PN-AAC-109
ISN 42110

FEASIBILITY REPORT ON RICELAND RECLAMATION IN GUINEA

Furnished to AID/W on lo
basis by USAID/Guinea in
response to AID/W Reque
Ref AIDTO 255 State 200
This is an attachment to
TOAID A-168.
July 16, 1968.

6.750013

KAKOSSA PROJECT

BY THE
HARZA ENGINEERING COMPANY

000057
000074

PREPARED FOR
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
FEBRUARY 1964

A.I.D. HISTORICAL AND
TECHNICAL REFERENCE
ROOM 1656 NS

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SUMMARY LETTER

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Table of Equivalents

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February 15, 1964

Agency for International Development
State Department
Washington 25, D. C.

Subject: Kakossa Project
Feasibility of Riceland Reclamation

Gentlemen:

We are pleased to submit our feasibility report on the Kakossa Project. This report contains the results of the engineering, agronomic, and economic studies of the Kakossa Project which we have made in compliance with the terms of our contract AID/afe-93, dated April 3, 1963. This contract provides for feasibility studies in connection with the reclamation of a series of four project areas totaling about 17,500 hectares in the Republic of Guinea. Our report on the Monchon Project was submitted on October 15, 1963. The Kakossa Report is the second of the series.

Our findings indicate that a flood control and agricultural improvement project covering about 2500 hectares on the island of Kakossa is economically justified and financially feasible. The project will result in an important increase in the supply of locally produced rice and thus reduce significantly dependence on foreign food sources.

Introduction

The Republic of Guinea presently has an agricultural economy, heavily dependent upon rice. Although rice is staple food in Guinea, domestic production has been insufficient to meet the ever-increasing needs of a growing population.

Kakossa Island has long been a rice producing region, but land use and particularly crop yields have been far below their potential. About

4

1530 hectares of ricelands are presently being cultivated year after year. Once every three or four years, very good crops are harvested: such a crop was observed in 1963. In other years, salt water intrusions cause a complete loss of the crops. Some damages are also occasionally caused by fresh water flooding. In addition, the lack of supporting agricultural improvement programs has prevented the development of satisfactory rice varieties.

Previous Reclamation Plan

A plan was developed in the 1950's for reclaiming from 2000 to 2500 hectares of arable land located along the western side of the island of Kakossa. The plan consisted of a system of dikes designed to prevent flooding of the lands during high tides, and a system of drainage canals designed to remove excess run-off from the fields. Three gated structures located across the main drainage channels were proposed to provide a control of fresh water discharge from the project area and of salt water discharge from the ocean.

Construction of the project was started in 1956, and funds in the amount of 90 million CFA francs were expended for the construction of about half of the dikes and one of the control structures. Financial difficulties, resulting from over-run of quantities and from an increase in unit prices, first threatened the successful completion of the project. Finally, in 1958, the uncompleted project was abandoned upon the departure of the French Colonial Administration.

The government of Guinea is now considering the resumption of this project, with the assistance of international financing agencies, as a means of increasing the production of rice in Guinea and of improving the economy of the Kakossa area.

Present Investigations

Our assignment has included both field and office studies to determine the adequacy of the proposed plan and the economic feasibility of the project. We have sent to Guinea a team of six engineers and agronomists who, from April to July and from October to December, 1963, reviewed all available data pertaining to the Kakossa and other

projects. This team carried out field investigations related to hydrology, topography, soils, hydraulics, agronomy and economics, and collected data for the development of a revised plan for reclamation. Analysis of the data and preparation of the plan were then completed in our Chicago office.

Project Description

The location of the Kakossa Project is shown on Exhibit A. Our plan for development is shown on Exhibit B, and represents an extension and modification of the previous plan. The project will consist of an enclosed system of surface canals designed to drain toward the ocean the excess run-off that would otherwise remain in the paddies for a prolonged period. The project area will be surrounded by a system of dikes designed to prevent the entrance of salt water from the ocean during periods of high tides, utilizing previously constructed dikes to the maximum extent. Four control structures will be at the locations where the four main drainage channels cross the dike alignments. One such structure is in existence, but must be rehabilitated. These structures will be provided with flap gates designed to prevent the uncontrolled entrance of salt water from the ocean.

The drainage system will comprise existing natural channels, plus new, excavated canals in the areas where natural waterways are inadequate. A total length of ten kilometers of canals will be excavated by dragline to sections varying from 1.0 to 4.0 meters in bottom width. These canal will receive the discharge from the field ditches. A total of about 85,000 cubic meters of excavation will be required for construction of the drainage system.

The dikes will extend between existing dunes to close the present gaps. A total of 15.2 kilometers of dikes will be part of the project, of which 6.7 kilometers of existing dikes will be rehabilitated and 8.5 kilometers will be newly constructed. The dikes will be homogeneous, rolled earth embankments. Their maximum height will be 3.0 meters above ground level most of the dikes being about 1.3 meters high. The crest of the dikes will be at about elevation 5.0. The dikes will require placement of about 80,000 cubic meters of earth fill.

At their crossing of the main waterways, the dikes will be replaced by gated control structures. One of them exists presently across the Soulemanya River, and will require rehabilitation. Three additional structures will be required. They will be constructed in reinforced concrete, and will be provided with a series of automatic flap gates.

The channel of the Soulemanya River, partially aggraded in recent years, will require rehabilitation by dredging of about 100,000 cubic meters between the structure and the ocean estuary.

A number of bridges have been included in the project for operation and maintenance access, and for use by the local inhabitants. Maintenance roads will be provided along all dikes and main drainage channels.

Construction of the project is estimated to take two years.

Project Cost

We have estimated the construction cost of the civil works including canals, dikes and structures, to be US $690,000 and GF 175,000,000. The cost of land preparation, including minor leveling and planing. is estimated to be an additional $10,000 and GF 25,000,000. Funding arrangements should include additional allowances for interest during construction and possible cost escalation. Financing requirements are estimated to be US $780,000 and GF 240 million, equivalent to a total of US $1,740,000, not including interest during construction. The rate of exchange used is GF 248 equal US $1.00. The costs indicated do not include previous investments in the project, estimated to be CFA francs 90 million for construction and CFA francs 20 million for studies and administration, or a total of CFA francs 110 million equivalent to about US $440,000.

The average annual cost of operation and maintenance is estimated to be GF 7 million. This amount includes the average cost of a comprehensive program for improvement of farming practices.

Project Benefits

The presently cultivated area of about 1530 hectares can be increased to about 2260 hectares with reclamation. From our studies of the agricultura

potential of the soils in the project area, we estimate that the present average annual production of about 1800 tons of rice paddy can be increased to about 2200 tons immediately upon completion of the project. This production can be progressively increased to about 5600 tons in about ten years and to an ultimate amount of 6000 tons in 20 years after project completion. These increases in production will require from the very beginning a comprehensive support program for the improvement of farming practices.

The achievement of these increases in production will represent a sizeable contribution to the Guinean economy, which is presently deficient in rice. Annual rice imports have increased steadily in the last few years, to about 35,000 tons in 1963. Rice imports now cost about $2.5 million yearly, or ten percent of the present deficit in the balance of international trade.

Economic Value

The economic value of this project has been measured by benefit-cost relationships. Capital costs have been based on an interest rate of six percent and an economic life of 50 years. The analysis of Project benefits is shown on Exhibit C. Included are both direct and indirect benefits that will accrue to the project and for which a monetary value could be assigned. The results obtained are as follows:

All amounts in equivalent U. S. Dollars 1/

	Upon Completion of Project	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Annual Benefits				
Direct Benefits	42,000	162,000	352,000	446,000
Indirect Benefits	8,000	36,000	68,000	76,000
Public Benefits	16,000	22,000	30,000	36,000
Total Annual Benefits	66,000	220,000	450,000	558,000

Equivalent Annual Direct Benefits 2/	$311,000
Equivalent Annual Total Benefits 2/	$395,000

Annual Costs for Completion of Project	
Capital Costs	$100,000
Operating Costs	$ 28,000
Total Annual Costs	$128,000
Benefit-Cost Ratios (excluding previous costs)	
With Direct Benefits only	2.4 to 1.0
With Total Benefits	3.1 to 1.0
Benefit-Cost Ratios (including previous costs)	
With Direct Benefits only	1.9 to 1.0
With Total Benefits	2.4 to 1.0

1/ Data in this table have been presented in equivalent U. S. Dollars for the convenience of non-Guinean readers, although most benefits will accrue in domestic currency.

2/ Determined by calculating the present-worth of future annual benefits accruing over a 50-year period, and amortizing this amount over 50 years at an annual interest rate of 6.0 percent.

We consider that the project is economically justified in view of the satisfactory benefit-cost ratios. For achievement of the potential benefits from the drainage of the lands, a supporting program of agricultural extension services will be required.

Financial Analysis

The source and terms of project funds are not yet known. For purposes of analysis we have assumed loans bearing interest at an annual rate of 0.75 percent, to be repaid in 40 years, with the first amortization payment due ten years after the completion of construction.

Our analysis of future revenues and costs shows that after only five years residual revenue will be greater than the interest, amortization, and operation costs for completion of the project. In fact, substantial surpluses will occur in future years, indicating that less liberal financing terms can be met by the project.

Timing of the Project

The timing of the Kakossa Project will be dependent on the total need for projects of this type in Guinea and upon the relative feasibility of the various projects. Ultimately, four projects will be studied by us, plus additional projects programmed for study by the Food and Agriculture Organization of the United Nations. However, at present, the only basis for comparison is with the Monchon Project.

On the basis of cost of development per hectare, the Kakossa Project would be more economical than the Monchon Project, if previous costs are not included. On the basis of benefit-cost ratios, the Kakossa investment would yield greater returns. The investment per ton of rice that would be produced in the next 50 years is about the same for both projects. These facts are demonstrated by the following comparison:

Basis of Comparison	Monchon Project	Kakossa Project
Net reclaimable area, hectares	2,400	2,260
Investment cost, GF million	580	400
Cost of reclamation, GF per hectare	240,000	180,000
equiv. US $ per acre	390	290
Benefit-cost ratios 1/:		
With direct benefits only	2.1	2.4
With all benefits	2.7	3.1
Anticipated rice production increase over the next 50 years, tons (paddy)	240,000	190,000
Capitalized value of proposed investments in Project, GF million	675	510
Cost invested in Project per ton of rice to be produced in 50 years, GF per ton (paddy)	2,800	2,700
US $ per bushel (paddy)	0.23	0.22

It should be noted that this comparison applies only to the new investments to be made. When the investment made previously in the Kakossa Project is taken into account, the Monchon Project appears to be somewhat more economical.

However, it appears that all projects which are economically feasible will be needed, if Guinea is to become self-sufficient in rice. Consequently, we believe that both the Kakossa and Monchon projects should be undertaken as the initial step of a major agricultural program.

1/ Benefit-cost ratios based on annual equivalent benefits were not presented in our report on the Monchon Project. The values presented here were determined later for the purpose of comparing the two projects on a similar basis.

Future Project Extension

Local government officials suggested an alternative plan of development which would provide flood protection to the proposed project area, plus an additional area of about 3000 hectares presently undeveloped. The general arrangement of the facilities included in this plan is indicated on Exhibit A.

We have made a preliminary study of this plan and found it to be worthy of consideration. However, the magnitude of such a project, if considered for implementation in lieu of the proposed project, would delay reclamation of the lands presently under cultivation. Therefore, we propose to defer construction of this alternative project until further increase of rice production on Kakossa Island is deemed opportune. The eventual extension of the Kakossa Project would constitute an economical second stage of development.

Recommendations

We recommend that negotiations be started by the Government of Guinea for financing of the proposed Kakossa Project, and that commitments be obtained for all necessary funds, both in foreign and domestic currencies before construction begins.

The Government of Guinea should engage an experienced consulting firm to revise and bring up to date the contract documents and detailed drawings that were prepared in 1955, and to supervise and inspect construction of the works.

Bids should be taken from qualified contractors for construction of the civil works. Preparation of the project lands for agricultural use can be carried out by the Center of Rural Mechanization.

We recommend that a rice agronomist be engaged by the Government of Guinea to direct a program for improvement of farming practices.

Very truly yours,

HARZA ENGINEERING COMPANY

Richard D. Harza

Richard D. Harza
Vice President

TABLE OF EQUIVALENTS

Length

1 - Millimeter (mm)	0.039 Inches
1 - Centimeter (cm)	0.394 Inches
1 - Meter (m)	3.281 Feet
1 - Kilometer (km)	0.621 Miles

Area

1 - Square meter (m^2)	1.196 Square yards
1 - Hectare (ha)	10,000 Square meters
1 - Hectare	2.471 Acres
1 - Square Kilometer (km^2)	0.386 Square miles

Volume

1 - Cubic meter (m^3)	35.31 Cubic feet
1 - Cubic meter	1.308 Cubic yards
1 - Million cubic meters (MCM)	810.7 Acre-feet

Weight

1 - Kilogram (kg)	2.205 Pounds
1 - Metric ton (mT)	1,000 Kilograms
1 - Metric ton	2,205 Pounds
1 - Metric ton	1.102 Tons (short)

Flow

1 - Cubic meter/second (m^3/sec.)	35.31 Cubic feet/second
1 - Cubic meter/second	70 Acre-feet/day

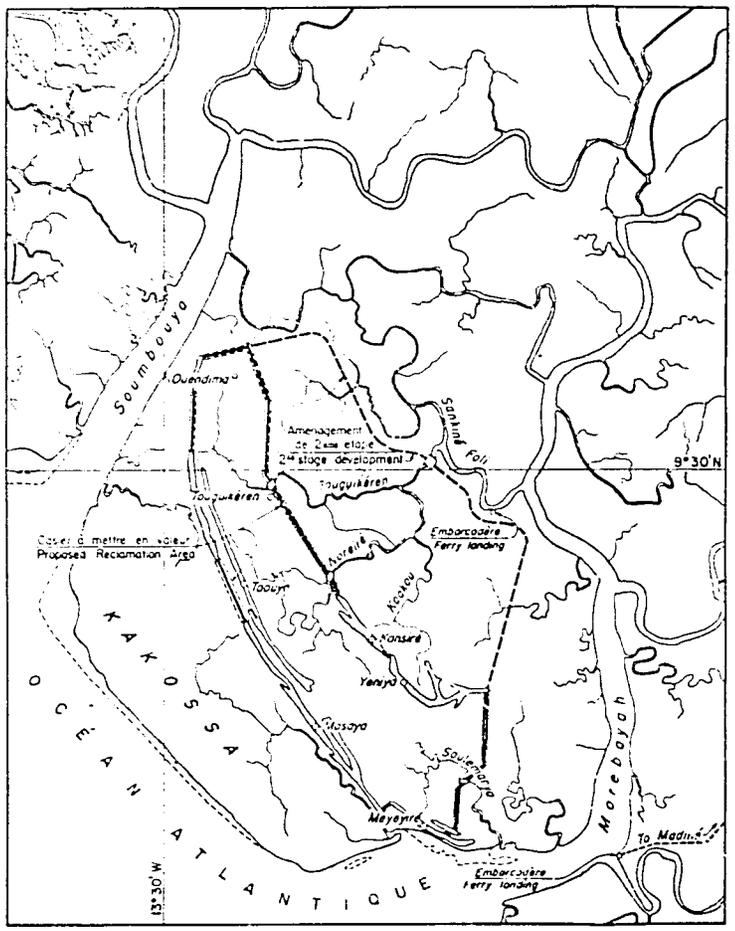
Agriculture

1 - Ton/hectare (paddy)	20 Bushels per acre
1 - Ton of paddy rice	49 Bushels (paddy)
1 - Bushel of rice (U.S.A.)	45 Pounds of rice paddy

Currency

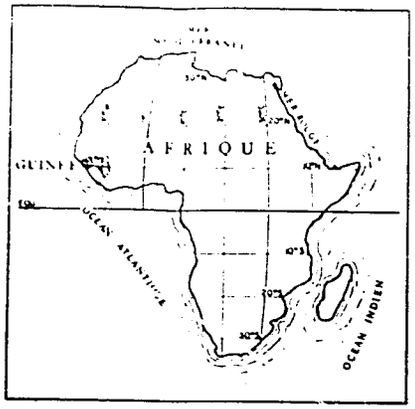
1 - Guinean Franc (GF)	0.004 US Dollars
1 - U.S. Dollar	248 Guinean Francs
1 - CFA Franc	0.004 US Dollars

PLANCHE / EXHIBIT A



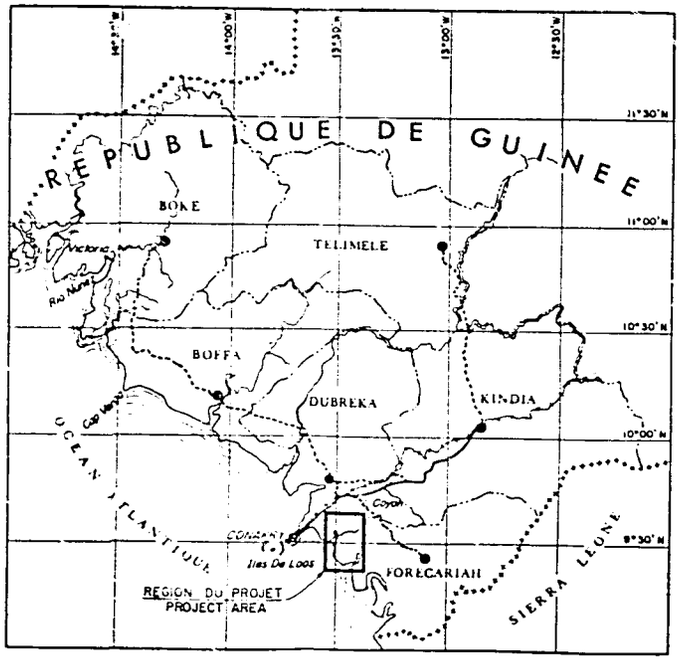
CARTE DE L'ILE DE KAKOSSA
MAP OF KAKOSSA ISLAND

Echelle / Scale 0 1 2 Kilomètres / Kilometers



SITUATION
KEY MAP

Echelle / Scale 0 1000 2000 3000 Kilomètres / Kilometers



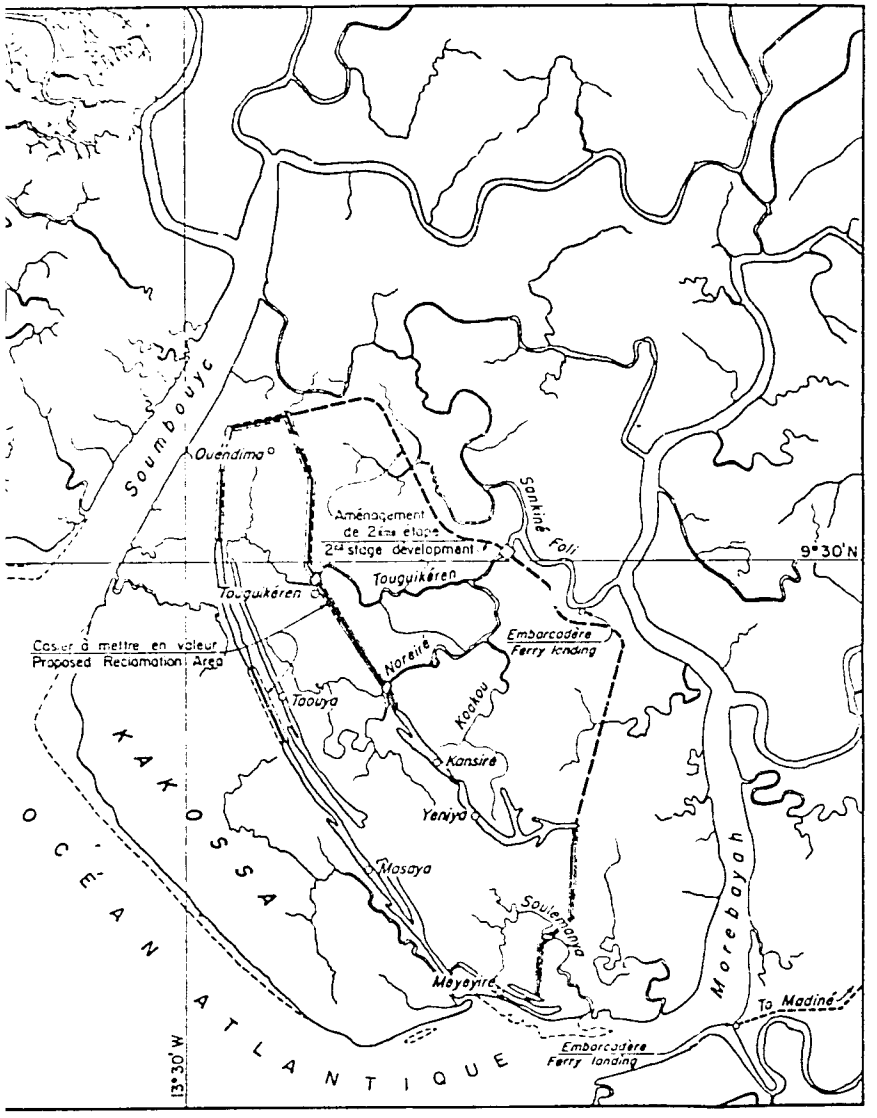
BASSE GUINEE
LOWER GUINEA

Echelle / Scale 0 10 20 30 40 50 Kilomètres / Kilometers

LEGENDE
LEGEND

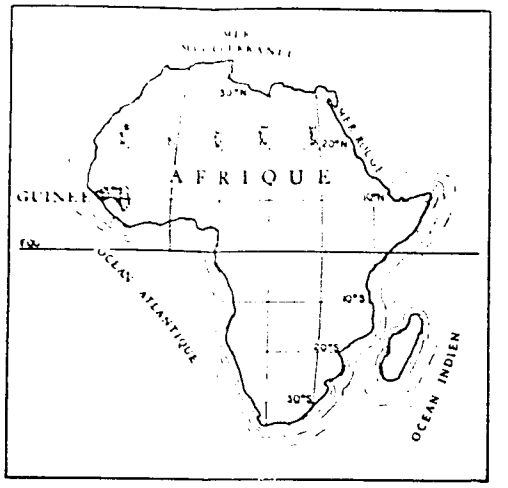
- Route / Paved road
- Piste / Unpaved road
- Chemin de fer / Railroad
- Villes et villages / Main cities and villages
- Frontière / National boundary
- Limite de région administrative / Regional boundary
- Réseau de canaux de drainage / Drainage canal system
- Cours d'eau / Streams
- Digue actuelle / Existing dike
- Digue proposée / Proposed dike
- Digue future / Future dike
- Dunes

CARTES D'ENSEMBLE
GENERAL MAPS



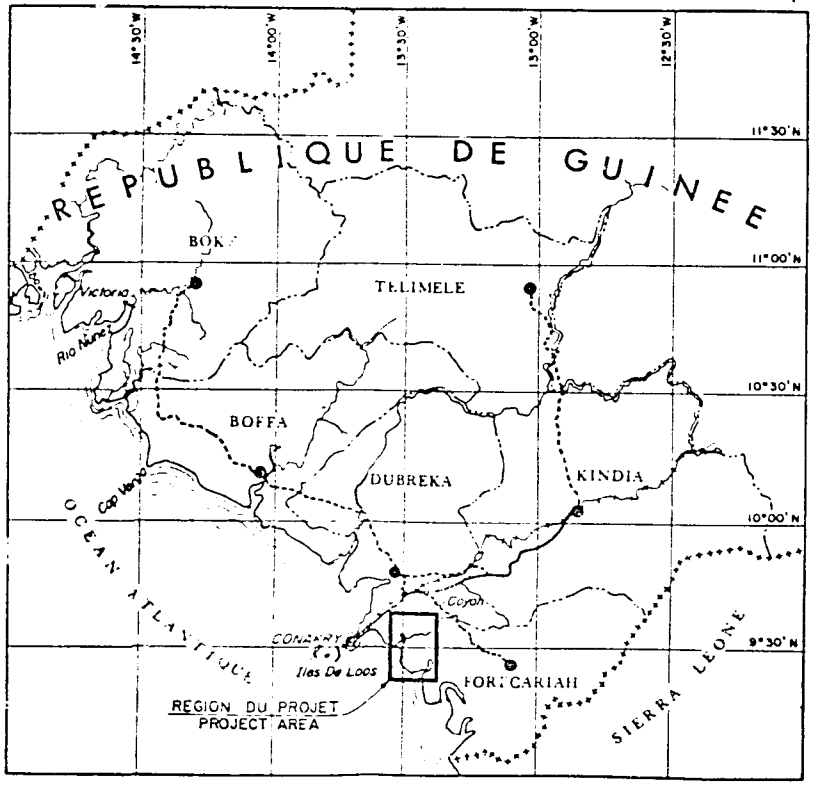
CARTE DE L'ILE DE KAKOSSA
MAP OF KAKOSSA ISLAND

Echelle / Scale 0 1 2 Kilomètres / Kilometers



SITUATION
KEY MAP

Echelle / Scale 0 1000 2000 3000 Kilomètres / Kilometers



BASSE GUINEE
LOWER GUINEA

Echelle / Scale 0 10 20 30 40 50 Kilomètres / Kilometers

LEGENDE
LEGEND

- Route / Paved road
- Piste / Unpaved road
- Chemin de fer / Railroad
- Villes et villages / Main cities and villages
- Frontière / National boundary
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- Réseau de canaux de drainage / Drainage canal system
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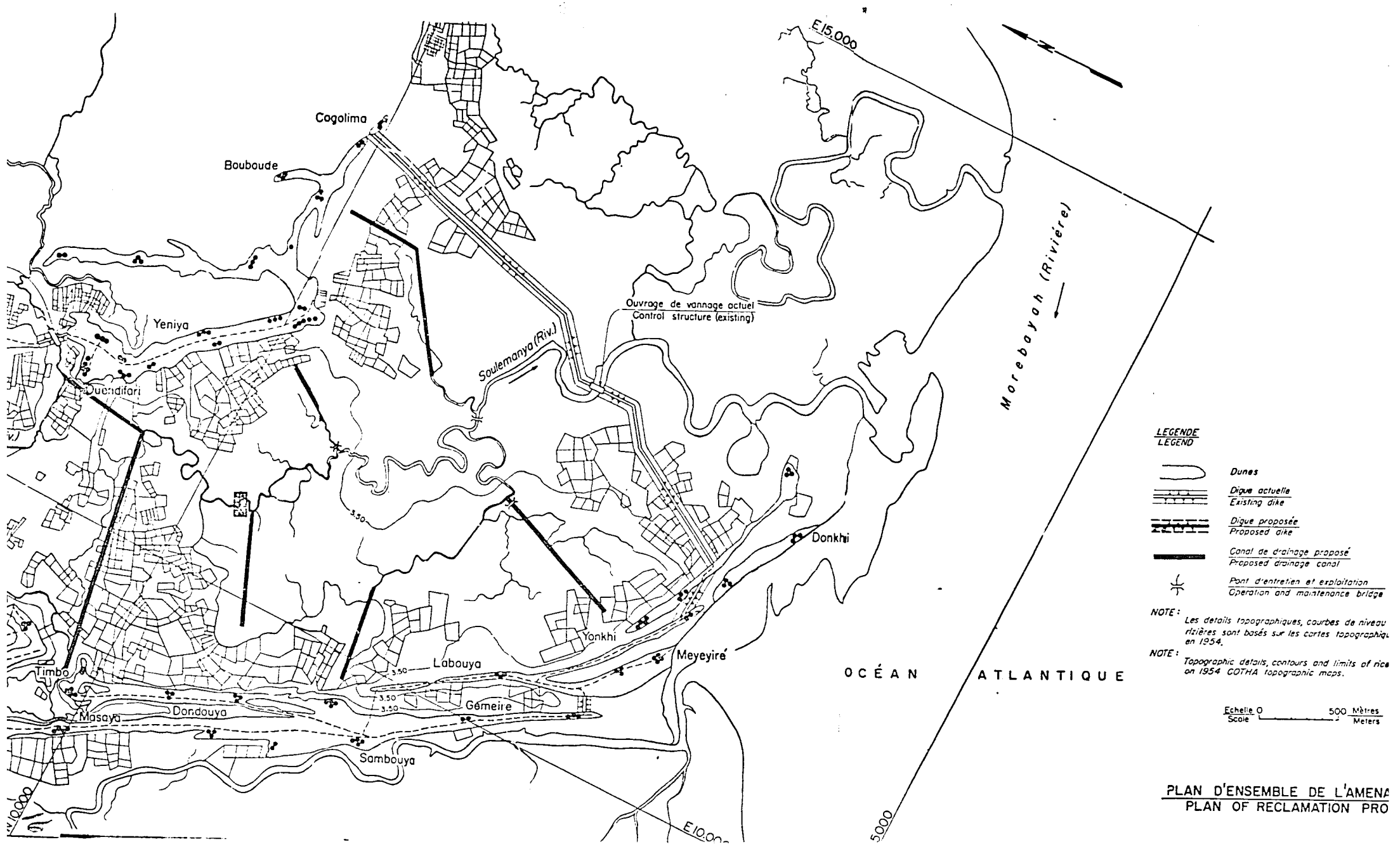
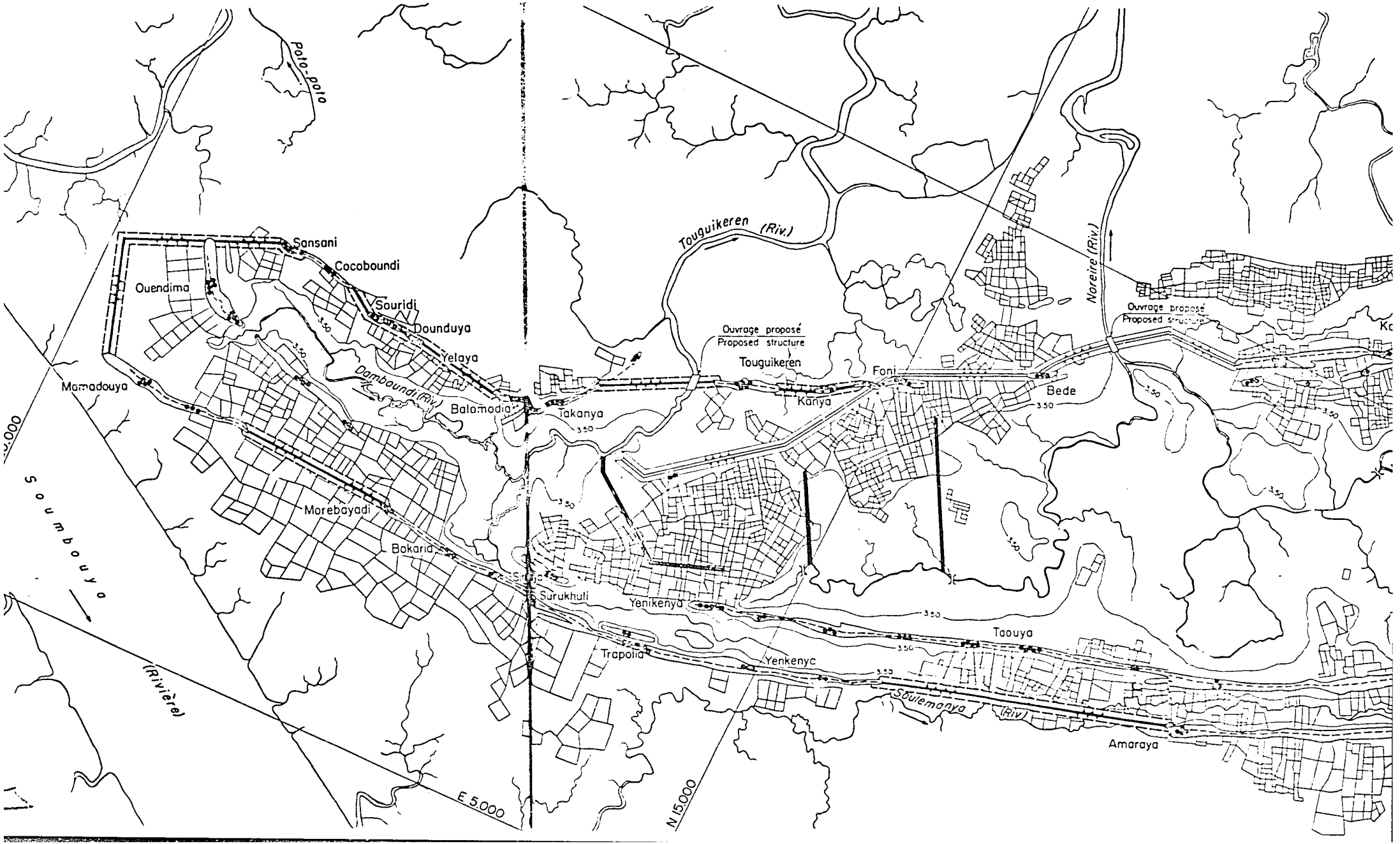
- Digue future / Future dike
- Dunes

CARTES D'ENSEMBLE
GENERAL MAPS


Cogolima
Bouboude
Yeniya
Ouendifari
Soulemanya (Riv.)
Ouvrage de vannage actuel
Control structure (existing)
E15,000
Moreboyah (Rivière)
Donkhi
Yonkhi
Meyeyiré
Labouya
Timbo
Masaya
Dondouya
Gémeire
Sambouya
OCÉAN ATLANTIQUE
E10,000
LEGENDE
LEGEND
Dunes
Digue actuelle
Existing dike
Digue proposée
Proposed dike
Canal de drainage proposé
Proposed drainage canal
Pont d'entretien et exploitation
Operation and maintenance bridge
NOTE : Les details topographiques, courbes de niveau
rizières sont basés sur les cartes topographiqu
en 1954.
NOTE : Topographic details, contours and limits of rice
on 1954 COTHA topographic maps.
Echelle 0 500 Mètres
Scale Meters
PLAN D'ENSEMBLE DE L'AMENA
PLAN OF RECLAMATION PRO


Poto-poto
Sansani
Cocoboundi
Ouendima
Souridi
Dounduya
Yelaya
Dambboundi (Riv.)
Mamadouya
Balamodia
Takanya
Touguikeren (Riv.)
Ouvrage proposé
Proposed structure
Touguikeren
Kanya
Foni
Bede
Noreire (Riv.)
Ouvrage proposé
Proposed structure
Morebayadi
Bokaria
Surukhuli
Yenikenya
Trapolia
Yenkenyc
Taouya
Souleimanya (Riv.)
Amaraya
Soumbouya (Rivière)
E 5.000
N 15.000
3.50

ANNUAL BUDGET OF 4-HECTARE FARM UNIT

Item	Unit	Under Present Conditions	With Reclamation Project: Upon Completion	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Farm Production and Cash Value						
Average rice yield	kg/ha	1,200	1,830	2,500	3,720	4,000
Farm production, rice (paddy)	kg	4,800	4,941	6,750	10,040	10,800
Part of rice production consumed (paddy)	kg	1,200	1,500	1,500	1,500	1,500
Part of rice production used for seed	kg	180	154	154	154	154
Total amount of rice used on farm	kg	1,380	1,654	1,671	1,671	1,671
Total amount of rice available for sale	kg	3,420	3,287	5,079	8,369	9,139
Amount available for sale (polished)	kg	2,390	2,300	3,560	5,860	6,400
Cash receipts from rice sales, at GF 45/kg	GF	107,500	103,500	160,200	263,700	288,000
Equivalent net income from other crops	GF	-	-	3,300	11,065	49,745
Value of rice used on farm, at GF 32/kg	GF	44,160	52,928	52,928	52,928	52,928
Farm Investments	GF					
Land development		-	29,625	29,625	29,625	29,625
Dwelling (farm share)		50,000	50,000	87,500	87,500	87,500
Other developments		15,000	20,000	25,000	30,250	35,500
Equipment and supplies		15,600	15,600	19,700	25,265	32,000
Livestock		-	-	-	22,500	45,000
Miscellaneous		4,030	5,760	8,590	9,760	11,460
Total Farm Investments	GF	84,630	120,985	170,415	204,900	240,725
Current Farm Expenses	GF					
Interest on investments		5,080	7,259	10,225	12,295	14,445
Taxes		3,500	3,500	7,000	7,000	7,000
Depreciation & repairs: buildings & improv.		7,120	7,665	12,320	12,895	13,500
equipment		2,230	2,230	3,630	4,185	4,740
Rice processing		14,040	14,361	19,788	24,645	31,940
Hired labor		9,000	8,000	10,000	12,500	14,000
Marketing (hauling)		6,100	5,750	8,900	14,650	16,000
Fertilizers		-	3,350	6,700	8,770	12,655
Equipment rental			-	-	10,200	12,000
Crop seed				667	1,000	2,545
Plant protection				-	1,550	4,265
Livestock expenses		-	-	-	400	1,000
Miscellaneous		2,360	2,280	3,890	5,510	6,700
Total Current Farm Expenses	GF	49,430	47,895	83,120	115,640	140,790
Financial Statement	GF					
Cash sales		107,500	103,500	163,500	274,762	337,745
Farm privileges: used on farm		38,400	48,000	51,295	56,030	59,695
rental value of house		5,475	5,475	9,375	9,375	9,375
Total income		151,375	156,975	224,170	340,170	406,815
Total expenses		49,430	47,895	83,120	115,640	140,790
Net income		101,945	109,080	141,050	224,530	266,025
Return to family labor and management		101,945	109,080	120,000	140,000	170,000
		-	-	41,050	84,530	96,025

SUMMARY OF PROJECT BENEFITS

Item	Unit	Under Present Conditions	With Reclamation Project: Upon Completion	After 5 Years of operation	After 10 Years of operation	After 20 Years of operation
Reclaimed area	ha	1,530	1,820	2,260	2,260	2,260
Equivalent number of farm units		383	455	565	565	565
Net project income	GF 1000	39,045	49,631	79,693	126,859	150,304
Increase in net income	GF 1000	-	10,586	40,648	87,814	111,259
Direct project benefits (rounded)	GF 1000	-	10,500	40,500	88,000	111,500
Indirect benefits	GF 1000		2,000	9,000	17,000	19,000
Public benefits	GF 1000		4,000	5,500	7,500	9,000
Total Annual Benefits	GF 1000		16,500	55,000	112,500	139,500

Equivalent annual direct benefits	GF 1000	77,800
Equivalent annual total benefits	GF 1000	98,800
Average annual project cost (excluding previous costs)	GF 1000	32,000
Average annual project cost (including previous costs)	GF 1000	42,000

Benefit-cost ratios (excluding previous costs)

With direct benefits only	2.4 to 1.0
With total benefits	3.1 to 1.0

Benefit-cost ratios (including previous costs)

With direct benefits only	1.9 to 1.0
With total benefits	2.4 to 1.0

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THE KAKOSSA PROJECT

The Reclamation Works

The Project Area

The Kakossa Project occupies part of Kakossa Island, which is located in the southern part of Lower Guinea, approximately 30 kilometers to the west of Forecariah and about the same distance to the east-southeast of Conakry. The relationship of the project to the country of Guinea is shown on Exhibit A, and details of the project area are indicated on Exhibit B.

