	58094				
	Tomatoes	.25	22000	20	110000				
	Niebe	.25	2100	85	44625				
	Walo	3.00	450	71.3	96255				
	Total	3.75			554574	134480	420094	485	242500
Matam	Rice	.25	9500	74.7	177413				
	Corn	.25	3500	69.5	60813				
	Sorghum	.25	3250	68.3	55494				
	Tomatoes	.25	22000	20	110000				
	Niebe	.25	2100	85	44625				
	Walo	3.00	450	68.3	92205				
	Total	3.75			540549	134480	406069	485	242500
Bakel	Rice	.25	9500	74.7	177413				
	Corn	.25	3500	69.5	60813				
	Sorghum	.125	3250	68.3	27747				
	Niebe	.125	2100	85	22313				
	Walo	1.00	450	68.3	30735				
	Dieri	2.00	500	68.3	68300				
	Total	3.50			387319	93038	294281	408	204000
Brakna	Rice	.25	9500	15.6	37050				
	Corn	.25	3500	16.4	14350				
	Sorghum	.25	3250	16.2	13163				
	Tomatoes	.25	22000	5	27500				
	Niebe	.25	2100	22	11550				
	Walo	3.00	450	16.2	21870				
	Total	3.75			125483	27646	97837	485	48500
Gorgol (Yrs 1-6)	Rice	.20	8500	15.6	26520				
	Corn	.07	2500	16.4	2870				
	Sorghum	.07	2500	16.2	2835				
	Tomatoes	.03	18000	5	2700				
	Niebe	.03	1800	22	1188				
	Walo	2.00	450	16.2	14580				
	Dieri	1.00	450	16.2	7290				
	Total	3.30			57983	13317	44666	306	30600
Guidimaka	Rice	.08	9500	16.1	12236				
	Corn	.31	3500	17.2	18662				
	Sorghum	31	3250	17	17128				
	Tomatoes	.11	22000	5	12100				
	Niebe	.11	2100	22	5082				
	Walo	1.00	450	17	7650				
	Dieri	2.00	500	17	17000				
	Total	3.50			89858	18342	71516	394	39400

A.15.a. Irrigated Farm Budgets (animal traction technique) Years 7-plus

Zone	Crop	Area (ha)	Yield (kg/ha)	Price (local P)	Value of Prod (local P)	Farm Costs	Income	# Labor Days	Value of Household Labor
Podor	Rice	.50	12500	76.7	479375				
	Corn	.50	4500	72.5	163125				
	Sorghum	.50	4250	71.5	151938				
	Tomatoes	.50	25000	20	250000				
	Niebe	.50	2800	85	119000				
	Walo	2.50	450	71.3	80213				
	Total	4.00			1243650	413166	830484	655	327500
Matam	Rice	.50	12500	74.7	466875				
	Corn	.50	4500	69.5	156375				
	Sorghum	.50	4250	68.3	145138				
	Tomatoes	.50	25000	20	250000				
	Niebe	.50	2800	85	119000				
	Walo	2.50	450	68.3	76838				
	Total	4.00			1214225	413166	801059	655	327500
Bakel	Rice	.75	12500	74.7	700313				
	Corn	.75	4500	69.5	234563				
	Sorghum	.375	4250	68.3	108853				
	Niebe	.375	2800	85	89250				
	Walo	1.00	450	68.3	30735				
	Dieri	1.00	550	68.3	37565				
	Total	3.50			1201278	279769	921509	600	300000
Brakna	Rice	.50	12500	15.6	97500				
	Corn	.50	4500	16.4	36900				
	Sorghum	.50	4250	16.2	34425				
	Tomatoes	.50	25000	5	62500				
	Niebe	.50	2800	22	30800				
	Walo	2.50	450	16.2	18225				
	Total	4.00			200350	85070	195280	655	65500
Gorgol (Yrs 1-6)	Rice	.90	12500	15.6	175500				
	Corn	.27	4500	16.4	19926				
	Sorghum	.27	4250	16.2	18590				
	Tomatoes	.13	25000	5	16250				
	Niebe	.13	2800	22	8008				
	Walo	1.00	450	16.2	7290				
	Dieri	.00	450	16.2	0				
	Total	2.30			245564	77096	168468	546	54600
Guidimaka	Rice	.30	12500	16.1	60375				
	Corn	.83	4500	17.2	64242				
	Sorghum	.83	4250	17	59968				
	Tomatoes	.37	25000	5	46250				
	Niebe	.37	2800	22	22792				
	Walo	1.00	450	17	7650				
	Dieri	1.00	550	17	9350				
	Total	3.50			270627	79625	191002	558	55800

A.16. Project Costs, Irrigated Agriculture ('000 local currency)

	PY1	PY2	PY3	PY4	PY5
Construction Costs per farm					
Podor	18.81	377.61	355 97	295 95	386.83
Matam	18.81	377.61	355.97	295.95	386.83
Bakel	490.80	306.30	28.82		
Brakna	3.76	76.01	71.19	59.25	77.37
Gorgol	17.68	20.57	22.25	43.59	43.59
Guidimaka	28.05	32.63	35.29	12.00	3.13
Irrigation Equipment Costs					
Podor	178.0[illegible]	52.21	76.48		
Matam	178.08	52.21	76.48		
Bakel	105.04	63.03	21.85		
Brakna	35.62	10.44	15.30		
Gorgol	13.04	13.04			
Guidimaka	4.55				
Commodities Costs:					
Senegal	22.24	8.18		17.17	
Mauritania	9.81	.43		8.90	
Operating Costs:					
Senegal	4.42	9.32	10.14	10.14	
Mauritania	6.15	6.15	4.28	4.28	

