FEDERAL REPUBLIC OF NIGERIA

FEDERAL DEPARTMENT OF AGRICULTURE

FEASIBILITY REPORT ON THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES

STUDY REPORT

MAY 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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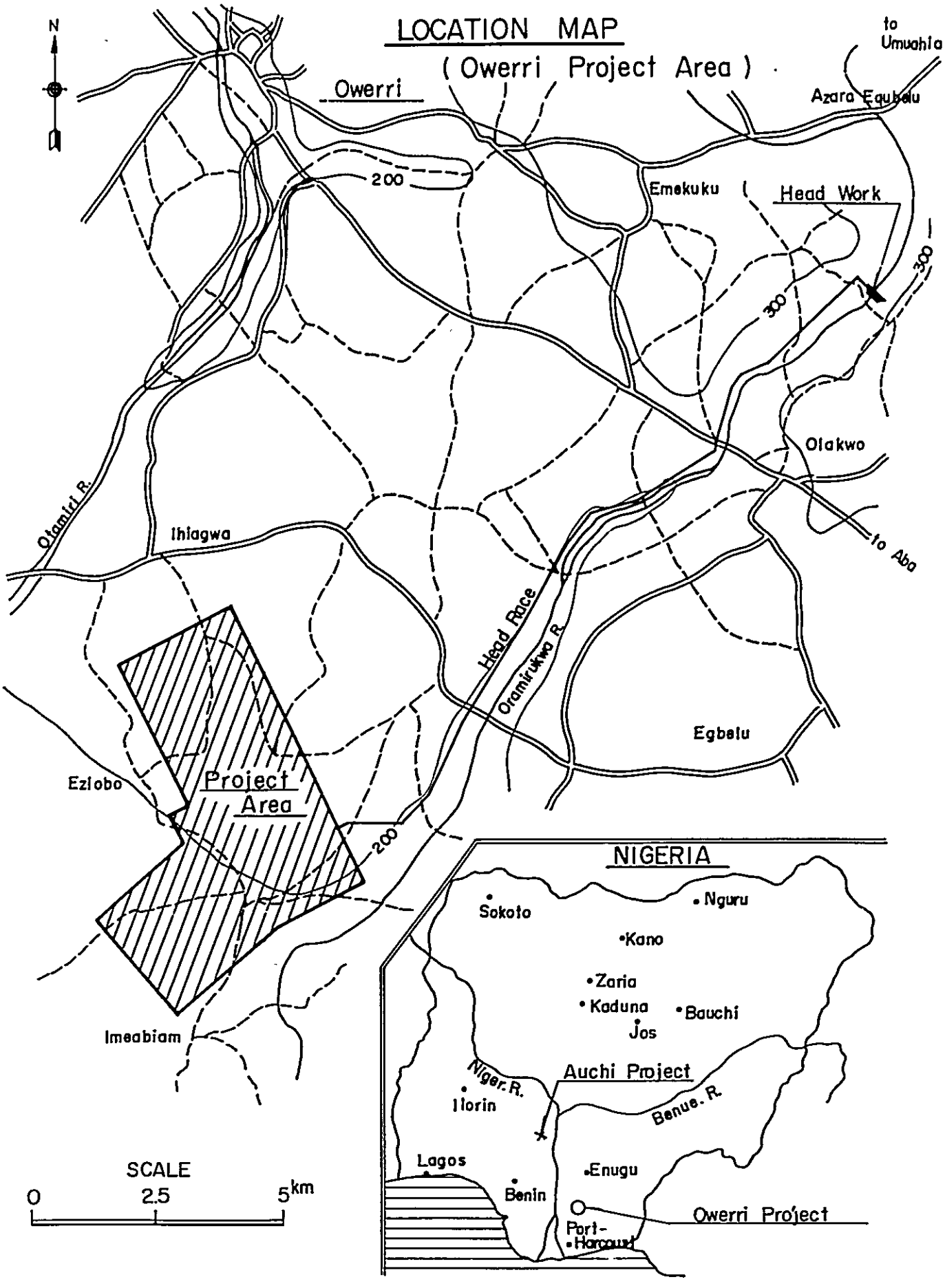
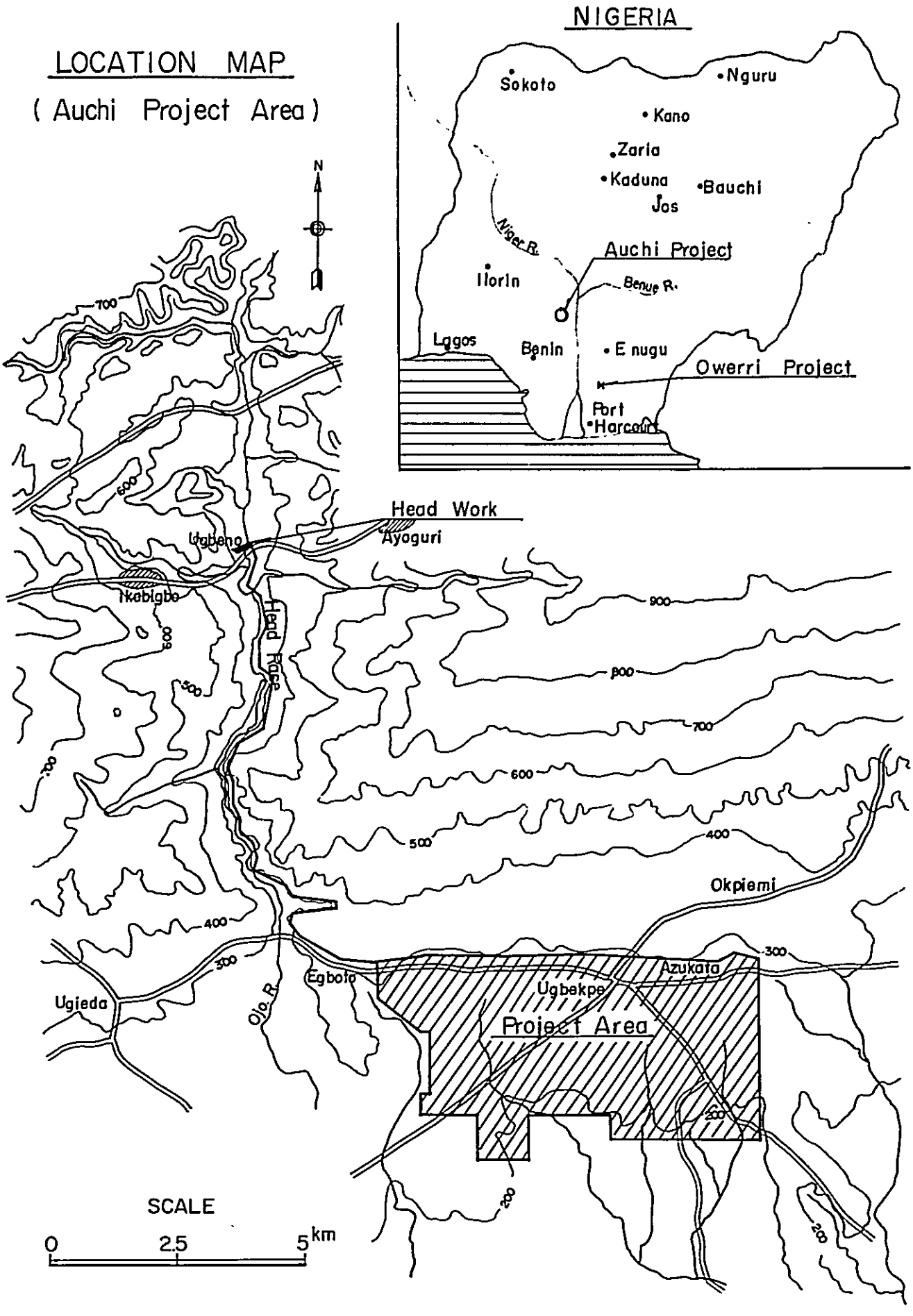