The island of Kakossa, with a length of 17 kilometers and a width of 13 kilometers, is about 190 square kilometers in area. Much of the island is covered by thick mangrove vegetation. The western part of the island is occupied by relatively flat lands only 0.5 to 1.3 meters above mean sea level, where rice cultivation has been practiced for many decades. The project area is traversed longitudinally by a number of long, narrow sand dunes, on which numerous villages are located. One of the largest villages is Yeniya. The island is settled by about 8000 people, three quarters of which are Soussous, and one quarter Balantas.

The project area occupies an elongated area about five kilometers long and two kilometers wide, a large portion of which is presently under cultivation. A series of dunes oriented in a general north-northwesterly direction separate the project area from the Atlantic Ocean. Another dune, parallel to the former, forms the boundary of the southern portion of the project area.

The project area is crossed in a general easterly direction by three main tidal streams, the Soulemanya, the Noreire and the Touguikeren rivers, which are tributaries of the Morebayah River. These tidal streams serve as natural drainage channels in the wet season.

About 2500 hectares of fertile land are included within the area, two thirds of which have had limited cultivation of paddy rice for many decades. In the early 1950's the French Colonial Administration studied the area with the purpose of increasing the rice production. The first studies showed that inadequate drainage and frequent flooding of the island by tide waters were obstacles to the achievement of full potential use of the land.

In 1954 and 1955, the consulting engineering firm COTHA[1/] performed engineering studies for the development of a plan of reclamation. These studies ended with the preparation of contract documents and specifications. This plan consisted of two main dikes, surrounding a total area of about 2500 hectares, to prevent flooding of the lands by tide waters. Three gated structures were provided where the dikes crossed the Soulemanya, the Noreire and the Touguikeren rivers. Drainage of fresh water from the project area by the natural streams was to be improved by means of excavated canals. The engineer's estimate of the cost of the project was CFA Francs 104 million.

Contracts for construction of this project were awarded in 1956 by the Service du Genie Rural. By the middle of 1957 the dikes on the southern and eastern edges of the project area and the Soulemanya control structure had been completed at a cost of approximately CFA

1/ Presently SOGETHA

Francs 90 million. The project was halted upon the departure of the French Administration. Much was left to be done, but no further construction was carried out thereafter. The Soulemanya structure and dikes benefited a limited portion of the total area to some extent. The local people attempted to operate this part of the facilities, but salt water intrusions from the northern side of the project area prevented their effectiveness. Moreover, the lack of proper maintenance resulted in a deterioration of the gated structure.

The Modified Project Plan

The plan proposed in this report for reclamation of the Kakossa ricelands is an extension of the COTHA plan of reclamation, with some modifications. Much better information is now available concerning the hydrology, topography, and agricultural potential of the area, due to the field surveys recently conducted. These surveys and subsequent analyses have served to define the lands worth reclaiming, and to permit designs of a complete flood control system. A general plan of the proposed reclamation project is presented on Exhibit B.

The proposed facilities will serve two main purposes:

(a) prevent flooding of the lands by salt water during high tides;

(b) prevent sustained flooding of the fields by fresh water from rainfall.

The project area will be surrounded by a system of dikes constructed to elevation 5.0 meters, sufficient to prevent the most extreme tides from inundating the lands. All dikes constructed in 1956-57, from Meyeyire to Cogolima, and from the vicinity of Kansire to Foni will be

incorporated in the project, and will require only nominal rehabilitation. The alignment of the new dikes will extend in a northerly direction to the vicinity of Ouendima and will be tied to the dune near Mamadouya. A dike will close the gap between the villages of Mamadouya and Morebayadi. Another dike between Yenkenya and Amaraya will provide protection of a strip of riceland located between the two most westerly dunes of the project area.

The area located within the proposed dike system is somewhat larger than that originally contemplated by COTHA. Substantial areas under cultivation had not been included in the project area, although their protection would have been economically justified. Reclamation of all these lands would now require abandoning existing facilities and constructing new dikes. For sake of economy, such areas are not included in the project area. However, wherever no facilities are presently existing, the alignment of proposed dikes has been relocated so as to provide flood protection to as many cultivated fields as is economically feasible.

Rehabilitation of existing dikes will consist of stripping their top and replacing earth fill to obtain a horizontal 3-meter top width, practicable for operation and maintenance traffic. A 4-meter right-of-way strip will be provided along the existing dikes for passage of heavy equipment for maintenance purposes.

The new dikes will be embankments made of rolled earth excavated from near-by borrow pits. They will have a top width of three meters, and side slopes of 2.5 to 1.0. Their maximum height will be 3.0 meters.

Drainage of the project area will be provided by the natural streams which cross it, supplemented by a number of new excavated

canals where the natural waterways are inadequate. Existing streams will be cleared of obstructions such as fish barrages and overgrown trees. Maintenance roads will be provided along the main streams. New canals will be excavated by draglines to their design section. A total of 10 kilometers of canals will be excavated, with bottom widths varying from 1.0 to 4.0 meters. The drainage canals will discharge into the main streams crossing the project area. At their intersection with the proposed dike alignment, these streams will be provided with control structures. The control structures will permit the unobstructed discharge of water drained from the project area into the Morebayah River, toward the ocean. At the same time, they will prevent the uncontrolled entrance of salt water into the project area during periods of high tides, by means of flap gates.

The existing control structure across the Soulemanya River will be incorporated to the project facilities after rehabilitation. Severe corrosion of the gate guides has rendered this structure inoperative. The gates will be dismantled and new stainless steel guides will be installed.

Three new control structures will be constructed across the Koakou, the Noreire and the Touguikeren rivers. The Koakou structure will improve drainage of the Soulemanya drainage basin. This structure was not included in the COTHA plans. The other two structures will be provided at the locations selected by COTHA. The control structures will be tied to the dikes on both sides by wing retaining walls, made of precast concrete cribbing.

Basically, the new structures will be similar to the existing Soulemanya structure. They will be founded on piles, on which a thick

slab of reinforced concrete will rest. Corrugated metal pipes, with reinforced concrete headwalls at both ends, will be covered by earth fill placed between the headwalls. A flap gate mounted on a vertical lift frame will be provided at each end of each pipe. In the detailed design of the project, consideration should be given to a simpler and more economical design, such as proposed for the Monchon Project.

Access roads and bridges are an important adjunct to the project. At present, roads follow the ridges of the sand dunes, which are above the reach of flooding waters. These roads will continue to serve as the principal access route to the area. Several population centers in the northern part of the plains presently have difficult access. These locations will become readily accessible upon completion of the project by means of the maintenance roads to be provided along the proposed dikes. Several single-lane bridges will be constructed across the drainage canals, to carry construction and maintenance equipment. An economical and simple design is proposed for these secondary bridges, using precast concrete cribs for abutments, and creosoted timber decks. A few foot-bridges of lighter design are also proposed for foot traffic across the canals to permit farm access.

Construction of the project is estimated to take about two years.

Protection Against Tidal Flooding

The plains of Kakossa lie between 0.5 and 1.3 meters above mean sea level. The highest tides reach up to 2.0 meters above the mean sea level, or 0.7 to 1.5 meters above the ground level of the plains. In order to protect the plains from direct inundation by salt

water as a result of tidal action, the dikes surrounding the project area will be constructed to a top elevation of approximately 5.0, or 2.6 meters above mean sea level. This will provide an additional 60 centimeters for wave action and freeboard.

Drainage Design

It is neither practical nor economic that agricultural land be protected against maximum flooding from rainfall. In the case of the Kakossa Project, we believe that the optimum benefits to the use of the land will result with control of surplus waters from rainfall which might occur once in ten years.

In our investigations, we examined precipitation records in Guinea and analyzed the meteorologic conditions in the Kakossa area. We have concluded that a t tal rainfall of 840 millimeters in 10 days and 1060 millimeters in 15 days is probable at a ten-year recurrence interval. This is about 65 percent more than the 475 millimeters in 10 days used in the original design of the project. The difference results primarily from the longer period of record available for the present studies. The drainage system has been designed to cope with these intensities, taking into account groundwater percolation, evaporation, and field retention.

During rainfall less than the design intensity, the canal system can rapidly and effectively remove excess waters. With full design intensity, some ponding of surplus waters would occur on the rice paddies. However, our calculations indicate that this ponding would reach no more than twelve centimeters above the youngest rice plants, and would endure no longer than seven days. Subsequently, the water

levels in the fields could be lowered to about one-half of plant height and held at this level for several days before another severe rain might be expected. With these limitations on inundation the production of rice should not be adversely affected.

Adequate drainage and control of salt water intrusion can be achieved by the proposed works, sufficient to protect the fields against all but the most infrequent and severe conditions.

Agricultural Production

The lands of Kakossa Island are fertile and well suited to agriculture, rainfall is ample, and increased rice production is needed in Guinea. The Kakossa Project can convert the potentials of the area into positive contributions to the regional and national economy.

The Soils and Land

The soils of Kakossa Island are predominantly clays, having a high content of sodium and magnesium ions as a result of frequent salt water intrusions. The soils are only slightly permeable after wetting has taken place. However, these soils will be well adapted to rice culture when the intrusion of salt water on the lands during the growing season is prevented and when the salts present in the topsoil have been leached.

The soils in areas of present cultivation are low in organic matter content, whereas the topsoil of the non-cultivated areas is richer. In general, the fertility of the soils of Kakossa Island is adequate for initial cropping.

Certain precautions are necessary when the project lands are drained. Lowering of the groundwater table could encourage excessive oxidation, the creation of free iron and aluminum in the soil, and an acidity level which might be toxic to the crops. The control gates of the structures across the drainage channels should be operated in a manner that will prevent the ground-water level from being lowered more than is necessary.

The lands of the area have been classified according to their suitability for agriculture, taking into account soil quality, topography, and present drainage. With the improvements of the proposed project, much of the land will be upgraded. A summary of the land classification within the reclaimable area of the project is given in Table 1.

TABLE 1

Summary of Land Classification

Land Class	Quality	Total Area - Hectares Present	Total Area - Hectares Future
1	Very Good	-	2525
2	Good	-	-
3	Fair	1765	-
4	Presently unsuited	760	-
	Total	2525	2525 1/

Crop Yields

About 1530 hectares within the project area are presently under rice cultivation. Average annual production is estimated to average abou 1810 tons of rice paddy, 2/ or about 1.2 tons per hectare.

1/ An allowance of about 10 percent for canals, dikes, maintenance road and other unproductive areas reduces the cultivated area to 2260 hecta

2/ 100 kilograms of unpolished rice, or rice paddy, yields about 70 kilograms of polished rice.

In some years, the production of the project area is considerably higher than the estimated average of 1810 tons, and may reach and exceed 3500 tons. This happens about once every three or four years, when the maximum tide levels reached during the growing season do not result in excessive saline intrusions. Completion of the protective works, particularly dikes and control gates, will result in the dependability of such crop yield almost every year. Subsequently, substantial increases in rice yield should result from the reclamation program.

Our estimates of the yields that can be expected from the various land classes are shown in Table 2.

TABLE 2

Anticipated Rice Yields

Land Class	Annual Yield Tons per hectare
1	4.0
2	2.0-3.3
3	0.8-2.0
4	0

The conversion of land from one class to the next higher class, and the achievement of higher yields will take place gradually over a period of 20 years, after the lands have been reclaimed.

Cropping Pattern

The project area is predominantly suited for rice. However, continuous rice cropping would not be proper, and one-third of the

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land should be left fallow each year or devoted to some other crop. With drainage of the lands and control of the salt water in the reclaimed area, it is possible that other crops could be introduced to the area over an extended period of time. Maize, grain sorghum, and lespedeza could be used for production of poultry. Some of the land of the Kakossa Project would be expected to support other food crops during the time when the land is not used for rice. Such crops as beans, maize, and improved varieties of sweet potatoes would be well adapted to the better drained, less saline soils. These crops would add both quantity and variety to the food crops. Nutritionally, these crops would be beneficial.

A three-year rotation of rice on two-thirds of the reclaimed land is anticipated for the first five years of operation. Thereafter, other crops mentioned above could be advantageously introduced on the remaining one-third of the land. A cropping intensity of 100 percent should be feasible after 20 years of project operation. The projections of crop land use and cropping intensity are shown in Table 3. The intensities shown could be advanced, if sufficient technical and financial assistance were made available to the farmers.

TABLE 3

Projected Crop Land Use and Cropping Intensity

(In Percent of Reclaimed Land)

	Number of Years After Reclamation			
	0	5	10	20
Rice	67	67	67	67
Lespedeza (clover)	-	8	15	20
Maize	-	-	3	9
Grain Sorghum	-	-	-	4
Cropping Intensity	67	75	85	100

Total Crop Production

The cropping patterns and anticipated yields have been combined for estimates of future agricultural production, as shown in Table 4.

TABLE 4

Estimated Annual Agricultural Production in the Kakossa Area

(Metric Tons)

Crops	Number of Years After Reclamation				
	Present	0	5	10	20
Rice (paddy)	1810	2220	3780	5620	6030
Lespedeza	--	--	1800	3400	4600
Maize	--	--	--	140	500
Grain Sorghum	--	--	--	--	200
Total	1810	2220	5580	9160	11330

Project Costs

Construction Costs

The construction costs of civil works and land preparation are based on the quantities of work derived from the preliminary project plans. Appropriate unit costs or lump sums have been applied to these quantities, using price levels of June 1963.

Costs have been segregated into foreign and domestic expenditures. The foreign component has been estimated in U. S. Dollars and the domestic component in Guinean Francs (GF), with an exchange rate of GF 248 equal to one U. S. Dollar.

The construction of the Kakossa Project will require the services of a foreign contractor. Although the project is of only moderate size, facilities available locally are not considered sufficient to have the project constructed either by a local contractor, or under force account by the Guinean government. We have assumed that the construction contract will be awarded, after public advertising and submittal of sealed competitive bids, to a private American or European contractor with the required experience, equipment, and working capital. Most of the construction equipment, and such materials as steel, timber, cement, and fuel will need to be imported. Skilled labor is also expected to come from abroad. Common labor, however, should be available locally. Local labor rates used in the estimates conform with wages now officially in force, and liberal fringe benefits customary in Guinea have been taken into account. The construction prices include allowances for contractor's plant, equipment, labor, home office and local overhead, profit, performance bond, insurance and taxes. Customs duties and taxes on imported equipment and materials have not been included.

A contingency allowance of 15 percent was added to the subtotal of direct costs obtained from the quantities and unit prices. This allowance is intended to cover possible unforeseen difficulties of construction, omissions from the estimates, and possible variations in unit prices. The contingencies provided should be adequate in view of the detailed field information now available and the conservative values used in the individual estimates.

The addition of the contingency allowance established the total direct cost. An allowance of 15 percent was then applied for such indirect costs as engineering, supervision of construction, and owner's

overhead. The addition of this allowance to the total direct cost gives the estimate of total construction cost. The total construction cost of the civil works is estimated to be U. S. $690,000 and GF 175,000,000, or a total equivalent to U. S. $1,390,000. This amount does not include the prior investment by the French Administration for construction of the dike from Meyeyire to Cogolima and the Soulemanya control structure. Some benefits have already been derived from that investment. However, the cost of rehabilitation of these facilities has been included as part of the proposed project.

The cost of land preparation allows for a limited amount of leveling and planing required in the rice fields. These operations can be carried out by the local government with mechanized facilities, and with local common labor. The cost of land preparation is estimated to be GF 25,000,000 and $10,000. The costs of excavating ditches and constructing levees in each paddy are not included in this amount.

Project Investment

The project investment includes interest during the estimated construction period of two years, in addition to the construction costs of civil works and land preparation. Since financing terms are not yet established, net interest during construction can only be assumed. We have used for this purpose an annual interest rate of six percent, to be applied as funds are withdrawn for construction. A breakdown of the project investment is shown in Table 5.

Operating Costs

Annual operating costs will be incurred for normal operation and maintenance of the project, and for renewals and replacements

TABLE 5

Kakossa Project Investment

	Foreign Currency (U. S. $)	Domestic Currency (GF)
Civil Engineering Works	$690, 000	175, 000, 000
Land Preparation	10, 000	25, 000, 000
Total Construction Cost	700, 000	200, 000, 000
Interest during Construction	40, 000	10, 000, 000
Project Investment	$740, 000	GF 210, 000, 000

Total equivalent to U. S. $1, 580, 000, or GF 400 million.

beyond normal maintenance. Annual operating costs for the civil works are estimated to be about one percent of the total construction cost including the cost of previously constructed facilities, or about GF 6 million.

Other annual costs will be incurred for the agricultural extension services to the farmers. These costs may be greater during the early years of project operation, but the long-term average should be about GF 1 million per year.

Total annual operating costs, not including interest and amortization of the initial investment, will be about GF 7 million.

Average Annual Costs

Interest, amortization, and operating costs together represent the annual costs of the Project. The total investment in the project has been estimated as the equivalent of GF 400 million. At six percent

annual interest and 50-year amortization, the annual costs would be as shown on Table 6.

TABLE 6

Average Annual Costs

	GF Million
Interest and Amortization	25
Operating Costs	7
Total Annual Costs	32

Previous Investment

About 90 million CFA francs were expended by the French Administration in 1956-57 for the construction of a dike between Meyeyire and Cogolima and a control structure across the Soulemanya River. The cost of engineering studies amounted to about 14 million CFA francs. Estimating administrative expenses at 6 million CFA francs, the total investment made prior to 1957 amounted to about 110 million CFA francs.

Although a reservoir of salinity behind the dike was noted, the benefits derived from this investment have been relatively small. Since the existing works, after rehabilitation, will become part of the proposed project, there may be some interest in considering the economic value of the project in terms of the total project investment, including the previous investment. It is estimated that the total construction cost of the previously constructed facilities might be about 200 million CFA francs at present day price levels. However, since the investment was

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made in 1957, we have determined the value it would have yielded in 1963 at an annual rate of 6.0 percent. This value would be 156,000,000 CFA francs, equivalent to GF 156 million at the official rate of exchange. The equivalent annual cost corresponding to this investment is about GF 10 million.

Project Benefits

The Project will result in substantial direct agricultural benefits to the farmers due to increased crop production about the present level. Other indirect benefits will accrue to the regional and national economy.

Direct Agricultural Benefits

The direct agricultural benefits are equal to the net increase in farm income due to the effects of the Project. Thus the values of future production with the project must be reduced by the values that could be achieved without the project. Also, farm costs which are needed to obtain the increased production must be deducted.

For estimates of the direct benefits, we have analyzed the future budgets of a typical four-hectare farm, as shown on Exhibit C. In general, we have used the procedures of the U.S. Bureau of Reclamation. Some modifications were necessary due to the lack of agricultural statistics, and to the unusual conditions of a non-private land tenure system, a nomadic and shifting system of farming, and a government controlled price-wage structure.

Land tenure practices in Guinea do not recognize the right of private sale of agricultural land. Any land not being cultivated may be occupied and developed by new settlers. Also, improvements made

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during occupancy may not be sold or transferred. Thus, it is impossible to assign a value to land in an economic analysis.

Gross income to the individual farm units will include cash receipts from rice sales and the value of rice consumed on the farm. The price of rice is now set by the government at GF 45 per kilogram for polished rice, and GF 32 per kilogram of paddy rice. Our budgets are based on these set prices without regard to free-market values or long-term variations.

Farm costs are related to capital investments and operating expenses. The investment to be made by the individual farmer starts with his land developments, which include the excavation of ditches to drain his own paddies, the small levees surrounding each paddy, and some minor leveling. In addition, the farmer must provide his own buildings, equipment and supplies, livestock, and other miscellaneous investments.

These improvements will take place over a period of years as the farmer increases his earnings. As at present, the population of the island of Kakossa will be able to grow manioc, palms for oil, and other crops on the sand dunes, and will continue the practice of fishing. Some increase in these crops will result as more people are attracted to the reclaimed area. Although the value of agricultural production outside of the reclaimed areas is not included in the farm budgets, one-half of future on-farm investments has been allocated to use outside the project.

Operating expenses in the budgets include interest on farm investments, taxes, depreciation, and the annual costs of maintenance,

supplies, and hired labor. These expenses will increase with time, as greater investments are made, more equipment and labor are employed, and the use of fertilizers and other agricultural aids are extended. Hired labor has been estimated at the present government-controlled rate of GF 28 per hour.

Net income to a typical farm unit is equal to the receipts from cash sales, plus the value of food consumed on the farm and the rental value of the farm home, less farm expenses.

Budgets were made, as shown on Exhibit C, for intervals following completion of the Project. An additional budget was made to show what the net farm income would be, if the project were not completed.

Total income to the project will be proportional to the farm-unit income and the number of farms. The estimated income to the project in future years is shown in Table 7.

TABLE 7

Annual Income to Project

(in GF 1000)

	Under Present Conditions	With Project			
		Year 0	Year 5	Year 10	Year 20
Typical Farm Unit	101.9	109.1	141.1	224.5	266.0
Number of Units	(383)	(455)	(565)	(565)	(565)
Theoretical Income	39,045	49,631	79,693	126,859	150,304
Net Increase	--	10,500	40,500	88,000	111,500

Direct agricultural benefits from the project have been taken equal to the net income increase shown in Table 7.

Other Benefits

Indirect benefits from the project will accrue to those persons, other than the farmer, who participate in the marketing of the cash crops. We have estimated the unit value of these benefits to be about equal to the difference between farm prices and retail prices of polished rice, or GF 4.5 per kilogram. The total value is proportional to the increased sale of rice due to the project.

Further public benefits will result to the regional and national economy, through the increased employment during construction and operation of the project, and through the stimulation of other economic activities. Estimates of these public benefits are based on an employment value of the construction labor cost of GF 52 million, plus an annual economic value of five percent of direct benefits.

Benefits will also arise from the opportunity to settle more people in the region as more land is available for cultivation. These, however, are difficult to evaluate and have not been included in the analyses.

Total Annual Benefits

The net benefits due to the Kakossa Project are summarized in Table 8.

Equivalent Annual Benefits

The values shown in Table 8 show that annual benefits will increase progressively in the future. However, the project investment will be made initially. Therefore, we have determined the present

TABLE 8

Net Annual Benefits

(GF 1000)

Years after Completion	Direct	Indirect	Public	Total
1	10,500	2,000	4,000	16,500
5	40,500	9,000	5,500	55,000
10	88,000	17,000	7,500	112,500
15	111,500	19,000	9,000	139,500

worth of the future benefits accruing to the Kakossa Project over its economic life of 50 years as follows:

Present worth of future direct benefits:	GF 1,227 million
Present worth of all future benefits:	GF 1,573 million

The corresponding annual values of these benefits, amortized at six percent over 50 years, are:

Equivalent annual direct benefits:	GF 77.8 million
Equivalent annual total benefits:	GF 98.8 million

Contribution to the National Economy

The Kakossa Project will increase rice production by about 400 tons in the first year of operation, by 2000 tons five years later, and ultimately by more than 4000 tons. These increases will make significant contributions to the national economy of Guinea.

The present population of the Republic is estimated to be about three million and increasing by about three percent per annum. At this

rate, which is expected to be maintained or possibly exceeded in the future, the total population will reach nearly six million in about 20 years.

Food production per capita in Guinea has been declining since 1958. Production of the major subsistence crops, cassava and rice, have not kept pace with the population increase. The annual production of cassava has been maintained around 350,000 tons, and the production of rice has averaged about 310,000 tons of paddy, equivalent to about 220,000 tons of polished rice.

In the past, the country has generally been self-sufficient in most subsistence crops, except rice. The rice shortages stem from the fact that, in addition to the population increase, the average per capita consumption of rice has been increasing consistently. It went from about 170 grams of polished rice per day in 1948, to 220 grams per day in 1953, and to 230 grams per day in 1962.

Guinea is the largest rice producer in Africa after Egypt and Madagascar. However, because of the increase in population and in per capita consumption, increasing amounts of rice have had to be imported since 1958, as shown in Table 9.

The projected increase of rice production in the Kakossa Area, as small as it is when compared to the total deficiency, nevertheless will help to reduce imports and save foreign exchange. The production of rice at the Kakossa Project should be dependable, as great fluctuations in rainfall are not common in the area. This is not true in many other areas of Guinea, particularly in the highlands. During the extreme dry year of 1962, national production of rice paddy dropped to only 220,000 tons, or 30 percent below average.

TABLE 9

Rice Imports

	1958	1959	1960	1961	1962	1963
Metric tons (polished rice)	7,000	25,000	20,000	25,000	30,000*	35,000*
Cost, equiv. U.S. $ million	1.0	2.2	1.7	2.1	(Not available)	

* Estimated on the basis of present trade agreements.

Economic and Financial Analyses

Benefit-Cost Ratios

The economic value of the project can best be measured by a comparison of its annual benefits and annual costs. The ratios shown in Table 10 have been derived from benefits and costs previously described.

In addition to the benefit-cost ratios corresponding to the proposed investment, we have determined the benefit-cost ratios of the project including the investment made prior to 1958 by the French Administration. No benefits from the previous investment were considered in this analysis, as they are small. These benefit-cost ratios are shown in Table 11.

TABLE 10

Benefit-Cost Ratios Corresponding to Proposed Investment

(GF million)

	Direct Benefits Only	All Benefits
Equivalent annual benefits	77.8	98.8
Average annual cost of proposed investment	25	25
Average annual cost of O & M	7	7
Total average annual costs	32	32
Project Benefit-Cost ratios	2.4 to 1.0	3.1 to 1.0

TABLE 11

Benefit-Cost Ratios Including Previous Investment

(GF million)

	Direct Benefits Only	All Benefits
Equivalent average annual benefits	77.8	98.8
Average annual cost of previous investment	10	10
Average annual cost of proposed investment	25	25
Average annual cost of operation and maintenance	7	7
Total average annual costs	42	42
Project Benefit-Cost ratios	1.9 to 1.0	2.4 to 1.0

The ratios given in Table 10 indicate that the incremental investment costs for completion and rehabilitation of previous works will be well justified by the benefits which are anticipated from operation of the project. Table 11 indicates that the project is justified, even when taking into account the previous investments. However, it must be emphasized that the benefits indicated can be achieved only if the proposed reclamation works are accompanied by a modest program of land management and agricultural assistance. Such a program can be simple enough to be easily accepted and put in practice by the local farmers, with the guidance of trained personnel of the regional administration.

Financial Requirements

The investment costs of the Kakossa Project amount to U. S. $740, 000 in foreign expenditures and GF 210 million in domestic expenditures. Neither the local communities nor the Regional Administration could obtain such funds.

The national government could finance the project from appropriations. However, this is only one of several reclamation works being considered, all of which together would reclaim about 40, 000 hectares. Collectively, these projects could not be financed out of currect income without very adverse effects upon an already serious deficit in the nation's balance of payments. It is probable, therefore, that loans will be sought from sources outside Guinea.

The source and terms of such financing are not now known. For the purpose of our analysis, we have assumed that liberal terms can be obtained, such as are currently offered for this type of project by the International Development Agency (IDA) and by the United

States' Agency for International Development (AID). These institutions have been making agricultural development loans to national governments with a 0.75 percent annual service or interest rate and repayable over 40 years following a 10-year initial moratorium period.

With such terms, and including interest during construction, investments of U. S. $750,000 and GF 212,000,000 have been used in our financial analyses.

Effect on Foreign Exchange

Loans received to finance foreign expenditures would probably require repayment in foreign currency. Under the terms cited above, annual repayments and interest after ten years would be about U. S. $36,000. At the same time the increased rice production alone would reach over 3000 tons per year, reducing annual imports by a value of more than U. S. $300,000. Even at far less favorable terms, a positive saving in foreign exchange would result.

Financial Feasibility

In the case of the Kakossa Project, the financial obligations to be incurred will probably be made by the national government with international lending institutions. Part of these obligations may require repayment in foreign currency, which only the national government could guarantee. Any assessments against the farmers of the project will be set by the sponsoring government agency, and will be payable in domestic currency.

Although the credit of the national government is ultimate assurance of financial repayment, the economy of the project gives a measure

of financial feasibility. The best measure is the relationship between the residual income of the project beneficiaries and the total annual costs of the project.

The farm budgets, shown on Exhibit C, have included an allowance for the return to family labor and management in the computation of residual income available for profit and repayment. The total residual income to the project is equal to that of a typical four-hectare unit times 455 such units until the fifth year, and 565 thereafter.

The annual costs used previously in the benefit-cost analysis were long-term averages based on a six percent return on capital. For a financial analysis, the anticipated year-by-year expenditures should be used, including specific values for interest and amortization, and considering moratorium periods. In the case of the Kakossa Project, our financial evaluation is based on the liberal terms of agricultural loans. However, we have recognized that expenditures for agricultural extension services should be greater in the early years.

The computed values of residual income and annual costs are given in Table 12.

Only during the first five years of project operation will residual income of the farmers be less than the total annual costs of the project. From then afterward, income becomes substantially greater than project costs. The comparison indicates that the project has financial merit, even if the interest and amortization terms were less liberal than has been assumed.

TABLE 12

Financial Analysis

(Amounts in GF Million)

Years After Completion	Residual Income Available for Profit and Repayment	Annual Costs			
		Interest and Amortization	Operating Costs	Extension Services	Total
0	0	3	7	4	14
1	0	3	7	4	14
2	0	3	7	4	14
3	0	3	7	1	11
4	4	3	7	1	11
5	12	3	7	1	11
6	24	3	7	1	11
7	32	3	7	1	11
8	39	3	7	1	11
9	44	3	7	1	11
10	48	11	7	1	19
15	53	11	7	1	19
20	54	11	7	1	19

Project Repayment

Agricultural and reclamation developments such as the Kakossa Project must yield sufficient financial return to the beneficiaries as an incentive for private investment and for increased production. Thus, it is not always advisable that the entire cost of the common works be borne by the farmer, even if residual income should indicate such a possibility.

The extent to which the farmers are required to repay project costs is a matter of national policy. For example, in the United States

water rates are frequently set at 15 to 25 percent of the computed repayment ability. The term "repayment ability" is usually taken to mean the net income to the farmer less an adequate return for his family's labor and management effort, or what we have herein defined as residual income.

Repayment requirements which are less than project costs amount to a national subsidy. Justification for such subsidy is usually based upon the indirect and public benefits which result from the project.

It will be important, particularly in the early years of operation, that farmers be given the incentive and opportunity to make the best possible use of the reclaimed land. This is particularly true in the case of the Kakossa area, which is already at a relatively advanced stage of development, although plagued periodically by tidal flooding. Constructive participation of the cultivators toward the realization of the potential production will be contingent upon the economic advantages which they will derive therefrom. Assessments which are initially too great will discourage the farmers or siphon off the capital needed for on-farm improvements. Yet, little or no assessment in future years will encourage indolence on the part of those settlers who are satisfied with only a subsistence living.

A flexible policy on repayment is indicated, beginning at a minimum level and increasing as the productivity of the area reaches its true potential.

Implementation of the Project

The Kakossa Project can be economically valuable and is financially feasible. However, its success will depend upon prudent

arrangements for financing, engineering, construction, administration, fiscal control and operation, and upon an adequate agricultural extension program.

Financing Arrangements

The previous attempt at construction of the Kakossa Project was started with insufficient funds and guarantees to complete the necessary civil works. A new start should only be made if the full financial needs of the project are firmly committed in advance, including both foreign and domestic currency.

To insure that funds will be adequate, loan authorizations should include a supplemental financing contingency to allow for possible cost increases during any delayed negotiations and during the subsequent construction period. This financing contingency should be about five percent of foreign currency requirements and 15 percent of local currency requirements. Loan applications should be made for U. S. $780, 000 and GF 240 million, not including interest during construction.

Engineering

Planning and engineering studies had been prepared prior to commencement of construction undertaken in 1956-57. Specifications and detailed construction drawings prepared by COTHA formed the basis for contract award at that time. While they can be advantageously used for preparation of the proposed construction work, they must be modified to reflect changes in the project plan and new contract documents should be established.

The changes in economic conditions that have taken place since 1956 and the new administrative and legal conditions in force in Guinea

will require different contract specifications. International financing will require stricter accounting of expenditures and more rigid supervision of construction than has been practiced in the past. Changes in the size of the required structures that resulted from the hydrometeorological data that have been accumulated since 1954 will require important modifications to the COTHA designs.

A competent and independent consulting engineering firm should be retained for the preparation of new contract documents and modified construction drawings. Such a firm should be free of any association with contractors, manufacturers, or other adverse interests, to allow unbiased professional direction of the work.

Construction

Construction of the project should be carried out under one general contract. Any division of the work into separate contracts would lessen the interest of the larger and more competent firms, reduce competition, and add to administrative costs. Only pre-qualified contractors, with proven experience and adequate resources, should be allowed to bid. Contracts should be let at fixed unit prices with adequate guarantees of performance bond and insurance.

Preparation of the project lands for agricultural use should proceed concurrently with the construction of the civil works. This work can be carried out under force account by the Center of Rural Mechanization (C. M. R.), an agency of the Service of Production of the Administrative Region of Forecariah, or any other governmental agency to which suitable mechanized equipment and operators are available.

Proper coordination between the land preparation and the contractor's operation will allow a partial rice crop to be harvested at the end of the first construction year.

Administration

As soon as the project is authorized, an organization should be established for the administration of construction and of subsequent operation. This organization should be a regional agency, with budgetary support from the national government. It should have a reasonable degree of autonomy and be held responsible for the success of the project. This agency should exercise fiscal and operational control of the project, be able to employ expert assistance when needed, and have call upon the agricultural supporting facilities of other agencies.

The administrative agency should have a fiscal department to control construction funds released by the national government and the lending agencies for the project, and later to control assessments on the farmers and payments for operation. A department closely associated to the project is needed to insure that proper certification is made for disbursements, that assessments are made in accordance with project obligations, and that collections due are in fact received.