A.17. Rates of Return, Irrigated Agriculture/manual, Podor

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			215	1720	5375	11180	19135	29240	29240
Incremental Value of Production			77.37	618.94	2017.04	4354.53	7631.42	11847.71	12775.77
Project costs		29.69	110.14	488.99	1081.22	1686.12	2303.66	2900.38	220.46
Extension costs		.91	4.19	16.25	44.33	87.17	144.80	200.94	200.94
Incremental Farm Costs									
Seeds			.75	6.00	18.76	39.02	66.78	102.05	
Fertilizer			10.07	80.60	251.87	523.89	896.67	1370.19	
Chemicals			1.48	11.83	36.98	76.92	131.65	201.17	
Fixed chg perim maint			3.70	29.64	92.61	192.63	329.70	503.81	
Water			8.15	65.22	203.82	423.95	725.60	1108.78	
Small tools			.29	2.34	7.32	15.23	26.06	39.82	
Farm transport			.65	5.16	17.20	37.84	67.06	104.92	
Seasonal wkg capital			.51	4.08	12.74	26.50	45.35	69.30	
Subtotal		.00	25.61	204.87	641.30	1335.97	2288.68	3500.03	3500.03
Incremental Labor Costs		19.35	39.38	218.30	607.78	1216.07	2049.16	2888.21	3002.95
Total Costs		49.95	179.32	928.42	2374.63	4327.34	6786.50	9489.57	
Net returns with project		-49.95	-101.95	-309.48	-357.59	27.19	844.92	2358.14	5851.39
Net present value @ 15%	67.77611								
Internal rate of return	15.3								
Increased benefits to security			15.32	122.55	382.96	796.56	1363.35	2083.32	2083.32
New net returns w/security		-49.95	-86.64	-186.93	25.37	823.75	2208.27	4441.46	7934.71
New NPV	1861.580								
New IRR	23.3								

A.18. Rates of Return, Irrigated Agriculture/animal traction, Podor

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			215	1720	5375	11180	19135	29240	29240
Incremental Value of Production			206.72	1656 53	5396.14	11634.38	20292.62	31405.33	33380.94
Project costs		32.73	202.78	959.38	2140.40	3355.22	4603.84	5819.52	459.68
Extension costs		1.81	8.38	32 51	88.65	174.35	289 60	401 89	401.89
Incremental Farm Costs									
Seeds			1.99	16.02	51.48	109.45	187 33	286.26	
Fertilizer			37.87	302.98	946.81	1969.36	3370.63	5150.63	
Chemicals			10.32	82.56	258.00	536.64	918.48	1403.52	
Fixed chg perim maint			6.76	54 11	169.10	351.72	601.99	919.89	
Water			16.31	130 46	407.69	848.00	1451.39	2217.85	
Small tools			.29	2.34	7.32	15.23	26.06	39.82	
Farm transport			1.94	15.48	48.38	100.62	172.22	263 16	
Seasonal wkg capital			1.69	13 53	42.29	87.96	150.55	230.06	
Oxen bought/sold		12.04	24.08	133 95	312.21	500.53	695.57	764.90	
Animal care			7.49	59.94	187.31	389.60	666.82	1018.96	
Animtrac equip repaymt			5.39	37.70	97.96	180 65	295.38	442.14	
Subtotal		12.04	114 13	849 07	2528.55	5089.77	8536 41	12737.18	12737.18
Incremental Labor Costs		38.70	73.96	400.33	1135.20	2323.72	3904.62	5479 06	5701.8
Total Costs		85.28	399.25	2241.28	5892.80	10943.06	17334.47	24437.65	
Net returns with project		-85.28	-192.53	-584.76	-496.66	691.33	2958.15	6967.68	14060.39
Net present value @ 15%	1393.449								
Internal rate of return	18.1								
Increased benefits to security			27.38	219	684.39	1423 53	2436.42	3723.07	3723.07
New net returns w/security		-85.28	-165.15	-365.76	187.73	2114.86	5394.57	10690.75	17803.46
New NPV	4170.198								
New IRR	25.5								

A.19. Rates of Return, Irrigated Agriculture/manual, Matam

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			245	1960	6125	12740	21805	33320	33320
Incremental Value of Production			91.72	726.36	2248.35	4664.93	8187.58	12723 56	13781.15
Project costs		30.12	123.07	554.04	1224.65	1907.95	2603.87	3274.32	220.46
Extension costs		1.03	4.78	18.52	50.51	99.34	165.00	228.98	228.98
Incremental Farm Costs									
Seeds			.80	6.19	15.88	27.26	46.66	71.30	
Fertilizer			11.48	91.85	287.02	597.00	1021.78	1561.38	
Chemicals			1.69	13.48	42.14	87.65	150.02	229.24	
Fixed chg perim maint			4.22	33.77	105.53	219.51	375.70	574.10	
Water			9.29	74.32	232.26	483.10	826.85	1263.49	
Small tools			.33	2.67	8.34	17.35	29.70	45.38	
Farm transport			.74	5.88	19.60	43.12	76.44	119.56	
Seasonal wkg capital			.58	4.65	14.52	30.19	51.68	78.97	
Subtotal		.00	29.13	232.81	725.29	1505.19	2578.83	3943.43	3943.43
Incremental Labor Costs		22.05	57.98	348.23	919.22	1719.27	2902.02	4157.53	4288.28
Total Costs		53.20	214.95	1153.60	2919.66	5231.75	8249.72	11604.27	
Net returns with project		-53.20	-123.23	-427.24	-671.32	-566.82	-62.14	1119.29	5099.99
Net present value @ 15%	-1027.47								
Internal rate of return	11								
Increased benefits to security			17.46	139.65	436.40	907.71	1553.58	2374.02	2374.02
New net returns w/security		-53.20	-105.78	-287.59	-234.92	340.89	1491.45	3493.31	7474.01
New NPV	850.9241								
New IRR	18.2								