LOCATION MAP
(Owerri Project Area)
N
Owerri
to Umuahia
Azara Equbelu
200
Emekuku
Head Work
300
300
Olakwo
Otamiri R.
Ihiagwa
to Aba
Head Race
Oramiriukwa R.
Egbelu
Eziobo
Project Area
200
Imeabiam
NIGERIA
Sokoto
Nguru
Kano
Zaria
Kaduna
Bauchi
Jos
Auchi Project
Niger R.
Benue R.
Ilorin
Lagos
Enugu
Benin
Owerri Project
Port-Harcourt
SCALE
0
2.5
5km


LOCATION MAP
(Auchi Project Area)
NIGERIA
Sokoto
Nguru
Kano
Zaria
Kaduna
Bauchi
Jos
Niger R.
Auchi Project
Ilorin
Benue R.
Lagos
Benin
Enugu
Owerri Project
Port Harcourt
N
Head Work
Ayoguri
Ugbeno
Ikabigbo
Head Race
Okpiemi
Azukata
Egboto
Ugbekpe
Ugieda
Ola R.
Project Area
SCALE
0
2.5
5 km

C O N T E N T S

		Page
1.	METEOROLOGY	1
	1.1 General	1
	1.2 Meteorology in Owerri Area	1
	1.2.1 Rainfall	1
	1.2.2 Other Meteorological Factors	3
	1.3 Meteorology in Auchi Area	3
	1.3.1 Rainfall	3
	1.3.2. Other Meteorological Factors	5
2.	HYDROLOGY	17
	2.1 Hydrology of Oramirukwa River	17
	2.1.1 River and Basin	17
	2.1.2 Monthly Mean Discharge	17
	2.1.3 Flood Discharge	21
	2.2 Hydrology of Orle-Edion River	22
	2.2.1 River and Basin	22
	2.2.2 Monthly Mean Discharge	23
	2.2.3 Flood Discharge	24
3.	SOIL AND GEOLOGY	36
	3.1 Soil and Land Capability	36
	3.1.1 Introduction	36
	3.1.2 Procedure of Soil Survey	36
	3.1.3 Soil Classification and Main Features of Major Soils	37
	3.1.4 Land Capability	41
	3.2 Geology	43
	3.2.1 General	43
	3.2.2 Geology in Owerri Area	43
	3.2.3 Geology in Auchi Area	44
4.	PRESENT AGRICULTURAL SETTING	64
	4.1 Socio-Economic Background	64
	4.2 Land Use	65
	4.3 Cropping Pattern and Farming Practices	66
	4.4 Agricultural Production	70
	4.5 Farm Economy	71
	4.6 Marketing and Institutions	72
	4.6.1 Marketing and Processing	72
	4.6.2 Agricultural Institutions	73

5. AGRICULTURAL DEVELOPMENT PLAN 80
5.1 General 80
5.2 Proposed Land Use 80
5.3 Proposed Cropping Pattern 82
5.3.1 Selection of Crops 82
5.3.2 Proposed Cropping Pattern 82
5.4 Proposed Farming Practices and Operation 83
5.4.1 General 83
5.4.2 Proposed Farming Practices 84
5.5 Farm Inputs and Farm Machineries 88
5.5.1 Farm Inputs 89
5.5.2 Farm Machineries 90
5.6 Rice Mill and Storage Facilities 91
5.7 Anticipated Yield 91
5.8 Pilot Farm 93
5.8.1 General 93
5.8.2 Location and Scale of the Pilot Farm 93
5.8.3 Scope of Work 94

6. IRRIGATION PLAN 105
6.1 General 105
6.2 Irrigation Water Requirement 105
6.2.1 General 105
6.2.2 Potential Evapotranspiration 106
6.2.3 Consumptive Use of Water to Paddy 107
6.2.4 Puddling Water Requirement and Percolation 108
6.2.5 Effective Rainfall 108
6.2.6 Diversion Water Requirement 109
6.3 Headworks 109
6.3.1 Headworks for Owerri Project 109
6.3.2 Headworks for Auchi Project 110
6.4 Irrigation Canals and Related Structures 111
6.4.1 Layout of Irrigation Canals 111
6.4.2 Preliminary Design of Irrigation Canals 112
6.4.3 Preliminary Design of Related Structures 113
6.5 Drainage Canals and Related Structures 115
6.5.1 Layout of Drainage Canals 115
6.5.2 Preliminary Design of Drainage Canals 115
6.5.3 Preliminary Design of Related Structures 115
6.6 Farm Road 116
6.6.1 Road Layout 116
6.6.2 Typical Sections of Road 116
6.7 Layout of Paddy Field 117

7. ORGANIZATION AND MANAGEMENT 150
7.1 General 150
7.2 Project Coordination Committee 150
7.3 Project Executing Organization 151
7.3.1 Owerri Project Office 151
7.3.2 Auchi Project Office 153
7.4 Agricultural Cooperative 154