An operations and maintenance department will be needed to control outlet gates, keep canals free of obstructions, and maintain the levees.

Agricultural Extension Program

It is of utmost importance for the success of the proposed project that all of the reclaimed lands be brought to cultivation as early as possible and that farming practices be improved.

We recommend that an experienced rice agronomist be employed full time in the project area for a period of several years from the beginning of the construction phase. Because of the present shortage of trained Guinean technicians, this agronomist may have to be an expatriate. He should direct the agricultural program, and guide and advise the farmers on methods of increasing production.

The agronomist could also direct the program of land levelling and farm preparation.

Under the direction of the agronomist, pilot demonstration plots should be formed in the project area for experimentation with rice varieties and fertilizers. The results of these research programs should be disseminated in an easily understood manner among the farmers. Practical demonstrations of improved cultural practices, particularly through mechanization, should be given to the farmers. Also, the agronomist should perform routine physical and chemical tests on the project soils.

If the agronomist engaged for the project is an expatriate, he should be assigned a Guinean assistant who should be a young agronomist with college training.

PART II

SUPPORTING INFORMATION

Chapter	I	Geography of the Project Area
	II	History of the Kakossa Project
	III	Field Investigations
	IV	Project Lands
	V	Agriculture
	VI	Project Design
	VII	Project Construction
	VIII	Project Economics
	IX	Project Operation and Development

Chapter I

GEOGRAPHY OF THE PROJECT AREA

General Description

The Republic of Guinea is located on the Atlantic coast of the "Bulge of Africa" 700 kilometers southeast of Dakar (Republic of Senegal) as shown on Exhibit A. It extends from latitude 9° to 12.5°N and from longitude 17° to 12°W. The country is bounded by Portugese Guinea on the northwest, the Atlantic Ocean on the west, Sierra Leone on the southwest, Liberia on the south, the Republic of Ivory Coast on the southeast, and the Republics of Senegal and the Mali on the north. The country has an area of about 250,000 square kilometers.

Guinea is divided into four regions. The coastal area (Lower Guinea) forms a band along the Atlantic which averages 100 kilometers in width. This area is characterized by heavy rainfall from May to September. There is little variation in temperature throughout the year--the average maximum temperature is 85°F and the average minimum 75°F. The second region, occupying over half the total area, is the Fouta Djallon, a plateau averaging about 300 meters above sea level but rising in places to over 1000 meters. This area has less rainfall and lower temperatures than does the coastal region. Upper Guinea, the third region, is a low land to the north and east of the Fouta Djallon, where the Sahara belt is approached. The rainfall is relatively light and the temperatures are much higher than on the coast. Finally, there is the forest region, immediately north of Liberia. This is an

area of typical West African tropical rain forest with high temperatures. The rainfall, while heavy, is somewhat less than on the coast.

The Island of Kakossa is located in the southern part of Lower Guinea, approximately 30 kilometers west of Forecariah, the seat of the Administrative Region of Forecariah. Its general location is shown on Exhibit A. The Island of Kakossa, located along the Atlantic Ocean, is isolated from the mainland of Lower Guinea by the Soumbouya River on the northwest, the Sankinefoli River on the northeast, and the Morebayah River on the east.

Like a large part of the Guinean coastal zone, the island of Kakossa is fertile, with a great potential for rice production. Climatologic, physiographic and hydrologic factors play an important role in the successful exploitation of ricelands. This chapter presents the conditions that prevail in the Kakossa area which are typical of those in Lower Guinea, as well as conditions that are peculiar to Kakossa Island.

Climatology

General

The climate of Lower Guinea is monsoonal, characterized by a dry season followed by a very wet one.

The dry season extends from December through April. It is hot, with high relative humidity, but is somewhat tempered by moist marine winds. There is generally no precipitation in the Kakossa area during the December-April period. Vegetative growth may cease for several months because of the complete lack of precipitation.

The wet season extends from May through November. The monsoon is at a maximum in July and August, with a high persistence. Precipitation during the wet season is in the form of violent and continuous rains. Relative humidity is very high during the wet season. Total precipitation for the May-November period averages about 4000 millimeters in the Kakossa area.

Air Masses

The fundamental cause of the climate of Lower Guinea is the seasonal migration of two air masses, the Tropical Continental and the Tropical Maritime. Some role is also played by the Inter-tropical Front.

The Tropical Continental Air, warm and dusty, extends from the Sahara southward, reaching its maximum extent in January between about 5 and 7°N. Associated with it are dry north-easterly or easterly winds. The mass of Tropical Maritime Air, warm and humid, trends from the ocean inland in July or August to about 17°N on the coast and to about 21°N in the interior. Associated with it are wet south-westerly or westerly winds.

These two masses alternate seasonally over Lower Guinea. Owing to different densities of the two air masses, the front slopes upward toward the south, so that the maritime air forms a wedge under the continental air. This wedge penetrates northward as the maritime mass becomes predominant in and after May, and brings the heavy monsoonal rainfalls. It retreats southward in August or September.

Between these two main air masses is the Inter-tropical Front, which lies north of the Equator throughout the year. With the penetration inland of the maritime air mass, the Front pushes north-westward. It returns south-eastward upon the retreat of the maritime tropical air.

Prevailing Winds

Line Squalls. At the change of season in May, with the north-westward advance of the Inter-tropical Front, the dominant winds may change suddenly. This is accompanied with thunderstorms or "line squalls," often misnamed tornadoes. These north-easterly storms are the partial cause of almost all rain received on the Guinea coast between May and July, and again from September to October.

"Line squalls" are preceded by a day or two of high temperatures and oppressively still air. Finally, the sky darkens, there is vivid lightning and the noise of rushing wind. Winds become south-westerly and temperatures drop by 10 to 20°F (5 to 10°C). Heavy rain, up to 50 millimeters in less than an hour, follows the wind and dust. This rain then gives way to a gentler rain without lightning. When the rain ceases, the clouds disappear and temperatures rise again.

South-westerlies. Associated with the moist maritime air mass are south-westerly winds. They prevail all the year south of Guinea, and penetrate up the coast in July. During the prevalence of these winds, continuous rains may occur for long periods. Skies are frequently cloudy, and early morning mist is common. Visibility is good, except during actual rainfall.

Sea Breeze. The sea breeze in Lower Guinea may reverse the normal winds. In January, for example, a westerly wind frequently replaces the North-east Trades during the afternoon. They may also reinforce the south-westerly winds during the monsoon period.

Precipitation

In Lower Guinea substantial precipitation generally starts in the beginning or the middle of May and ends in the first half of November.

The number of rainy days as well as the amount of rain vary considerably from year to year and from north to south.

The average number of rainy days in the year varies from 100 to 150, and the average annual precipitation varies from about 2850 to 4300 millimeters depending upon the location.The highest annual precipitation in Lower Guinea generally occurs around Conakry.

Average Rainfall in the Project Area. Three rain gage stations are located in the vicinity of the project area. They are located at Conakry (airport), Forecariah, and Coyah. 1/ The Conakry-Aviation (airport) station has been in continuous operation since 1949. The Forecariah station was installed in 1923, but only records from 1950 to date were available for the purpose of the present studies. The Coyah station was installed in 1950 and has been in service to date. In addition, one station was in service during part of the rainy season of 1954 at Yeniya, on Kakossa Island. This station was installed to obtain basic data in connection with the COTHA studies.

Average monthly precipitation for the periods of record at Conakry-Aviation, Forecariah, and Coyah is given in Table I-1. Precipitation outside of the May-November period is small and is not indicated in this and the following tables. Long term averages were estimated for the Forecariah and Coyah stations by comparison of their periods of record with concurrent periods for Conakry. These adjusted values are shown in Table I-2.

In adjusting the average precipitation for the period of record, a good correlation was found between the stations of Conakry and Forecariah.

1/ Another station is located at Conakry (city). This station has not been used because of its proximity to the ocean. The data recorded at Conakry-Aviation are more indicative of conditions prevailing on the coast of Lower Guinea.

Table I-1 - Average Monthly Rainfall

(in millimeters)

Month	Conakry-Aviation (1949-63)	Forecariah (1950-62)	Coyah (1950-62)
May	148	210	178
June	487	442	485
July	1297	853	1149
August	1264	1106	1297
September	758	666	702
October	306	356	397
November	127	160	169
Average for the wet season	4387	3793	4377

Table I-2 - Estimated Long-Term Average Monthly Rainfall

Month	Conakry-Aviation	Forecariah	Coyah
May	148	200	170
June	487	420	460
July	1297	830	1100
August	1264	1110	1290
September	758	660	680
October	306	370	400
November	127	160	170
Average for the wet season	4387	3750	4270

The correlation between Conakry and Coyah was weaker, possibly because Coyah is located closer to the hills than both Conakry and Forecariah.

The precipitation recorded in 1954 at Yeniya is summarized in Table I-3. Also shown are the corresponding values for the other three stations.

Table I-3 - Comparison of Rainfall Recorded at Yeniya in 1954 with that Recorded at Other Stations

(in millimeters)

Record Period	Yeniya	Conakry-Aviation	Coyah	Forecariah
July 11-31	1245	1555	1045*	912
August 1-31	1285	1626	1440	1182
Total (July 11-August 31)	2530	3181	2485	2094
Long-term August average	--	1264	1290	1110

* Estimated

Table I-3 indicates the following: August 1954 was definitely more rainy than average at the three permanent observation stations. The precipitation recorded at Yeniya from July 11 through August 31 was smaller than that for Conakry-Aviation, but higher than that for Forecariah. However, it was of the same order of magnitude as that recorded at Coyah, although with more variability inside of the period of record. It can also be noted that the precipitation recorded at Yeniya

during its short period of record was about 10 to 20 percent higher than that for Forecariah and 20 percent lower than that for Conakry-Aviation.

Extreme Precipitation. Annual precipitation in the project area varies from year to year by not more than about 30 percent above or below the yearly average. At Conakry-Aviation, where the average annual precipitation is about 4400 millimeters, the driest year on record was 1949, when about 3200 millimeters of rainfall were recorded. The wettest year was 1954, with a total precipitation of about 5600 millimeters. The monthly precipitation for these years is shown on Exhibit 1

Monthly precipitation is more variable, as is evidenced by the data summarized in Table I-4.

Table I-4 - Range in Monthly Precipitation at Conakry-Aviation

Month	Driest on Record	Average	Wettest on Record
May	39	148	348
June	273	487	925
July	661	1297	1890
August	922	1264	1628
September	328	758	1341
October	151	306	667
November	31	127	208

Atmospheric Humidity

Atmospheric humidity in Lower Guinea does not vary much from year to year. However, its monthly variations are great, and so are its diurnal variations. The average minimum and maximum monthly humidity at Conakry-Aviation, determined from observations made from 1949 through 1963, are presented in Table I-5.

Table I-5 - Average Minimum and Maximum Monthly Humidity at Conakry-Aviation, in percent

Month	Minimum	Maximum
January	52	94
February	48	92
March	50	90
April	51	90
May	60	93
June	71	97
July	77	98
August	80	98
September	75	98
October	69	98
November	67	97
December	57	94

The diurnal variations of the relative humidity follow, in reverse, those of the temperature. The humidity is highest at night and lowest during the day. A graph showing typical variations of the relative humidity recorded at Boke in 1962 at 6:00 a.m., 12:00 noon, and 6:00 p.m. has been presented in an earlier report. 1/ These variations are representative of conditions in Lower Guinea.

1/ Feasibility Report on Riceland Reclamation in Guinea-Mochon Project, by Harza Engineering Company, October 1963.

The shapes of the curves reflect the movements of the maritim and continental air masses.

Temperature

No temperature data are available for Kakossa, but conditions are similar to those at Conakry-Aviation. The average minimum and maximum monthly temperature at Conakry-Aviation, determined fron observations made from 1949 through 1963, are presented in Table I-6.

Table I-6 - Average Minimum and Maximum Monthly Temperature at Conakry-Aviation, in °C.

Month	Minimum	Maximum
January	22	31
February	22	31
March	23	32
April	23	32
May	23	31
June	23	29
July	22	28
August	22	27
September	22	29
October	22	30
November	23	30
December	22	31

The maximum and minimum temperatures recorded at any time generally do not depart fromthe corresponding monthly values indicated in Table I-6 by more or less than two degrees centigrade.

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Physiography

The Coastal Belt

The coastal belt of Lower Guinea is a continental shelf that was submerged by the ocean in recent geologic times. In earlier eras it was crossed by important rivers flowing to the ocean in well-defined valleys. Structural upsets of the Fouta Djallon then displaced and faulted the old summit line. New tectonic breaks, generally oriented along two perpendicular directions, deeply modified the relief. Later, the level of the ocean rose, flooding the old alluvial valleys which became the estuaries of rivers whose watersheds were made smaller by the surface twisting of the Fouta Djallon. Thus were formed the broken coast line and numerous islands that are now present along the coast.

There is no smooth coast, because the continental shelf is comparatively wide, the tidal range is relatively high, tidal scour is strong, and because the coast is oriented directly across the path of south-west or north-west winds that agitate the waters.

The relief of the coastal plain is cut deeply inland by the old estuaries. During the dry season, when surface runoff in the coastal belt is practically non-existent, the submerged valleys become tidal inlets bordered by saline, muddy lands. The coast line and the coastal plain of Lower Guinea are broken at two points by rocky spurs, at Cape Verga and behind Conakry. The former consists of micaceous schists and quartzite, and the latter of granite and ultra-basic eruptive rocks, found also in the Loos Islands and north-east of Conakry.

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The Tidal Estuaries

Tidal variations extend far inland into the deep estuaries, since the coastal plain is at an elevation of only a few meters above sea level. During the wet season, the estuaries provide natural drainage outlets fro the large surface runoff of fresh water. The discharge capacity of the channels is substantially reduced during the high tides, and increases during low tides. During the dry season, there is practically no fresh water discharge in most of these channels, and salt water flows up and down the channels under the influence of the tide. Their downstream reaches carry water with a high salt content, somewhat reduced during the rainy season.

These tidal streams, called locally "marigots," generally present pronounced meanders which, in places, cause real archipelagos. But nowhere deltas are found, primarily because of the turbulence that prevails at the estuaries.

Salt water vegetation in the form of mangrove is present along those reaches where the salt content remains high throughout the year. The mangrove forms a border, several hundred meters wide, along the tidal streams. It is thick, and mangrove trees may reach an impressive height in the vicinity of the ocean. They become smaller and less dense in the upper reaches, where the tidal variations are smaller and where the salinity decreases during the wet season.

Along the tidal streams and their estuaries, the coast is covered by an alluvial, muddy sediment which is very viscous, called locally "poto-poto." Its bluish-black color and its marine salt content indicate an oceanic rehandling of its continental, clayey constituents. These

soils are very soft when wet. Their moisture content can be extremely high. They constitute a good support for the mangrove-type vegetation.

The two rivers that bound the island of Kakossa on its north and east sides, the Soumbouya River and the Morebayah River, are two such tidal streams.

The Soumbouya and Morebayah Rivers

The Soumbouya and Morebayah Rivers separate Kakossa Island from the mainland. They are shown on Exhibit A. Both rivers are typical tidal streams, or marigots, discharging fresh water to the ocean during the wet season and salt water to and from the ocean, alternatively, during the dry season. The Morebayah River drains an area of approximately 300 square kilometers, and the Soumbouya River an area of about 100 square kilometers. Both have well defined channels with widths of about one kilometer at their estuaries. Both rivers are navigable at all tide levels. At low tide, clay flats are visible on the sides of the main channels. The widths of the navigable channels at low tide are approximately 200 meters. The depths at high tide are over 4.0 meters in the center channel and 1.2 meters on the sides.

Tidal Variations

Ocean Tides

The coast of Guinea along the Atlantic Ocean is subject to comparatively large tidal variations. Tide tables for Conakry, with

corrections for the harbors of Benty and Taboria, are published yearly.[1] Also, tide tables for Casablanca, Morocco, are published yearly[2] with corrections for Tanna Island (Estuary of the Mellacoree River), Conakry, Dubreka, and Taboria.

Tidal variations at Conakry have an amplitude reaching a maximum of approximately four meters. From north to south of the Guinean coast the amplitude varies by less than 0.2 meters. The tides do not reach their ebb and flood levels at the same time on all points of the coast, although the difference is not very great. Maximum and minimum levels near Tanna Island (35 kilometers south of Kakossa Island) may be reached 25 minutes after they occur at Conakry.

Each tidal cycle has a period of 28 days, with two subcycles characterized by a series of high and low levels reached at full moon (spring tide), and another series of high and low levels, although not as extreme as the former, reached at new moon (neap tide). The difference between them is relatively small. The maximum flood levels of each year do not occur in a given season because the solar and lunar cycles are not in phase.

1/ "Table des Marees des Territoires Francais d'Outre-Mer et de quelques Ports Etrangers" (Tide Tables for French Overseas Territories and some Foreign Harbors, Imprimerie Nationale, Paris.

2/ "Tide Tables - Europe and West Coast of Africa, including Mediterranean Sea," U. S. Department of Commerce and Coast and Geodetic Survey, U. S. Government Printing Office, Washington 25, D. C.

Tide Propagation in the "Marigots"

Variations of the ocean level induce corresponding water level fluctuations in the tidal streams or "marigots." These variations are propagated in an upstream direction along the streams according to well-defined patterns.

In the absence of fresh water discharge in the tidal streams, rising (or flooding) tides induce a flow of salt water from the ocean in an upstream direction. As the level of the ocean stops rising and begins falling (ebbing), the flow in the tidal streams decreases, a reversal of the current occurs and the marigot empties itself into the ocean where the water level is dropping to its ebb.

At a given point of a tidal stream, the water level undergoes fluctuations similar in character to the ocean tides that cause them. The amplitude of these tidal fluctuations decreases as the distance from the ocean to the point considered increases. The length of the period of tidal fluctuations is about the same as at the ocean, but the occurrence of the maximums and minimums is delayed by a period of time (lag) that increases as the distance from the ocean increases. These two changes in the characteristics of the tidal fluctuations in a tidal stream--decrease in amplitude, and lag of peaking time--result from the frictional resistance which the stream channel opposes to the propagation of tidal currents. Smaller and longer channels cause a greater resistance and, therefore, result in a greater dampening of tidal waves.

When substantial fresh water flows are discharged in the tidal streams, the downstream current may be strong enough to prevent the upstream flow that occurs in the dry season, but during high tides the channel discharge capacity is invariably reduced by an amount that can be considerable.

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Tidal Fluctuations in the Soulemanya, the Noreire and the Touguikeren Rivers

Five water level recorders were installed by COTHA in 1954 on the island of Kakossa to collect data on tidal fluctuations in the project area. Three recorders were installed on the various streams, the Soulemanya, the Noreire, and the Touguikeren Rivers, at the proposed locations of the control structures. Two recorders were located in the vicinity of the villages of Yeniya and Taouya. The recorders were operated from August 1954 through March 1955. Graphs showing the flood and ebb levels as recorded at the stations were included in the COTHA reports. 1/

The water level observations indicate that the three marigots behave as typical tidal streams. The amplitude of ocean tides is reduced as the tidal waves are propagated along the streams. This dampening of tidal fluctuations in the Noreire River, for example, is about 0.5 meters for tidal amplitudes of 1.5 to 2.0 meters, but becomes 1.5 to 3.0 meters for amplitudes of 3.0 to 4.0 meters, respectively. Similar dampenings are experienced in the other marigots.

The observations made in the plains were not very conclusive because the recorders were installed in the middle of rice paddies. Consequently, only the highest levels observed are significant. These levels were generally 0.70 meters lower than the flood tide levels.

1/ "Etudes Preliminaires" de l'Amenagement Hydro-agricole de l'Ile de Kakossa (Preliminary Studies of the Reclamation Project for Kakossa Island), Report No. RCT 161, by COTHA, May 1955.

Chapter II

HISTORY OF THE KAKOSSA PROJECT

Introduction

The plains located on the island of Kakossa are fertile lands where the cultivation of rice has been practiced to some extent for many decades by local Soussou populations. They were systematically investigated for the first time by the French colonial administration in the early 1950's for the purpose of increasing the production of rice in Guinea.

Initial Studies (1950-54)

In the initial agricultural studies made by the French administration it was concluded that the lands of Kakossa Island were suitable for rice cultivation, and that climatic conditions were favorable to one crop annually. However, these studies pointed to the need for solving two major problems before the cultivated area and the average yield could be increased:

a. the flooding of arable lands by salt water backing up in the marigots during high tides; and

b. the insufficient natural drainage during the wet season.

Following this agricultural reconnaissance of 9000 hectares of land on Kakossa Island, it was concluded in the studies that reclamation of part of these lands would be justified economically and would contribute to the increase of rice production in Guinea.

The Section of Rural Engineering, newly organized, ordered the performance by contract of a general map at the scale of 1:20,000, which was drawn from an aerial photographic coverage by the National Geographic Institute (Institut de Geographie Nationale). A base line surrounding the central part of the island was laid out in the field, bench marks were installed and their elevations determined by leveling. Subsequently, a complete topographic map at a scale of 1:5000 of the central part of the island was prepared for the Genie Rural under contract. This very detailed map formed the basis for the detailed design of a reclamation project. These two surveys were performed at a cost of approximately 7,100,000 CFA francs.

COTHA Studies (1954-55)

The performance of engineering studies aimed at the development of a reclamation project was entrusted to the Compagnie des Techniques Hydrauliques et Agricoles (COTHA), a French consulting engineering firm specializing in the design of similar projects. The COTHA studies, started in May 1954, consisted of the following:

a. collection of basic data in the fields of climatology, hydrology, topography and soil mechanics;

b. planning studies for the purpose of developing a plan of reclamation, consisting of dikes preventing the flow of salt water on the lands, drainage canals designed to discharge excess runoff, and gated structures across the dikes to permit fresh water flow toward the ocean during low tide levels;

c. preparation of contract drawings and specifications for construction of the various structures involved.

These studies, summarized in three reports, were completed in September 1955, at a total cost of about 7,200,000 CFA francs.

The COTHA Reclamation Project

This project was developed by COTHA on the basis of the planning that had been done by the Service du Genie Rural. It consisted of two main dikes surrounding a total area of about 2600 hectares, about two kilometers in width, extending in a NW-SE direction. The dikes, with heights up to about 2.5 meters but generally on the order of 1.5 meters, would have their crests between elevations 4.50 and 5.30. They would tie into natural dunes. Existing gaps between dunes would also be crossed by shorter dikes.

One of the main dikes, located at the southern end of the project area, between Meyeyire and Cogolima, would have a length of about four kilometers. It would cross the Soulemanya River, and a gated structure constructed at the crossing. The gated structure would be provided with two series of six gates each, automatically controlled with provisions for manual adjustment. The other main dike, located along the north-eastern boundary of the project area, would extend from a point north of Kansire to Ouendima, over a length of about 7.5 kilometers. It would cross the Noreire River and the Touguikeren River, where gated structures similar to the Soulemanya structure would be constructed. The Noreire structure would also have six series of gates, whereas the Touguikeren structure would have only two. About 1.5 kilometers of shorter dikes would be required to close the gaps between dunes.

The top elevation of the dikes were designed so as to be about 0.75 meters above the highest tide levels, thus providing the project area with full protection against salt water.

The drainage of the flat plains located within the protected area would be provided by a series of channels supplementing the natural network of streams. Each of the three main drainage areas would be drained through the corresponding gated structure. The design of the drainage system was based on a precipitation of 366 millimeters in six days (five-year recurrence interval). The average flow to be discharged was found to be about 9 liters per second per hectare. The dimensions of the canals were determined so as to limit the rise of the water level in the paddies to a maximum of 0.25 meters above the ground level, and to bring it back to a depth of 0.15 meters within a period of six days. The maximum water level on the upstream side of the gated structures was found to be lower than the maximum level of tides on the downstream side.

The main quantities and construction costs estimated by COTHA consisted of the following:

Structures	Main Item of Work	Estimated Cost (CFA francs)
Dikes	Length: 13 km Volume: 100,000 m^3	53,000,000
Gated Structures	Number: 3 Volume of Concrete 500 m^3 Sheet Piles: 2000 m^2	34,000,000
Drainage Canals	Length: 9 km Volume of excavation: 50,000 m^3	12,000,000
Contingencies	5%	5,000,000
	Total	CFA 104,000,000

Project Construction (1956-57)

Funds in the amount of CFA 115,000,000 were appropriated by the French Administration to the Service du Genie Rural for construction of the Nakossa Reclamation Project under the 1953-58 FIDES program (capital investments). The excavation of drainage canals was deferred, to be constructed later by force account or other methods, and contracts awarded for the remainder of the civil works.

After restricted competitive bidding, the contracting firm Societe Dumez was awarded in April 1956, a contract for construction of the dikes and control structures in the estimated amount of 89,500,000 CFA francs approximately. A separate contract for furnishing the control gates was awarded to the firm Hamelle, at a cost of approximately 5,500,000 CFA francs.

The contract provided for construction to be completed by June 30, 1958. Payment for the work was to be on the basis of unit prices submitted by the contractor with his bid. However, these prices were based on economic conditions prevailing in November 1955. The contract provided for changes in the unit prices to take into account possible variations of economic conditions by means of a formula of price variations.

Although the contractor moved to the site in May 1956, actual construction started after the rainy season, about October 1956. Work began at the southern end of the plains, with the dike from Meyeyire to Cogolima, 4.2 kilometers long, and the Soulemanya control structure. By June 1957 this work had been completed, together with an additional 2.5 kilometers of dikes on both sides of the Noreire, to the vicinity of Touguikeren. The quantity of fill in the dikes amounted to 90,000 cubic meters, or an increase of 40 percent over the estimated quantities.

The cofferdams for construction of the Noreire control structure had been completed, and excavation of the foundations had been started.

In addition to the unexpected increase in the embankment quantities, the formula of price variations yielded unit prices well above the expected values. A total of about 90,000,000 CFA francs has already be expended or committed by June 1957.

It was then decided to reduce temporarily the reclamation area to about 2000 hectares by deleting from the project the Touguikeren control structure, and constructing a dike between Touguikeren and Yenikenya. In anticipation of the total amounts still needed to carry this reduced project through completion, additional funds in the amount of 60,000,000 CFA francs were requested by the Genie Rural from the FIDES.

In addition to this change to the scope of the project, foundation conditions encountered at the site of the Noreire structure required changes in its basic design. The structure had been designed to rest on a consolidated laterite outcrop; however, soft foundation was encountered.

Construction was not resumed, however, due to the suspension of the FIDES funding program, and later to the departure from Guinea of the French Administration.

Recent Studies

In 1960, upon request by the Government of Guinea, two experts[1/] of the Food and Agriculture Organization of the United Nations (FAO) investigated the steps to be taken in order to increase the production of rice in Guinea. Among other recommendations, they

1/ Messrs. J. de Meredieu and H. A. A. M. Wirtz

proposed to increase the area of lands suitable for land cultivation by construction of hydraulic control structures, and to increase the yield of cultivated areas by means of an agricultural extension program.

More particularly, with regard to the Kakossa Project, the following steps were recommended:

a. Rehabilitation of the Soulemanya control gates and assignment of a technical agent who would be responsible for the operation and maintenance of the structure, at an estimated total cost of GF 2 million;

b. Construction of the Noreire control structure and completion of the dike between Touguikeren and Yenikenya, at an estimated cost of GF 25 million;

c. Engineering of the drainage facilities, at an estimated cost of GF 5 million, and construction of the canals by the local beneficiaries, requiring an estimated average of 8000 man-days of labor annually, over a 15-year period.

List of Reports Relative to the Kakossa Project

1. "Rapport Pedologique" (Soils Report), Secteur des Recherches Rizicoles, Service de l'Agriculture de Guinee (Department of Rice Research, Service of Agriculture of Guinea), 1950.

2. "Reconnaissance Agricole de l'Ile Kakossa" (Agricultural Reconnaissance of Kakossa Island), Report No. 73 AGR I, by F. de Cock, February 13, 1954.

3. "Etudes des Possibilites d'Amenagement des Terres de l"Ile de Kakossa" (Feasibility Study of Land Reclamation Works in the Island of Kakossa), by M. Nungesser, undated.*

* Although this report was referred to in other publications, it was not found in the files of the Ministry of Rural Economy, and could not be examined.

4. "Projet d'Execution du Plan Quadriennal 1953-57 - Production (Riz) - Rapport Complementaire" (Project of Implementation of the Four-Year Plan 1953-57 - Production (Rice) - Supplementary Report), undated. The date of publication is estimated to be May 1953.

5. "Les Plaines Rizicoles de la Basse-Cote de Guinee - La Riziculture Actuelle - Perspective de Developpement" (The Rice Producting Plains of the Coast of Lower Guinea - The Present Rice Cultivation - Outlook for Development), undated. The date of publication is estimated to be 1955.

6. "Etudes Preliminaires" de l'Amenagement Hydro-agricole de l'Ile de Kakossa (Preliminary Studies of the Reclamation Project for Kakossa Island), report No. RCT 161, by COTHA, May 1955.

7. "Avant-Projet" de l'Amenagement Hydro-agricole de l'Ile de Kakossa (Planning Studies of the Reclamation Project for Kakossa Island), Ouvrages de regulation des eaux, Reseaux de drainage (Water control structures, drainage system), Report No. RCT 162, by COTHA, January 1955.

8. "Projet d'Execution" de l'Amenagement Hydro-agricole de l'Ile de Kakossa (Contract Documents for construction of the Kakossa Reclamation Project), Report No. RCT 163, by COTHA, September 1955.

9. "Compte-rendu d'Activite de la Section du Genie Rural dans le cadre du programme FIDES 1953-57" (Report on the Activities of the Section of Rural Engineering within the scope of the 1953-57 program of the FIDES), No. 523 GR, undated. The date of publication is estimated to be June 1955.

10. "Marche sur Appel d'Offres et Serie de Prix - Amenagement Hydro-agricole de l'Ile Kakossa" (Construction Contract Awarded after restricted, competitive bidding - Reclamation Works in Kakossa Island), Service du Genie Rural, dated April 21, 1956.

11. "Memoire Presente par le Service du Genie Rural au Comite Consultatif Local de la Production Agricole-Annee 1957" (Report presented by the Department of Rural Engineering to the Advisory Committee on Agricultural Production - for 1957), No. 491/[illegible] Service de l'Agriculture, Ministere de la Production, Guinee Francaise.

12. "Rapport au Gouvernement de la Republique de Guinee sur les Possibilities d'Amenagement Hydro-Agricole des Terres Rizicultivables de la Basse-Guinee" (Report to the Government of the Republic of Guinea on the Feasibility of Hydro-Agricultural Installations in the Potential Ricelands of Lower Guinea), by J. de Meredieu, Food and Agriculture Organization of the United Nations, Rome, Italy, January 1961.

13. "Augmentation de la Production de Riz en Basse-Guinee-Rapport au Gouvernement de la Guinee" (Report to the Government of Guinea for increasing the Production of Rice in Lower Guinea), by H. A. A. M. Wirtz, Food and Agriculture Organization of the United Nations, Rome, Italy, 1961.

Chapter III

FIELD INVESTIGATIONS

Introduction

In compliance with the terms of its contract with the United States and its executing agency, the Agency for International Development (AID), the Harza Engineering Company sent to Guinea a team of six engineers and agronomists for the purpose of making field investigations for four reclamation projects, including the Kakossa Project. This team included the following personnel:

Project Manager
Hydrologist and Field Engineer
Irrigation and Drainage Engineer
Soils Agronomist
Rice Agronomist
Agricultural Economist

The activities of the Harza team were directed toward the following:

(a) review all existing data;

(b) conduct field reconnaissance and studies for the purpose of determining the adequacy of the existing data; and

(c) supplement the existing data as necessary for an evaluation of the project.

The Harza team remained in Guinea from April, 1963, until the start of the rainy season, in July. This allowed only sufficient time for investigation of the Monchon Project and the Kapatchez Project, and for collection of miscellaneous basic data applicable to all four projects.

The Harza team returned to Guinea after the rainy season, and spent in Guinea the months of November and December, 1963. Investigation of the Koba and the Kakossa Projects were completed during this time. The investigations that were conducted and the results that were obtained are summarized in the remainder of this Chapter.

Review of Existing Documents

A large number of reports and various documents relative to the production of rice in Lower Guinea were reviewed in Conakry. A fairly complete documentation relative to the Kakossa Project was found to be available. This consisted primarily of reports prepared by the consulting engineering firm COTHA relative to a plan of development of Kakossa Island.

Little was found about the works actually performed, with the exception of contract drawings and specifications pertaining to the construction contract prosecuted in 1956-57. No "as-built" drawings were found in Conakry, and it is believed that none were prepared. A pedologic report relative to the soils of Guinea in general, and those of the Kakossa area in particular, was found to be available. The data contained in this report were reviewed and found to be useful.

The analysis of the data contained in these various reports permitted a reasonable understanding of the basic ideas that guided previous planning of the Kakossa Project.

Field Reconnaissance

A field reconnaissance of the project area was made for the purpose of determining the present condition of existing structures, to identify

the problems involved, and to gain intimate, direct knowledge of possible solutions. This reconnaissance also served to formulate a program of more detailed field investigations.

The existing facilities were found to be out of service and in poor condition. Only one of three proposed control structures was installed, the Soulemanya structure. Its location is indicated on Exhibit B. Presently, this structure does not serve the purpose for which it was intended, primarily because its gates are no longer serviceable. Although some deterioration was observed at the surface of the concrete, its structural integrity did not appear to have been affected.

No drainage canals were excavated as part of the reclamation project. Drainage of surface water is effected by means of natural water courses forming three separate systems. The smaller channels are generally in poor condition. Their side slopes and bottoms are covered with brush in many places, and fish barrages have been erected at random. These numerous obstructions restrict the flow of water in the channels. The flow in the smaller channels is collected by three main water courses, which are generally in good condition outside of the project area. Aggradation is apparent in the lower reaches of the Soulemanya.

Existing dikes have been subjected to normal wear and tear without proper maintenance since they were constructed in 1957. While they are generally sound, they will require rehabilitation to be made completely serviceable.

Local officials and farm operators were contacted and interviewed at length to obtain information on various specific points. Data were obtained on the extent of flooding and salt water encroachment in the project area and on the present difficulty of economic rice agriculture. All

persons concerned seemed to recognize the problems involved and their magnitude. All were obviously eager to carry out the works necessary to reach full production.

Topography

The following topographic data were found in Conakry:

(a) a set of 32 aerial photographs at a scale of 1:20,000, taken in the 1950's and covering the entire project area;

(b) a topographic map at a scale of 1:20,000 without elevations, made by COTHA from an uncontrolled mosaic of the aerial photographs;

(c) a detailed topographic survey made about 1955 by COTHA to a scale of 1:5000, in three sheets, with contours at 50-centimeter spacing and numerous spot elevations.

The accuracy of the 1955 survey was verified in the field. Numerous bench marks were identified and the difference in elevation between bench marks was determined by the Harza team. Results established that the survey is acceptable as a basis for design. These maps were used to prepare the drawings presented in this report.

The COTHA topographic survey mentioned above used an arbitrary reference datum. However, by comparison of tide elevations measured at Kakossa and given in the tide tables, it was established that the datum of the COTHA survey is located about 0.30 meters below the tide table datum, itself about 2.10 meters below mean sea level. The COTHA reference datum is, therefore, about 2.4 meters below mean sea level. The COTHA system of reference was used in the present report.

Cross-section and slopes of existing canals were determined. This permitted determination of the capacity of the existing canals and, where additional work is proposed, calculation of the amount of earthwork that has already been done.

Hydrography

Hydrographic investigations were carried out for the following purposes:

(a) to determine the present condition of the main outlets with respect to accumulation of sediment;

(b) to collect data on the cross-section of the main channels and the tidal streams, to be used in hydraulic design; and

(c) to collect data on tidal variations for hydraulic studies.

A detailed reconnaissance of the Touguikeren, Noreire, and Soulemanya Rivers and their ocean estuaries was made on a 12-foot boat with outboard motor. Soundings of the water depth were made from the boat at various locations. At both the Touguikeren and the Noreire structure sites, outcrops of consolidated material were found at low tide. However, these outcrops are not extensive and may be removed easily when the structures are installed. Otherwise, the Touguikeren and the Noreire River channels proved to be wide and deep, with no evidence of aggradation.