A.20. Rates of Return, Irrigated Agriculture/animal traction, Matam

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			245	1960	6125	12740	21805	33320	33320
Incremental Value of Production			239.13	1908 73	6098.99	12960.69	22615.65	35010.45	37261.72
Project costs		33.57	228.63	1089 47	2427.27	3798.87	5204 27	6567.41	459.68
Extension costs		2.06	9.55	37 04	101.02	198 68	330.01	457.97	457.97
Incremental Farm Costs									
Seeds			2.21	17.60	53.13	107.40	183 82	280.89	
Fertilizer			43.16	345.25	1078.92	2244.15	3840.95	5369 32	
Chemicals			11.76	94.08	294.00	611.52	1046.64	1599.36	
Fixed chg perim maint			7.71	61.66	192.69	400.80	685.99	1048.25	
Water			18.58	148.67	464.58	966.33	1653.91	2527.32	
Small tools			.33	2.67	8.34	17.35	29.70	45.38	
Farm transport			2.21	17.64	55.13	114.66	196.25	299.88	
Seasonal wkg capital			1.93	15 42	48.19	100.24	171.56	262 16	
Oxen bought/sold		13.72	27.44	152.64	355.77	570.37	792 62	871.63	
Animal care			8.54	68.30	213.44	443 96	759.86	1161.14	
Animtrac equip repaymt			6.14	42.96	111.63	205.86	336.59	503.83	
Subtotal		13.72	130.00	966.89	2875.83	5782.64	9697.88	14469.15	14469.15
Incremental Labor Costs		44.10	98.90	567.77	1558.58	3059.94	5155.65	7323.85	7583.30
Total Costs		93.46	467.09	2661.17	6962.70	12840 13	20387.81	28818.38	
Net returns with project		-93.46	-227.96	-752.45	-863.71	120.56	2227.85	6192.07	14291.63
Net present value @ 15%	351.0185								
Internal rate of return	15.7								
Increased benefits to security			31.20	249.56	779.88	1622.16	2776.39	4242.57	4242.57
New net returns w/security		-93.46	-196.76	-502.89	-83.83	1742.72	5004.24	10434.64	18534.20
New NPV	3509.522								
New IRR	22.5								

A.21. Rates of Return, Irrigated Agriculture/manual, Bakel

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			40	320	1000	2080	3560	5440	5440
Incremental Value of Production		.00	8.95	71.98	239.59	525.09	918.37	1423.86	1526.08
Project costs		36.48	35.54	79.22	103.10	307.98	456.50	608.94	287.66
Extension costs		.11	.52	2.02	5.50	10.81	17.96	24.92	24.92
Incremental Farm Costs									
Seeds			.02	.13	.60	1.56	2.66	4.07	
Fertilizer			1.12	8.95	27.97	58.18	99.57	152.16	
Chemicals			.05	.43	1.34	2.79	4.77	7.29	
Pump operation			1.61	12.91	40.35	83.93	143.65	219.50	
Pump loan repayment			1.17	9.35	29.23	60.80	104.06	159.01	
Small tools			.05	.44	1.36	2.83	4.85	7.41	
Farm transport			.08	.64	2.20	4.96	8.92	14.08	
Seasonal wkg capital			.08	.62	1.93	4.01	6.86	10.49	
Subtotal		.00	4.18	33.47	104.98	219.05	375.34	574.01	574.01
Incremental Labor Costs		3.60	7.36	41.13	119.32	247.35	417.01	592.31	615.16
Total Costs		40.19	47.60	155.84	332.90	785.19	1266.82	1800.18	
Net returns with project		-40.19	-38.64	-83.86	-93.30	-260.10	-348.45	-376.32	24.34
Net present value @ 15%	-507.3								
Internal Rate of Return	-7.7								
Increased benefits to security			2.85	22.80	71.25	148.20	253.65	387.60	387.60
New net returns w/security		-40.19	-35.79	-61.06	-22.05	-111.90	-94.80	11.28	411.94
New NPV	-218.744								
New IRR	7.9								

A.22. Rates of Return, Irrigated Agriculture/animal traction, Bakel

(million CFA)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			40	320	1000	2080	3560	5440	5440
Incremental Value of Production		.00	37.86	303.24	980.54	2101.31	3655.45	5647.40	5954.11
Project costs		56.11	71.63	196.25	234.01	767.43	1101.97	1457.90	545.22
Extension costs		.34	1.56	6.05	16.49	32.44	53.88	74.77	74.77
Incremental Farm Costs									
Seeds			.31	2.51	8.03	17.00	29.10	44.47	
Fertilizer			7.07	56.54	176.69	367.52	629.03	961.21	
Chemicals			.47	3.79	11.85	24.64	42.18	64.45	
Pump operation			4.62	36.94	115.44	240.11	410.95	627.97	
Pump loan repayment			3.51	28.05	87.66	182.33	312.07	476.87	
Small tools			.05	.44	1.36	2.83	4.85	7.41	
Farm transport			.44	3.52	11.40	24.48	42.76	66.24	
Seasonal wkg capital			.21	1.66	5.20	10.81	18.49	28.26	
Oxen bought/sold		2.24	4.48	24.92	46.89	93.12	129.41	142.31	
Animal care			1.27	10.15	31.72	65.96	112.92	172.56	
Animtrac equip repaymt			1.00	7.01	18.23	33.61	54.95	82.26	
Subtotal		2.24	23.43	175.54	525.65	1062.44	1786.72	2674.01	2674.01
Incremental Labor Cost		7.70	14.69	81.80	231.57	470.35	789.93	1114.71	1147.84
Total Costs		65.88	111.31	459.63	1007.72	2332.65	3732.50	5321.39	
Net returns with project		-65.88	-73.45	-156.39	-27.18	-231.34	-77.04	326.01	1512.27
Net present value @ 15%	-326.441								
Internal rate of return	10.9								
Increased benefits to security			5.09	40.75	127.32	264.84	453.28	692.67	692.66
New net returns w/security		-65.88	-68.36	-115.64	100.14	33.50	376.24	1018.68	2204.93
New NPV	189.2326								
New IRR	17.4								