8. IMPLEMENTATION SCHEDULE AND CONSTRUCTION PLAN 168
8.1 Implementation Schedule 168
8.2 Construction Plan 169
8.2.1 General 169
8.2.2 Construction Plan for Owerri Project 169
8.2.3 Construction Plan for Auchi Project 171

9. COST ESTIMATE 178
9.1 General 178
9.2 Project Cost 178
9.2.1 Construction Cost of Civil Works 178
9.2.2 Construction Cost of Processing, Storage, Office Facilities 179
9.2.3 Initial Farm Investment 179
9.2.4 Total Project Cost and Annual Disbursement Schedule 179
9.3 Operation, Maintenance and Replacement Cost 179

10. MARKETING, PRICE PROSPECTS AND BUDGET ESTIMATION 205
10.1 Market and Price Prospects 205
10.1.1 Market Prospects of Rice 205
10.1.2 Price Prospects 207
10.2 Estimate of Irrigation Benefit 208
10.2.1 Estimate of Net Income per Crop 208
10.2.2 Estimate of Net Incremental Value 208

11. PROJECT EVALUATION 223
11.1 Economic Evaluation 223
11.1.1 General 223
11.1.2 Economic Project Costs and Benefits 223
11.1.3 IRR of the Project 224
11.2 Financial Evaluation 225
11.2.1 General 225
11.2.2 Farm Budget Analysis 225
11.2.3 Repayability of the Project 226
11.3 Socio-Economic Impact of the Project 228

LIST OF TABLE

No.	Title	Page
Table 1.1	Monthly Mean Rainfall and Numbers of Rainy Days, Owerri Project	6
1.2	Monthly Mean Rainfall and Numbers of Rainy Days, Auchi Project	6
1.3	Data of Other Meteorological Factors, Owerri Project	7
1.4	Data of Other Meteorological Factors, Auchi Project	8
2.1	Monthly Mean Discharge at Azara Egbelu Station	25
2.2	Converted Monthly Mean Discharge of Intake Site	25
2.3	Observed Maximum Flood and Probability of Flood in Nigeria	25
2.4	Observed Maximum Flood and Probability of Flood in Ghana	26
3.1	Results of Soil Analysis (Owerri Area)	45
3.2	Results of Soil Analysis (Auchi Area)	46
3.3	Descriptions on Typical Profile of Loamy Soil Type (1)	47
3.4	Descriptions on Typical Profile of Loamy Soil Type (2)	48
3.5	Descriptions on Typical Profile of Clay Loam Soil Type	49
3.6	Descriptions on Typical Profile of Sandy Loam Soil Type (1)	50
3.7	Descriptions on Typical Profile of Sandy Loam Soil Type (2)	51
3.8	Descriptions on Typical Profile of Sandy Loam Soil Type (3)	52
3.9	Descriptions on Typical Profile of Loamy Soil Type (1)	53
3.10	Descriptions on Typical Profile of Loamy Soil Type (2)	54
3.11	Descriptions on Typical Profile of Lateritic Soil with Plinthite	55
3.12	Descriptions on Typical Profile of Alluvial Soil	56

No.	Title	Page
Table 3.13	Description on Typical Profile of Regosol	57
4.1	Present Agricultural Production (Owerri Project Area)	74
4.2	Present Agricultural Production (Auchi Project Area)	74
4.3	Present Typical Farm Budget (Owerri Project Area)	75
4.4	Present Typical Farm Budget (Auchi Project Area)	76
5.1	Proposed Land Use	81
5.2	Proposed Farm Inputs per Ha	89
5.3	Labour Requirement for the Cultivation of 1.2 ha (Small Holder Area)	95
5.4	Required Farm Machinery	96
5.5	Main Features of Rice Mill and Storage Facilities	97
5.6	Results of Variety Trial in Anambra State	98
5.7	Rice Production Programe in the Owerri Project Area	99
5.8	Rice Production Programe in the Auchi Project Area	100
6.1	Climatic Data at Umudike Station (1976)	118
6.2	Climatic Data at Umudike Station (1972 - 1976)	119
6.3	Climatic Data at Auchi Station	120
6.4	Calculation Sheet for Radiation Method in Owerri Project	121
6.5	Calculation Sheet for Radiation Method in Auchi Project	122
6.6	Monthly Effective Rainfall for Paddy in Owerri Project	123
6.7	Monthly Effective Rainfall for Paddy in Auchi Project	124
6.8	Irrigation Water Requirement of the Owerri Project	125
6.9	Irrigation Water Requirement of the Auchi Project	129