Conditions at the Soulemanya were found to be different. At its mouth, the river channel appeared to have been seriously aggraded. This is evidenced by extensive deposits of sand and silt at the mouth of the river, and by a reduction of tidal amplitudes as measured at the site of the Soulemanya control structure.

Data on cross-sections of the Touguikeren, Noreire, and Soulemanya river channels as measured near high tide, are summarized in Table III-1

Table III-1 - Dimensions of Tidal Streams

(measured near high tide)

Stream	Approximate Location	Side Slope	Surface Width (meters)	Max. Depth (meters)	Water Area (square meters)
Touguikeren	100 m. downstream from proposed structure site	4:1	30	>2	45
Touguikeren	200 m.upstream from confluence with Noreire	4:1	60	>2	110
Noreire	100 m. downstream from proposed structure site	4:1	35	>2	55
Noreire	100 m. upstream from confluence with Touguikeren	4:1	80	>2	170
Soulemanya	100 m. downstream from existing structure	6:1	40	1.8	55
Soulemanya	200 m. upstream from mouth	6:1	60	1.4	105
Soulemanya	200 m. into tidal estuary	-	--	1.4	-

The three tidal streams drain areas as follows:

Soulemanya:	12 square kilometers
Touguikerer:	4 square kilometers
Noreire:	10 square kilometers

A comparison of the data in Table III-1 shows that the cross-sectional areas of the Noreire and the Soulemanya channels at the structure sites are comparable. However, near its mouth, the Soulemanya has a cross-section of only 105 square meters, as compared with 170 square meters for the Noreire, even though the area drained by the Soulemanya is about 20 percent greater than that drained by the Noreire. This would support the observation that the downstream reaches of the Soulemanya are presently undergoing a process of sediment deposition. As mentioned above, this is also substantiated by the observations of tide elevations made by the Harza team.

Water surface elevations at high and low tide were measured at the sites of the existing Soulemanya control structure and at the sites of the other proposed structures. These elevations were compared to the observations made in 1955 by COTHA, as reported in their report. 1/

Amplitudes on the order of two meters were measured on the Touguikeren and on the Noreire. These results are within the range of the COTHA measurements. However, measurements on the Soulemanya were quite different, as shown in Table III-2.

Data presented in Table III-2 show that the level of high tides at the site of the Soulemanya structure is now lower by about 0.2 meters than in 1955, and that the level of low tides is now higher by about 1.2 meters. This change in tide levels is typical of an aggrading channel.

The reasons for this aggradation have not been investigated in detail, but it is likely that it is the result of the construction of the Soulemanya control structure and its operation, as discussed in Chapter VI.

1/ "Etudes Preliminares" de l'Amenagement Hydro-agricole de l'Ile de Kakossa (Preliminary Studies of the Reclamation Project for Kakossa Island), report No. RCT 161, by COTHA, May 1955.

Table III-2 - Comparison of Tide Elevations

Designation	Measured on February 21, 1955	Measured on November 28, 1963
Amplitude of tide in ocean	2.8	2.8
High tide elevation in ocean 1/	3.4	3.4
Low tide elevation in ocean 1/	0.6	0.6
Low tide elevation on Soulemanya 2/	2.8	1.6
High tide elevation on Soulemanya 2/	4.0	3.8

Foundations

The foundations of proposed sites for the control structures on the Noreire and the Touguikeren Rivers were investigated. The materials encountered consisted of very soft, blue-grey, organic clay, quite similar to the materials found underlying much of the area, and those found in other parts of Lower Guinea. 3/ Consolidated marine deposits were found on the bed of the Touguikeren. These will not be competent foundation materials for the structures and should be removed. It is expected that clay will be found under these deposits.

Soils

A reconnaissance report relative to the agricultural potential of the Island of Kakossa was prepared by the Service of Agriculture of Guinea in 1954. 4/ That report was reviewed and found to contain only a brief description of the types of soils encountered on the island. Although the

1/ Above datum of tide tables.
2/ Above COTHA datum.
3/ See results of soil mechanics tests presented in the Harza Report on Mamchon Project, page III-8.
4/ "Reconnaissance Agricole de l'Ile Kakossa" (Agricultural Reconnaissance of Kakossa Island), Report No. 73 AGR I, by F. de Cock, February 13, 1954.

report contained useful data, these were not sufficient for the purpose of the present studies. Consequently, a supplementary soil survey and an extensive series of chemical analyses were necessary for a proper evaluation of the present suitability of the land for rice production and of the yields that can be expected after reclamation. These investigations were performed by the Harza team.

A map prepared by the Agriculture Service entitled "Map of Damages to Rice Cultivation Caused by Salt Water Intrusion"[1/] was also found to be useful. The information it contained was used as a guide in the field investigations of present production.

A total of 19 auger holes were bored within the area of the Kakossa Project. The location of the holes is indicated on Exhibit 2. The profiles were examined to depths of 1.5 meters and preliminary, visual classification of the horizons encountered was made in the field. About 60 representative samples were taken, and tested in a laboratory set up in Guinea with equipment brought from the United States. These tests consisted of the determination of the pH (degree of acidity) and of the conductivity of saturation extracts (degree of salinity). The logs of the auger holes and the results of these tests are presented on Exhibit 3.

This series of preliminary tests led to the selection of 21 representative soil samples from seven typical areas for detailed chemical analyses. These samples were tested in the United States at the soils laboratory of the Department of Agronomy, University of Arkansas. The analyses performed were for the purpose of determining pH, total salt content, anions and cations of the saturated extract, cation exchange capacity, exchangeable aluminum, total sulphur, and percent water of

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saturation. Other determinations included organic matter, percent free iron, available phosphorus, and particle size distribution(mechancial analysis). These analyses are considered adequate for the economic feasibility studies.

Subsurface Drainage

For the purpose of subsurface drainage studies, the coefficient of permeability of the subsoil was determined in the field. Three typical areas were selected on the basis of the soils survey. One auger hole was bored in each of these areas, at the locations shown on Exhibit 2. A permeability test was performed at each of the auger holes. The auger hole was bored with a standard auger, 10 centimeters in diameter, to a depth of about one to two meters below the groundwater table. Water was pumped out of the hole by means of a plunger pump. The rate of rise of the water in the hole after interruption of pumping was measured with a float and a chronometer.

The data supplied by this test allowed determination of the order of magnitude of the coefficient of permeability of the subsoil. The test is relatively easy to perform and generally provides reliable results. The results obtained for the Kakossa area are summarized in Table III-3.

Table III-3 - Results of Permeability Tests

Auger Holes	Location	Soil Classification	Coefficient of Permeability (cm/sec)
A	N.E. of Donkhui	Silty Clay	0.5 to 0.6×10^{-3}
B	W. of Ouendifari	Silty Clay	0.5 to 0.6×10^{-3}
C	E. of Morebayadi	Silty Clay	0.7 to 0.8×10^{-3}

The values of permeability shown in Table III-3 indicate that:

(a) subsurface soil textures and subsurface drainage properties are generally uniform throughout the project area; and

(b) the coefficient of permeability is in the range of 0.5 to 0.8×10^{-3} centimeters per second.

Prior experience in other parts of Lower Guinea and other parts of the world indicates that the values found above are representative of soils having the textures as described. Therefore, the tests are considered to be reliable. The values they yielded reflect a relatively high degree of permeability.

Rice Agronomy

In the course of the field reconnaissance and other field investigations made on Kakossa Island, present land uses were observed and recorded. The result of these observations is shown as a land use map on Exhibit 2.

The fields presently cultivated were inspected for the purpose of determining the present cultural practices and production rates. Rice fields in various stages of development were observed. In general, all of the rice was well established in the paddy and varied from the late vegetative stage to full maturity and harvest. Transplanting appeared to have been completed in all areas. Exceptionally good crops were found in most of the project area, as a result of relatively low tide levels during the 1963 growing season.

No mechanical agricultural equipment was found to be available on the island. All agricultural operations were being carried out by

hand. Estimates of the total area presently under cultivation and estimates of the rice yields of each field were made. The results of these estimates are shown in tabular form on Exhibit 2.

The varieties of rice grown in the fields on Kakossa were examined. All were local varieties, varied in color and panicle conformation and appeared to be very well adapted to the salt and water conditions that prevailed in the various areas on the island. There were a large number of varieties grown on the island. These included Dissi, Kaolacko, Sekhouna, Bandioulou, Minikoni, Kouli-Mali, Tamba Adline, Toma, Yaye, Twenty-four, Kentikoro, Bountala-Kompan, and Koba-Fore. Dissi was the most salt resistant of all the varieties and was grown in extreme salt environments.

When inspecting the rice fields it was noted that the varieties had been badly mixed, giving extreme plant variation in many fields. Both the annual reports of the Koba Agricultural Experiment Station and a map showing where various varieties were grown on Kakossa proved very helpful in evaluating the rice production. 1/

Miscellaneous

Important basic data and information were obtained through direct contacts with various officials and individuals. Conferences were held with officials of several ministries in Conakry to obtain economic, agricultural and other data; with the Governor of the Region of Forecariah and his staff to obtain detailed information relative to local conditions; with village officials and individual farmers to secure first hand information on the agricultural practices; with government agencies to obtain

1/ "Carte des groupements varietaux des riz" (Map of rice varieties), Service de l'Agriculture, No. 73B AGR F.

miscellaneous data on the availability and cost of various commodities; with foreign contractors presently engaged in civil engineering works to obtain information relative to construction practices, labor and materials availability, and their experience in Guinea; and with U. S. Embassy and AID officials to obtain economic and other data already compiled by them.

All individuals contacted were anxious to help, and their cooperation is appreciated. The information received through these contacts was sometimes contradictory, but this reflects the scarcity of accurate statistical data. First hand information was secured whenever possible and all other data were examined critically, with judgement being used to interpret apparent discrepancies.

Chapter IV

PROJECT LANDS

Introduction

A reconnaissance survey of the arable lands located on Kakossa Island was made to determine to what extent their soils are suited to the cultivation of rice. Approximately 2660 hectares were covered in the course of this survey. The area investigated was found to include lands with varying degrees of adaptability to rice production. A map of present land use is presented on Exhibit 2. These lands were classified with respect to their agricultural potential on the basis of topography, natural drainage, and soil properties.

The results of soil analyses and permeability tests made by the Harza team are given in Chapter III. The present chapter gives details with respect to soils, land use, land evaluation, and land management problems.

Soils Evaluation

Soils Classification

Most of the Kakossa Area consists of flat plains with alluvial clayey soils, traversed longitudinally by a series of low sandy ridges or dunes rising a few meters above the level of the plains.

Most of the lands of Kakossa Island are subject to tidal action. As a result, salinity is relatively high in many parts of the island (conductivity greater than eight millimeters per centimeter). Construction of the

dike between Cogolima and Meyeyire has lessened the influence of tides on the lands located to the northwest of the dike.

The classification of soils is based on their origin and their degree of salinity. Within the project area one finds two main groups: saline alluvial soils and non-saline alluvial soils.

Saline Alluvial Soils. The saline alluvial soils occupy the areas influenced by surface and subsurface salt water intrusions. The frequency of saline intrusions determines the various stages of profile development. Undeveloped saline soils (poto-poto) are found in areas subject to frequent flooding by the tides or permanently submerged. They are generally covered with mangrove vegetation. In the marine flood plain, these soils exhibit some of the characteristics of acid sulphate soils, or cat clays. The more developed soils are found in areas less subject to salt water intrusion. Their profiles exhibit a characteristic ochre brown to yellow or red color caused by the oxidation of iron.

Non-Saline Alluvial Soils. These soils generally have well developed profiles and are located in areas above the elevation influenced by tides. Only a limited area with such soils is found along the edge of the dunes in the southern portion of the project. One of these, near Yeniya, is underlain at various depths - generally below 40 centimeters - by a cemented sandstone material.

Soil Properties

Physical and chemical properties were derived from laboratory analyses performed on soil samples obtained from auger holes. The locations of the auger holes are shown on Exhibit 2.

Soil profiles were established on the basis of texture and other properties. Some of these properties are shown with the soil profiles on Exhibit 3. They include the soils texture, pH, conductivity of the saturated extract, presence of carbonates and the position of the water table at the date of sampling. The results of detailed laboratory analyses performed on selected, representative soil samples are presented in tabular form on Exhibit 4.

Composition and Physical Properties. The surface soils of the area are mainly clays. These clay soils have a well developed horizon differentiation with respect to color texture and organic matter content, but are without structure or have a weak structure depending on their stage of development. The more developed soils are granular to nutty and very friable or sometimes blocky to slightly prismatic.

A soil sample typical of the area was taken at hole No. 5 from 10 to 30 centimeters depth. It contains 4 percent sand, 24 percent silt, and 72 percent clay. The cation exchange capacity of these soils varied from 10 to 31 milliequivalents per 100 grams. Ex-ray diffractograms of four representative samples show the clays to be predominantly kaolinite (80 to 90 percent) with moderate quantities of montmorillonite (5 to 20 percent) and traces of illite (less than 1 to 3 percent). The fine and medium silts are predominantly kaolinite and quartz. The sand fractions were inspected under a petrographic microscope and found to be predominantly angular grains of quartz.

The subsurface soils are also made up of clays. In addition, roots and root spaces were found in the soil profiles. Their presence tend to increase the rate of water movement through the profile.

Chemical Properties. Many of the characteristics and properties of the soil can be ascribed to the constitution of the soil mass. Some of their properties are a low to medium exchange capacity and the absence of a well developed blocky or prismatic structure.

The pH of the saturated paste was acid in reaction, ranging from slightly acid (pH of 6.7) to very strongly acid (pH of 3.3). Generally, with soils of this nature, the pH will rise during the wet season and fall during the dry season. The degree of acidification of the soil depends on the relation of the bases to the sulphates present. Soil profiles with low pH were generally found to contain a high percentage of free iron and a high content of sodium and magnesium on the cation complex. Calcium and potassium are less. There is a possibility that the so-called magnesium clays could be formed if there were no accumulation of sulphides or calcium carbonates. These magnesium clays have the same poor characteristics as the sodium clays: they have a very unstable and a very unfavorable structure.

Salinity. The salt contained in the alluvial soils of the Kakossa Project Area is generally associated with the marine origin of the sediments. It may also be caused by salt water intrusions and subsequent evaporation of water from the ground surface. These salt deposits have remained in the soil because of lack of effective drainage and further salt water intrusion. The degree of salinity in the profile is based on measurements of the electrical conductivity of the saturation extracts. The degree of salinity of the soil has been described in accordance with the following scale:

Degree of Salinity	Electrical Conductivity in millimhos per centimeters
Non saline	0- 4
Slightly saline	4- 8
Moderately saline	8-16
Strongly saline	above 16

The higher lands, located to the northwest of the existing dike, generally have non-saline to a slightly saline topsoil and a slightly saline to moderately saline subsoil. The lands east of the dike, and all other lands subject to frequent salt water intrusions within the project area generally have a moderately saline topsoil and a strongly saline subsoil. The difference between the salt content of the soils to the east of the dike and that of the soils to its west side indicates that the presence of the dike - although incomplete - has resulted in a reduction of the soil salinity.

Although rice exhibits a natural tolerance to moderate contents of salt, particularly when transplanting is practiced, salinity conditions presently prevailing in about 45 percent of the project area limit the potential yields to some degree. In about 30 percent of the project area, potential yields would be seriously limited by strongly saline conditions.

Fertility. The degree of fertility of the soils in the project area is indicated by the content of organic matter in the top layers, the content of available phosphorus, and the content of exchangeable potassium. Fluctuation of the pH complicates the assessment of the soil fertility.

The content of organic matter in the top six to eight centimeters of the soil profiles ranges from 2.8 percent in a cultivated area to 7.9 percent in a non-cultivated area. This percentage for either profile is much less at depths greater than eight centimeters below the ground surface.

The available phosphorus content of the topsoil, expressed as P_2O_5, varies from 13 to 72 kilograms per hectare. A favorable response to phosphate fertilizers is likely for most of the project area. Since phosphate fixation in tropical soils is large, because of the formation of insoluble compounds of iron and aluminum, the addition of phosphate fertilizers as early as practicable will be helpful if the expected yields are to be achieved. It is difficult to estimate what proportion of the phosphate fertilizers applied to the soil is lost by fixation. If sufficient, it should be regarded as a special problem in the management of the soils.

The tests for exchangeable potassium show contents in the topsoil ranging from 0.37 to 2.10 milliequivalents per 100 grams. These amounts will be adequate to obtain the yields that are expected during the first few years of cultivation. Fertilizers may have to be added thereafter.

Present Land Use

About 60 percent of the project area is presently under cultivation. Present use of these lands was investigated to gain information on the problems particular to the project lands and to determine the present agricultural production of the project area.

The project lands were classified into four groups, designated I through IV. Each designation corresponds to a grouping of lands with similar characteristics and present production capabilities. The boundaries of each group are delineated on the map of present land use, presented on Exhibit 2.

Group I includes about 640 hectares of lands which are the best adapted to rice cultivation under present conditions. Approximately

56 percent of the area is cultivated. Rice yields are estimated to be about 1.5 tons of rice per cultivated hectare.

Group II includes about 1125 hectares of lands presently under cultivation, but producing rice in appreciable quantities only once in three or four years on the average as a result of flooding by extreme high tides. Approximately 80 percent of the area is presently cultivated. Rice yields are estimated to average about one ton per cultivated hectare.

Group III includes about 265 hectares of lands that are clear of trees, but not cultivated because of frequent salt water intrusions.

Group IV includes about 475 hectares of land covered by mangrove vegetation, and subject to frequent salt water intrusion.

This analysis of present land use indicates that, although 60 percent of the project area is under cultivation, rice yields are severely limited by adverse natural conditions.

Reclaimable Area

Inspection of the lands located in the project area enabled the identification of those parts of each area which are susceptible of economic reclamation. Table IV-1 summarizes these data. It shows that, in addition to the 58 percent of total arable lands presently under cultivation, about 37 percent can be reclaimed, thus bringing the area under cultivation to about 95 percent of the total arable land area.

The data in Table IV-1 indicate that reclamation will result in a substantial increase of the cultivated area. However, this is not the only effect that will result from it. In addition to an increase of the cultivated area, the yields obtained from the lands presently under cultivation will be greatly increased as a result of drainage and land management.

Table IV-1 - Presently Cultivated and Reclaimable Areas in Each Present Land Use Class

Present Land Use Designation	Arable Land Area (hectares)	Presently Cultivated Area		Reclaimable Area 1/	
		ha	% 2/	ha	% 2/
I	650	560	86	640	97.5
II	1230	970	79	1125	96.5
III	265	0	0	265	100
IV	510	0	0	495	97
Total	2655 ha	1530 ha	58%	2525 ha	95%

Topography

The project area is nearly flat. The ground slopes gently in two general directions: eastward toward the Soulemanya and northeastward toward the Noreire. A small area located at the northern end of the project area is drained southward to the Touguikeren. Low spots or depressions are present between the dunes. These low areas are subject to ponding of water, creating a flooding problem, and possibly a salinity problem.

The flat areas will require little land preparation. Some leveling will be required to fill the existing depressions and insure drainage of surface water toward the canals. Land planing will be required over most of the project area.

1/ Includes presently cultivated area.

2/ Percent of arable land area.

Land Evaluation

Land Classification

The lands located in the project area were classified to estimate their potential value for rice cultivation. This classification takes into account the present land use, soils evaluation, and topography.

Four classes of land were established to represent significant degrees in the potential of lands for rice cropping. Each class corresponds to a grouping of lands having similar present uses, physical and chemical properties, and topographic features. Each class corresponds, therefore, to a certain productivity level and to a certain cost of land preparation for satisfactory production. The classes are defined below:

Class 1. Lands with features of soils, topography and drainage which will provide for high yields at low production costs.

Class 2. Lands which are slightly less adaptable; therefore, with lower productive capacity and increased production cost.

Class 3. Lands with features which materially restrict their production capacity such as flooding, salinity, salt intrusion, hardpan near the soil surface, or pH. Greater expenses for drainage, leaching and land preparation will be necessary.

Class 4. Lands which are temporarily unsuited for agriculture because of flooding, tidal action, salinity, or tree cover.

Each land class was assigned a rating indicating the yields that can be expected. The rating for each land class is indicated in tabular form on Table IV-[illegible].

Table IV-2 - Rice Yields that can be Expected from each Land Class

Land Class	Rice Yield Range (tons/hectare)

It is estimated that at the present time about 1530 hectares of Class 3 land yield about 1.2 tons of rice per hectare on the average. About 765 hectares are presently Class 4 land. They are not in production. These data are shown in Columns (1) through (4) of Table IV-3.

It is estimated that immediately upon completion of the proposed dikes, control structures and drainage canals, the lands that are presently Class 3 will be upgraded to a Class 2 rating. At the same time, the yields of all arable lands will be increased, as shown by Column (9) of Table IV-4. Thus, about 1765 hectares will have a Class 2 rating, with production yields of about 2.0 tons per hectare. Considering that about ten percent of the area will be occupied by canals and levees, the net area of cultivable lands will then be about 1570 hectares. About 265 hectares of Class 4 lands will be upgraded to Class 3, and they will yield an estimated 0.8 ton per hectare. These data are shown in Columns (2) through (9) of Table IV-4.

After a short period of development of five years, it is expected that the yield of these lands can be increased substantially: the best

Table IV-3 - Project Land Class Ratings through Varying Development Periods

Present Land Use Designation (1)	Area of Reclaimable Lands (2)	Present Conditions		After Project Construction		After 5 Years		After 10 Years		After 20 Years	
		Land Class Rating (3)	Rice Yield (tons/ha) (4)	Land Class Rating (5)	Rice Yield (tons/ha) (6)	Land Class Rating (7)	Rice Yield (tons/ha) (8)	Land Class Rating (9)	Rice Yield (tons/ha) (10)	Land Class Rating (11)	Rice Yield (tons/ha) (12)
I	640	3	1.5	2	2.0	2	3.0	1	4.0	1	4.0
II	1125	3	1.0	2	2.0	2	3.0	1	4.0	1	4.0
III	265	4	0	3	0.8	3	2.0	2	3.3	1	4.0
IV	495	4	0	4	0	3	1.0	2	3.0	1	4.0
Total	2525										

Table IV-4 - Reclaimed Area and Yields Expected from Each Land Class

Land Class Rating	Present Conditions				After Project Construction				After 5 Years				After 10 Years				After 20 Years			
	Area, in Hectares		Yield, in tons/ha		Area, in Hectares		Yield, in tons/ha		Area, in Hectares		Yield, in tons/ha		Area, in Hectares		Yield, in tons/ha		Area, in Hectares		Yield, in tons/ha	
	Gross	Net	Range	Av.	Gross	Net	Range	Av.	Gross	Net	Range	Av.	Gross	Net	Range	Av.	Gross	Net	Range	Av.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1													1765	1570	4.0	4.0	2525	2260	4.0	4.0
2					1765	1570	2.0	2.0	1765	1570	3.0	3.0	760	690	3.0-3.3	3.1				
3	1765	1530	1.0-1.5	1.2	265	250	0.8	0.8	760	690	1.0-2.0	1.4								
4	760	-	0	0	495	440	0	0												
5	-	-	0	0																

lands would yield about three tons of rice per hectare, the remainder about 1.4 tons per hectare. This is indicated on Table IV-4. During this development period, the following improvements will be made: very limited land preparation, surface leaching, agricultural and educational training, some fertilizing, and some other improvements of present agricultural practices. The project lands are not considered suitable for other crops at the present time, nor the first few years of project operation.

The yields that can ultimately be expected from each area are shown in the last columns of Table IV-4.

Land Management Problems

General

Maximum production from the lands of the project will depend to a great extent on the way in which the soil, water, and land management problems are handled. Important management problems will be connected with land drainage and its effects on the chemical and physical properties of the soils, salinity control, and soil fertility. Immediately after completion of the proposed project construction, it will be advisable to begin a measurement program to establish records on the properties of the soils. Any changes in these properties during the period of development of the Project can then be noted. If necessary, any action program will follow, aimed at correcting the problems that may arise.

It is possible at this time to anticipate three major sources of difficulty that can be kept under control if properly diagnosed and treated.

They are associated with soil toxicity, salinity, and fertility. The presence in the area of acid sulfate soils and soils with a high sodium absorption complex will probably pose the most difficult management problem.

Toxicity

Acid sulphate soils generally contain a high content of sulphides. The lowering of the water table that results from surface drainage changes the reduction process to one of oxidation, indicated by a decrease of the measured pH. As a result of the formation of sulphuric acid, free iron and aluminum appear in the soils. These elements, when present in excessive quantity, may be toxic to the rice plants and hinder their growth. It will be important, therefore, to maintain the degree of acidity within a range that is high enough to prevent the formation of toxic elements. One way of accomplishing this consists of controlling the position of the groundwater table, thereby decreasing the rate of oxidation. Liming with careful and progressive drainage will also help by releasing and neutralizing the potential acidity.

Workability

Some of the alluvial soils in the project area contain a high percentage of sodium and a fairly low amount of calcium. Leaching of the calcium may change the absorption complex to one of sodium. This may affect the structure of the soil, causing it to be easily puddled and difficult to work. Such an objectionable soil complex can be modified by the addition of an electrolyte such as $CaCO_3$, by the introduction of water containing calcium salts, and by the addition of organic matter.

Salinity

Control of the degree of salinity will be very important, particularly in the areas affected by salt intrusions. When the salt content level is high, the best time to leach them effectively will be at the beginning of the rainy season. Drainage must be effective at that time so as to remove the salts from the soil profile.

Fertility

The maintenance of soil fertility is also important to the success of the project. Organic matter decomposes rapidly in tropical conditions, particularly in well-drained areas. Maintenance and improvement of the content of organic matter should be accomplished for the following reasons:

(a) to preserve and improve soil physical conditions by maintaining good tilth and reducing soil erosion.

(b) to maintain the nutrient level of the soil and increase its base exchange capacity.

Crops residues, when ploughed back into the soil, help maintain soil fertility and act as a source of organic matter and plant nutrients. The addition of fertilizer will also contribute to an increase of soil organic matter by increasing the amount of crop residue, including both stubbles and roots.

Chapter V

AGRICULTURE

National Production Requirements

National Economy

A presentation of the Guinean economic structure is difficult because of the lack of accurate statistical data. The following data, based on estimates by Guinean and U. S. agencies, are intended to provide an economic background of the Kakossa Project.

The population of Guinea is estimated to be about three million. Over 90 percent of the people receive their living directly or indirectly from agriculture, largely on a subsistence basis. Only about 120,000 persons are wage earners, most of them being employed in non-agricultural enterprises. The income per capita in rural areas is much lower than in the urban areas.

The gross national product appears to have been increasing constantly since 1959, largely as a result of gains in the mining industry. However, the per capita value of the gross national product has remained at about $100. The production per man-hour of agricultural labor is believed to have declined.

The amount of cash income received per capita is estimated to be about $40. However, for a large majority of the people, money is of little use except to buy a few products not available from the land. The usual pattern is for the family to consume most of the goods they produce and to use a small part for sale, or to barter for other products. The

shortage of transportation facilities handicaps the movement of products beyond a relatively small radius.

Foreign Trade

For many years Guinea has suffered from a serious trade deficit. This deficit will probably continue for some time unless energetic measures are taken toward self-dependency and economic development programs. A comparison of imports and exports is given in Table V-1.

The principal exports of Guinea are bananas, coffee, diamonds, and alumina.

Table V-1 - Guinea's Foreign Trade, 1957-63
(GF millions)

	1957	1958	1959	1960	1961	1962	1963
Imports	12,600	15,300	15,300	12,300	18,000	16,200	not
Exports	7,200	5,700	7,200	13,600*	15,200	11,100	avail.
Balance	-5,400	-9,600	-8,100	+1,300*	-2,800	-5,100	-4,000

* Restudy of 1960 export figures by the U.S. Embassy indicated that errors made in that year's trade figures would actually show a barely balanced account, if not an actual deficit.

Prior to 1959 three-quarters of the country's total value of exports were agricultural products and the remaining quarter were minerals. However, since that time, the composition of Guinea's exports has changed significantly. Agricultural commodities accounted for 62 and 41 percent of exports in 1959 and 1960, respectively, but only 32 and 30 percent in 1961 and 1962.

The main imports consist of machinery, cotton cloth, petroleum products, and rice. The value of agricultural imports in 1962 amounted to 18 percent of total imports, with rice being the most important, amounting to about 53 percent of total agricultural products.

The value of agricultural exports has exceeded value of imports in all recent years. However, in 1962 the difference was small because of large imports of rice and wheat flour.

Available data indicate that Guinea has become more dependent on imports to provide adequate food for her people, particularly rice and flour. Imports of rice amounted to approximately ten percent of domestic production in 1962. Although it is believed that domestic production of food has increased slightly in recent years, population appears to have increased at a greater rate. However, official statistics on this point may be misleading because it is suspected that important quantities of agricultural commodities are smuggled out of the country.

Agricultural Production

Although mineral production has become increasingly important in Guinea's export trade, agriculture remains the foundation of the country's economy. Guinean agriculture is segmented into an export sector and a subsistence sector. The export sector is the plantation-type farming consisting mainly of bananas, palm nuts, peanuts, coffee, pineapple, and rubber. The major staple food crops produced on subsistence farms are cassava, rice, millet, corn, and sweet potatoes. Livestock production is important economically but cattle are of poor quality and pastures are seriously over-grazed. It is estimated that there are about 1,300,000 head of cattle in Guinea, mostly undersized bush animals.

It is the custom for farmers to be either a cultivator or a herdsman but not both. The grazing of livestock is free to cattle owners, who are usually nomad farmers.

Agricultural land in Guinea is held under three general types of ownership, each with distinct production practices and problems. Over 80 percent of agricultural land is farmed by the individual subsistence farmer. Individual holdings are generally small and crop yields are low. For the most part, these farmers have no cash surplus to spend on fertilizers or insect sprays. There is little money for even basic mechanization, although the majority of holdings are so small that mechanization would generally not be profitable. There is little understanding of crop rotation or proper land utilization. Burning of the vegetative cover to develop new fields is the usual practice. Imports of fertilizers go mostly to export crops.

The second type of ownership, that of the large commercial plantations, was introduced by the former colonial administration by issuing titles to land that was either not claimed or was tribal land not in use. These lands are used mostly for coffee and bananas.

The third general type of land ownership is a commercial kind of ownership, based on tribal affiliation. It is estimated that ten percent of the arable land in Guinea is tribal land, existing mainly in Upper Guinea and in the coastal region of Lower Guinea. The land is owned in common by tribal groups but is divided into small plots and farmed by individual families. In practice, plots remain with the same family from generation to generation.

Much of the deficiency in agricultural production stems from the social condition of the average farmer. Lacking capital and training,

he barely succeeds in feeding himself. However, one of the most important factors holding down productivity is the high incidence of crop diseases. For this reason, serious failures have occurred in recent years for most crops, particularly bananas and rice.

Economic development programs for Guinea have recently been adopted by the Government with heavy emphasis on an increase of agricultural production. A Ministry of Rural Economy was organized in January 1961 to carry out the proposed agricultural programs. Development is to be concentrated on the reorganization of land tenure into cooperative holdings to the greatest extent possible, most of them to be owned either by the state or by commercial organizations. Production centers have been organized for the principal crops with emphasis on export crops. The Ministry of Rural Economy plans to furnish each of about 5000 villages with agricultural tools and machinery not now available.

Rice Production

Estimates of total production of rice in Guinea are presented in Table V-2. Total production in 1962 was approximately one-third higher than in 1952-53, however, there has been practically no change since 1957-58. On the basis of a per capita index, rice production has consistently declined since 1958.

It is estimated that approximately 240,000 hectares of land are devoted to rice. The yield of rice is extremely variable but averages less than 1.5 tons of rice paddy per hectare.

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Table V-2 - Production of Rice in Guinea

(rice paddy)

Year	Total Production (metric tons)	Production Index (percent)	Per Capita Production Index (percent)
1952-53 and 1954-55 (ave.)	243	100	100
1957-58	312	128	113
1958-59	299	123	106
1959-60	319	131	109
1960-61	320	132	108
1961-62	320	132	104

Food Requirements

Guinea is the third largest producer of rice in Africa, after Egypt and Madagascar, yet is unable to meet her own consumption requirements. Annual imports have increased consistently from about 7000 tons in 1959 to 30,000 tons in 1962 (polished rice). It is estimated that approximately 35,000 tons will be imported in 1963.

Much of the rice imported in recent years came from the United States. The quantity imported in 1962 under the surplus commodity program authorized by U.S. Public Law 480 amounted to almost 27,000 metric tons.

Rice is the basic staple in the average Guinean diet. It is estimated that each person consumes food equivalent to 2100 to 2400 calories per day of which almost 50 percent is supplied by rice.

Table V-3 - Guinea's Import of Rice

Year	Metric Tons
1959	7,000
1960	20,000
1961	25,000
1962	30,000
1963	35,000 1/

1/ Estimated on basis of present trade agreements.

On the basis of production estimates plus imports, the consumption of rice per capita has increased consistently during the past 15 years. Consumption of milled rice was computed at 170 grams per day in 1948 but increased to 220 grams in 1953, and 230 grams by 1962. It is expected that consumption per capita will continue to increase if adequate supplies are available.

As was seen in Table V-2, production per capita has consistently decreased since 1958. Unless this downward trend is reversed, the national deficit of rice will continue to rise and increasing amounts of imports will be required to meet the increasing demands of a growing population. At current consumption rates, an annual increase in supply of over 20,000 tons is necessary to meet requirements for the increase in population. This situation could easily become more critical if the rate of population growth exceeds the present rate of three percent per annum. This appears now highly probable.

Present Production in Project Area

General Country Practices

Rice production in Guinea may be separated into two general methods: (1) mountain rice and (2) plain or marsh rice. Estimates for the combined period of 1947-49 and 1952-54, presented in Table V-4, show that approximately 60 percent of the total production is mountain rice.

Mountain rice is produced by nomad farmers. The common practice is to cultivate a plot of land continuously until the natural soil fertility is depleted and then left idle for several years until regenerated by natural vegetation. The plots are very small, usually sufficient to supply only the families needs. Because of increasing demands for food, shorter periods of time are allowed for regeneration of organic matter while brush fires, repeated each year to clear the land, prevent the natural replacement by trees and other vegetation. This practice is detrimental to the land, particularly in mountainous areas, because it brings about a systematic destruction of the vegetative cover and an accelerated degradation of the topsoil through excessive erosion. The potential for increasing production of rice through improved management and cultural practices in all areas of Guinea is very great.

Data in Table V-3 show that approximately 15 percent of the total production of rice in Guinea is marsh or plain rice. It is difficult to estimate how much of this production is from the marsh areas but it is believed to be a large proportion.

Table V-4 - Estimated Production of Rice for Guinea and Lower Guinea, 1947-49 and 1952-54

(metric tons)

Area	1947-49	1952-54
Guinea		
Mountain rice	100,000	140,000
Plain or marsh rice	75,000	103,000
Total all Guinea	175,000	243,000
Lower Guinea		
Mountain rice	24,000	23,000
Plain or marsh rice	25,000	36,000
Total for Lower Guinea	49,000	59,000

Although the production from marsh lands in Lower Guinea is presently a relatively small portion of the total Guinean production, it is in this coastal zone that the potential for increasing rice yields is the greatest. Heavy precipitation during the wet season from June to November permits the culture of one annual crop of rice without irrigation. The soils, composed mainly of heavy alluvial clays, are for the most part fertile and suited for rice production.

Because of low elevation, these areas are poorly drained during the wet season and subject to the influence of salt water during high tides. The potential amount of riceland in Lower Guinea has been estimated at about 150,000 hectares of which 90,000 hectares are below sea level. Approximately 50,000 hectares are now sparsely cultivated. In recent years, 8000 hectares have been reclaimed and are being cultivated by methods generally adapted to local conditions, although this varies considerably from one area to the next.

Among the ricelands presently under cultivation in Lower Guinea, only those located in the valleys of the Konkoure or the Forecariah rivers produce relatively high yields. The large flows of these rivers prevent the intrusion of salt water on the land during the growing season, and yields of over four tons per hectare are not rare.

Most of the other ricelands in Lower Guinea suffer from excessive flooding during the wet season by fresh water due to lack of drainage or from salinity by salt water intrusion during high tide. The cultivators have attempted to reclaim some of these areas by construction of dikes and drainage channels but yields still are generally very low. Although reclamation of most of these lands is technically possible, the magnitude of the work involved is beyond the financial and physical capabilities of the cultivators.