A.23. Rates of Return, Irrigated Agriculture/manual, Brakna

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of irrigated farms			88	700	2188	4550	7788	11900	11900
Incremental Value of Production			7.13	56.75	185.12	399.81	701.32	1088.54	1175.24
Project costs		16.21	14.19	49.43	119.46	203.68	302.19	412.17	193.66
Extension costs		.09	.41	1.58	4.30	8.45	14.04	19.48	19.48
Incremental Farm Costs									
Seeds			.10	.81	2.54	5.29	9.05	13.83	
Fertilizer			.85	6.75	21.10	43.88	75.12	114.78	
Chemicals			.11	.88	2.75	5.73	9.81	14.98	
Fixed chg perim maint			.30	2.41	7.54	15.68	26.84	41.01	
Water			.67	5.31	16.59	34.51	59.06	90.25	
Small tools			.02	.13	.41	.85	1.45	2.21	
Farm transport			.05	.42	1.40	3.08	5.46	8.54	
Seasonal wkg capital			.04	.33	1.04	2.16	3.69	5.64	
Subtotal		.00	2.14	17.05	53.38	111.17	190.47	291.24	291.24
Incremental Labor Costs		7.92	9.39	36.10	78.93	139.00	215.96	223.48	232.05
Total Costs		24.22	26.13	104.15	256.07	462.29	722.66	946.36	
Net returns with project		-24.22	-19.00	-47.40	-70.95	-62.48	-21.64	142.18	438.81
Net present value @ 15%	-148.994								
Internal rate of return	9.6								
Increased benefits to security			1.25	9.98	31.10	64.84	110.98	169.58	169.58
New net returns w/security		-24.22	-17.75	-37.43	-39.77	2.35	89.34	311.75	608.39
New NPV	-22.7299								
New IRR	14.2								

A.24. Rates of Return, Irrigated Agriculture/animal traction, Brakna

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			88	700	2188	4550	7788	11900	11900
Incremental Value of Production			18.99	151.28	493.43	1064.53	1857.80	2875.93	3061.51
Project costs		16.46	21.74	87.27	202.99	332.86	477.06	629.97	193.66
Extension costs		.18	.81	3.15	8.60	16.91	28.08	38.97	38.97
Incremental Farm Costs									
Seeds			.24	1.89	6.03	12.76	21.85	33.38	
Fertilizer			3.28	26.07	81.50	169.47	290.08	443.24	
Chemicals			.85	6.75	21.10	43.87	75.09	114.74	
Fixed chg perim maint			.55	4.40	13.77	28.63	49.00	74.87	
Water			1.33	10.62	33.19	69.02	118.14	180.52	
Small tools			.00	.00	.00	.00	.00	.00	
Farm transport			.16	1.26	3.94	8.19	14.02	21.42	
Seasonal wkg capital			.14	1.10	3.44	7.16	12.26	18.73	
Oxen bought/sold		.99	1.96	10.90	25.42	40.74	56.63	62.27	
Animal care			.61	4.88	15.25	31.71	54.28	82.94	
Animtrac equip repaymt			.41	2.84	7.39	13.62	22.27	33.33	
Subtotal		.99	9.53	70.71	211.02	425.18	713.62	1065.45	1065.448
Incremental Labor Costs		3.17	6.02	32.60	92.40	189.16	317.82	445.97	464.1
Total Costs		20.79	38.10	193.74	515.01	964.10	1536.58	2180.36	
Net returns with project		-20.79	-19.12	-42.46	-21.57	100.42	321.22	695.57	1299.34
Net present value @ 15%	180.8575								
Internal rate of return	19.5								
Increased benefits to security			2.24	17.83	55.72	115.87	198.33	303.05	303.05
New net returns w/security		-20.79	-16.88	-24.63	34.15	216.29	519.55	998.62	1602.39
New NPV	406.5019								
New IRR	25.9								

A.25. Rates of Return, Irrigated Agriculture/manual, Gorgol

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			90	720	2250	4680	8010	12240	12240
Incremental Value of Production			2.96	23.59	142.66	335.74	618.80	983.52	1072.70
Project costs		16.44	7.97	17.44	102.64	169.01	242.51	320.35	95.59
Extension costs		.04	.17	.91	3.71	7.99	13.73	19.33	19.33
Incremental Farm Costs									
Seeds			.03	22	1.47	3.03	5.39	8.40	
Fertilizer			.30	2.42	17.18	40.62	72.73	113.53	
Chemicals			.03	20	2.13	5.19	9.38	14.71	
Pump operation			.50	3.97	9.24	17.62	29.09	43.67	
Pump loan repayment			.32	2.52	14.12	32.55	57.81	89.89	
Small tools					.28	.74	1.36	2.14	
Farm transport			.03	22	1.14	2.82	5.26	8.43	
Seasonal wkg capital			02	19	91	2.06	3.64	5.65	
Subtotal			1.22	9.75	46.48	104.62	184.67	286.42	286.42
Incremental Labor Costs		8.10	9.26	33.56	88.75	159.51	256.07	285.76	294.58
Total Costs		24.57	18.61	61.67	241.59	441.12	696.99	911.86	
Net returns with project		-24.57	-15.66	-38.08	-98.93	-105.38	-78.19	71.65	376.78
Net present value @ 15%	-192.756								
Internal rate of return	7.7								
Increased benefits to security		-24.57	1.28	10.26	32.06	66.69	114.14	174.42	174.42
New net returns w/security			-14.38	-27.82	-66.87	-38.69	35.95	246.07	551.20
New NPV	-62.9042								
New IRR	12.5								