No.	Title	Page
Table 6.10	Diversion Water Requirement for the Owerri Project	133
6.11	Diversion Water Requirement for the Auchi Project	134
6.12	Design Criteria of Irrigation Canals	135
7.1	Function of the Departments for the Owerri Project Office and the Auchi Project Office	156
7.2	Required Number of Staffs of the Owerri Project Office	158
7.3	Required Number of Staffs of the Auchi Project Office	161
8.1	Workable Days for Construction Works	173
8.2	List of Construction Machinery and Equipment	174
8.3	Features of Major Project Works	175
9.1	Construction Cost of Civil Works for Owerri Project	180
9.2	Construction Cost of Civil Works for Auchi Project	181
9.3	Detailed Breakdown of Construction Cost for Owerri Project	182
9.4	Detailed Breakdown of Construction Cost for Auchi Project	187
9.5	Procurement Cost of Construction Machinery and Equipment	194
9.6	Construction Cost of Processing, Storage and Office Facilities, Owerri	195
9.7	Construction Cost of Processing, Storage and Office Facilities, Auchi	196
9.8	Cost of Rice Mill and Storage Facilities for Owerri Project	197
9.9	Cost of Rice Mill and Storage Facilities for Auchi Project	198
9.10	Initial Farm Investment	199
9.11	Farm Machinery and Equipment of the Owerri Project Area	200
9.12	Farm Machinery and Equipment of the Auchi Project Area	201

No.	Title	Page
Table 9.13	Project Cost for Owerri Project	202
9.14	Project Cost for Auchi Project	202
9.15	Annual Disbursement Schedule of Project Cost, Owerri Project	203
9.16	Annual Disbursement Schedule of Project Cost, Auchi Project	203
9.17	Annual Operation and Maintenance Cost	204
10.1	Demand Forecast of Rice	206
10.2	Economic and Financial Farm Gate Price of Flood Crops	209
10.3	Economic and Financial Price of Farm Inputs	210
10.4	Local Market Price of Rice, Bendel State	211
10.5	Local Market Price of Rice, Imo State	211
10.6	Recent Local Price of Rice (Mill Gate Price)	212
10.7	Prices of Other Food Crops	213
10.8	Economic Price of Paddy (Import Substitution)	214
10.9	Economic Price of Maize (Import Substitution)	215
10.10	Net Income per Ha for the Owerri Project	216
10.11	Net Income per Ha for the Auchi Project	217
10.12	Net Income per Crop per Ha (without-Project)	218
10.13	Net Income of Paddy Production per Ha, Direct Sowing (with-Project)	219
10.14	Net Income of Paddy Production per Ha, Transplanting (with-Project)	220
10.15	Estimate of Irrigation Benefit (Owerri Project)	221
10.16	Estimate of Irrigation Benefit (Auchi Project)	222

No.	Title	Page
Table 11.1	Economic Construction Cost of the Owerri Project	230
11.2	Annual Disbursement of Economic Construction Cost, Owerri Project	231
11.3	Economic Construction Cost of the Auchi Project	230
11.4	Annual Disbursement of Economic Construction Cost, Auchi Project	232
11.5	Sensitivity Analysis of the Owerri Project	233
11.6	Sensitivity Analysis of the Auchi Project	233
11.7	Typical Farm Budget in the Owerri Project Area (Future with-Project)	234
11.8	Typical Farm Budget in the Auchi Project Area (Future with-Project)	235
11.9	Project Revenue and Cost, Owerri Project	236
11.10	Project Revenue and Cost, Auchi Project	237
11.11	Cash Flow Statement of the Owerri Project	238
11.12	Cash Flow Statement of the Auchi Project	239