Most of the rice is produced by antiquated hand methods, but attempts by the government are being made to mechanize and improve cultural practices. Present efforts are concentrated on reorganization of land tenure into cooperative holdings owned by the State or communal organizations (C.A.P.). To assist the cooperatives, Centers of Rural Mechanization (C.M.R.) are being established. These are, in effect, combination experiment stations, machinery pools, and land agent services. It was announced in March 1962 that 295 cooperatives, and 27 C.M.R.'s had been established. Machinery and equipment are being imported, including about 400 tractors. The C.M.R.'s are operating rice enterprises by force account, mostly on new reclaimed land.

Though progress is being made, total production of rice from C.M.R., C.A.P., and private enterprises have fallen short of established goals. Primary problems are associated with lack of trained

personnel, machinery parts, fertilizers, and storage facilities; with losses from diseases and insects; and with poor cultural practices. Much of the machinery that has been imported is useless because of being unsuited to local conditions and because of lack of mechanics, trained operators, and spare parts.

Practices in the Project Area

As in most ricelands of Lower Guinea, widespread flooding by fresh water during the wet season and by salt water during high tides is the major limitation to rice production in the Kakossa area. The influence of high tides is particularly felt on the island of Kakossa, where large tidal amplitudes result in the backing up of sea water into the tidal streams and their tributaries. Because of the low elevation of the natural ground over the entire island, the paddies are occasionally contaminated by salt water either by direct spilling from the marigots, or by underground intrusion. Little, if any, increase in production through improved management and cultural practices can be expected without, first, an effective control of inundation by salt water. Excessive flooding by fresh water in certain areas contributes to the reduction of production, but by far the most serious problem on the island is that of sea water intrusion, which reduces rice production to negligible levels about three years out of four on the average. The lands adversely affected by salinity from tidal flooding are shown on Exhibit 2.

The cultivators have adopted rice production practices which reflect the influences of the flooding and salinity problems, and of age-old cultural practices. The variety Dissi is grown in the most severe saline areas. Other varieties: Minikoui, Kaolacka, Bandioulou, Tamba, Adline, Toma, Twenty-four, and Koba Tore are grown on a large majority

of the Kakossa project lands where the salinity problems are not as severe as where the variety Dissi is required.

Nearly all of the rice in the project area is produced in small paddies, mostly for subsistence, for the cultivator and his family. With the exception of clearing the land and preparing the seed bed, most of the work is performed by women. Clearing is accomplished by burning and the seed bed is prepared by mere scratching of the surface with simple native grubbing hoes. The seed is planted in primary beds in July or early August, depending on flooding conditions, and after about six weeks, are transplanted in the paddy. Harvesting is done in about 145 days after planting, usually in November-December.

The value of weeding is recognized and weeds are apparently not a serious problem. Generally several families work together and go from one field to another, cleaning out and destroying the weeds. After the rice is in head, the fields are guarded by watchers to scare away birds. However, losses caused by animals are much less than on the mainland of Lower Guinea.

The rice is cut by hand with a sickle or knife. Usually, only the heads are cut, leaving stubbles about eight to ten inches long which are subsequently burned-off in preparation for the next crop. The rice is carried by women on their heads, usually to the native village, where it is dried and threshed. Threshing is done with flails and the straw separated from the rice by tossing it into the air. Hulling is accomplished by placing small amounts at a time in a crude basin hued out of a log and then pounding with a stick or pole. The rice kept for home use is stored in the family hut, with the portion kept for seed usually better protected against insects than the rice used for food.

Modern methods of controlling diseases and insects are not used, nor did they appear to be necessary on Kakossa Island. Frequently, complete crop failures are experienced and in most every year some damage and loss in production occurs. This loss in production on the Kakossa Project is primarily from salt water intrusion, especially during the years when very high tide levels are reached during the growing season. This occurs about three years out of four, on the average. Since fertilizers are not used, yields diminish rapidly after two or three years of continuous cropping. The cultivator then moves to paddies that others have left, or to new land, allowing the old paddy to remain out of production for a year or so, and then eventually moving back or leaving it to another family to cultivate. Although government officials indicated that there is ample land for the local population at the present time, it seems to be increasingly difficult to obtain plots that have been out of production long enough to regain the original fertility.

Transportation and Markets

The surplus rice above the family's need for food and seed is bartered for other products among the natives, or sold to government stores, called "Comptoirs." No Comptoir is located on the island of Kakossa, and much of the excess rice is exchanged among the inhabitants. As modern means of transportation and even animal-drawn wheeled vehicles are not available, the rice is carried on a man's head in bags weighing up to 50 kilograms to the nearest village. Walking distance may be as much as 15 kilometers. During good crop years, when excess rice is available from the island's production, bags of rice to be sold are transported to the mainland in dug-out canoes (pirogues), to be delivered to the Comptoir.

Until recently (September, 1963), the government of Guinea, through the Comptoirs, was in charge of distribution between regions. Private traders are now authorized to handle inter-regional commerce. The government sets the price to be paid the cultivator for the rice, usually prior to planting time, and presumably on the basis of supply and demand conditions existing throughout the country. The Comptoir also acts as the retailer and sells rice at prices set by the Government, as well as private traders.

Present Production

Statistics on actual yields of rice on the project lands are lacking. Estimates by cultivators and local officials vary considerably, mainly because the exact area or the production are seldom measured. The cultivators themselves do not have sufficient information to even estimate their average yield per hectare.

Our estimates of yields presently obtained in the Kakossa area are shown in Table IV-3. Estimated production from each of the areas delineated on Exhibit 4 is given in Table V-5. The total production from the cultivated area of 1530 hectares is 1810 metric tons or an average of about 1200 kilograms per hectare.

Table V-5 - Estimated Crop Yields and Total Production of Rice on Project Lands

Area Designation	Cultivated Riceland (hectares)	Average Yield (tons per ha)	Total Production (tons)
I	560	1.5	840
II	970	1.0	970
III	-	-	-
IV	-	-	-
Project a[illegible]	1530		1810

These estimates are based on interviews with local cultivators and government officials acquainted with the area, and on personal knowledge of the productivity of rice as evaluated by such factors as thickness of stands, extent of salinity and productive capacity of the soil, known performance of existing varieties, and estimated losses from diseases, insects, and salinity. It must be pointed out that the data presented in Table V-5 reflect long term average conditions, and that in some years the production may exceed 3500 tons. However, in many years, most of the cultivators do not even obtain enough paddy rice for the next year's seeding.

The characteristics of the soil, as affected by salt water and shortage of water during the dry seasons, limit production to one crop per year. Provision of water from surface or underground storage during the dry season would enable double cropping. This possibility is beyond the scope of this investigation but does not appear to be feasible in this area.

Anticipated Project Production

Methods of Improving Production

Without provisions for drainage and reclamation of saline soils, production of rice on the project lands will remain at low levels. With proper drainage and reclamation of saline soils, lands now only partially productive and most of the non-productive swampy lands will be capable of full production. Sustained production is possible providing adequate fertilizers are added and systematic rotations are introduced. Large increases in total production of rice will be possible as a result of:

(1) bringing swampy and marshy lands into full production, (2) increased yield from varieties better adapted to well drained and non-saline soils, and (3) more intensive use of lands presently cultivated.

Early transplanting of the rice to take advantage of the frequent but not too excessive rains at the end of the wet season will insure adequate good quality water for the rice, encourage maximum rice production and an early harvest. An adequate supply of good quality water is essential, especially in areas where salinity is a problem as it is in the Kakossa project area.

New and fertile riceland would be provided for additional cultivators, and existing plots could be enlarged to permit mechanization and more efficient operation. Additional forage for grazing of livestock will be available as a result of the enlarged and more productive cultivated area. Although rice cultivation and livestock raising are not integrated operations, the opportunity for integration will be improved as the lands will be more adaptable to systematic rotation with crops that are now restricted because of flooding and salinity conditions.

It is expected that a few years will be required after the project is in operation before the full productive potential is attained. Numerous changes and improvements in cultural practices are necessary which will take considerable time even if extension and research programs, and financial assistance to the cultivators are available.

The production potentials due to drainage and reclamation, and to anticipated technological advancements for 20 years after the project is in operation have been estimated. Estimates of yields, cropping intensities, and crop rotations were analyzed for four five-year time intervals over this period. Progressively higher crop yields corresponding

to consistent improvement due to drainage and gradual reduction in salinity, increasing use of fertilizers, better seed, mechanization, plant protection, and systematic crop rotations were assumed.

Rice Submergence Criteria

The lands in the project area are flat and surface drainage toward the marigots is effected on small natural slopes. It would not be economical to design the drainage system so as to avoid occasional submergence of the rice plants in the paddies. Consequently, it was determined to what extent rice plants could be submerged without being damaged.

Rice, when still in the vegetative stage of growth, can be completely submerged in clear water for short periods of time without being seriously affected insofar as production of seed is concerned, if the water is moving around the plants. The rice plants will withstand intermittent periods of complete submergence for about four days provided that the water level is subsequently lowered to about one-half of the plant height for at least four days before complete submergence occurs again. An allowable cycle of submergence following these principles has been shown graphically on Exhibit 5. It was assumed that before initial submergence the rice plants would be about 30 centimeters tall, which is about the plant height when they are transplanted from the seed beds to the paddies.

If the rice is planted on butts or ridges that are 25 centimeters high, as is presently the practice in Lower Guinea, the allowable water surface elevations can be correspondingly higher.

These criteria are based on the fact that light penetrating shallow depths of clear water will enable the process of photosynthesis to continue. The criteria apply to water allowing at least 70 percent of light

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transmission. When sediments are in suspension, the allowable depth of submergence or the length of the period of submergence must be reduced.

The time of change from vegetative stage of growth to the reproduction cycle of the rice plant occurs from 70 to 80 days after seeding. After the rice plant has entered the reproduction phase, it rapidly becomes more susceptible to excess flood water. This is particularly true during the period starting two weeks before the panicle emerges and ending two weeks after panicle emergence.

However, taking into account the fact that this generally occurs in September, this period does not appear to be critical. The plants are then taller and precipitation is less intense. Flooding of the lands that may have occurred in August will be relieved by the drainage system shortly afte. its occurrence.

The implication of the above submergence criteria is that direct seeding in the fields will not be possible without risk of losing the crop. The use of seed beds and transplanting when the plants are about 30 centimeters tall will be necessary. Although this method requires additional labor, it is believed that the yields can be higher than those obtained from direct broadcasting.

Projected Crop Yields

Rice yields that can reasonably be expected over the 20-year development period have been presented in Table IV-3. For the first crop-year after the project is in operation, an average yield increase from 0.5 to 1.0 tons per hectare is expected. Most of this increase would be attributable to the improved drainage conditions, with little

change from cultural practices or from reduction in soil salinity anticipated.

It is believed that five years will be required to leach the saline soils by alternate flooding and drainage from natural rainfall. At that time production levels equal to those presently obtained on non-saline soils could be realized. It is estimated that yields will be increased by 1.0 to 1.2 tons per hectare during this time, most of which would be attributable to the combined drainage and reclamation program. The average yields estimated with the project are similar to those obtained on well drained and non-saline soils using present cultural practices. With drainage and reclamation, higher yielding non-saline tolerant rice varieties will replace the low-yielding varieties. Also, increased yields will be possible because rapid drainage will permit better timing of planting and control of the fresh water supply. Improvements in cultural practices, fertilization, etc., are expected to be slow and will, therefore, not be significant factors towards increasing yields during the initial five-year period. Allowances for nominal applications of fertilizers, particularly phosphorus, were made in estimating probable yields and costs of production. Progressive increases due to these improvements are practical after this time up to 20 years after the project is in operation.

The potential for continued increases due to improvements in cultural practices is great. These will not occur, however, without technical assistance from agronomists working with the farmers and financial assistance to obtain fertilizers, insecticides, etc. It has been assumed that this assistance will be provided as an integral part of the clamation program after the project is in operation.

Anticipated Land Use and Crop Rotations

The anticipated land use, cropping intensities, and cropping rotations for each five-year period are presented in Table V-6. We have assumed a three-year rotation with rice occupying two-thirds of the cultivated land area but with increasing amounts of other crops occupying the remaining one-third of the land. The cropping intensity is expected to increase gradually from 67 to 100 percent. A cropping intensity of 100 percent will be possible sooner than 20 years if ample technical and financial assistance is available to the cultivators.

Table V-6 - Projected Crop Land Use and Cropping Intensity
(in percent)

Crops	Number of Years After Reclamation			
	1	5	10	20
Rice	67	67	67	67
Lespedeza*	--	8	15	20
Maize*	--	--	3	9
Grain sorghum*	--	--	--	4
Percent cultivated	67	75	85	100

* Or equivalent legume forages and grain crops.

Projected Agricultural Production

Total production anticipated for various time intervals after the project is in operation are summarized in Table V-7. These estimates are based on average yields for rice given in Table IV-3. The gross

reclaimed area has been reduced by ten percent to allow for land utilized by dikes, levees, and drainage channels from which no production will be obtained. The net reclaimed project area is 2260 hectares.

Table V-7 - Estimated Total Agricultural Production with the Project

(metric tons)

Years	Crop									
	Rice		Lespedeza		Maize		Grain Sorghum		Idle	Total in Prod.
	Ha.	Prod.	Ha.	Prod.	Ha.	Prod.	Ha.	Prod.	Ha.	(ha)
1	1200	2220	-	-	-	-	-	-	620	1820
5	1500	3780	180	1800 1/	-	-	-	-	580	2260
10	1500	5620	340	3400 1/	70	140	-	-	350	2260
20	1500	6030	460	4600 1/	200	500	100	200	-	2260

1/ Equivalent green weight.

Land Settlement

There is no specific national or regional policy for selection of settlers for the new project lands after reclamation. Assuming an average of four-hectare farm units, sufficient land would be available to support families. This would be equivalent to an addition of 182 units over those in existence at present.

The island is populated by about 8000 people at the present time, about 2000 more than in 1950, when the cultivated area was about the same. If necessary, local officials anticipate no problems in getting

voluntary movement of families from other areas immediately upon completion of the project. There is also the possibility that cooperatives may be developed to operate large sections of land with the help of mechanization. However, for the purpose of analysis, it is assumed that the lands would be settled for subsistence farming in units averaging four hectares each.

Chapter VI

PROJECT DESIGN

Introduction

A plan for the reclamation of Kakossa Island was developed in 1954-55 by COTHA under the general direction of the Service du Genie Rural, and its implementation started in 1956 with the construction of dikes and a gated control structure. The salient results of the COTHA studies, summarized in their reports, were reviewed in detail by the Harza Engineering Company within the scope of the feasibility studies presented in this report.

The basic concept of the COTHA plan of reclamation, i.e., prevention of saline intrusions by means of dikes surrounding the project area, and drainage of the plains toward the ocean through gated control structures, has been examined and found to be sound. However, certain engineering studies had to be performed in order to pass judgment on the adequacy of the structures as they were selected by COTHA.

In particular, precipitation data available to COTHA in 1954 covered only six years. Probability analyses based on such a short span had necessarily a limited accuracy. The data collected from 1955 through 1963 were used to supplement the COTHA studies, bringing them up to date.

Likewise, the behavior of the Soulemanya River since the completion of its control structure permitted to make observations useful in developing an improved plan of reclamation.

The engineering studies made to review and extend the COTHA studies consisted of hydrologic analyses, hydraulic investigations,

structural and foundation designs, and a survey of quantities. These studies are described in this chapter.

Tidal Flooding Under Present Conditions

It is reported that good crops are harvested on Kakossa Island about once every three or four years. In all other years, the crops are spoiled by salt water intrusions. These conditions were investigated within the scope of the present studies.

The plains of Kakossa are located between 0.65 and 1.30 meters above mean sea level. Almost every year, maximum tides reach an elevation of 2.0 meters above mean sea level, but this does not always occur at the same time of the year. The tide tables for the period 1957 through 1963 were reviewed, and the highest tide levels reached in each month were plotted on a graph shown on Exhibit 5. Also indicated on this graph are the rice growing seasons, beginning each year with August and ending with November.

Inspection of the graph indicates that the high tide levels reached during the past seven growing seasons have varied from year to year. In some years, such as 1963, flood tide levels were limited to 1.65 meters above mean sea level at the beginning of the growing season, and the highest tide levels were reached only near the end of the growing season. In 1961, maximum tide levels were comprised between 1.60 and 1.70 meters above mean sea level. These levels were remarkably low. However, in the following year, 1962, high tide levels (about 1.90 meters above mean sea level) were reached every month of the growing season.

This shows that high tide levels are always high enough to flood the periphery of the island and the lands adjacent to the marigots. However, unless the high levels are sustained over a long period of time, hydraulic friction would prevent the overland flow of salt water from progressing toward the center portion of the plains. From the tidal observations made in the plains by COTHA (in 1955), the hydraulic loss resulting from this friction is approximately 0.70 meters. Consequently, tide levels of 1.90 meters above mean sea level would result in water surface elevations of 1.20 meters in the plains. If tide levels at 1.90 meters above mean sea level are sustained over a long period, such as happened in 1958 and in 1962, most of the plains would be flooded by salt water. However, if, as in 1963, tide levels do not remain at the critical levels for a long portion of the growing season, flooding would be limited to the peripheral fields, and the lowest lands. The levels reached in 1961 probably resulted in minimum salt water encroachment on the project area.

Water Supply

Consumptive Use Requirements

An estimate of the consumptive use requirements of rice was made on the basis of evaporation recorded at Conakry, and using the results of systematic experiments made by the Rice Pasture Experiment Stations, Beaumont and Eagle Lake, presented in a report of the Texas Board of Water Engineers.[1/]

1/ Consumptive Use of Water by Major Crops in Texas, Bulletin 6019, by Louis L. McDaniels, Texas Board of Water Engineers, November 1960.

Monthly evaporation data for Conakry-Aviation are presented in Table VI-1. These data indicate relatively low rates of evaporation during the wet season, probably due to the high relative humidity that prevails at that time.

Table VI-1 - Measured Monthly Piche Evaporation at Conakry-Aviation, in millimeters

Year	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	129	60	36	18	39	48	51	78
1950	108	54	45	27	33	51	54	90
1951	87	54	45	33	39	42	*	114
1952	123	66	42	39	45	72	63	102
1953	129	57	48	36	54	66	78	120
1954	102	54	39	36	45	69	75	87
1955	93	54	36	33	42	51	75	90
1956	90	60	36	27	58	60	69	90
1957	132	78	33	*	*	48	57	81
1958	*	*	*	*	*	*	*	75
1959	93	60	33	33	45	66	60	93
1960	69	*	42	30	36	51	54	72
1961	96	51	27	24	30	48	57	69
1962	78	45	36	30	36	45	45	81

* Not available.

Although Piche measured evaporation is somewhat higher than the theoretical lake surface evaporation, measured evaporation data were used without correction. The highest evaporation recorded from 1949 to 1962 for each month were multiplied by the Use Coefficients KU found at the Texas Experiment Stations for the corresponding stage of growth, except that the June coefficient was used for the month of July, for conservatism. The results are summarized in Table VI-2.

Table VI-2 - Estimated Consumptive Use Requirements for Rice in Kakossa Area

Month	June	July	Aug.	Sept.	Oct.	Nov.	Total
Evaporation, mm	78	48	39	58	72	78	
Use coefficient KU	1.8	1.8	2.0	1.5	1.0	1.6	
Consumptive Use Requirement, mm	140	86	78	87	72	125	588

Available Moisture Supply

It is generally accepted that the moisture available from natural rainfall over Kakossa Island is sufficient for the cultivation of one crop of rice. This belief is based on the heavy precipitation that occurs during the growing season that extends from July through December. Rice generally requires from 1000 to 1500 millimeters of rain from seeding time to harvesting.

Although no drought records are available for Kakossa, rainfall estimates have been made on the basis of the long-term Conakry-Aviation records and of the precipitation recorded at Yenia in 1954. The conditions prevailing at Yenia are considered to be representative of those on the entire project area because of the relatively small size of Kakossa Island. The 1954 precipitation recorded at Yeniya was about ten percent greater than that recorded at Forecariah and about 20 percent smaller than that recorded at Conakry-Aviation. The annual precipitation recorded at Conakry and Forecariah from 1949 through 1963 was used to

construct frequency curves, presented on Exhibit 5. Also plotted on the same graph is a frequency curve which is considered to be representative of the annual precipitation over the Kakossa area. This curve indicates that 95 percent of the time the annual precipitation at Kakossa is equal to, or greater than, 2500 millimeters. This can be expressed differently: an annual precipitation of 2500 millimeters or less would occur not oftener than once every 20 years.

It would appear, since all of the annual precipitation occurs during the wet season, that the wet season rainfall is well in excess of the requirements for rice cultivation. However, it is reported that unusually dry years result in lower rice production in some parts of Guinea. Since this may result from an unfavorable distribution of rainfall over the growing season, this problem has been investigated for the meteorologic conditions that prevail in the project area.

An attempt to use the rainfall distribution as recorded during a representative dry year was not successful because of the poor correlation between dry years recorded at Conakry and at Forecariah. Consequently, judgment was used for the selection.

The critical months of the growing season are October and November. Prior to October the precipitation is always ample. The precipitation in October and November for each year, as recorded at Conakry-Aviation, was reviewed. The dryest two-month periods occurred in 1960 (229 millimeters) and in 1956 (301 millimeters). The recurrence of the 1956 event would be about once in ten years. Reducing the corresponding amount by 20 percent to transpose from Conakry to Kakossa, the unusual two-month rainfall would be 240 millimeters. A similar result is obtained by using the dryest two-month period recorded at

Forecariah: 218 millimeters in 1961, and increasing it by ten percent to transpose it to Kakossa. On the basis of actual distribution between October and November for various years, it would be reasonable to assume that two-thirds of the two-month precipitation would occur in October and one-third in November.

The distribution of rainfall during an unusually dry growing season would thus be:

October:	160 millimeters
November:	80 millimeters

A mass curve of cumulative rainfall for the months of October and November, patterned after the 1956 dry year at Conakry, was drawn as shown on Exhibit 5. The mass curve shows that an average daily rate of eight millimeters could be sustained until the middle of November, provided that a storage of 15 centimeters is available. This can be accomplished easily since the rice fields are surrounded by levees generally 15 to 30 centimeters in height, and cultural practice consists of storing water in the paddies until the beginning of November for the purpose of preventing the growth of weeds and storing water between rainfall periods. After the middle of November, the paddies are drained in anticipation of harvesting.

Adequacy of Water Supply

The consumptive use requirements of rice, including evapotranspiration, is estimated to be 2.4 millimeters per day in October and 4.2 millimeters per day in November. This would leave about four millimeters per day for losses by percolation. This is considered adequate, considering the properties of the soils as indicated by the permeability

tests and the high groundwater table. Therefore, a recurrence of conditions as severe as the 1956 drought would not result in any deficiency of water supply.

It is concluded from this study that the water supply available from natural rainfall is sufficient for cultivating rice in paddies on Kakossa Island, provided that the levees be high enough around the paddies.

Drainage Requirements

General

The Kakossa plan of reclamation developed in 1954-55 by COTHA and the Service du Genie Rural was designed to dispose of the runoff corresponding to a total precipitation of 366 millimeters in six days.

Criteria for allowable flooding of rice were developed as explained in Chapter V for the purpose of the present studies. These criteria are:

(a) rice can be submerged without undue damage for a period of not more than four days; and

(b) after submergence, the water level in the paddies must be lowered so as to leave 15 centimeters of the rice plants above water for a period of not less than 11 days.

On the basis of these criteria, the distribution of rainfall over a period of 15 days had to be considered. Therefore, an analysis of rainfall records was made to develop a 15-day design storm that would be used to determine the discharge capacity of the proposed drainage system.

Cumulative Precipitation at Kakossa

Daily precipitation recorded at Conakry-Aviation from 1949 through 1963 and at Forecariah from 1950 through 1962 were obtained from the National Meteorologic Service. These data were supplemented by precipitation data recorded at Yeniya from July 11 through August 31, 1954, within the scope of the COTHA studies.

The maximum precipitation recorded at Conakry-Aviation in one day for each year was tabulated, and the frequency of such occurrences was determined. Similarly, the maximum precipitation recorded in one, two, three, six, fifteen, and thirty consecutive days of each of the 15 years was determined on a Bendix G-15 electronic computer. Their frequencies were determined, the corresponding values were plotted on a logarithmic-probability chart, and frequency curves were drawn. From the frequency curves, the precipitation for one, two, three, six, fifteen, and thirty consecutive days corresponding to probabilities of ten percent (ten-year recurrence interval) was determined. These values were decreased by ten percent to account for the fact that the short period of available data at Yeniya indicated that precipitation recorded at Conakry-Aviation exceeded that at Yeniya. A reduction of ten percent, instead of the observed difference of 20 percent, was used to be conservative in view of the short duration of concurrent records. The resulting chart of cumulative rainfall for consecutive days, presented on Exhibit 5, is considered representative of the Kakossa area.

This chart shows that the difference between the 5-year, 10-year, and 30-year cumulative rainfalls is not great. A recurrence interval of ten years was selected for design purposes. This selection results in the acceptance of damages to agricultural crops in the event of

occurrence of a more intense rainfall. However, damages probably would not be great in view of the fact that the 30-year, 15-day rainfall (1260 millimeters) is only 18 percent greater than the 10-year, 15-day rainfall (1070 millimeters).

Table VI-3 shows the cumulative and incremental rainfall for 15 days that can be expected once every ten years. It should be noted that the incremental daily values given in the tabulation are not necessarily in chronological sequence, although the cumulative values correspond to consecutive days.

For the purpose of determining a realistic chronological sequence, the maximum 15-day precipitation period recorded in 1961 was examined. The year 1961 was considered because its annual rainfall of 5307 millimeters (4250 millimeters estimated at Kakossa) is the third largest on record. During the 15-day period from August 24 through September 7, 1961, a total rainfall of 930 millimeters were recorded at Conakry, corresponding to a precipitation of about 800 millimeters at Kakossa.

Table VI-4 shows the largest precipitation for consecutive days of the August 24, 1961, storm. Also shown in Table VI-4 are comparable values as given in Table VI-3. An examination of the last two columns of Table VI-4 reveals that the August-September 1961 storm is fairly close to the 10-year event for the first nine days. After the ninth day, the daily rainfall increments in the 1961 storm were definitely smaller than the 10-year event.

Design Storm

The 15-day storm selected for the purpose of designing the drainage facilities is identical to the August 24 storm for the first eight days.

Thereafter, a uniform daily rainfall of 40 millimeters was adopted, on the basis of the values shown in Table VI-3. The storm pattern thus obtained is believed to reflect realistic meteorological conditions typical of a 15-day storm with a 10-year recurrence interval. The total cumulative rainfall would be about 1070 millimeters. The distribution of this storm is shown graphically on Exhibit 5.

Table VI-3 - Kakossa 15-Day Precipitation with a 10-Year Recurrence Interval

Number of Consecutive Days	Cumulative Precipitation in Consecutive Days (mm)	Incremental Precipitation (mm)
1	280	280
2	360	80
3	440	80
4	505	65
5	570	65
6	640	70
7	690	50
8	740	50
9	790	50
10	840	50
11	890	50
12	940	50
13	980	40
14	1020	40
15	1060	40

Table VI-4 - Comparison of the August 24, 1961, Storm as Recorded at Conakry, with 10-Year Storm at Kakossa

Number of Consecutive Days	Precipitation of Storm from Aug. 24 - Sept. 7, 1961 (mm)		10-Year Event
	Daily Precipitation, in Chronological Order	Max. Cumulative Precipitation for Consecutive Days	Cumulative Precipitation for Consecutive Days (mm)
1	47	235	280
2	235	406	360
3	171	453	440
4	33	488	505
5	68	556	572
6	74	630	640
7	52	682	690
8	107	789	740
9	13	802	790
10	1	803	840
11	76	879	890
12	28	907	940
13	7	914	980
14	5	919	1020
15	11	939	1060

Comparison with the Design Criteria Used by COTHA

Design of the Kakossa reclamation project was originally based on a precipitation of about 475 millimeters in ten days. This storm was assigned a recurrence of once in five years. Table IV-5 shows a comparison of this storm with that developed as explained in the previous paragraphs.

Table VI-5 - Comparison of Design Storms

Number of Consecutive Days	Cumulative Precipitation, in mm		
	COTHA	HARZA	
	5-Year Recurrence	5-Year Recurrence	10-Year Recurrence
1	170	250	280
2	235	320	360
3	280	385	440
4	315	445	505
5	345	500	570
6	375	550	640
10	475	750	840

A comparison of the values given in Table IV-5 indicates that the precipitation obtained by the Harza studies for the 5-year storm are about 45 percent higher than those obtained by COTHA. This is due primarily to the fact that only six years of record were available to COTHA in 1954, whereas 15 years are now available. In addition, a 10-year recurrence was selected in the Harza studies, bringing the increase to about 65 percent.

Excess Rainfall

Excess rainfall is defined as that portion of the rainfall that is not lost through evaporation or percolation. It corresponds to the amount of water that must be drained from the land or temporarily stored in the fields to be drained later.

An estimate of the evaporation that can be expected during the design storm was made on the basis of observations made by the National Meteorologic Service during the August-September 1961 storm. The

average evaporation recorded at Conakry-Aviation in August 1961 on a Piche evaporation gage was approximately 25 millimeters per month. This amount was used as the evaporation at Kakossa.

On the basis of the results of permeability tests made in the Monchon area, percolation was estimated to amount to approximately 60 millimeters per month. This amount may appear too low, particularly in view of the relatively pervious nature of the soils in the project area. On the other hand, the ground water table during the wet season is generally very close to the ground surface. In any event, no further refinement of estimated percolation losses was made because of the small magnitude of these losses relatively to the rainfall itself.

A nominal amount of 30 millimeters per month was assigned to plant use during submergence.

On the basis of these estimates the total losses would be 115 millimeters per month. A total of 60 millimeters, uniformly distributed, were subtracted from the 15-day rainfall to obtain the excess rainfall. This is indicated graphically on Exhibit 5.

Design of the Drainage System

Water Level in the Paddies

The plains of Kakossa lie between 0.65 and 1.30 meters above mean sea level, or between elevations 3.05 and 3.70 above the COTHA datum of reference. The COTHA system of reference has been used exclusively in the following. Detailed topography of the project area is shown on Exhibit B by contours at vertical intervals of 50 centimeters. This topographic map shows that, with the exception of small, isolated

areas in the southwestern portion of the project, all the rice fields have an average ground elevation of 3.35 or higher.

The flooding criteria established in Chapter V, applied to fields located at an elevation of 3.35 meters, require that the water surface in these fields not exceed elevation 3.70 for more than four days, and that thereafter it be brought back to a maximum elevation of 3.60 for a period of at least 11 days. In the fields located at a higher elevation, the flooding criteria can be satisfied if the head loss in the secondary and lower order canals does not exceed the difference in elevation between the ground of the fields and elevation 3.35. The small areas located below elevation 3.35 may not benefit from the drainage facilities to the same degree as the remainder of the plains in the event of occurrence of a severe and prolonged storm. These areas must be accepted as being marginal for the sake of overall economy.

The design of canals was conducted so as to operate with a normal water surface elevation 3.40 at their upstream end. This condition corresponds to a water surface at elevation 3.45 in the nearby paddies, allowing a minimum head loss of five centimeters between the paddies and the canals.

Tide Criteria

The capacity of the main drainage canals will be influenced by the elevation of the water surfaces at their outlets. Observations made in 1955 by COTHA led to the conclusion that the levels of the outlet rivers are not significantly affected by the discharge of fresh water from run-off, but are dependent mainly upon the amplitude of ocean tides. This is confirmed by the observations of the cross-sectional area of the several outlet rivers as reported in Chapter III.

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The 1956 COTHA report mentioned the following tide observations:

	Soulemanya	Koakou	Noreire	Touguikeren
Ebb tide level	1.90-1.70		1.70-1.80	1.60-1.00
Flood tide level	3.10-4.10		3.0 -3.8	3.10-3.80
Amplitude, meters	1.2 -1.4		1.3 -2.0	1.5 -2.8
Highest flood tide elevation for design purposes	4.10	3.70 1/	3.80	3.80

1/ Measured on the plains near Yeniya; closest available to Koakou.

A field check of COTHA observations revealed them to be acceptable except for significant differences in tidal variations found at the site of the Soulemanya control structure. These differences were reported in Chapter III. They seem to result from an aggradation of the Soulemanya River channel which has taken place since the completion of the control structure. Since a dredging of this channel has been included in the proposed plan of reclamation, it was assumed that such dredging would result in the re-establishment of tide conditions antecedent to 1957. Consequently, all tidal elevations as recorded in 1955 by COTHA were adopted for the design of the canals and control structures.

Gated Control Structures

As mentioned in Chapter II, gated control structures provided with automatic flap gates across each of the three main natural waterways

were included as part of the plan of reclamation developed by COTHA in the early 1950's. These waterways are the Soulemanya River, the Noreire River, and the Touguikeren River. These structures were designed to prevent the entrance of salt water into the project area during the wet season, to permit an unobstructed discharge of fresh water from the project area toward the ocean in the wet season, and to allow the inflow of limited quantities of salt water into the drainage channel during the dry season.

One control structure was constructed across the Soulemanya River in 1957. This structure is made of reinforced concrete with six corrugated metal pipes, each gated at both ends. The gates are of the Calco 1001 type, made of a flap gate mounted on a vertical movable frame. A diagrammatic drawing of the installation is indicated on Exhibit 6.

Each gate, in its lowermost position, allows an unobstructed discharge in one direction but prevents the flow of water in the opposite direction. When both gates at each end of a conduit are set at their lowest position, no flow can take place through the conduit. When a gate is partially raised, it still allows unobstructed discharge in one direction, but permits limited flow of water in the opposite direction. This flow is limited by the vertical opening of the gate, determined by its distance above its lowest position.

Therefore, a judicious setting of each pair of gates provided at the ends of a conduit permits the control of flow in both directions. This arrangement provides the greatest flexibility in operating the project. In the wet season, it allows the maximum discharge of fresh water toward the ocean when the tide level is lower than the water level in the drainage channel, and prevents the entrance of water from the ocean into the

drainage canals when tide levels are high. At the end of the wet season, it permits the conservation of fresh water in the canals without permitting the entrance of salt water. During the dry season it permits the controlled entrance of determined quantities of salt water into the canals without letting it escape at low tide. This last operating condition helps maintain the ground water level in the project area at a predetermined elevation.

Although this flexibility of operation may appear to be an asset to the project, its advantages are questionable. Control structures provided with timber flap gates such as were proposed for the Monchon Project will probably perform satisfactorily, and will be less costly both initially and during maintenance. Therefore, it is proposed to give consideration, in the course of detail design of the new structures, to an arrangement different from the one adopted for the Soulemanya structure. However, for the purpose of the present feasibility studies, it was assumed that the same arrangement would be used, and the corresponding costs used in the estimates.

The total area of outlet pipes and gates, however, had to be modified from the COTHA designs, as a result of the more intense precipitation that was found in the present investigations. The Noreire and Touguikeren structures were increased in size. The Soulemanya structure was found inadequate to drain satisfactorily the 1200 hectares that make up its watershed. Only 960 hectares can be adequately controlled by this structure. Consequently, an additional control structure is proposed across the Koaku River, as shown on Exhibit B, and the canal system modified so as to drain part of the Soulemanya watershed toward the Koakou River. This arrangement presents the additional advantage

of reclaiming the area located behind the existing dike across the Koakou River, which is frequently flooded by fresh water in the present conditions.

The main dimensions of the control structures were determined by combining the design storm criteria applied to the respective drainage areas, the tide elevations criteria, the allowable rice submergence criteria, and the hydraulic characteristics of the drainage canals and control structures. The total conduit areas required at each structure for acceptable conditions are summarized in Table VI-6.

Table VI-6 - Dimensions of Conduits and Gates at the Proposed Control Structures

Basin	Area (hectares)	Excess Rainfall Yield Over 6-Day Period (liters/sec/ha)	Maximum Discharge of Structure (m^3/sec)	Conduit Gate Area (sq meters)	Number of Equivalent 42"-dia. Pipes
Soulemanya 1/	960	11.7	13.2 2/	5.4	6
Koakou	240	11.7	3.4	1.4	2
Noreire	1025	11.7	14.6	5.9	8
Touguikeren	404	11.7	5.4	2.3	3

1/ Existing structure.