A.26. Rates of Return, Irrigated Agriculture/animal traction, Gorgol

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			90	720	2250	4680	8010	12240	12240
Incremental Value of Production			17.51	140.56	442.16	941.79	1647.15	2554.21	2745.10
Project startup costs		18.35	13.51	43.01	226.99	389.67	577.69	785.49	335.96
Extension costs		.16	.72	2.93	8.53	17.07	28.57	39.77	39.77
Incremental Farm Costs									
Seeds			.24	1.92	5.70	11.43	19.30	29.30	
Fertilizer			3.00	24.02	81.01	171.52	295.55	453.11	
Chemicals			.36	2.86	17.61	41.04	73.15	113.93	
Pump operation			2.19	17.54	28.08	44.83	67.78	96.94	
Pump loan repyment			1.37	10.94	34.15	71.02	121.53	185.70	
Small tools			.00	.00	.00	.00	.00	.00	
Farm transport			.23	1.87	4.63	9.00	14.99	22.61	
Seasonal wkg capital			.13	1.07	3.42	7.30	12.54	19.20	
Oxen bought/sold		1.01	2.02	11.21	26.14	41.91	58.24	-64.97	
Animal care			.49	3.89	14.55	31.49	54.70	84.18	
Animtrac equip repaymt			.42	2.92	7.35	13.26	21.66	32.54	
Subtotal		1.01	10.45	78.25	222.70	442.80	739.46	972.55	972.55
Incremental Labor Costs		2.81	6.22	37.31	109.73	218.39	368.06	521.87	540.52
Total Costs		22.32	30.89	161.57	567.95	1067.93	1713.78	2319.68	
Net returns with project		-22.32	-13.38	-21.01	-125.80	-126.14	-66.62	234.53	856.31
Net present value @ 15%	-144.556								
Internal rate of return	11.1								
Increased benefits to security			2.29	18.34	57.31	119.19	203.99	311.71	311.71
New net returns w/security		-22.32	-11.09	-2.67	-68.49	-6.95	137.37	546.24	1168.02
New NPV	87.50082								
New IRR	17.8								

A.27. Rates of Return, Irrigated Agriculture/manual, Guidimaka

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			73	580	1813	3770	6453	9860	9860
Incremental Value of Production			3.41	27.29	92.69	206.28	363.62	566.59	621.38
Project costs		16.98	8.95	24.78	38.34	63.91	92.53	113.03	41.58
Extension costs		.05	.22	.87	2.37	4.67	7.76	10.76	10.76
Incremental Farm Costs									
Seeds			-.01	-.09	-.21	-.31	-.53	-.81	
Fertilizer			.52	4.12	12.88	26.77	45.83	70.03	
Chemicals			.05	.40	1.25	2.60	4.45	6.80	
Pump operation			.43	3.40	10.64	22.12	37.86	57.85	
Pump loan repayment			.42	3.36	10.52	21.87	37.43	57.19	
Small tools			.00	.00	.00	.00	.00	.00	
Farm transport			.06	.46	1.45	3.02	5.16	7.89	
Seasonal wkg capital			.03	.21	.65	1.35	2.32	3.54	
Subtotal		.00	1.49	11.86	37.17	77.42	132.52	202.48	202.48
Incremental Labor Costs		6.57	7.74	29.73	66.51	120.33	187.91	199.03	206.90
Total Costs		23.60	18.40	67.24	144.39	266.34	420.71	525.31	
Net returns with project		-23.60	-14.99	-39.95	-51.69	-60.06	-57.09	41.28	159.65
Net present value @ 15%	-161.898								
Internal rate of return	5.6								
Increased benefits to security			1.04	8.27	25.84	53.72	91.96	140.51	140.51
New net returns w/security		-23.60	-13.95	-31.69	-25.86	-6.34	34.87	181.78	300.15
New NPV	-57.2760								
New IRR	11.8								

A.28. Rates of Return, Irrigated Agriculture/animal traction, Guidimaka

(million UM)

	1983	1984	1985	1990	1995	2000	2005	2010	2011-40
Number of Irrigated Farms			73	580	1813	3770	6453	9860	9860
Incremental Value of Production			14.58	115.96	380.00	823.09	1441.19	2235.79	2403.79
Project costs		19.03	13.68	36.16	87.50	151.10	228.90	267.40	193.58
Extension costs		.15	.67	2.61	7.12	14.01	23.27	32.29	32.29
Incremental Farm Costs									
Seeds			.11	.89	2.86	6.08	10.42	15.91	
Fertilizer			2.74	21.73	67.93	141.25	241.72	369.41	
Chemicals			.54	4.33	13.53	28.13	48.15	73.58	
Pump operation			1.34	10.66	33.33	69.31	118.63	181.27	
Pump loan repayment			1.28	10.17	31.80	66.13	113.19	172.94	
Small tools			.00	.00	.00	.00	.00	.00	
Farm transport			.25	1.97	6.16	12.82	21.94	33.52	
Seasonal wkg capital			.71	.91	2.83	5.86	10.07	15.39	
Oxen bought/sold		.82	1.62	9.03	21.06	33.75	46.92	-56.84	
Animal care			.45	3.56	11.12	23.12	39.57	60.46	
Animtrac equip repaymt			.34	2.35	5.92	10.68	17.45	26.21	
Subtotal		.82	8.79	65.60	196.54	397.15	668.11	889.87	889.87
Incremental Labor Costs		2.63	5.03	27.36	76.62	155.08	259.68	363.08	373.85
Total Costs		22.62	28.17	133.74	367.78	717.34	1179.96	1572.63	
Net returns with project		-22.62	-13.60	-17.77	12.22	105.76	261.23	663.15	914.21
Net present value @ 15%	196.9195								
Internal rate of return	22.9								
Increased benefits to security			1.86	14.77	46.17	96.01	164.33	251.09	251.09
New net returns w/security		-22.62	-11.74	-3.00	58.39	201.77	425.56	914.24	1165.30
New NPV	383.8877								
New IRR	30.9								