LIST OF FIGURES

No.	Title	Page
Fig. 1.1	Nigeria: Climate Zoning	9
1.2	Monthly Mean Rainfall and Numbers of Rainy Days, Owerri Area	9
1.3	Probaility Distribution of the Annual Total Rainfall, Owerri Area	10
1.4	Design Monthly Rainfall, Owerri Area	11
1.5	Probability Distribution of the Daily Rainfall, Owerri Area	12
1.6	Monthly Mean Rainfall and Numbers of Rainy Days, Auchi Area	13
1.7	Probability Distribution of the Annual Total Rainfall, Auchi Area	14
1.8	Design Monthly Rainfall, Auchi Area	15
1.9	Probability Distribution of the Daily Rainfall, Auchi Area	16
2.1	Oramirukwa River Basin	27
2.2	Rating Curve at Azara Egbelu Station, Oramirukwa River	28
2.3	Relation between Discharge and Cumulative Rainfall, Oramirukwa River	29
2.4	Distribution of Rainfall and Discharge	30
2.5	Regional Relation of Peak Flood, Observed Max. Flood	31
2.6	Regional Relation of Peak Flood, 5 Year's Flood	32
2.7	Regional Relation of Peak Flood, 50 Year's Flood	33
2.8	Regional Relation of Peak Flood, 100 Year's Flood	34
2.9	Orle-Edion River Basin	29
3.1	Soil Map of the Owerri Project Area	58
3.2	Soil Map of the Auchi Project Area	59
3.3	Land Capability Map of the Owerri Project Area	60
3.4	Land Capability Map of the Auchi Project Area	61

No.	Title	Page
Fig. 3.5	Geological Profile of the Intake Site for Owerri	62
3.6	Geological Profile of the Intake Site for Auchi	63
4.1	Land Use Map of the Owerri Project Area	77
4.2	Land Use Map of the Auchi Project Area	78
4.3	Typical Cropping Calendar of the Major Crops (Owerri Project Area)	79
4.4	Typical Cropping Calendar of the Major Crops (Auchi Project Area)	79
5.1	Proposed Cropping Pattern (Owerri Project Area)	101
5.2	Proposed Cropping Pattern (Auchi Project Area)	101
5.3	Proposed Farming Practices (Estate Farm)	102
5.4	Proposed Farming Practices (Small Holder)	103
6.1	Comparison of Potential Evapotranspiration at Umudike Station (1976)	136
6.2	Crop Consumptive Unit Graph (ku) (Transplanting)	137
6.3	Crop Consumptive Unit Graph (ku) (Direct Sowing)	138
6.4	Crop Coefficient for Paddy (Transplanting)	139
6.5	Crop Coefficient for Paddy (Direct Sowing)	140
6.6	Classification of Canal Types	141
6.7	Typical Section of Irrigation Canals	142
6.8	Irrigation System Diagram for Owerri Project	143
6.9	Irrigation System Diagram for Auchi Project	144
6.10	Drainage System Diagram for Owerri Project	145
6.11	Drainage System Diagram for Auchi Project	146
6.12	Typical Section of Drains	147

No.	Title	Page
Fig. 6.13	Typical Section of Roads	148
6.14	Typical Layout of Farm Unit	149
7.1	Proposed Organization for Owerri Project	164
7.2	Proposed Organization for Auchi Project	165
7.3	Organization of Agricultural Cooperative for the Owerri Project	166
7.4	Organization of Agricultural Cooperative for the Auchi Project	167
8.1	Implementation Schedule for Owerri Project	176
8.2	Implementation Schedule for Auchi Project	177
11.1	Estimate of IRR, Owerri Project	240
11.2	Estimate of IRR, Auchi Project	241

LIST OF DRAWINGS

No.	Title	Page
01	GENERAL LAYOUT, OWERRI PROJECT	242
02	GENERAL LAYOUT, AUCHI PROJECT	243
03	HEAD WORKS, OWERRI PROJECT	244
04	HEAD WORKS, AUCHI PROJECT	245
05	HEAD RACE (1), OWERRI PROJECT	246
06	HEAD RACE (2), OWERRI PROJECT	247
07	HEAD RACE (3), OWERRI PROJECT	248
08	HEAD RACE (1), AUCHI PROJECT	249
09	HEAD RACE (2), AUCHI PROJECT	250
10	PILOT SCHEME, OWERRI PROJECT	251
11	PILOT SCHEME, AUCHI PROJECT	252

ABBREVIATION

km	kilometer	m	meter
cm	centimeter	mm	millimeter
t	ton	kg	kilogramme
g	gramme	km^2	square kilometer
m^2	square meter	ha	hectare
m^3	cubic meter	kl	kiloliter
ℓ	liter	m^3/sec	cubic meter per second
ℓ/sec	liter per second	ℓ/sec/ha	liter per second per hactare
t/ha	ton per hectare	ℓ/ha	liter per hectare
kg/ha	kilogramme per hectare	hr(s)	hour(s)
t/hr	ton per hour	mm/day	milli per day
^oC	degree centigrade	%	percent
El	Elevation above mean sea level	lb	pound
PS	Horse power	ft.	foot
L.S.	Lump Sum	No(s)	number(s)
US$	U.S. dollar	Fig.	Figure
		IRR	Internal Rate of Return