2/ Assumes that silted discharge channel is dredged.

The data given in the last column of Table VI-6 corresponds to the structures as adopted for the purpose of the cost estimates. The Kaokou stru ..re, as sized here, is predicated upon the rehabilitation of the Soulemanya discharge channel. An alternative solution would

consist of accepting the present capacity of the Soulemanya structure, and to design the Koakou structure for a larger capacity than shown in Table VI-6. The drainage canal system would in that case be more extensive, and the Koakou structure more costly. On the other hand, the cost of dredging the Touguikeren channel would be avoided. This alternative has not been investigated in details, but should be given consideration at the time of detail design of the project.

Water Surface Elevation in the Paddies

Using the discharge capacity of the gated control structure, the variations of the water surface elevation in the paddies were calculated. The analyses were made for the critical case of the 15-day design storm occurring while water was ponded in the paddies to elevation 3.50. It was assumed that during the first few days of the storm, average tide amplitudes would occur in the outlet rivers, so as not to compound several events, each of which have a small chance of occurrence.

The variations of the water surface in the paddies, as found from the calculations, are presented graphically on Exhibit 5. Also shown on the same graph is the submergence criterion. A comparison of the two graphs indicates that in the event of occurrence of the design storm, the water surface in the paddies will rise by less than 17 centimeters above the lowest rice plants. Submergence will last about six and one-half days, then the level will drop rapidly to its normal operating elevation. The duration of submergence, as found from the calculations, will be somewhat longer than that of the submergence criterion. However, since the depth of submergence reached was considerably smaller than that allowed, it is believed that no damage will be caused to the crops.

Therefore, it was concluded that the proposed gate openings will be satisfactory for the purpose of maintaining flood levels in the paddies within safe limits during intense storms.

The maximum flow through each structure during discharge of the ponded volume is given in Table VI-6. The canal sections selected and the natural channels permit the discharge of these flows.

Layout of the Drainage Canals

Drainage areas were laid out in accordance with natural boundaries as defined by the dunes, dikes, and natural drainage patterns of the project topography. Maximum use was made of the existing network of natural waterways. The existing natural drainage system was supplemented by excavated channels only where it proved inadequate to pass the design storm. The layout of existing and proposed drainage canals is shown on Exhibit B.

Canal Sections

The design storm was applied to the several areas served by the natural and excavated canals. The maximum average runoff to be discharged by the drainage system was found to be 1170 liters per second per square kilometers over a period of six days, and 925 liters per second per square kilometers over a period of ten days. This compares with about 930 liters per second per square kilometers over a six-day period as used by COTHA in their designs. The difference between the COTHA value and the one used in the present designs results primarily from the difference in intensity of the design storms adopted, as mentioned earlier in the present chapter.

The natural channels which were found to have a capacity adequate for the field drain systems they serve were incorporated in the drainage system. Those found to be too small were replaced by newly excavated drainage canals, laid out generally in a pattern similar to that originally proposed by COTHA.

The field drain systems, all of which have been constructed by the farmers, are considered satisfactory. The land included in the reclamation area, but not presently under cultivation, will also require similar field drain systems, to be constructed by the new farm operators.

Small water surface slopes permitted use of approximate backwater methods to properly adjust water surface levels throughout the system and prevent excess heading up in the paddies during the critical design storm period. Geometric elements of the channels were selected to sustain low flow velocities above silting values for self-maintenance and provide for subsidence of excavated side slopes. Exhibit 6 shows typical elevations for both excavated and expected ultimate canal sections.

Selection of the Reclaimable Area

As mentioned in Chapter II, the scope of the reclamation project had been reduced in 1957 to about 2000 hectares, primarily to maintain the total cost of the project within budgetary limitations. The lands thus excluded from the reclamation area are all in cultivation. Moreover, in the course of field investigations it was noticed that several hundreds of hectares in cultivation were located outside of the project boundaries as determined by COTHA. Preliminary studies indicated that these areas could be included in the project boundary at a relatively small additional cost. The economic studies indicated that the present

worth of total future project benefits amounts to about GF 695,000 per hectare, or the equivalent of $2800 per hectare. It can be assumed that this is also the value of the incremental benefits for the additional area involved.

A preliminary estimate of the cost of including these ricelands in the project are was made as shown in Table VI-7.

Table VI-7 - Incremental Unit Cost of Reclamation

	Area (hectares)	Incremental Cost (equiv. U. S. $)	Incremental Unit Cost (U. S. $ per ha)
Touguikeren Drainage Area 1/	310	410,000	1,300
Tembo-Taouya Area 2/	60	50,000	850
Touguikeren-Takanya Area 2/	40	50,000	1,200
Area north of Ouendima 2/	22	20,000	900

1/ Area included in COTHA project, but deleted in 1957 by the Genie Rural.

2/ Area not included in COTHA project.

The incremental unit costs lited in Table VI-7 are all between one-half and one-third of the incremental benefits. Consequently, these areas have been included within the project boundaries.

Alternative Plan of Reclamation

Local officials of the Forecariah Administrative Region suggested an alternative to the reclamation scheme originally proposed by the

French Administration. This alternative would permit the reclamation of about 3000 additional hectares located to the east of the present project area. A plan view of this scheme is shown on Exhibit A. It involves the construction of a dike, 16 kilometers in length, from Cogolima to Ouendima, by way of the Sankine Foli River. The dike alignment would cross the Noreire River 1000 meters downstream from its junction with the Touguikeren River, where a control structure would be constructed. This single structure would replace the three proposed structures across the Koakou, Noreire, and Touguikeren rivers. The structure would be about 120 meters in width and designed to discharge the runoff from an area of approximately 4400 hectares, estimated at about 50 cubic meters per second. The western side of the project area would be as in the proposed plan.

A preliminary study of this alternative scheme was made, primarily to determine its economic feasibility. The investment required to construct this alternative project is estimated to be equivalent to US$3,200,000. Considering that a total area of about 5300 hectares could be reclaimed, the cost of reclamation would be approximately $600 per hectare. This is slightly lower than the unit cost of development of the proposed project. Consequently, this alternative scheme appears to have great merits, and consideration was given to its adoption.

However, several factors would prevent its implementation in the near future:

(a) the agricultural potential of the additional 3000 hectares is not known, and agronomic and engineering studies would be necessary for a full economic justification of this scheme;

(b) construction of the control structure represents a major undertaking which will require extensive preliminary explorations and studies, as well as a construction period of about three years;

(c) the additional reclaimable land is presently covered with thick mangrove vegetation, and it is expected that several years will be required before this land can be put under cultivation;

(d) the increase in cultivable land that will result from construction of this project will require the relocation of additional residents of other areas to the island of Kakossa.

If this alternative were selected, benefits that could be derived within two years from construction of the proposed project would be foregone, and the economic development of the island would be delayed. Consequently, consideration has been given to a plan of development in stages whereby the proposed project would be constructed as early as possible, and the alternative project deferred until five or six years later. A large portion of the initial investment would be useful for a few years only, but it would permit an early reclamation of the areas presently under cultivation.

A comparison of the cost of this stage development with the cost of the alternative scheme is shown in Table VI-8.

Table VI-8 indicates that the costs of the two alternatives are equivalent. In this comparison, no credit has been given to the stage development for the benefits that would be foregone in the alternative plan for the first five years. Consequently, the proposed plan of development was adopted as the most economical as a first stage of development of Kakossa Island.

Table VI-8 - Economic Comparison of Stage Development with Alternative Plan

(equiv. U. S. $ million)

	Alternative Plan (proposed plan cancelled; alternative scheme constructed initially)	Stage Development (alternative scheme deferred until 5 years after construction of proposed plan)
Cost of Proposed Scheme	-	1.5
Cost of Alternative Scheme	3.2	2.2
Present Worth of Cost of Alternative Scheme	3.2	1.7
Present Worth of Total Costs	3.2	3.2

Chapter VII

PROJECT CONSTRUCTION

Introduction

The various features of the Kakossa Project are relatively simple, and no unusual difficulties are expected during construction. However, because of the present shortage in heavy construction equipment and skilled labor in Guinea, it is believed that the services of a foreign contractor will be required.

Past experience in the project area has shown that the local population will be capable of performing, both collectively and individually, only small scale work and only within the limits of their own lands. Consequently, it will be most advantageous to have the contractor perform as much of the civil works as is economically feasible. This will consist of the dikes, the canals, the control structures, and the bridges. Land preparation, consisting of levelling and planing operations, will be best accomplished with the mechanical equipment presently available to the Center of Rural Mechanization (C. M. R.). Installation of the new paddies and rehabilitation of existing ones will be left to the individual farmers.

Completion of the work is estimated to require about two years. A schedule of construction is presented on Exhibit 7. This schedule is designed to permit harvesting of a partial crop as early as the end of the first construction year. The first objective of construction operations will be to complete the reclamation of the Soulemanya watershed. For this purpose, the following items of work have been scheduled for completion during the first dry season (December, 1964 to June, 1965):

- Soulemanya River dredging;
- excavation of drainage canals in the Soulemanya watershed;
- rehabilitation of the existing dikes and control structure across the Soulemanya River;
- construction of the control structure across the Koakou River;
- construction of miscellaneous dikes required to prevent salt water encroachment on the watershed.

The remainder of the work could be started during the first dry season (1964-65), and would be completed during the second dry season (1965-66). This work will consist of:

- new dikes along the northern and western boundaries of the project area;
- control structures across the Noreire and Touguikeren rivers;
- excavation of drainage canals in the Noreire and Touguikeren watersheds;
- bridges.

Access to the Project Site

The project site is presently accessible from the mainland only by boat. Natives use dug-out canoes to cross the estuary of the Morebayah River. Two modern ferry boats are available to the Administrative Region of Forecariah, which supply access to the Island of Kakossa and the neighboring Island of Kabak on an unscheduled basis. Landing points are indicated on Exhibit A. The ferry terminal on the mainland is

accessible from Conakry over 70 kilometers of paved road and 40 kilometers of unpaved road. The nearest commercial airport is that of Conakry. The nearest port is also that of Conakry. Direct access by sea from Conakry is easily practicable along the coast and then either by way of the Soumbouya River to the northern part of the island, or by way of the Morebayah River to the southern part of the island.

Travel on the island itself by wheeled vehicles is generally practicable by way of roads located on the dunes. However, under present conditions, not all points of the island are accessible by vehicle. The network of tidal streams that cross the island provide an easy access by boat to most of these points.

Kakossa Island is separated from the mainland by the Soumbouya and the Morebayah rivers, which do not extend far inland. Direct access from the mainland would be possible if an earthfill was constructed across the mangrove from the main road between Conakry and Forecariah in a west-southwesterly direction. The fill, on which the road would be placed, would pass between the Morebayah River and an unnamed tributary of the Soumbouya River, and along the Sankine Foli to the vicinity of Quendima. Construction of this access road would probably not be economical for the purpose of project construction. However, it may be justified as a permanent means of communication to and from the project area.

Construction of the Dikes

One of the main items of work will be construction of the dikes. About 80,000 cubic meters of earthfill will be required for this item. Material for the dikes will be excavated by power shovels from two or

more borrow areas located in the immediate vicinity of the project area. Dump trucks will haul the materials to the location of the dikes. The materials will be spread by graders and rolled by sheepsfoot rollers. It is estimated that two 3/4 cubic yard power shovels and about ten dump trucks will permit completion of the dikes within the time shown on the construction schedules. D-8 type bulldozers and other miscellaneous earth-moving equipment will also be necessary on the project.

Excavation of the Canals

Another main item of work for construction of the project consists of channel excavation, divided into three main classes:

(a) excavation of material deposited in the Soulemanya River downstream from the control structure;

(b) excavation of drainage canals in the project area to supplement the network of natural streams;

(c) clearance of natural streams and removal of obstructions to the flow that may be located in their channels.

Although final selection of the construction method will be left to the contractor's option, it is expected that item (a) will be done by means of a floating dredge, and items (b) and (c) with crawling draglines and bulldozers. The estimates of cost are based on this solution.

It is expected that shortly after award of the construction contract the contractor will move a floating dredge to the project site. This dredge would be of the suction type, with cutterhead and about ten-inch suction and discharge pipes. The average excavating capacity of a ten-inch dredge would be about 100 cubic meters per hour. This capacity would be sufficient to perform the work within economic time limits. The dredge

would be shipped to Guinea in a knocked-down condition, and partly reassembled near the project site. The dredge would be moved to the Soulemanya River by towing or by self-propulsion. Assembly would be completed at the project site.

Excavation of the Soulemanya River by the dredge will be started at the downstream end, and the dredge will proceed upstream as the channel is excavated to the specified dimensions. About 100,000 cubic meters will be dredged from the main canal.

The draft of a ten-inch dredge is about 0.75 meters. Operation of the dredge during the lowest tides will be possible without a cofferdam across the channel.

Dredging during the wet season will be advantageous since most of the fine material put in suspension by operation of the cutterhead will be transported by the flow. The material sucked by the dredge will be pumped through the discharge pipe and deposited along the canal. These spoil areas will be located far enough from the bank's edge so as to allow for sloughing of the banks without excavated material being brought back into the canal. Maintenance roads will be located on the spoil banks.

The drainage canals will be excavated by draglines during the dry seasons. It is estimated that two draglines with 3/4 cubic yard buckets will be used by the contractor, together with D 8 type bulldozers and hauling trucks. The total amount of material to be excavated by the draglines is estimated to be about 85,000 cubic meters.

Structures

The project includes four gated control structures across the main tidal streams, of which one is already existing; a few vehicular bridges

over the tidal streams; and smaller structures and bridges throughout the project area.

Rehabilitation of the existing structure across the Soulemanya River will consist of the replacement of gate guides and other miscellaneous metal parts by similar parts made of stainless steel.

Construction of the new gated control structures will require temporary cofferdams enclosing the work area during the first dry season. The work area at the site of the Noreire structure is already cofferdammed. Wooden piles will then be driven in the foundations and reinforced concrete placed in the dry for the slab and the piers. The deck and the gates will then be installed and the temporary cofferdams removed.

Construction of the bridges can be carried out without cofferdams.

A small, portable, concrete batching plant will be required on the project. Materials for concrete aggregates are not available on the island. They will have to be hauled from a quarry. Cement to be used in the concrete structures will be Type V cement, or Type II mixed with pozzolan admixtures, so as to give the concrete a better resistance to the action of salt water.

Precast concrete elements for cribs will be cast near the batching plant, to be transported and used for construction of the abutments of structures and bridges. Materials for the bridge decks, such as creosoted timber, structural steel and miscellaneous metal parts will be brought to each site, and the bridges erected.

Land Preparation

Preparation of the lands for project operation will consist of minor leveling and smoothing over approximately one-quarter of the reclaimed

project area. Paddies will be made level to permit dikes to be spaced at reasonable intervals and provide operating room for machinery. Local surface irregularities will be removed at the same time.

This work will be best performed by the C. M. R. Coordination of the land preparation with the civil works construction will be effected by the resident engineer and the project agronomist. Preparation of a portion of the project lands can thus be carried out before the entire project is completed.

Each area to be leveled will be surveyed and appropriately marked to indicate cut and fill areas. Rubber tired tractors developing about 60 horsepower, and self-loading scrapers with a capacity of about two cubic meters will be required to perform the leveling. The same equipment can also be used to construct and maintain the levees in the paddies.

Quaternary Canals and Levees

Quaternary canals will be small ditches excavated along the paddies. It is estimated that about 100 meters of such canals will be excavated for each hectare of land. This excavation will be performed by hand by each farmer and his family. The material excavated from the ditches will be spoiled on the sides to form the levees surrounding the paddies. This work has been estimated to involve about 20,000 cubic meters of hand excavation.

Chapter VIII

PROJECT ECONOMICS

Scope and Procedure

This chapter presents details of the economic appraisal of the Kakossa Project. The principal objectives sought were: (1) to determine if increases in production anticipated from the project are sufficient to justify the estimated costs, and (2) to estimate the ability of the farmers to pay the costs of operation, maintenance, replacement, and amortizing the project investment.

The analyses follow general principles used by international financing institutions and most United States government agencies in determining economic and financial feasibility of resource development projects. Some modifications of standard procedures were necessary because of lack of data required to complete a rigorous analysis, and because of unique conditions of a non-private land tenure system, nomad and "shifting" cultivation, subsistence farming, and a non-market economy.

The validity of the estimates of increased income due to the drainage and reclamation programs is dependent upon a careful analysis of benefits resulting from anticipated land use under conditions with and without project development. This was accomplished by farm budgeting which provided for systematic outlining of the organization and operation of agricultural enterprises in the area, and included the anticipated income and expenditures for a normal cropping season.

Projected Farm Income

General Procedure

The general approach was to estimate the increase in farm income with the project over that existing without the project.

The basic agricultural unit in the Kakossa area was considered to be a four-hectare farm. Economic budgets for this farm unit were analyzed assuming that the project would not be constructed, and under conditions anticipated at four stages of development of the reclamation project: immediately upon completion of construction, and five, ten, and twenty years thereafter.

The first step was to obtain the gross farm income from total agricultural production under all conditions considered, by estimating the production of the four-hectare farm unit and the corresponding value of the crops.

The second step consisted of estimating the production costs. Farm investments were determined. The corresponding annual value and the current expenses of the farm yield the total annual production costs.

The third step was to determine the net crop income for each of the stages of development considered by deducting the production costs from the gross farm income. The increase in net income with the project was then computed by deducting the net income without the project from that with the project.

Projected Prices

The prices of farm products and items of farm costs should theoretically reflect long-term supply and demand relationships anticipated

over the economic life of the project. Because prices are arbitrarily set by the Government, projected prices based on anticipated supply and demand relationships would not be realistic. Prices for major farm products at the farm and retail levels for 1961, 1962, and 1963, as shown in Table VIII-1, were used in the study.

Inspection of Table VIII-1 indicates that the relation between farm and retail prices of white rice (polished) was 90 percent of the retail price in 1963, but only 75 percent in 1961. For some products, the farm price is only 60 percent of the retail price. This variation in spread presumably reflects the costs of marketing. However, according to estimates by some government officials, this difference is unrealistic for many products.

Farm Expense

Investment in Land. There is little private capital, in the form of cash outlay, invested in the project lands. An exclusive "de facto" right to use land is established by each cultivator when he settles on it, but neither the land nor improvements made during occupancy may be sold or transferred. Existing improvements including clearing, leveling, drainage and diking have been accomplished by individual cultivators almost entirely by hand without cash expenditures. Although these improvements increase the value of land for production, they do not represent an increased equity for the land users. Therefore, the present private capital investment in land has been assigned no value.

Additional land development necessary for proper cultivation and drainage of individual farm units will consist of one or more of the following operations: (1) land leveling and grading, (2) renovation of levees;

(3) installation of quaternary canals connecting to the tertiary and other canals.

Table VIII-1 - Farm and Retail Prices for Farm Products in Guinea, 1961-1963

(Guinean Francs)

Products	Unit	1961 Farm	1961 Retail	1962 Farm	1962 Retail	1963 Farm	1963 Retail
Palm nuts	kg	15-20	32-40	25	37-40	25	37-40
Palm oil	liter	60	80	68	125	70	125
White rice, polished	kg	30-40	50	45	55	45	50
Red rice, polished	kg	25-30	40	40	50	40	45
Rice paddy	kg	17-50	25	25	30	27	30
Peanuts, non-shelled	kg	20	35-40	25	35	25	40
Millet	kg	20	25	20	25	20	25
Coconuts	each	5	10	7	15	7	15
Fonio, cleaned	kg	15	25	30	40	30	40
Fonio, paddy	kg	10	20	20	25	20	25
Sweet potatoes	kg	10	15	10	15	10	15
Bananas	kg	23	30	23	30	23	30
Pineapples	kg	-	90	-	90	-	90
Meat: beef	kg	-	-	-	-	-	180-225
mutton	kg	-	-	-	-	-	250-350
pork	kg	-	-	-	-	-	500-800
Poultry	each	-	-	-	-	-	200-500
Eggs	each	-	-	-	-	-	15-20
Fish	kg	-	-	-	-	72-90	80-115

The cost of leveling and grading has been included in the project investment. Quaternary canals and levees within each farm land will be constructed by hand by the farmers. The spoil material from the canals will be used for construction of the levees surrounding the paddies. It is expected that a nominal amount of cash outlay for simple tools will be required for performance of this work. The value of this work, however, has been estimated to be about GF 29,625 per farm,

including grading at a unit price of GF 4625 per hectare and surface drains at a unit price of about GF 2,780 per hectare.

It is expected that some technical services will be required to supervise the installation of these facilities. Costs for these services are not included in the farm expenses, since they are included in the project operating costs.

Investment in Buildings. The amount of investment in farm buildings is very small. Existing buildings consist primarily of a mud-thatched house for the family, and a small wooden-thatched structure to provide protection for a few sheep, goats, or chickens. Additional buildings per farm are not expected with the project, although some improvements in the type of house will gradually be made, and new units will be established.

A typical house consists of dried mud walls on a lathing of wood branches, and roofed with grass thatching. The floors are mud and in some cases, the front step is dried mud blocks with a thin covering of cement plaster. The house can be built in approximately three months by two men and three women. The men do most of the actual construction, with the women helping by transporting materials. Most of the materials are gathered by the family. Total cost of the house and other structures is estimated to be GF 100,000 including all materials and the value of labor. The breakdown of this estimate is shown in Table VIII-2.

Table VIII-2 - Estimated Cost of Typical Farm Family Dwelling

Item	Unit Costs (GF)	Total Costs (GF)
Thatch grass	2,000	2,000
Wall lathing	1,500	1,500
Roof timber	1,500	1,500
Mason	12 days at 1000	12,000
Family labor	15 man-months at GF 5,333	80,000
Nails, wire, etc.		3,000
	Total	100,000

A few houses are now being constructed with galvanized iron roofs, walls of cement blocks covered with a thin layer of cement plaster, and floors covered with sand-cement mortar. It has been assumed that with improved economic condition as a result of the project this type of house will be the most prominant after a few years of operation. The cost including labor for a cement-iron roof house was estimated to be GF 175,000 on the basis of unit costs of basic material shown in Table VIII-3.

Table VIII-3 - Costs of Various Items Used in Construction of Farm Dwelling and Buildings

Item	Unit	Unit Cost (GF)
Lumber for doors and window flaps	per meter	100
Galvanized - iron roofing	2-meter lengths	600
Cement	45 kg bag	575
Sand - transported by canoe from the mainland	1/2 m^3	1000
Carpenter - labor	per man-day	3500
Family labor	per man-day	225

It is estimated that other farm buildings, including a shelter for a few head of livestock plus storage space for tools and rice, would cost about GF 25,000 per family unit. This includes an equivalent value for family labor and materials expended for construction which, for the most part, does not represent cash expenditures. The size and

total cost for farm buildings will increase proportionately with increases in crop and livestock production.

For analytical purposes, one-half of the investment cost for the family dwelling and all of the other farm buildings are charged as a farm investment. Annual costs for depreciation are based on a five percent sinking fund extended over the estimated useful life of the house at 100 percent of the original cost. This assumes an accumulation of funds to replace the buildings at the end of their useful life. Cost of repairs are calculated at three percent of the original cost.

Other Improvements. There are few other farm improvements present or considered necessary. Farm fences are non-existent. Domestic water is carried, usually by the women on their heads, from nearby stream or shallow village wells. Public utilities such as telephones and electricity are not available. Machine sheds and repair shops are not needed because there is little, if any, machinery except as owned and operated by the CMR on the mainland. Minor repairs on equipment is done mostly by the cultivator, but in some instances, facilities for building and repairing crude tools are available in the nearby village centers. For the most part, significant changes in these types of improvements are not anticipated within the foreseeable future.

Machinery and Equipment. At the present time, most rice is produced by hand methods. The average inventory and estimated cost of equipment used by the typical farm family are presented in Table VIII-4.

For the minor equipment listed in Table VIII-4, annual repair costs, excluding labor, are computed as two percent of the initial cost. Depreciation is based on a five percent sinking fund over the useful life, and calculated on 90 percent of first cost, with ten percent allowed for salvage value.

Table VIII-4 - Estimated Amount, Original Cost, and Annual Costs of Equipment Per Subsistence Farm

Item	Number	Original Cost (GF)	Estimated Life (years)	Annual Depreciation (GF)	Cost Repairs (GF)
Grubbing hoes	3	650	10	52	13
Axes	2	600	10	48	12
Machette - Sickles	4	1,000	10	80	20
Flails	3	600	2	293	12
Shovels	2	800	5	145	16
Rice sacks	10/ton	1,000	3	317	20
Storage container	1	1,250	10	100	25
Screens for cleaning	-	600	5	108	12
Wheel barrel 1/	1	7,150	10	560	153
Polishing container	1	500	5	90	10
Miscellaneous		1,450	-	115	29
Total		15,600		1,908	322

1/ Assumed owned only at later stages of development.

Mechanization of rice production is expected to develop very slowly. Government officials stated that the services of the CMR will eventually be extended to private cultivators, although cooperatives and force account enterprises have first choice on existing machinery at the present time. Some small plows, suited to pulling by animals, have been imported but none were being used at present.

It was assumed that little change from present hand cultivation methods will occur during an initial five-year development period. For subsequent periods, it is assumed that machinery and equipment for plowing and for harvesting will be available on a rental basis. Estimated

rental charges for machinery to perform various operations are presented in Table VIII-5. For machinery assumed to be rented, annual costs are included in the rental charge.

Table VIII-5 - Rental Charges for Farming Operations

Item	Unit	Total Costs (GF)
Plowing	hectare	3000 1/
Discing, harrowing, etc.	hectare	2000 1/
Combining	hectare	3500 1/
Drying rice	100 kg.	150
Cleaning or hulling rice	100 kg.	125

1/ Includes cost of fuel at GF 500 per hectare.

Fuel and oil for operation of a tractor was based on local costs. The price for gasoline varies from GF 41 to GF 45 per liter. Diesel fuel is sold at GF 28 per liter, and oil from GF 250 to GF 300 per liter.

Inventory Value of Livestock. The inventory value of livestock is presented in Table VIII-6. These data were used in the analysis to represent future conditions that may be expected with integrated crop and livestock enterprises, 10 to 20 years after the project is in operation.

Table VIII-6 - Inventory Value of Livestock

Item	Value (GF)
Milk cow	20-25,000
Beef steer	15-25,000
Sheep	4- 5,000
Goat	2,000
Pig	20-30,000
Chicken	200
Eggs (dozen)	60

Taxes. All agricultural enterprises are exempt from taxation. There is at present a head tax of GF 500 which must be paid on all persons of working age, except indigents. There are no real estate taxes on agricultural land.

Improvements in education, medical and transportation facilities, contemplated for the future will require additional taxes. Although it is not known how taxes for improvements will be assessed it was assumed that taxes will be increased to GF 1000 per person by the fifth year of operation of the project, seven persons being taxable on a farm.

Interest. There has been little need for credit facilities for agricultural purposes by subsistence farmers. Provisions are being made by the government to establish credit for plantation and cooperative-type farming for export crops. Current interest rates for these enterprises and for non-agricultural businesses are adopted for this analysis, and amount to the following:

Length of Loan			Interest Rates
Short-term	-	up to 9 months	4%
Medium-term	-	up to 5 years	5%
Long-term	-	5 years and up	6%

Other Crop and Livestock Expenses. The annual requirements and estimated costs for commercial fertilizer, seed, plant protection, and miscellaneous livestock expenses are presented in Tables VIII-7 through 10. These data were obtained mostly from local sources but with some adjustments to assure adequate requirements for the levels of production assumed for the study.

It is assumed that seed for planting would be home-grown, exceptions being for pasture crops and specialty crops, such as grain sorghum.

Table VIII-7 - Fertilizer Requirements and Annual Cost per Hectare[1/]

Crop	Portion of Area Fertilized Each Year (%)	Amount of Fertilizer Hectare (kg)	Annual Costs Per Hectare (GF)
Rice and Grain Sorghum[4/]	80	134[2/]	8300[3/]
Legume grass	40	56	2740[3/]

1/ Recommended rates for full production potential.

2/ Based on 78 kgs. of nitrogen and 56 kgs. of phosphates per hectare.

3/ Based on cost of nitrogen at GF 71 per kilogram and phosphate at GF 49 per kilogram. Phosphate applied to legume grass (Lespedeza) only.

4/ Portion of area fertilized upon completion (one-year) estimated at 25%.

Table VIII-8 - Seeding Rates and Annual Costs per Hectare

Crop	Seed Required (kg)	Cost per Kilogram (GF)	Seeding Interval (years)	Annual Costs (GF)
Rice	57.27	32	Annual	Farm
Legume clover	15	400	3	2000
Maize	33	35	Annual	1155
Sorghum	10	300	Annual	3000

Table VIII-9 - Cost of Seed Treatment, Pest and Weed Control[1/] Per Hectare

Crops	Costs Per Measure (GF)				
	Pests	Diseases	Weed Control[1/]	Seed Treatment	Total Costs
Rice	500	445	-	275	1220
Legume clover (Lespedeza)	500	-	-	250	750
Grain sorghum	500	250	-	-	750
Maize	500	250	-	-	750

1/ Rates of application and costs for full protection program.

Table VIII-10 - Miscellaneous Costs for Livestock Expenses Per Head

	GF
Beef and dairy cattle:	
Vaccinations	125
Minerals, salt, etc. (2 kg. at GF 75)	150
Miscellaneous equipment and supplies	125
Total per Head	400
Sheep:	
Dippings, parasite control, etc.	60
Miscellaneous equipment and supplies	75
Total per Head	135

Miscellaneous Farm Expenses. Miscellaneous expenses, estimated at five percent of total itemized farm expenses, are included in the budgets to cover unforeseen contingencies and minor expenses

normally incurred but not specifically identified with a specific crop enterprise.

Labor Requirements and Wage Rates. Few statistical data are available on the amount of labor expended in producing rice or other crops on subsistence farms. Estimates obtained from cultivators and government officials varied considerably. It was generally agreed that a typical family of one man with two wives plus their children, could cultivate about three hectares of rice plus sufficient other land to provide their own food requirements, and have a small portion of the production for sale. In most instances some additional labor, usually exchange labor with neighbors, is required during the peak work load seasons.

The man labor requirements for rice was estimated at 800 man-hours per hectare, or 100 eight-hour days, excluding time spent in hulling and preparation for cooking. An increase of approximately ten percent for each additional increase in yield of 1.0 ton per hectare was used in projecting future requirements without mechanization, most of which is assumed to be hired or exchange labor. Use of tractors and powered machinery for plowing, harvesting, and threshing would reduce labor requirements by more than one-half. Estimates for labor requirements and equivalent costs in producing rice are presented in Table VIII-11.

Wage rates, set by the government, are GF 28 per hour for farm labor and GF 32 for non-farm labor, primarily in Conakry. This amounts to about GF 225 or about $0.90 per day. Work contributed by women in producing crops is considered equally productive as for men.

Although wage rates may appear low, there is evidence that they are high relative to the marginal value productivity of labor. Because labor

comprises the major portion of total costs an inbalance in its pricing tends to affect adversely the economic feasibility of the project. On most subsistence farms much of the available labor is under-employed and alternative employment opportunities offering greater economic returns are practically nil. Assuming this represents future conditions throughout the period of analysis the cost of family labor could justifiably be excluded as a production cost in computing project benefits. Because of the uncertainty of this situation and because present cultivators do sustain themselves economically, the input value of family labor has been considered as an economic cost and it has been included in computing net returns to the drainage and reclamation program.

Table VIII-11 - Estimated Man Labor Requirements, and Equivalent Costs for Rice Production Under Present Cultural Methods

Operation	Unit	Annual Man-hour Requirement per Hectare 1/	Equivalent Labor Costs per Hectare (GF)
Preparing seed bed	Plot	20	450
Seeding primary bed	Plot	10	225
Preparing land in paddy	Hectare	100	2,250
Transplanting rice 2/	Hectare	60	1,350
Weed control	Hectare	200	4,500
Harvesting	Hectare	200	4,500
Threshing and cleaning	Hectare	200	4,500
Total		790	17,775

1/ Does not include time of one man hour per four kilograms of rice estimated for hulling and preparation for cooking and cleaning for sale.

2/ Assumed to continue to be done manually in the future.

Farm Budgets

The five farm budgets established for conditions without the project and for conditions anticipated upon completion of the construction and after five, ten, and 20 years of operation are presented in summary form on Tables VIII-12 through 16. The net income found in each of the five farm budgets were used to determine the increase in net income as shown in Table VIII-17 for each farm unit.

For conditions without the project, it has been assumed that each family of cultivators would continue to cultivate the four hectares which it is now cultivating, year after year. Substantial crops are - and will be - obtained only once in three or four years, and the production, as calculated, represents an average production over these three or four years.

For conditions after the project has been constructed, it has been assumed that the cultivators could be persuaded to establish a systematic crop rotation of two-thirds rice annually. One-third of the land would be idle initially with gradual introduction of crops complementary to rice production as improved cultural practices are introduced.

Results of the analysis show that net income, after a five-year development period, will increase from GF 36,904,000 to GF 79,693,000 or by an average of about GF 19,000 per hectare for the net reclaimed area of 2260 hectares. Much of this increase is attributable to production from about 800 hectares of new land which is now essentially non-productive because of salt water intrusions and inadequate drainage conditions. The total increase includes the value of farm privileges, composed of non-cash allowances for the equivalent rental value of the

farm dwelling, and the market value of the rice and other products consumed by the farm family.

The results for conditions anticipated after 10 and 20 years of operation show that large increases in production and income are possible with moderate applications of fertilizers, insecticides, improved plant varieties, and better cultural practices. It is estimated that net income after 10 and 20 years of operation could be increased by about 60 and 90 percent, respectively, above that estimated after five years without these improvements.

Economic Analysis

General Procedure

The economic value of the Kakossa Project has been analyzed on the basis of the relative measure of benefits and costs. Project benefits are defined as those benefits resulting from the increases in services and production of goods attributable to construction of the project. They have been classed as direct, indirect, and public benefits, and their annual values have been estimated separately for several stages of project development. In addition to benefits susceptible to monetary measurement, the project will result in significant benefits which are intangible and to which no monetary value can be assigned. Although these were not included in the analyses, their importance should not be discounted.

Project costs have been estimated on an average annual basis, using a rate of return of six percent per annum, which is what could be expected from equivalent investments in alternative enterprises in Guinea.

Table VIII-12 - Farm Budget No. 1 - Estimated Income and Expenses From Subsistence Rice Farm Under Present Conditions

(In Guinean Francs)

Crop	Production and Value						Disposition of Production		
	Hectares	Unit	Yield	Total	Price	Value	Seed	Consumed	Sales
Rice	4.0	kg	1,200	4,800	GF 32	153,600	3,840	38,400	109,800
Idle	-		-	-		-	-	-	-
Total	4.0					153,600	3,840	38,400	109,800

Farm Investment

Item	Value
Land Development	GF -
Dwelling (Farm Share)	50,000
Other Improvements	15,000
Equipment and Supplies	15,600
Miscellaneous	4,030
Total	GF 84,630

Farm Expenses

Item	Value
Interest on Investment	GF 5,080
Taxes	3,500
Depreciation and Repairs:	
a. Buildings and Improv.	7,120
b. Equipment	2,230
Cleaning at GF 3/kg.	14,040
Hired Labor 1/	9,000
Marketing at GF 2.5/kg.	6,100
Miscellaneous (5%)	2,360
Total	GF 49,430

Financial Summary

Item	Value
Cash Sales	GF 107,500
Farm Privileges:	
a. Conumed by Family	38,400
b. Rental Value of Dwelling	5,475
Total Income	151,375
Total Expenses	49,430
Net Income	GF 101,945
Family Labor Income 2/	101,945

1/ Equivalent value of hired or exchange labor.

2/ Total equivalent value of labor estimated at GF 90,000 of which GF 9,000 is exchange or hired labor, plus return for management of farming interprise.