A.29. Number of Farms, Projected Rural Riverine Population minus Projected Farm Involvement/Irrigation ('000)

Zone	1980	1985	1990	1995	2000	2005	2010
Podor farm number projection	12.94	14.42	16.06	17.89	19.92	22.19	24.72
Number o farms in project		.22	1.72	5.38	11.18	19.14	29.24
Matam farm number projection	24.32	27.06	30.11	33.51	37.29	41.49	46.17
Number of farms in project		.25	1.96	6.13	12.74	21.81	33.32
Bakel farm number projection	2.84	3.16	3.52	3.91	4.35	4.84	5.38
Number of farms in project		.04	.32	1.00	2.08	3.56	5.44
Brakna farm number projection	7.05	7.48	7.94	8.43	8.95	9.50	10.08
Number of farms in project		.09	.70	2.19	4.55	7.79	11.90
Gorgol farm number projection	12.21	13.35	14.59	15.95	17.44	19.07	20.85
Number of farms in project		.09	.72	2.25	4.68	8.01	12.24
Guidimaka farm number projection	7.37	8.14	8.99	9.92	10.96	12.10	13.36
Number of farms in project		.07	.58	1.81	3.77	6.45	9.86

A.30. Foodgrain Consumption Estimates (million tons)

Zone	Per Capita Consm.(t)	1980	1985	1990	1995	2000	2005	2010
Podor								
Rural	.15	20.66	23.01	25.63	28.54	31.79	35.41	39.45
Urban	.10	.78	.89	1.02	1.16	1.33	1.51	1.73
Total		21.44	23.90	26.64	29.71	33.12	36.93	41.18
Matam								
Rural	.15	23.46	26.11	29.05	32.33	35.97	40.03	44.54
Urban	.10	1.08	1.23	1.40	1.60	1.82	2.08	2.37
Total		24.54	27.34	30.45	33.92	37.79	42.10	46.91
Bakel								
Rural	.15	3.81	4.24	4.71	5.24	5.83	6.48	7.21
Urban	.10	.34	.39	.44	.50	.57	.65	.74
Total		4.15	4.62	5.15	5.74	6.40	7.14	7.95
Total Senegal								
Rural	.15	47.93	53.35	59.39	66.11	73.59	81.93	91.20
Urban	.10	2.20	2.51	2.86	3.26	3.72	4.24	4.84
TOTAL		50.13	55.86	62.25	69.37	77.31	86.17	96.04
Mauritania								
Brakna								
Rural	.15	21.49	22.81	24.21	25.70	27.28	28.95	30.73
Urban	.10	1.37	1.45	1.54	1.64	1.74	1.84	1.96
Total		22.85	24.26	25.75	27.33	29.01	30.79	32.69
Gorgol								
Rural	.15	20.38	22.28	24.36	26.64	29.12	31.84	34.83
Urban	.10	2.18	2.46	2.77	3.12	3.51	3.95	4.45
Total		22.57	24.74	27.13	29.75	32.63	35.79	39.26
Guidimaka								
Rural	.15	12.29	13.57	14.98	16.54	18.26	20.16	22.26
Urban	.10	.64	.70	.78	.86	.95	1.05	1.15
Total		12.93	14.27	15.76	17.40	19.21	21.21	23.41
Total Mauritania								
Rural	.15	54.16	58.66	63.55	68.87	74.66	80.95	87.80
Urban	.10	4.19	4.61	5.09	5.61	6.19	6.84	7.56
TOTAL		58.35	63.27	68.64	74.48	80.85	87.79	95.36

A.30. Foodgrain Consumption Estimates (million tons)

Zone	Per Capita Consm.(t)	1980	1985	1990	1995	2000	2005	2010
Mali								
Kayes								
Rural	.15	23.08	26.23	29.81	33.87	38.49	43.74	49.70
Urban	.10	5.50	6.28	7.16	8.17	9.32	10.63	12.13
Total		28.58	32.51	36.97	42.04	47.81	54.37	61.84
Bafoulabe								
Rural	.15	14.14	16.06	18.24	20.72	23.53	26.73	30.36
Urban	.10	.80	.92	1.05	1.20	1.37	1.56	1.78
Total		14.94	16.98	19.29	21.92	24.90	28.29	32.14
Total Mali								
Rural	.15	37.22	42.29	48.05	54.59	62.02	70.47	80.06
Urban	.10	6.31	7.20	8.21	9.37	10.69	12.20	13.91
TOTAL		43.53	49.48	56.26	63.96	72.71	82.66	93.98
TOTAL SENEGAL RIVER BASIN								
RURAL	.15	186.12	204.56	224.99	247.64	272.76	300.64	331.59
URBAN	.10	27.41	31.70	36.74	42.66	49.64	57.87	67.58
TOTAL		213.53	236.26	261.73	290.30	322.40	358.51	399.18

A.31. Foodgrain Self-Sufficiency Estimates under improved Rainfed Agriculture (million tons)