O&M	Operation and Maintenance
GDP	Gross Domestic Product
GNP	Gross National Product
L.G.A	Local Government Area
FDA	Federal Department of Agriculture
MANR	Ministry of Agriculture and Natural Resources
ADC	Agricultural Development Corporation
NAB	Nigerian Agricultural Bank
JICA	Japan International Cooperation Agency

FAO	Food and Agriculture Organization of the United Nations
IBRD	International Bank for Reconstruction and Development
IITA	Internal Institute of Tropical Agriculture
C.I.F.	Cost, Insurance and Freight
F.O.B.	Free on Board

CONVERSION TABLE OF MEASURES

1 ton = 2,204.6 pounds	1 ha = 2,471 acres
1m = 39.37 inches	1 m^3 = 35.31 cubic feet
= 3.3 feet	
1 km = 0.62 miles	

CURRENCY EQUIVALENT

Naira (₦) $1 = 100 Kobo

₦1 = US$1.58	₦1 = ¥458	US$1 = ₦0.63

1. METEOROLOGY

1.1 General

Nigeria has a tropical climate with year-round high temperatures. The climate is governed mostly by the seasonal winds e.g. (a) the moist south-west wind and (b) the dry north-east Trade and "Hamattan" winds. Under the influence of each of these winds, the year can be divided into the rainy season and the dry season, respectively.

Rainfall comes from the moist south-west wind and hence the climate of Nigeria varies according to the distance from the sea. The whole country is divided into three belts climatologically as shown in Fig. 1.1. Imo State is located in SOUTH BELT and Bendel State, in the transitional zone between SOUTH BELT and MIDDLE BELT, respectively. As shown in the figure, the average annual rainfall at Owerri is about two times as much as that at Auchi. In both Project areas, temperature and relative humidity are quite high with little variation throughout the year.

1.2 Meteorology in Owerri Area

1.2.1 Rainfall

1) Available data and general features of rainfall

In the neighborhood of the Owerri Project area there are four meteorological stations as below.

Meteorological Stations

Station	Location		El	Recorded Period	
	Latitude	Longitude		Daily Rainfall	Monthly Rainfall
Owerri (Meteorological Service)	5°29'N	7°02'E	300ft.	1974-1976	1907-1976*
Owerri (A.I.C.E.)/1	5°29'N	7°01E	230ft.	1973-1976	1973-1976
Umudike (Experimental Farm)	5°29'N	7°33'E	400ft.	1971-1976	1934-1976*
Okigwi (Meteorological Service)	5°50'N	7°21'E	-	-	1936-1966*

/1 A.I.C.E.: Alvan Ikoku College of Education
/2 * : involves some intermittent periods.

Average monthly rainfalls and numbers of rainy days for these stations are shown in Table 1.1 and Fig. 1.2. As a general trend of seasonal variation, rainfall increases gradually from March, attains to maximum in September, and declines abruptly in November. There exists a short lull in the rainfall usually in August. The rainy season lasts approximately seven months from April to October and the dry season, from November to March.

According to the data at Owerri which covers more than 90% of the Oramirukwa basin in terms of the Thiessen polygon, the annual rainfall ranges from about 1700 mm to about 3200 mm of which about 85% is concentrated in the rainy season. Rainy days average at 140 in a year.

2) Design drought rainfall for irrigation planning

Frequency analysis of the annual total rainfall at Owerri has been made by using the Thomas method. The results are summarized in the following table and illustrated in Fig. 1.3.

Probable Annual Rainfall

Probability (%)	50	20	10	2
Annual Total Rainfall (mm)	2,400	2,100	1,900	1,800

Probability of the drought rainfall for the purpose of the irrigation planning has been decided at 20% or once in five years. The annual total rainfall thus estimated has been distributed to each month in proportion to the average monthly rainfall pattern at Owerri. The results are shown in the following table and Fig. 1.4.

Design Drought Monthly Rainfall for Owerri Project

(Unit: mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
20	41	105	172	233	262	313	261	364	244	65	20	2,100

3) Design maximum daily rainfall

Since the data of the daily rainfall at Owerri are scanty, the data at Umudike have been used for estimation of the design maximum rainfall.