Table VIII-13 Budget No. 2 - Estimated Income and Expenses From Subsistence Rice Farm Upon Completion of the Reclamation Project

(In Guinean Francs)

Crop	Production and Value: Hectares	Unit	Yield	Total	Price	Value	Disposition of Production: Seed	Consumed	Sales 1/
Rice	2.7	Kg	1,830	4,941	GF 32	158,000	4,928	48,000	103,500
Idle	1.3			-		-	-	-	-
Total				4,941		158,000	4,928	48,000	103,500

Farm Investment

Item	Value
Land Development	GF 29,625
Dwelling (Farm share)	50,000
Other Improvements	20,000
Equipment and Supplies	15,600
Other	5,760
Total	GF 120,985

Farm Expenses

Item	Value
Interest on Investment	GF 7,259
Taxes	3,500
Depreciation and Repairs:	
a. Buildings and Improve.	7,665
b. Equipment	2,230
Cleaning at GF 3/kg	14,361
Hired Labor 2/	8,000
Marketing at GF 2.5/kg	5,750
Fertilizer	3,350
Miscellaneous	2,280
Total	GF 47,895

Financial Summary

Item	Value
Cash Sales	GF 103,500
Farm Privileges:	
a. Consumed by family	48,000
b. Rental value of dwelling	5,475
Total Income	156,975
Total Expenses	47,895
Net Income	GF 109,080
Family Labor Income 3/	109,080

1/ 3,287 kg paddy or 2,300 kg polished at GF 45.

2/ Equivalent value of hired or exchange labor.

3/ Labor requirements of equivalent to GF 63,000 of which GF 8,000 is hired or exchange labor.

Table VIII-14 Budget No. 3 - Estimated Income and Expenses From Subsistence Rice Farm Five Years After the Reclamation Project

(In Guinean Francs)

Crop	Production and Value						Disposition of Production			
	Hectares	Unit	Yield	Total	Price	Value	Seed	Consumed	Sales 1/	Feed
Rice	2.70	kg	2,500	6,750	GF 32	216,000	4,928	48,000	160,200	-
Lespedeza	.33	kg	10,000	3,300	3.7	12,210	-	-	-	12,210
Idle	.7					-	-	-	-	-
Total	4.0					228,210	4,928	48,000	160,200	12,210

Farm Investment

Item	Value
Land Development	GF 29,265
Dwelling (Farm Share)	87,500
Other Improvements	25,000
Equipment and Supplies	19,700
Miscellaneous	8,590
Total	GF 170,055

Farm Expenses

Item	Value
Interest on Investment	GF 10,225
Taxes	7,000
Depreciation and Repairs:	
a. Buildings and Improv.	12,320
b. Equipment	3,630
Cleaning rice at GF 3/kg	19,788
Hired Labor 2/	10,000
Marketing at GF 2.5/kg	8,900
Fertilizer	6,700
Seed (Lespedeza)	667
Miscellaneous	3,890
Total	GF 83,120

Financial Summary

Item	Value
Crop Sales:	
a. Rice	GF 160,200
b. Fodder (Equiv. products)	3,300
Farm Privileges:	
a. Rice consumed	48,000
b. Other products	3,295
c. Rental value of dwelling	9,375
Total Farm Income	224,170
Farm Expenses	83,120
Net Income	GF 141,050
Family Labor 3/ and Management	120,000
Residual Income Available for Profit and Repayment	21,050

1/ 5,079 kg. paddy or 3,560 kg. polished rice at GF 45.

2/ Assumed hired labor or equivalent value of exchange labor.

3/ Labor requirements of equivalent value at GF 78,500 of which GF 10,000 is hired or exchange labor.

Table VIII-15 Budget No. 4 - Estimated Income and Expenses From Subsistence Rice Farm Ten Years After the Reclamation Project

(In Guinean Francs)

Crop	Production and Value						Disposition of Production			
	Hectares	Unit	Yield	Total	Price	Value	Seed	Consumed	Sales	Feed
Rice	2.7	kg	3,720	10,040	GF 32	321,280	4,928	48,000	263,700 1/	-
Maize	.1	kg	2,000	200	35	7,000	115	1,925	4,960	-
Lespedeza	.6	kg	10,000	6,000	3.7	22,200	-	-	-	22,200 2/
Total	4.3					350,480	5,045	49,925	268,660	22,200

Farm Investment

Item	Value
Land Development	GF 29,625
Dwelling	87,500
Other Buildings	30,250
Equipment and Supplies	25,265
Livestock	22,500
Miscellaneous	9,760
Total	GF 204,900

Farm Expenses

Item	Value
Interest on Investments	GF 12,295
Taxes	7,000
Depreciation & Repairs:	
a. Building & Improv.	12,895
b. Equipment	4,185
Equipment Rental	10,200
Marketing	14,650
Crop Seed	1,000
Cleaning Rice	24,645
Fertilizer	8,770
Plant Protection 3/	1,550
Hired Labor	12,500
Livestock Expenses	400
Miscellaneous	5,510
Total	GF 115,640

Financial Summary

Item	Value
Crop Sales:	
a. Rice	GF 263,700
b. Other Crops	11,065
Farm Privileges:	
a. Rice Consumed	48,000
b. Other Products	8,030
c. Rental value dwelling	9,375
Total Farm Income	340,170
Total Expenses	115,640
Net Income	224,530
Family Labor & Management	140,000
Residual Income Available for Profit & Repayment	84,530

1/ 8,369 kg of paddy or 5,860 polished at GF 45/kg.

2/ Equivalent value of livestock products at GF 12,210 assumed sold or eaten in home.

3/ Assumes 40% coverage of cultivated area.

Table VIII-16 Budget No. 5 - Estimated Income and Expenses From Subsistence Rice Farm 20 Years After Completion of the Reclamation Project

(In Guinean Francs)

Crop	Production and Value: Hectares	Unit	Yield	Total	Price	Value	Disposition of Production: Seed	Consumed	Sales 1/	Feed
Rice	2.7	kg	4,000	10,800	GF 32	345,600	4,928	48,000	288,000	-
Maize	.3	kg	2,500	750	35	26,250	350	1,925 2/	23,975 2/	-
Lespedeza	.8	kg	12,000	9,600	37	(35,520)	-	(9,770)	(9,770)	(35,520)
Grain Sorghum	.2	kg	2,000	400	40	16,000	-	-	16,000	-
Idle	-		-	-		-	-	-	-	-
Total	4.0					389,920	5,278	49,925	327,975	(35,520)

Farm Investment

Item	Value
Land Development	GF 29,265
Dwelling (Farm Share)	87,500
Other Improvements	35,500
Equipment and Supplies	32,000
Livestock	45,000
Miscellaneous	11,460
Total	GF 240,725

Farm Expenses

Item	Value
Interest on Investment	GF 14,445
Taxes	7,000
Depreciation and Repairs:	
a. Buildings & Improv.	13,500
b. Equipment	4,740
Equipment Rental	12,000
Marketing	16,000
Crop Seed	2,545
Cleaning Rice	31,940
Fertilizer	12,655
Plant Protection	4,265
Hired Labor	14,000
Livestock Expenses	1,000
Miscellaneous	6,700
Total	GF 140,790

Financial Summary

Item	Value
Crop Sales:	
a. Rice	GF 288,000
b. Other Crops	49,745
Farm Privileges:	
a. Rice Consumed	48,000
b. Other Products	11,695
c. Rental value of home	9,375
Total Farm Income	406,815
Total Expenses	140,790
Net Income	GF 266,025
Family Labor & Management	170,000
Residual Income Available for Profit and Repayment	96,025

1/ Rice sold 8,589 kg. at GF 45.

2/ Equivalent value of sales or amounts consumed on farm.

Table VIII-17 - Summary of Increased Net Crop Income With Drainage and Reclamation, Kakossa Project

Item	Unit	Under Present Conditions	With Project: Upon Completion	With Project: Five Years After Completion	With Project: Ten Years After Completion	With Project: Twenty Years After Completion
Rice	Hectare	1,530	1,200	1,500	1,500	1,500
Other Crops	Hectare	-	-	180	410	760
Idle	Hectare	-	620	580	350	-
Total		1,530	1,820	2,260	2,260	2,260
Gross Income	GF 1000	57,977	71,423	126,656	192,196	229,850
Farm Expenses	GF 1000	18,932	21,792	46,963	65,337	79,546
Net Income	GF 1000	39,045	49,631	79,693	126,859	150,304
Per Hectare	GF	25,500	27,269	35,260	56,132	66,506
Net Increased Income	GF 1000	-	10,586	40,648	87,814	111,259
Per Hectare	GF	-	5,816	17,986	38,855	49,229

Annual Equivalent Costs of the Project

The total annual equivalent costs are the amortized net project investment (construction cost plus interest during construction) plus the average annual operation, maintenance, and replacement costs. The economic life of the project, taken as 50 years, was used as the length of the period of analysis.

A rate of interest of six percent per annum was selected as applicable to the project investment, as indicated on page VIII-10.

The construction cost of the project has been estimated to be $700,000 and GF 200,000,000, or a total equivalent to GF 380 million. The detailed estimate of the project construction cost is presented on Exhibit 8. At an interest rate of six percent, the interest during construction amounts to about 20 million. The project investment is GF 400 million. Amortized over a period of 50 years at six percent per annum, the project investment is equivalent to GF 25 million. Annual charges for operation, maintenance and replacement, estimated to be GF 7 million, were added to obtain the annual equivalent cost of the project, GF 32 million.

Direct Benefits

Direct benefits are the increases in net income anticipated for the entire project area after completion of the reclamation project. The net project income for conditions without the project and for each stage of development was derived from the net farm income and the corresponding number of farm units. The increases in total net income for each level of development from the net income accruing to the Monchon area

were thus calculated. These values are the direct benefits corresponding to each stage of development. They are shown in Table VIII-18.

Table VIII-18 - Determination of Direct Project Benefits

(Amounts in GF 1000)

	Under Present Conditions	Upon Completion of Project	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Net farm income	101,945	109,080	141,050	224,530	266,025
Number of farms	383	455	565	565	565
Net project income	39,045	49,631	79,693	126,859	150,304
Increase in net income (direct benefits)	-	10,586	40,648	87,814	111,259
Use, GF 1000	-	10,500	40,500	88,000	111,500

Indirect Benefits

Indirect benefits are increases in net income to persons other than the cultivators as a result of the increased flow of rice and other crops from the project lands. These benefits are normally estimated by the use of factors representing the ratio of a share of profits in processing and retailing to the increased value of the crop sales. As such factors are not available for Guinea, estimates have been made on the basis of differences between farm and retail prices of the products sold.

In 1963, the farm price of rice paddy was GF 27 per kilogram, and the retail price of polished red rice was GF 45 per kilogram, or GF 32 per kilogram of equivalent paddy. As farm and retail prices are established by the government, the difference between farm and retail prices of rice does not necessarily correspond to the actual added value due to processing. For the purpose of determining indirect benefits, the added value for increased sale per kilogram of rice paddy polished and processed by the farmers for their consumption and for marketing was taken conservatively as GF 4.5 per kilogram. The determination of indirect benefits is summarized in Table VIII-19.

Table VIII-19 - Determination of Project Indirect Benefits

	Upon Completion of Project	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Increase in rice production (not including seed), tons paddy	410	1,970	3,810	4,220
Added value, GF 1000	1,845	8,850	17,150	19,000
Use, GF 1000	2,000	9,000	17,000	19,000

Public Benefits

Public benefits are defined as the value of achieving national objectives other than those included in direct and indirect benefits. Their evaluation represents a judgement estimate, more than a rigourous determination. The following benefits have been estimated.

(1) Employment Opportunities. This consists of benefits resulting from the contribution of the project to stabilization of income, employment, and investment opportunities outside of the project area. Although there is no accurate criteria for estimating these benefits, experience in the United States show such benefits to be at least five percent of direct project benefits. It is believed that these benefits would not be less for Guinea.

In addition, employment will be afforded during the construction and development period. It is estimated that no less than GF 75,000,000 of the construction costs will be spent in purchase of local goods and services. Depending on actual contracting arrangements, at least 70 percent of this, or about GF 52,000,000 would be paid to local laborers. This would result in employment and training for many local workers, and in stimulating the national economy. At six percent annual interest, this benefit would amount to an equivalent of GF 3,300,000 annually.

The combined public benefits from increased employment and economic stimulation of the region are shown in Table VIII-20. They are the only public benefits for which we have made a monetary evaluation.

Table VIII-20 - Determination of Public Benefits

(GF 1000)

	Upon Completion of Project	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Employment outside of project	530	2,032	4,195	5,563
Employment during construction	3,300	3,300	3,300	3,300
Total Public Benefits	3,830	5,332	7,495	8,863
Use, GF 1000	4,000	5,500	7,500	9,000

(2) Settlement Opportunities. Reclamation of the project lands will provide opportunities for the establishment of additional subsistence farms, or enlargement of existing farms and creation of cooperative enterprises. At four hectares per subsistence farm, about 200 new subsistence units could be established. Public benefits from providing settlement opportunities would result, equivalent to at least the alternative earnings of the new cultivators. Although these benefits have not been evaluated in monetary terms, they would be very significant to the economy of the region and to Guinea. The magnitude of these benefits will increase as the population continues unless equal alternative economic opportunities are provided.

(3) Reduction in Foreign Currency Expenditures. The additional production anticipated from the project will contribute to a reduction of import requirements and, in turn, a reduction in expenditures of Guinea's scarce foreign currency. The value of additional production to the nation would, therefore, be equal to the alternative cost of imported rice. The value of rice imported from the United States in 1962 was about $140 per metric ton, including shipping costs. Increased production of rice to offset this expenditure for import rice would be extremely important in bolstering the economy of Guinea. Although this has not been included in the evaluation of public benefits, the importance of this factor can be easily illustrated. The foreign currency component of the project investment is $740,000, which corresponds to the cost of about 5000 tons of rice. These foreign currency expenditures can be recovered by the project through reductions in imports in the first six years of operation, on the basis of present worth at an annual rate of six percent.

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Equivalent Annual Benefits

Benefits will start accruing at the beginning of project operation and will increase gradually, to reach their full value 20 years after completion of the project, as shown in summary form on Table VIII-21.

Table VIII-21 - Summary of Project Benefits
(GF 1000)

Annual Benefits	Upon Completion of Project	After 5 Years of Operation	After 10 Years of Operation	After 20 Years of Operation
Direct Benefits	10,500	40,500	88,000	111,500
Indirect Benefits	2,000	9,000	17,000	19,000
Public Benefits	4,000	5,500	7,500	9,000
Total Annual Benefits	16,500	55,000	112,500	139,500

For the purpose of economic studies, the equivalent annual benefits were calculated as follows. The net annual benefits that are expected to accrue after one, five, ten, and twenty years of project operation were plotted on a chart, and the values corresponding to intermediate years were interpolated. These values are tabulated on Table VIII-22. Also listed in this table are the single payment - present worth factors for an annual rate of six percent. These were used to obtain the present worth of the benefits accruing each year of the period of analysis, listed in Column (4). The present worth of future annual benefits accruing over a 50-year period was found equal to GF 1,573 million. By amortizing this amount over 50 years at a rate of six percent, the equivalent annual benefits were determined as GF 98,818,000.

Table VIII-22 - Determination of the Equivalent Annual Benefits

Year (1)	Total Benefits (1000 GF) (2)	Present Worth Factor (3)	Present Worth of Benefits (4)
1	16,500	.9434	15,566
2	25,000	.8900	22,250
3	34,500	.8396	28,966
4	44,500	.7921	35,248
5	55,000	.7473	41,102
6	71,000	.7050	50,055
7	85,500	.6651	56,866
8	96,000	.6274	60,230
9	105,000	.5919	62,150
10	112,500	.5584	62,820
11	118,500	.5268	62,426
12	123,500	.4970	61,380
13	127,500	.4688	59,772
14	131,000	.4423	57,941
15	133,500	.4173	55,710
16	136,000	.3936	53,530
17	137,500	.3714	51,068
18	138,500	.3503	48,517
19	139,000	.3305	45,940
20	139,500	4.604	642,258
50	139,500		
Total			1,573,795

Equivalent annual benefits:

$$1,573,795 \times 0.0634 = \text{GF } 99,818,000$$

A similar calculation of the equivalent annual direct benefits - excluding indirect and public benefits - yielded GF 77,761,000.

Benefit-Cost Ratios

The ratios of total benefits to total costs and direct benefits to total costs were determined as follows:

With direct benefits only:	2.4 to 1.0
With total benefits:	3.1 to 1.0

Financial Analysis

Financing Terms

Construction of the Kakossa Project will require funds in the amount of $740,000 and GF 210 million, to be expended over a period of about two years. These amounts will probably be secured through an international lending institution. Since the terms of such financing are not known, it has been assumed that the entire project investment would be financed, to be repaid over a period of 40 years with an interest rate of 0.75 percent per annum. The first payment would be deferred to the eleventh year after beginning of operation. These terms are those currently offered by international lending institutions such as the International Development Association (IDA), an affiliate of the International Bank for Reconstruction and Development (IBRD, World Bank), and by the Agency for International Development (AID), an agency of the United States, Department of State.

Annual Costs

Such financing terms would require repayments at an annual rate of $12,000 for the first ten years, and $44,000 for the following 40 years, equivalent to GF 3 million and GF 11 million, respectively.

The annual costs of operating the project, including operation, maintenance, replacements, and the support of an agricultural extension program have been estimated to be GF 11 million for the first three years of operation, and GF 8 million thereafter.

Repayment Ability

The repayment ability of the farmers has been evaluated by determining the amounts available annually to them after all farm expenses are met. The net farm incomes calculated in the farm budgets were reduced by amounts corresponding to the values of the family labor utilized in operating the farm unit. These amounts, shown on Tables VIII-12 through 16, were estimated on the basis of current wages for farm labor. The remaining amounts, multiplied by the number of farms to be operated in the project area, are the residual amounts available for profit of the farm enterprises and for repayment of the project. They are indicated on Table VIII-23. Also shown in the table are the project annual costs.

Inspection of Table VIII-23 indicates that only during the first five years of project operation will residual income of the farmers be less than the total annual costs of the project. From then afterward, income becomes substantially greater than project costs.

Table VIII-23 - Financial Analysis

(Amounts in GF Million)

Years After Completion	Residual Income for Profit and Repayment	Annual Costs			
		Interest and Amortization	Operating Costs	Extension Services	Total
0	0	3	7	4	14
1	0	3	7	4	14
2	0	3	7	4	14
3	0	3	7	1	11
4	4	3	7	1	11
5	12	3	7	1	11
6	24	3	7	1	11
7	32	3	7	1	11
8	39	3	7	1	11
9	44	3	7	1	11
10	48	11	7	1	19
15	53	11	7	1	19
20	54	11	7	1	19

Chapter IX

PROJECT OPERATION AND DEVELOPMENT

Introduction

Ultimate success of the proposed project is contingent upon the following essentials: (1) bringing the reclaimed land into production as early as possible; (2) increasing yields through improvements of research and production techniques; (3) effective operation and maintenance of the project facilities; (4) effective transportation, storage, processing and marketing facilities. These elements are interrelated and must be attacked simultaneously which will require joint and well-coordinated efforts between the farmers and a designated administrative authority from the very beginning of construction.

Administrative Authority

The responsibility for project operation and development must be firmly established at the start of construction. It is not known at present what type of organization will be implemented to carry out the project.

It is recommended that responsibility be vested in an administrative and supervisory authority at the project level. This responsibility should include overall coordinating functions covering all technical, educational, and operational matters pertinent to the success of the new venture.

It is recommended that an experienced rice agronomist be employed full time to direct this agency for several years beginning at the time of construction. Because of the present shortage of experienced Guinean

technicians, this agronomist may have to be an expatriate. Guinean assistants should be assigned to work with him with the objective of ultimately assuming full responsibility after sufficient experience is gained.

The agronomist would also be assigned the technical direction of the CMR or such organization created specifically for the purpose of controlling the available mechanized equipment, acquiring and distributing farm supplies, and maintenance operation. He would be responsible also for conducting research and experiments on test plots, and extension activities to extend results to the farmers.

The Kakossa Project could also serve as a pilot project for demonstration purposes and for training personnel for projects contemplated in other areas of Lower Guinea. Several trainees could be assigned to the project, under the technical direction of the agronomist, for subsequent assignment to other projects.

Land and Soil Preparation

Proper coordination between the land preparation and the contractors' operations is an absolute essential for integration of the drainage and reclamation scheme. Considerable reorganization and consolidation of presently cultivated lands will be necessary. Farm units of proper size and shape, and surface drains to be installed by the farmers must be laid out in proper patterns at the time the primary drainage channels are constructed. The spoils from these channels may be used for dikes and farm borders. Also the construction and land preparation must proceed systematically to permit as much land being brought into production as rapidly as possible. This will enable

partial production during the construction period without serious disruption of current farming operations.

The technical services of the agronomist, and other specialists as required, must be available during construction to assist farmers with proper land preparation, and operation of the drainage facilities.

Agricultural Development Programs

The primary goal of the administering authority will be to assist the farmers in achieving and sustaining substantial increases in rice production. Substantial improvements are possible from a technological standpoint but realistic objectives must fit within the present patterns of land holdings and cultural methods. There are severe limitations to the range of improved practices that can be introduced. A rapid enlistment of peasant and nomad farmers in a change from traditional practices to intensive and modern practices is not expected. Short and long range programs should be initiated simultaneously with emphasis on those factors which will bring immediate results with least cost and management.

Short Range Programs. The immediate steps must deal with proper drainage and control of the fresh water supply, reduction of salinity in the surface soils, seed bed preparation, and adoption of varieties most suitable to the changed soil conditions. These improvements can be accomplished with practically no cash expenditures or changes in use of available hand implements.

The use of fertilizers, particularly phosphorus, and plant protection measures should be introduced at the start of the project. Initially this may require government assistance under communal rather than

individual programs. It is expected that several years will be required to inform the farmers of the factors of utility, availability, use, supply, and planning necessary to secure substantial universal application of inorganic fertilizers. However, adaption will have to be more rapid in certain fields. For instance, the improvement of drainage facilities will alter the water levels to which the farmers are accustomed in the paddies. Proper timing in seed bed preparation, transplanting, spacing of plants, etc. are expected to be changed. Rapid adjustment to these new conditions is necessary to obtain the production levels anticipated.

Long-Range Programs. It is essential to introduce programs concerned with the primary factors of production at the beginning, even though the results may not be realized for several years. These include research for improvement of seed, introduction of complementary crops to be used in rotation with rice, test plots for fertilization trials with various combinations of plant food elements, soil testing and drainage studies, and a training program.

It is likely that at least five years will be needed before the first seeds from the research programs may be available for widespread distribution. However, the potential for increased yields from this source justifies this endeavor. Extensive plant protection measures are required for effective disease and pest control. These activities fall logically under the purview of the project area and can best be employed where substantial contiguous areas are planted to the same crop.

The long-range program should include integrated studies and analysis of the soils and corrective measures necessary to improve their fertility. This will involve fertilization trials, crop rotations with green manure and other crops, and chemical analysis. This

program would be integrated also with drainage studies for reduction and control of salinity, and control of water tables.

With the exception of plowing and threshing, mechanization is not expected to be a significant goal in improving rice production. These operations could be handled through machinery pools or the operating agency. Much improvement in production techniques, however, is possible with adoption and use of improved simple tools and equipment. For instance, hand plows pulled by animals would do much to lighten the burden of the farmer.

The success of the project will stand or fall with the success of contact with the farmers. Technical information must be transferred to the farmers which requires communication skills and methods. Also, the farmers must be motivated to change traditional methods and to intensify production.

We recommend that extension services be established through locally trained field agents in getting the farmers to accept and adopt new practices and materials. As the Kakossa Project is small, only one or two agents may be required. The beginning technical tasks should be relatively simple, but growing more complex as the project develops. The agents can be trained through short courses, field demonstration, and working with the technical director.

Maintenance and Operation

The maintenance and operation program will be one of the most important responsibilities of the technical director. The drainage channels, the tide control gates, and the other structures must be kept in a good state of repair. This will include constant cleaning to keep

them free of debris, dredging to maintain grades, and other miscellaneous operations.

The responsibility for these operations must be with the technical director to enforce strict discipline throughout the project. Close cooperation and understanding from the farmers must be obtained for continued success. It is recommended that a farmers' committee be appointed to work with the director on these and other functions of the project. This arrangement frequently creates interest in the farmers for maintaining the project because of understanding the problems and recognizing the benefits to them.

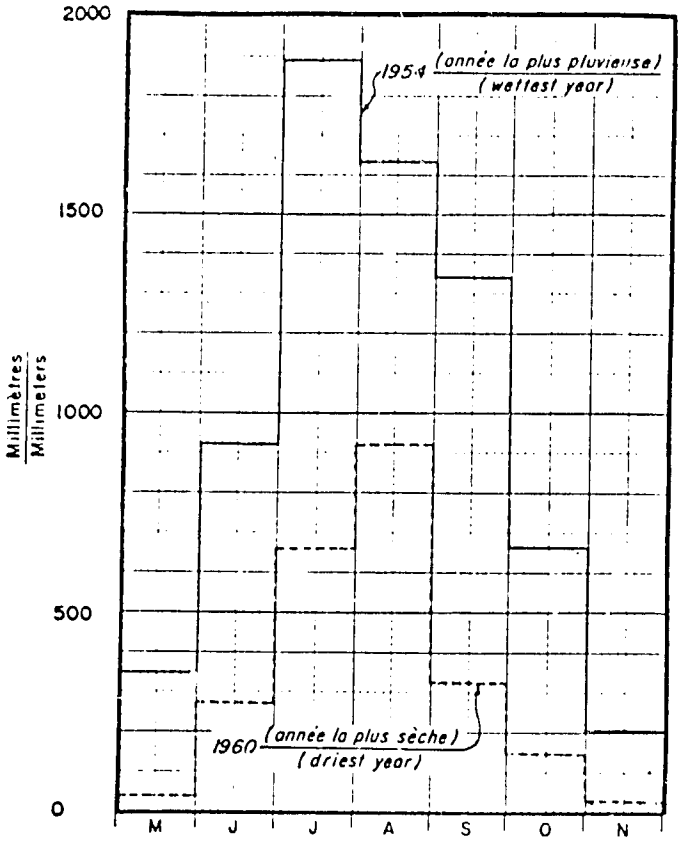
Financial Arrangements

To carry out the duties and services recommended for the project the agency responsible will need a budget sufficient to enable an effective operation. This budget should be earmarked for this specific purpose by the government of Guinea and allocated to the administrative agency directly or through the Forecariah regional executive government.

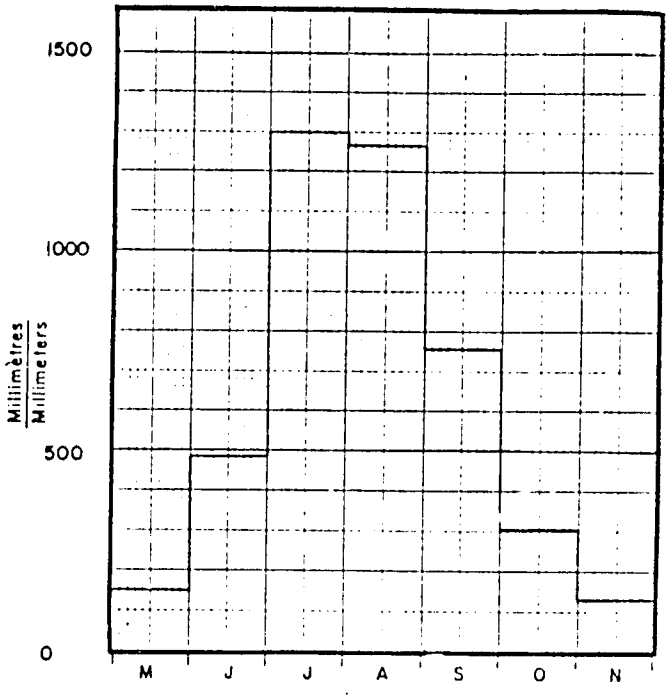
It is expected that costs for services involving training of field agents to be used elsewhere would not be charged to the Kakossa Project. It is recommended that the regional budget be allocated additional funds for these services, if provided. Financing arrangements and sources of revenue for costs of services for the Kakossa Project were discussed in Part One. A well-managed Kakossa Project will ultimately yield sufficient returns to the Republic of Guinea to justify the programs necessary for assuring its success.

THE EXHIBITS

Exhibit 1. Climatological and Hydraulic Data
2. Land Use Map
3. Logs of Auger Holes
4. Results of Laboratory Tests
5. Results of Hydraulic Analyses
6. Details of Structures
7. Construction Schedule
8. Estimate of Project Construction Cost

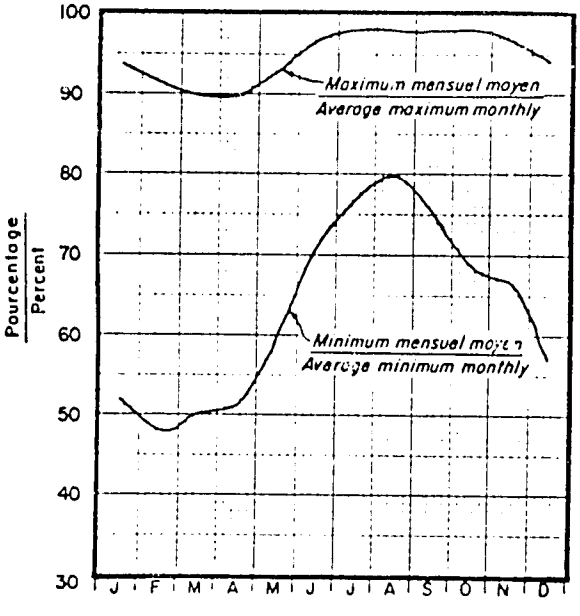


ANNEES EXTREMES / EXTREME YEARS

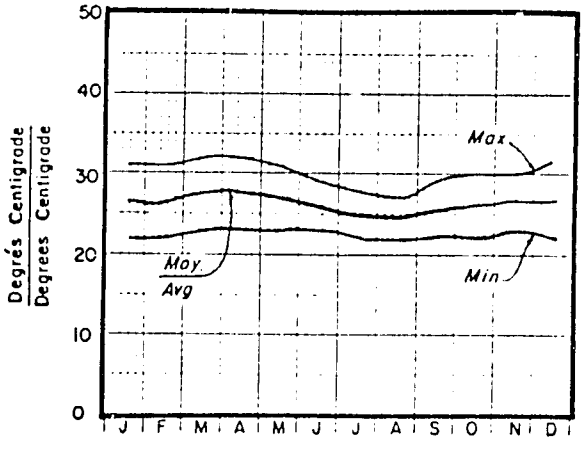


ANNEE MOYENNE / AVERAGE YEAR (1949 - 1963)

PLUVIOMETRIE MENSUELLE A CONAKRY-AVIATION
MONTHLY RAINFALL AT CONAKRY-AVIATION



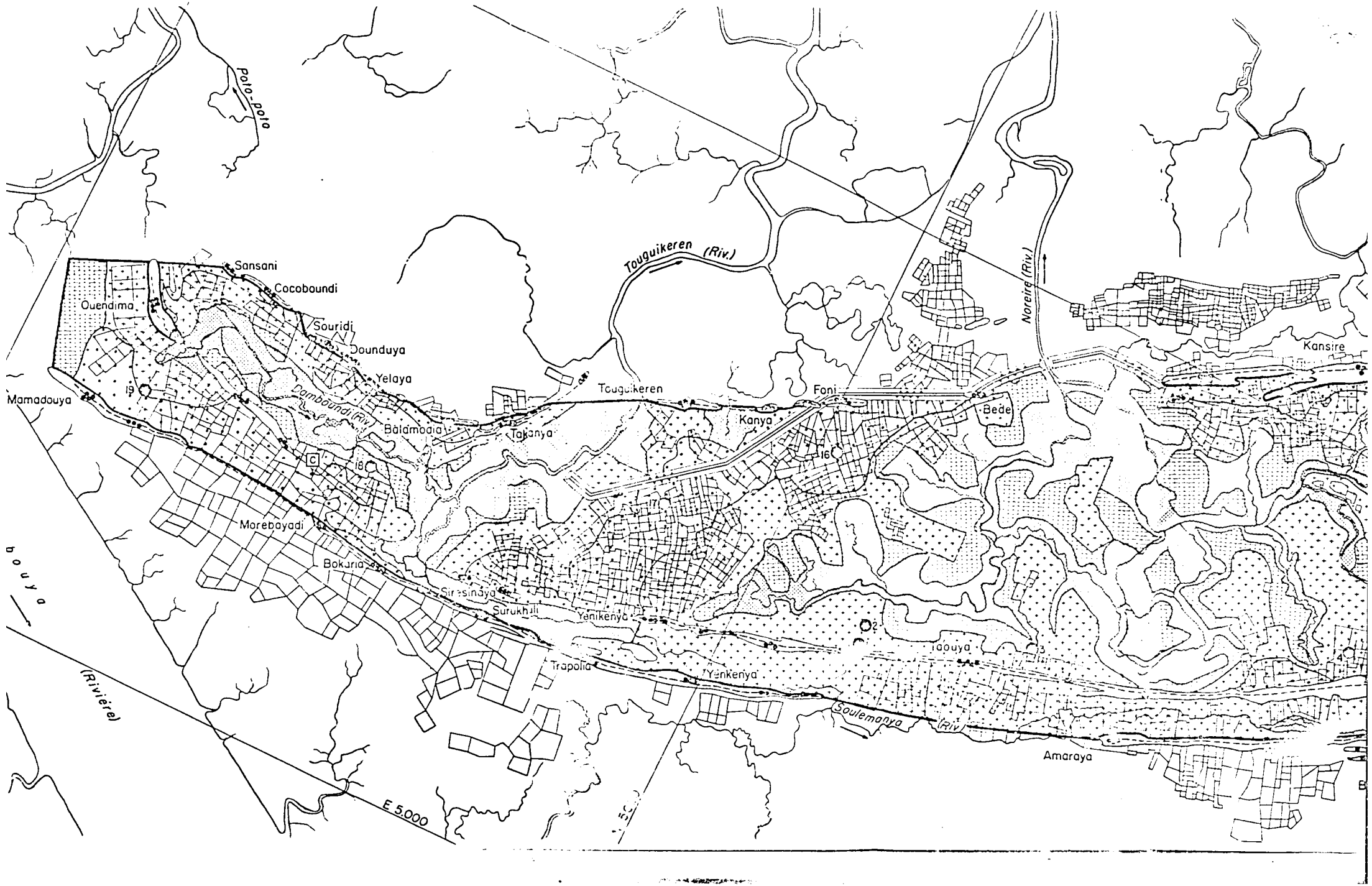
HUMIDITE A CONAKRY-AVIATION
HUMIDITY FOR CONAKRY-AVIATION
(1949 - 1962)



TEMPERATURES A CONAKRY-AVIATION
TEMPERATURES FOR CONAKRY-AVIATION
(1949 - 1962)

NOTE:
Données sur pluviométrie, la température, et l'humidité à Conakry-Aviation proviennent des archives du Service Météorologique National.

Precipitations, temperatures and humidity at Conakry-Aviation were obtained from the files of the National Meteorological Service.