Zone/Technique	1985	1990	1995	2000	2005	2010	2011-40
Matam							
Production		2.05	5.00	3.99	7.85	13.08	14.31
Consumption	23.90	26.64	29.71	33.12	36.93	41.18	
Excess production	-23.90	-24.59	-24.70	-29.13	-29.08	-28.10	
Bakel							
Production		.40	1.26	2.04	3.75	6.00	6.22
Consumption	4.62	5.15	5.74	6.40	7.14	7.95	
Excess production	-4.62	-4.75	-4.48	-4.37	-3.38	-1.95	
Gorgol							
Production		.75	1.84	1.47	2.88	4.80	5.26
Consumption	24.74	27.13	29.75	32.63	35.79	39.26	
Excess production	-24.74	-26.38	-27.91	-31.16	-32.91	-34.45	
Guidimaka							
Production		.73	2.29	3.69	6.80	10.88	11.27
Consumption	14.27	15.76	17.40	19.21	21.21	23.41	
Excess production	-14.27	-15.02	-15.10	-15.52	-14.41	-12.54	
Kayes/Bafoulabe/manual							
Production		5.23	21.00	47.39	85.24	134.25	135.86
Consumption	49.48	56.26	63.96	72.71	82.66	93.98	
Excess production	-49.48	-51.03	-42.95	-25.32	2.58	40.27	
Kayes/Bafoulabe/animal traction							
Production		9.33	38.64	89.60	162.52	257.41	262.71
Consumption	49.48	56.26	63.96	72.71	82.66	93.98	
Excess production	-49.48	-46.93	-25.31	16.89	79.86	163.43	
Total Excess Production/manual							
Senegal	-28.52	-29.34	-29.18	-33.50	-32.46	-30.05	
Mauritania	-39.01	-41.40	-43.02	-46.68	-47.32	-46.99	
Mali	-49.48	-51.03	-42.95	-25.32	2.58	40.27	

A.32. Foodgrain Self-Sufficiency Estimates under Irrigated Agriculture/Senegal (million tons)

Zone	1980	1985	1990	1995	2000	2005	2010	2011-40
Podor								
Production/manual		1.02	7.89	21.78	40.69	71.24	110.52	118.80
Consumption	21.44	23.90	26.64	29.71	33.12	36.93	41.18	
Excess production/manual	-21.44	-22.88	-18.75	-7.93	7.57	34.31	69.34	
Production/animal traction		2.23	17.69	54.34	111.84	194.61	300.70	317.25
Consumption	21.44	23.90	26.64	29.71	33.12	36.93	41.18	
Excess production/animal traction	-21.44	-21.67	-8.95	24.63	78.72	157.68	259.52	
Matam								
Production/manual		1.16	9.00	24.82	46.37	81.18	125.94	135.38
Consumption	24.54	27.34	30.45	33.92	37.79	42.10	46.91	
Excess production/manual	-24.54	-26.18	-21.45	-9.10	8.58	39.08	79.03	
Production/animal traction		2.54	20.16	61.92	127.45	221.76	342.66	361.52
Consumption	24.54	27.34	30.45	33.92	37.79	42.10	46.91	
Excess production/animal traction	-24.54	-24.80	-10.29	28.00	89.66	179.66	295.75	
Bakel								
Production/manual		.18	1.43	4.36	8.93	15.53	24.00	25.33
Consumption	4.15	4.62	5.15	5.74	6.40	7.14	7.95	
Excess production/manual	-4.15	-4.44	-3.72	-1.38	2.53	8.39	16.05	
Production/animal traction		.54	4.33	13.65	28.70	49.89	77.03	81.02
Consumption	4.15	4.62	5.15	5.74	6.40	7.14	7.95	
Excess production/animal traction	-4.15	-4.08	-.82	7.91	22.30	42.75	69.08	
Total Excess Production/manual	-50.13	-53.50	-43.93	-18.41	18.68	81.78	164.42	
Total Excess Production/animal trac	-50.13	-50.55	-20.07	60.54	190.68	380.09	624.35	

A.33. Foodgrain Self-Sufficiency Estimates under Irrigated Agriculture/Mauritania (million tons)

Zone	1980	1985	1990	1995	2000	2005	2010	2011-40
Brakna								
Production/manual		.42	3.21	8.87	16.56	28.99	44.98	48.35
Consumption	22.85	24.26	25.75	27.33	29.01	30.79	32.69	
Excess production/manual	-22.85	-23.84	-22.54	-18.46	-12.45	-1.80	12.29	
Production/animal traction		.91	7.17	21.53	43.47	75.70	117.02	123.06
Consumption	22.85	24.26	25.75	27.33	29.01	30.79	32.69	
Excess production/animal traction	-22.85	-23.35	-18.58	-5.80	14.46	44.91	84.33	
Gorgol								
Production/manual		.31	2.35	6.73	13.22	4.57	39.59	49.73
Consumption	22.57	24.74	27.13	29.75	32.63	35.79	39.26	
Excess production/manual	-22.57	-24.43	-24.78	-23.02	-19.41	-31.22	.33	
Production/animal traction		1.14	9.07	26.91	53.49	90.63	137.54	132.80
Consumption	22.57	24.74	27.13	29.75	32.63	35.79	39.26	
Excess production/animal traction	-22.57	-23.60	-18.06	-2.84	20.86	54.84	98.28	
Guidimaka								
Production/manual		.27	2.11	6.41	13.08	22.88	35.46	37.99
Consumption	12.93	14.27	15.76	17.40	19.21	21.21	23.41	
Excess production/manual	-12.93	-14.00	-13.65	-10.99	-6.13	1.67	12.05	
Production/animal traction		.75	5.92	18.75	39.53	69.02	106.89	114.01
Consumption	12.93	14.27	15.76	17.40	19.21	21.21	23.41	
Excess production/animal traction	-12.93	-13.52	-9.84	1.35	20.32	47.81	83.48	
Total Excess Production/manual	-58.35	-62.27	-60.97	-52.47	-37.99	-31.35	24.67	
Total Excess Production/animal trac	-58.35	-60.47	-46.48	-7.29	55.64	147.56	266.09	