Pola-pola
Sansani
Cocoboundi
Ouendima
Souridi
Dounduya
Yelaya
Mamadouya
Damboundi (Riv.)
Baldmodia
Takanya
Touguikeren (Riv.)
Touguikeren
Foni
Kanya
Bede
Noreire (Riv.)
Kansire
Morebayadi
Bokaria
Sirassinaya
Surukhili
Yenikenya
Trapolia
Yenkenya
Iadouya
Soulemanya (Riv.)
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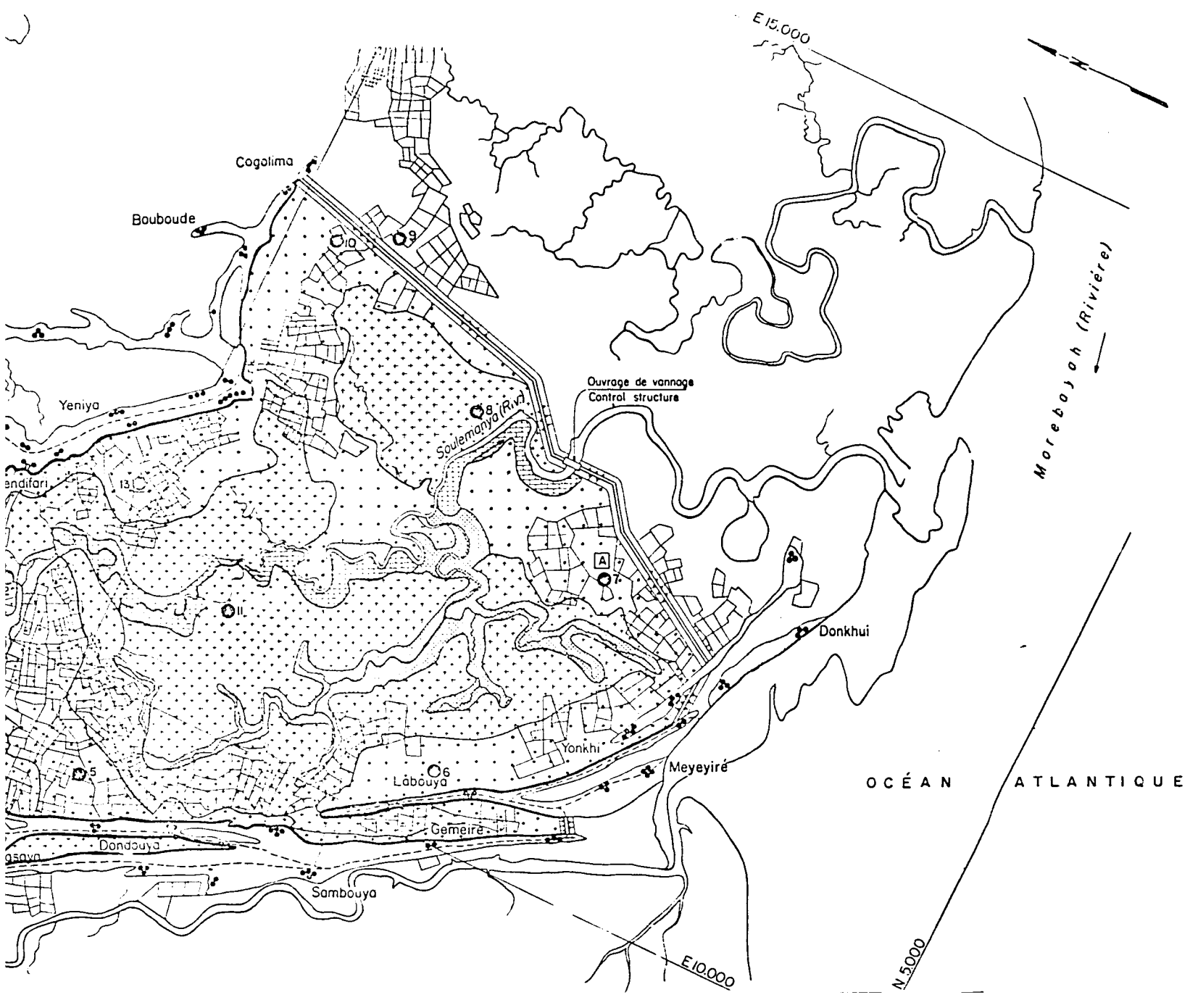


LEGENDE
LEGEND

PLANCHE 2
EXHIBIT

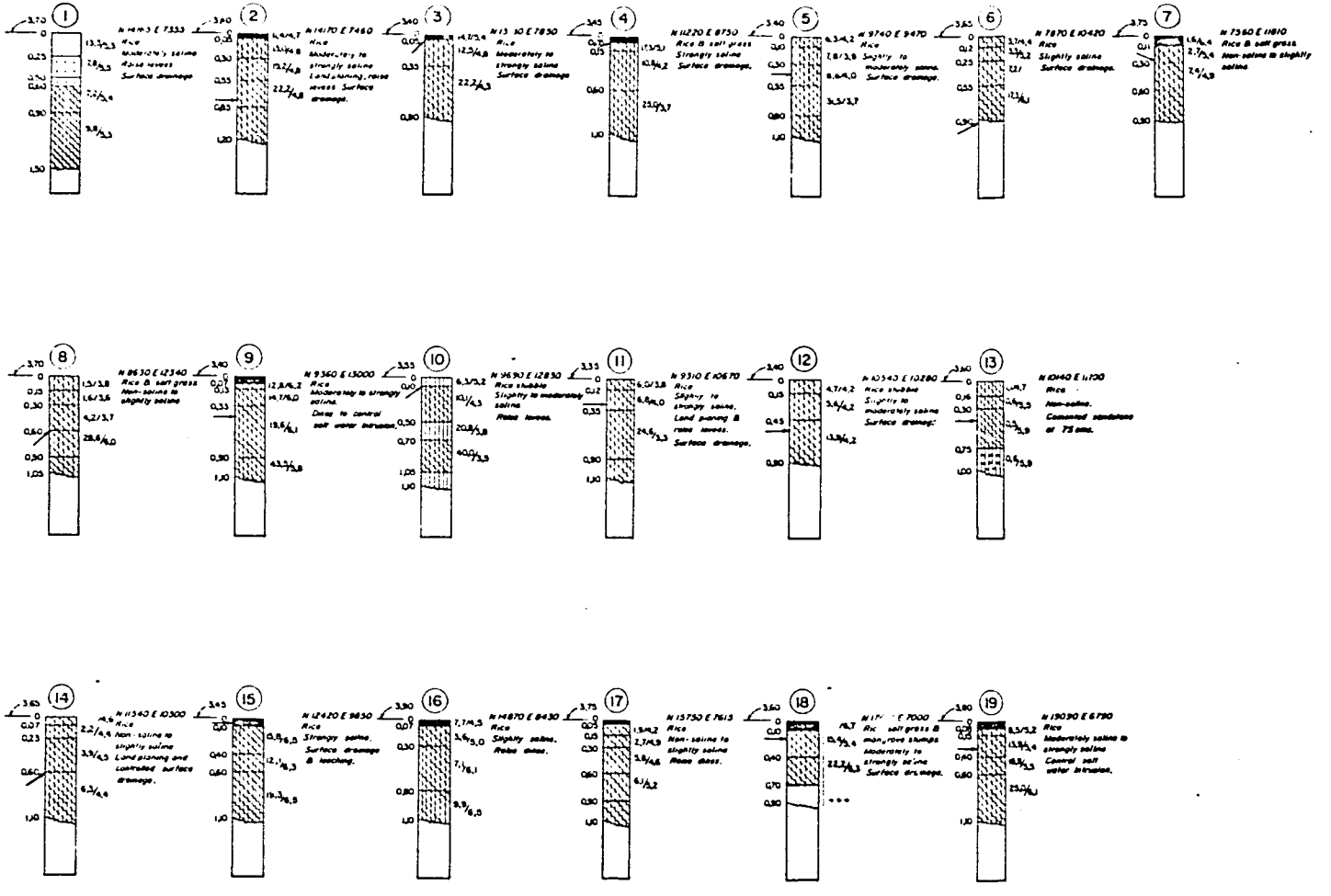
- Piste / Unpaved road
- Village
- Cours d'eau / Streams
- Limites des rizières / Limits of rice paddies
- Dunes
- Digues / Dikes
- Limite de la région du projet / Limits of Project Area
- 6 Point de prélèvement d'échantillons de sol / Soil sampling site
- Terres catégorie I / Group I lands (640 ha.) — Terres les plus élevées et les mieux adapt à la riziculture dans les conditions actuel. Higher lands, best adapted to rice production under present conditions.
- Terres catégories II / Group II lands (125 ha.) — Rizières actuellement cultivées. De bonnes récoltes y sont obtenues une fois tous le trois ans en moyenne à cause d'intrusio des marées extrêmes. Ricelands presently cultivated. Good crop produced once in three years on the average as a result of extreme high tides
- Terres catégories III / Group III lands (265 ha.) — Terres basses débroussaillées non cultivée à cause d'intrusions salines fréquentes. Low areas clear of trees. Not cultivated because of frequent salt water intrusions
- Terres catégories IV / Group IV lands (495 ha.) — Terres basses à mangrove, sujettes à de fréquentes intrusions salines. Low areas with mangrove cover. Subject to frequent salt water intrusions.
- A Point de mesure du coefficient de perméabilité / Permeability test site

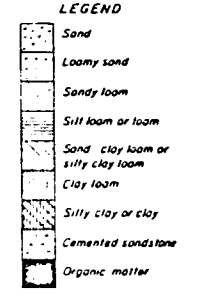
NOTE :
Les details topographiques, courbes de niveau et limites des rizières sont basés sur les cartes topographiques COTHA préparées en 1954.

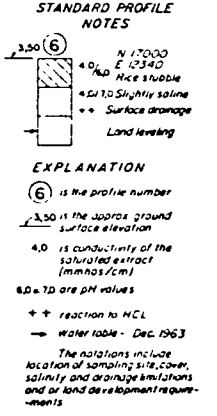
NOTE :
Topographic details, contours and limits of rice fields are based on 1954 COTHA topographic maps.

Echelle / Scale 0 — 500 Mètres / Meters

CARTE DES CULTIVATIONS
LAND USE MAP







COUPES VERTICALES DES TERRAINS
SOIL PROFILES

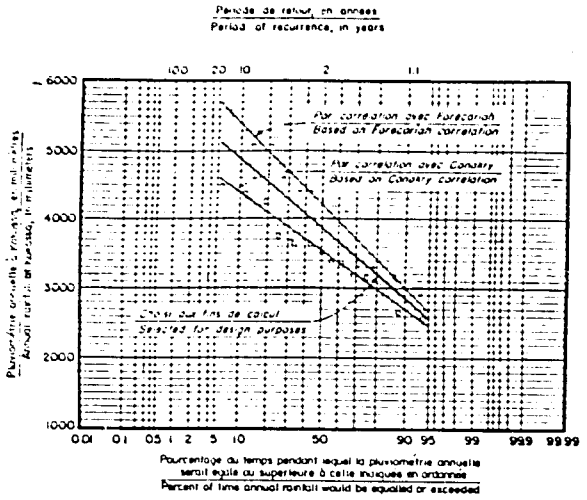
Exhibit 4

CHEMICAL & PHYSICAL ANALYSES OF SOIL SAMPLES

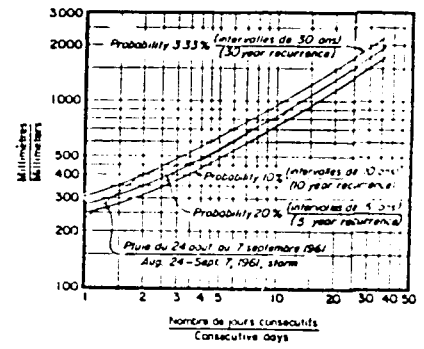
KAKOSSA - 1963

LOCATION	HOLE NO.	DEPTH	SOIL DETERMINATIONS: WATER AT SATURATION	pH SATURATED PASTE	pH SATURATED EXTRACT	CATION EXCHANGE CAPACITY (NaOAc)	EXTRACTABLE CATIONS me/100 grams: K	Ca	Mg	Na	H	TOTAL	ORGANIC MATTER	AVAILABLE P	P_2O_5	MECHANICAL ANALYSIS: SAND	SILT	CLAY	SOIL TEXTURE	FREE IRON	EXTRACTABLE ALUMINUM
		cms	%			me/100 g							%	kg/ha	kg/ha	%	%	%		%	me/100 g
B9740-E9420	5	0-10	79	4.2	5.8	20.0	0.7	1.3	6.2	5.0	18.1	31.3	2.8	6	14	2.7	27.9	69.4	C	5.0	5.6
		10-30	87	3.9	5.6	18.0	0.8	1.3	6.7	6.7	17.0	32.1	1.1	6	14	4.0	23.8	72.2	C	6.1	2.0
		30-55	158	4.0	6.5	18.2	1.0	1.7	7.9	10.8	15.7	37.0	1.1	6	14	3.2	20.4	76.4	C	5.9	8.7
		55-90	88	3.7	5.9	21.0	1.2	3.2	9.4	2.2	13.3	29.4	1.1	26	61	1.0	17.4	81.6	C		4.4
B8310-E10670	11	0-12	145	3.8	4.7	21.0	0.8	1.0	6.2	6.3	20.6	34.9	7.9	6	14	1.4	18.6	80.0	C	2.6	18.7
		12-35	146	4.0	6.2	21.0	1.0	1.0	7.1	7.3	17.4	33.7	2.6	13	28	2.1	27.1	70.8	C	1.0	4.4
		35-90	192	3.3	4.3	19.3	1.0	3.4	8.3	23.0	21.5	57.3	2.8	25	57	6.0	30.7	63.3	C	3.1	6.3
B10140-E11100	13	0-16	118	4.7	5.7	20.3	0.2	2.8	3.3	0.8	16.6	23.7	2.2	6	14	4.7	12.5	82.8	C	2.3	16.9
		16-30	101	5.5	6.5	20.0	0.4	3.8	7.1	0.4	8.6	20.4	0.5	6	14	2.0	15.3	82.7	C	3.8	0.2
		30-75	101	5.9	6.4	21.0	0.4	3.8	7.3	0.7	7.8	20.0	0.2	6	14	3.4	16.0	50.6	C	2.7	0.2
		75-100	41	5.8	6.5	10.4	0.2	2.1	4.2	0.5	6.2	13.2	0.1	15	34	64.7	13.3	22.0	SCL	6.0	0.1
B11540-E10500	14	0-7		4.6	7.0		0.4	3.3	6.2	3.8	18.6	32.3	2.6	6	14					6.0	
B12420-E9850	15	10-40	189	6.5	7.0	20.0	2.1	1.4	7.3	11.5	4.6	26.9	0.8	13	30	3.5	18.0	78.5	C	2.4	0.1
		40-60	187	6.3	6.7	19.2	2.0	1.1	7.3	8.7	5.6	25.7	0.9	7	16	1.0	19.1	79.9	C	2.4	0.1
		60-110	183	6.5	6.2	20.6	2.4	4.5	8.3	30.4	6.0	51.7	1.6	21	50	2.1	20.0	77.9	C	1.6	0.1
B14870-E8430	16	0-7	91	4.5	5.5	31.3	0.5	1.4	5.2	4.7	28.8	40.1	14.4	31	72	4.5	40.8	54.7	SiC-C	1.2	10.7
		7-30	107	5.0	7.0	16.6	0.8	1.5	7.1	4.4	18.4	24.2	0.2	6	14	1.2	19.4	79.4	C	1.6	2.1
		30-80	107	6.1	6.7	20.0	1.2	2.1	10.0	4.5	5.8	23.5	0.3	6	14	2.9	18.0	79.1	C	4.8	0.1
		80-110	97	6.5	6.8	20.4	1.3	2.5	9.4	4.8	4.8	22.1	0.2	10	24	1.3	15.9	82.8	C	4.0	0.1
B17610-E7000	18	0-10		6.7	4.4		1.4	2.8	7.3	8.0	5.6	26.0	3.3	6	14					3.1	

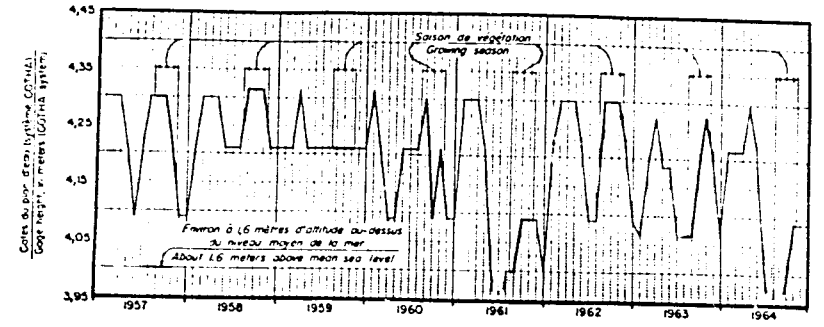
LOCATION	HOLE NO.	DEPTH	SATURATION EXTRACT DETERMINATIONS: ELECTRICAL CONDUCTIVITY	CATIONS me/liter: Ca	Mg	Na	K	TOTAL	ANIONS me/liter: CO_3	HCO_3	SO_4	CL	TOTAL	SODIUM ADSORPTION RATIO	TOTAL S
		cms	mmhos/cm											(SAR)	%
B9740-E9420	5	0-10	6.3	1.3	14.1	45.0	1.0	61.4	NIL	1.0	1.6	59.0	61.6	16	0.11
		10-30	7.8	1.5	16.8	56.7	1.2	76.2	NIL	1.5	1.6	64.5	67.6	19	0.50
		30-55	8.6	1.4	20.9	55.5	2.0	79.8	NIL	2.5	23.4	65.0	90.9	17	
		55-90	31.5	18.8	80.8	335.9[1]	6.0	451.5[1]	NIL	2.5	88.5	360.5	451.5		
B8310-E10670	11	0-12	6.0	0.9	11.5	39.9	1.2	53.5	NIL	2.5	16.7	52.5	71.7	11	0.12
		12-35	6.8	1.3	14.1	45.9	2.3	63.6	NIL	0.0	24.5	47.5	72.0	16	0.06
		35-90	24.6	13.5	77.0	157.4	4.3	252.2	NIL	2.5	75.0	177.8	255.3	23	
B10140-E11100	13	0-16	1.1	0.1	2.0	11.8	0.8	14.7	NIL	2.5	2.8	7.5	12.8	12	
		16-30	0.6	0.0	1.0	5.4	0.1	6.5	NIL	1.0	1.6	1.9	4.5		
		30-75	0.5	0.0	1.0	5.0	0.1	6.1	NIL	1.5	3.5[1]	1.0	6.0[1]		
		75-100	0.6	0.0	1.2	3.0	0.1	4.3	NIL	0.0	0.3	3.0	3.3		
B11540-E10500	14	0-7													
B12420-E9850	15	10-40	15.8	3.1	31.6	104.0	5.4	144.1	NIL	0.0	25.0	137.5	162.5	25	0.02
		40-60	12.1	2.0	22.3	77.0	3.7	105.0	NIL	2.5	8.3	102.5	113.3	22	1.21
		60-110	19.3	4.3	33.7	115.7	6.7	166.4	NIL	0.0	31.3	177.5	208.8	25	
B14870-E8430	16	0-7	7.7	2.1	20.9	45.9	0.9	70.8	NIL	0.5	21.9	55.7	78.1	14	
		7-30	3.6	0.5	5.9	23.9	0.5	30.8	NIL	1.0	7.1	22.5	30.6	13	0.16
		30-80	7.1	1.3	16.8	52.1	0.8	71.0	NIL	0.0	14.6	55.0	69.6	17	
		80-110	9.9	2.4	25.0	81.7	1.1	90.2	NIL	0.0	20.3	81.5	101.8	17	
B17610-E7000	18	0-10													



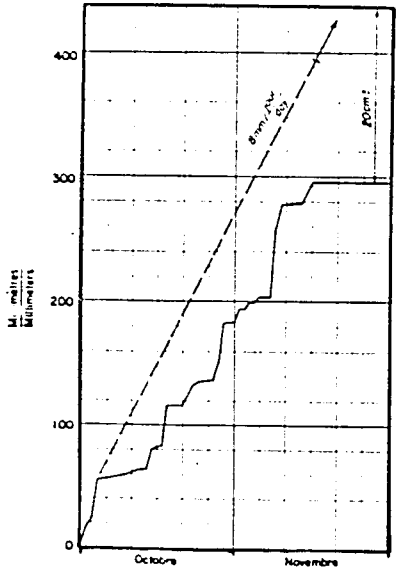
PROBABILITE ESTIMEE DE LA PLUVIOMETRIE ANNUELLE A KAKOSSA
ESTIMATED PROBABILITY OF ANNUAL PRECIPITATION AT KAKOSSA



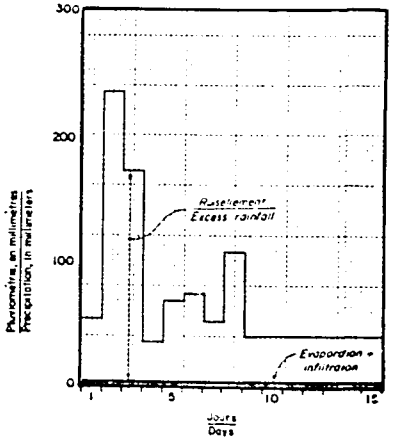
PLUVIOMETRIE CUMULEE A KAKOSSA PENDANT LE NOMBRE DE JOURS CONSECUTIFS INDIQUÉ EN ABSCISSES
CUMULATIVE RAINFALL AT KAKOSSA FOR CONSECUTIVE DAYS



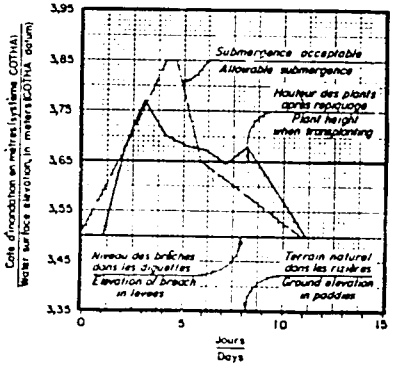
NIVEAUX DES MAREES LES PLUS HAUTES DE CHAQUE MOIS A KAKOSSA DE 1957 A 1964.
HIGHEST MONTHLY TIDE LEVELS AT KAKOSSA 1957-1964



PLUVIOMETRIE CUMULEE DU 1er OCTOBRE AU 30 NOVEMBRE 1956 A KAKOSSA
CUMULATIVE RAINFALL AT KAKOSSA FROM OCTOBER 1st TO NOVEMBER 30 1956

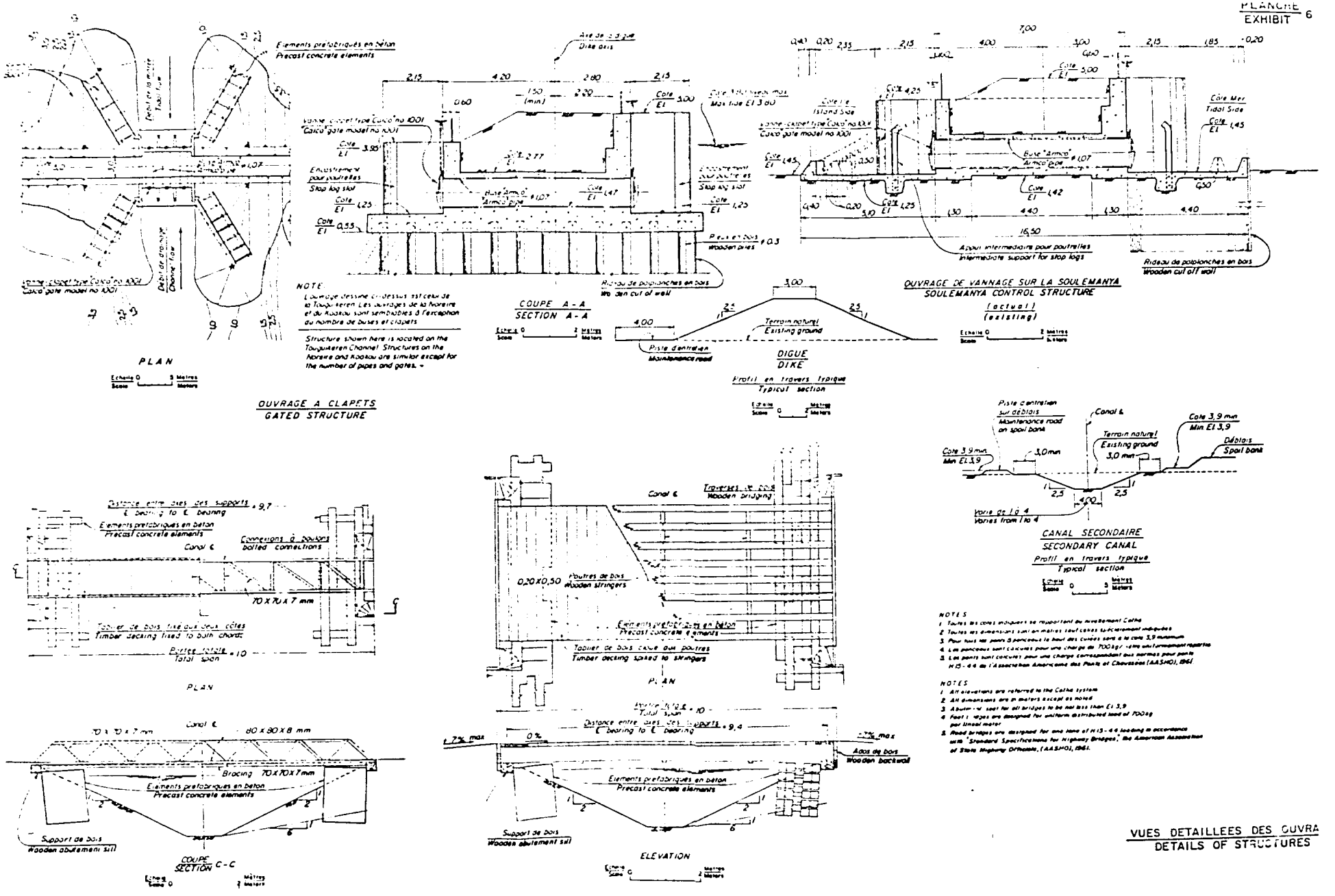


AVERSE-TYPE DE 15 JOURS
15-DAY DESIGN STORM



NIVEAU D'EAU DANS LES RIZIERES PENDANT L'AVERSE-TYPE DE 15 JOURS
WATER SURFACE IN PADDIES DURING DESIGN 15-DAY STORM

RESULTATS DES ETUDES HYDRAULIQUES
RESULTS OF HYDRAULIC ANALYSES



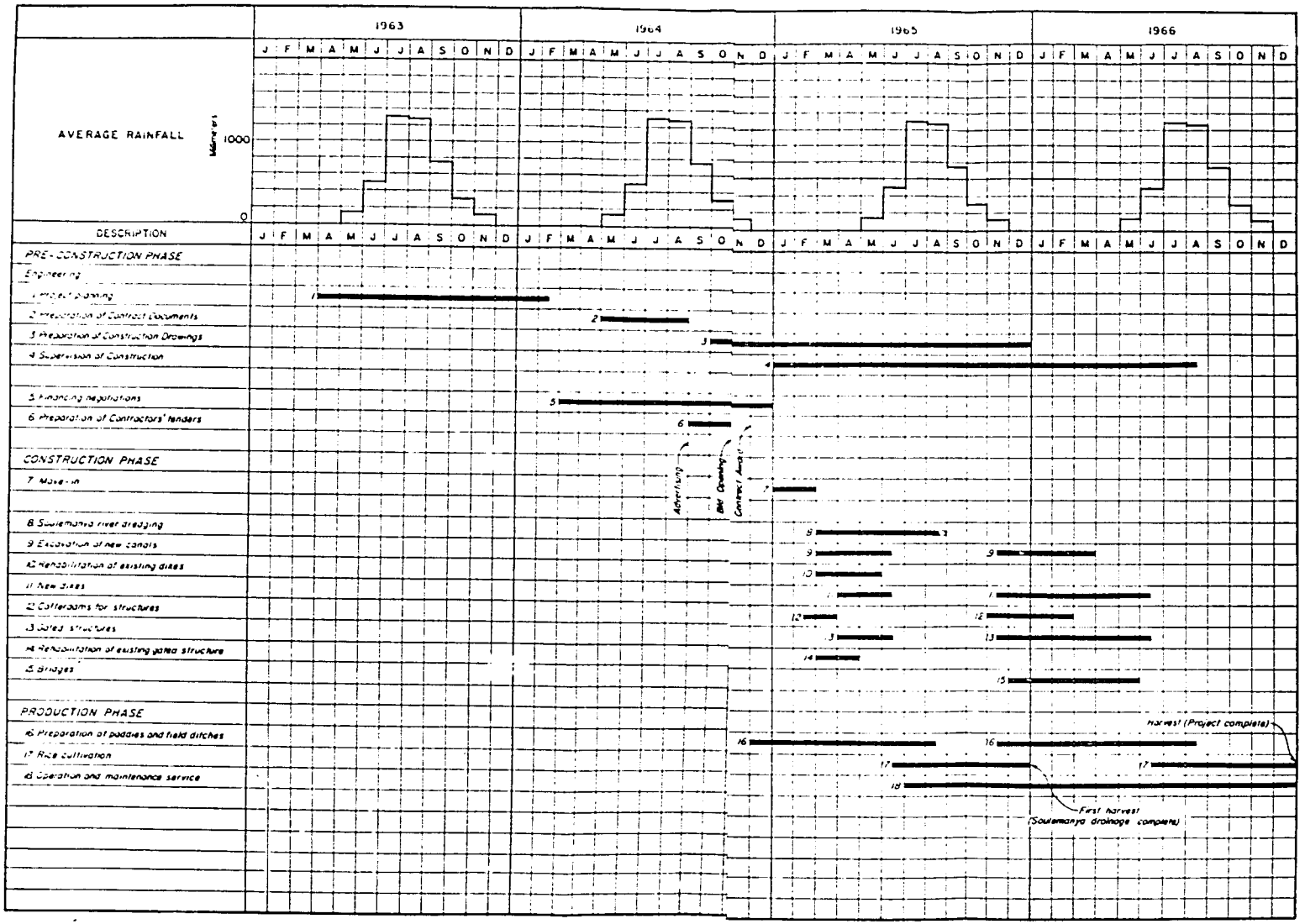
NOTES

1. Toutes les cotes indiquées se rapportent au nivellement Cathe
2. Toutes les dimensions sont en mètres sauf cotes spécialement indiquées
3. Pour tous les ponts 3 ponceaux le bout des cordes sont à la cote 3,9 minimum
4. Les ponceaux sont calculés pour une charge de 700 kg/ cette uniformément répartie
5. Les ponts sont calculés pour une charge correspondant aux normes pour ponts H 15 - 44 de l'Association Américaine des Ponts et Chaussées (AASHO), 1961

NOTES

1. All elevations are referred to the Cathe system
2. All dimensions are in meters except as noted
3. Abutment seat for all bridges to be not less than El 3,9
4. Foot bridges are designed for uniform distributed load of 700 kg per linear meter
5. Road bridges are designed for one lane of H 15 - 44 loading in accordance with "Standard Specifications for Highway Bridges," the American Association of State Highway Officials, (AASHO), 1961.

VUES DETAILLEES DES OUVRA
DETAILS OF STRUCTURES



CONSTRUCTION SCHEDULE

ESTIMATE HARZA ENGINEERING COMPANY INTERNATIONAL

Exhibit 8

Project Number 309

Project KAKOSSA Date 1.14.64 Page 1 of 3

Structure Project Construction Cost Estimated by JAT/MB Checked by JJN

Item No.	ITEM	Quantity	Unit Price GF (Local)	Unit Price U.S. Dollars	Amount GF (Local)	Amount U.S. Dollc
1	Clearing					
	Streambeds	18 ha	315,000	40.00	5,670,000	72
	Roadways & New Cnls.	17 ha	250,000	30.00	4,250,000	51
2	River Dredging					
	Soulemanya	100,000 m^3	187	0.80	18,700,000	80,00
3	Canal Excavation					
	New drainage canals	85,000 m^3	110	1.00	9,350,000	85,00
4	Earth Fill					
	New dikes	72,000 m^3	325	2.80	23,300,000	201,60
	Exist. dikes rehabil.	6,200	250	2.00	1,550,000	12,40
5	Bridges					
	Oper. & Maintenance	7 ea.	1,650,000	1300	11,550,000	9,10
	Foot bridges	5 ea.	220,000	220	1,100,000	1,10
6	Control Structures					
	Koakou Structure		Lump Sum 1/		14,081,000	16,500
	Noreire Structure		Lump Sum 1/		34,943,000	56,000
	Touguikeren Structure		Lump Sum 1/		20,803,000	34,500
	Soulemanya (Rehab.)		Lump Sum 1/		1,000,000	6,000
	Subtotal, Direct Cost				146,297,000	503,430
	Contingencies (15% ±)				21,703,000	36,570
	Total, Direct Cost				168,000,000	540,000
	Engineering & Supery. of Construction (15% ±)				7,000,000	150,000
	Construction Cost of Civil Works				175,000,000	690,000
	Cost of Land Preparation				25,000,000	10,000
	Total Project Construction Cost				200,000,000	700,000

1/ See pages 2 and 3 for detailed estimates.

ESTIMATE HARZA ENGINEERING COMPANY INTERNATIONAL

Exhibit 8

Project Number 309

Project KAKOSSA Date 1.14.64 Page 2 of 3 Pages

Structure Project Construction Cost Estimated by JAT/MB Checked by JJM

Item No.	ITEM	Quantity	Unit Price GF (Local)	Unit Price U.S. Dollars	Amount GF (Local)	Amount U.S. Dollars
6	Control Structures					
	Koakou Control Structure					
	Diversion, Cofferdam	2,400 m^3	200	2.00	480,000	4,800
	Excavation, Structural	400 m^3	165	1.80	66,000	720
	Pile Foundation, Timber	930 m^3	3,300	2.70	3,069,000	2,511
	Cut Off Wall, Timber	8 m^3	7,590	8.00	60,720	64
	Concrete Structural	150 m^3	17,600	-	2,640,000	-
	Formwork	220 m^2	2,530	3.20	556,600	704
	Concrete Precast (Cribs)	60 m^3	35,200	-	2,112,000	-
	Steel Reinforcement	17,000 kg	198	-	3,366,000	-
	Flap Gates, 42" Dia.	4 each	17,600	640.00	70,400	2,560
	Pipe, Steel, Corr. 42" Dia.	14 m	10,800	130.00	151,200	1,820
	Earth Fill, Cribs	240 m^3	693	4.60	166,320	1,104
	Backfill, Structural	500 m^3	125	1.35	62,500	675
	Miscellaneous				128,260	1,542
	Subtotal Koakou Control Structure				14,081,000	16,500
	Noreire Control Struc.					
	Diversion, Cofferdam	10,000 m^3	200	2.00	2,000,000	20,000
	Excavation, Structural	400 m^3	165	1.80	66,000	720
	Pile Fdn., Timber	3,100 m^3	3,300	2.70	10,230,000	8,370
	Cut Off Wall, Timber	11 m^3	7,590	8.00	83,490	88
	Concrete, Structural	411 m^3	17,600	-	7,233,600	-
	Formwork	650 m^2	2,530	3.20	1,644,500	2,080
	Conc. Precast (Cribs)	91 m^3	35,200	-	3,203,200	-
	Steel Reinforcement	31,000 kg	198	-	6,138,000	-
	Flap Gates, 42" Dia.	16 each	17,600	640.00	281,600	10,240
	Pipe Steel, Corr. 42" Dia.	56 m	10,800	130.00	604,800	7,280
	Earth Fill, Cribs	280 m^3	693	4.60	194,040	1,288
	Backfill, Structural	700 m^3	125	1.35	87,500	945
	Miscellaneous				3,176,270	4,989
	Subtotal Noreire Control Structure				34,943,000	56,000

Exhibit 8

ESTIMATE

HARZA ENGINEERING COMPANY INTERNATIONAL

Project Number 309

Project KAKOSSA Date 1.14.64 Page 3 of 3 Pages

Subject Project Construction Cost Estimated by JAT/MB Checked by JJM

Item No.	ITEM	Quantity	Unit Price GF (Local)	Unit Price U.S. Dollars	Amount GF (Local)	Amount U.S. Dollars
6	Control Structures (cont.)					
	Touguikeren Control Structure					
	Diversion, Cofferdam	8,000 m^3	200	2.00	1,600,000	16,000
	Excavation, Structural	150 m^3	165	1.80	24,750	270
	Pile Fdn., Timber	2,000 m^3	3,300	2.70	6,600,000	5,400
	Cut Off Wall, Timber	9 m^3	7,590	8.00	68,310	72
	Concrete, Structural	200 m^3	17,600	-	3,520,000	-
	Formwork	285 m^2	2,530	3.20	721,050	912
	Conc., Precast (Cribs)	58 m^3	35,300	-	2,041,600	-
	Steel Reinforcement	19,000 kg	198	-	3,762,000	-
	Flap Gates 42" Dia.	6 each	17,600	640.00	105,600	3,840
	Pipe Steel, Corr. 42" Dia.	21 m	10,800	130.00	226,800	2,730
	Earth Fill (Cribs)	240 m^3	693	4.60	166,320	1,104
	Backfill, Structural	600 m^3	125	1.35	75,000	810
	Miscellaneous				1,891,570	3,362
	Subtotal Touguikeren				20,803,000	34,500
	Soulemanya Control Structure					
	Misc. Repairs to Existing Metalwork				1,000,000	6,000
	Subtotal, Control Structures				70,827,000	113,000