A.34. Project Investment Costs: Improved Rainfed Agriculture

	1983	1984	1985	1990	1995	2000	2005	2010	Total
Matam									
Project costs			36.29	6.36	25.46	57.27	101.82	159.10	1772.19
Extension costs				70.72	141.43	318.22	565.72	883.94	8039.44
Bakel									
Project costs			5.92	1.04	4.16	9.35	16.62	25.98	289.34
Extension costs				12.32	24.63	55.42	98.52	153.94	1400.06
Subtotal, Senegal (mill CFA)			42.21	90.43	195.67	440.26	782.69	1222.95	11501.02
Gorgol									
Project costs			2.66	.47	1.87	4.21	7.48	11.69	130.14
Extension costs				6.19	12.38	27.85	49.51	77.36	703.58
Guidimaka									
Project costs			2.15	.38	1.51	3.39	6.03	9.43	104.96
Extension costs				2.22	4.43	9.96	17.73	27.71	250.56
Subtotal, Mauritania (mill UM)			4.81	9.25	20.19	45.43	80.76	126.18	1189.26
Kayes/Bafoulabe, manual									
Project costs			148.05	25.98	103.91	233.80	415.65	649.45	7234.05
Kayes/Bafoulabe, manual				147.85	295.70	665.33	1182.80	1848.13	16808.66
Subtotal, Mali (mill MF)			148.05	173.83	399.61	899.13	1598.45	2497.58	24042.72
Kayes/Bafoulabe, animal traction									
Project costs			148.05	25.98	103.91	233.80	415.65	649.45	7234.05
Kayes/Bafoulabe, animal traction				221.49	442.98	996.70	1771.92	2768.62	25180.55
Subtotal, Mali (mill MF)			148.05	247.47	546.89	1230.51	2187.57	3418.08	32414.60
Total costs in US $ (mill) (incl. Mali/manual)			.47	.75	1.65	3.72	6.62	10.34	98.23
Total costs in US $ (mill) (incl. Mali/animal trac.)			.47	.87	1.90	4.28	7.60	11.88	112.16

A.35. Project Investment Costs: Irrigated Agriculture/manual

	1983	1984	1985	1990	1995	2000	2005	2010	Total
Podor									
Project costs		29.69	110 14	488 99	1081.22	1686.12	2303.66	2900.38	36826 38
Podor		.91	4.19	16.25	44.33	87.17	144.80	200 94	2080 75
Matam									
Project costs		30 12	123.07	554 04	1224.65	1907 95	2603 87	3274 32	41635 32
Extension costs		1.03	4.76	16 52	50.51	99 34	165 00	228 98	2371 09
Bakel									
Project costs		36.48	35 54	79 22	103.10	307 98	456 50	608 94	6715 68
Extension costs		.11	.52	2 02	5.50	10 61	17 96	24 92	258 08
Subtotal, Senegal (mill CFA)		98 34	278.23	1159 03	2509 30	4099 38	5691 79	7238 50	89887.29
Brakna									
Project costs		16.21	14 19	49 43	119.46	203 68	302 19	412 17	4656 86
Extension costs		.09	41	1 58	4.30	8 45	14.04	19 48	201 76
Gorgol									
Project costs		16 44	7 97	17 44	102.64	169 01	242 51	320 35	3667 41
Extension costs		.04	17	91	3.71	7 99	13.73	19 33	189.63
Guidimaka									
Project costs		16.98	8 95	24 73	38 34	63 91	92 53	113 03	1514 02
Extension costs		05	.22	.87	2.37	4 67	7 76	10 76	111 45
Subtotal, Mauritania (mill UM)		49 80	31 90	95 01	270.82	457 71	672 75	895 12	10341 12
Total project costs in US $ (mil		1.16	1.46	5 45	12.88	21 29	30.19	39 05	471.98 mill

A.36. Project Investment Costs: Irrigated Agriculture/animal traction

	1983	1984	1985	1990	1995	2000	2005	2010	Total
Podor									
Project costs		32.73	202 76	959 38	2140 40	3355 22	4603 84	5819 52	73293 61
Extension costs		1 61	8 38	32 51	88.65	174 35	289 60	401 89	4161 50
Matam									
Project costs		33 57	228 63	1089 47	2427 27	3778 87	5204 27	6567.41	82911 48
Extension costs		2.06	9 55	37.04	101.02	198 68	330 01	457 97	4742.17
Bakel									
Project costs		56.11	71 63	196 25	234 01	767 43	1101 92	1457 90	16075 86
Extension costs		.34	1 56	6 05	16 49	32 44	53 88	74 77	774 23
Subtotal, Senegal (mill CFA)		126.62	522 53	2320 69	5007 85	8326 98	11583 56	14779 45	181 96 bill
Brakna									
Project costs		16.46	21 74	67 27	202 99	332 86	477 06	629 97	7458 19
Extension costs		16	.81	3 15	8 60	16 91	28 08	38 97	403 51
Gorgol									
Project costs		18.35	13.51	43 08	226 99	389 67	577 69	785 49	8647 78
Extension costs		.16	72	2 93	8 53	17 07	26 57	39 77	407.07
Guidimaka									
Project costs		19 03	13 66	36 16	87 50	151 10	228 90	287 40	3475 26
Extension costs		15	67	2 61	7 12	14 01	23 27	32 29	334 34
Subtotal, Mauritania (mill UM)		54.31	51 14	177 21	541 72	921.61	1363.56	1813 88	20726 17
Total project costs in US $ (mil		1.33	2 59	10 69	25 72	43 12	61 34	79 50	951 97 mill