Probability of the occurrence has been analysed by using also the Thomas method. The results are illustrated in Fig. 1.5 and summarized as below.

Probable Daily Maximum Rainfall

Probability (%)	50	20	10
Daily rainfall (mm/day)	86	100	110

Probability of the daily maximum rainfall has been decided at 20% or once in five years as the basis of drainage planning.

1.2.2 Other Meteorological Factors

The other meteorological data such as temperature, relative humidity, wind speed, and evaporation are shown in Table 1.3.

Temperature

High atmospheric temperature prevails throughout the year in this area without noticeable seasonal changes. The temperature averages at about 26°C every year. It rises highest in February to about 28°C, whereas it falls lowest in the period from July to August to about 25°C.

Relative Humidity

The relative humidity is rather high with around 80% on an annual average. It is kept rather high in the rainy season during the period from April to November.

Wind Speed

The wind speed is 109 km/day or about 1.3 m/sec on an annual average. As a general tendency, it is high in the rainy season and low in the dry season.

Evaporation

Evaporation has been measured by the Piche evaporimeter at Umudike for five years, whereas the measurement by means of US Weather Bureau Class A pan covered only one year. The annual average Piche evaporation is about 3 mm per day ranging from 3-4 mm per day in the dry season to about 2 mm per day in the rainy season.

1.3 Meteorology in Auchi Area

1.3.1 Rainfall

1) Available data and general features of rainfall

The available rainfall data are as follows.

Meteorological Stations

Station	Location		El	Recorded Period	
	Latitude	Longitude		Daily Rainfall	Monthly Rainfall
Auchi (Auchi Gov. School)	7°04'N	6°14'E	800ft.	1961-1976	1961-1976
Irrua (Irrua Gov.Farm)	6.77°N	6.22°E	400ft.	1970-1976	1952-1976

Note: All data involve some intermittent periods.

Average monthly rainfalls and numbers of rainy days at these stations are shown in Table 1.2 and Fig. 1.6.

The Irrua station is far from the Auchi Project area. Therefore the data at the Auchi station have been used as the basis of planning. The seasonal rainfall pattern at Auchi is almost the same as that of Owerri. Rainfall begins to increase in March, reaches at its maximum in September intervened also by the short lull in August, and decreases to its minimum in December or January.

Rainfall during the rainy season of seven months from April to October ranges between 1,500 mm and 1,100 mm occupying about 90% of the anuual total. Number of rainy days is 90 on an annual average.

2) Design drought rainfall for irrigation planning

The method used for the estimation is the same as that for the Owerri area. The results are obtained as follows. (Refer to Fig. 1.7 and 1.8)

Probable Annual Rainfall

Probability (%)	50	20	10	2
Annual Total Rainfall (mm)	1,220	1,050	940	800

Design Drought Monthly Rainfall for Auchi Project

(Unit: mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
5	17	54	117	140	151	153	114	161	115	17	6	1,050

3) Design maximum daily rainfall

The method applied to the Owerri area has also been used for the estimation. The results are summarized below. (Refer to Fig. 1.9)

Probable Daily Maximum Rainfall

Probability (%)	50	20	10
Daily Rainfall (mm/day)	90	122	145

1.3.2 Other Meteorological Factors

No data has been available at the Auchi station concerning the other meteorological factors. Therefore, the data at the neighbouring other stations are cited as shown in Table 1.4.

Temperature

The annual average temperature is about 26°C around the Auchi area. Usually, the temperature is highest in March and lowest in December with about 27°C and 22°C, respectively on the monthly mean basis.

Relative Humidity

The relative humidity around the Auchi area has been measured only one year at Warrake. No reliable data have been accumulated yet, however, in view of the data from Benin Nifor and Lokoja, it is estimated that the relative humidity is about 79% on an annual average ranging from about 75% in the dry season and about 80% in the rainy season.

Sunshine Hours

Also from the data at Benin Nifor and Lokoja, the annual average sunshine hours are estimated at about 6 hours per day around the Auchi area. It varies from 7 hours per day in the dry season to 5 hours per day in the rainy season.

Evaporation

Evaporation data by the Class A pan are available from Warrake for a period of only one year. According to the data, the surface evaporation is about 5 mm per day on an annual average rising to 6 mm per day in the dry season and decreasing to 4 mm per day in the rainy season.

Table 1.1 Monthly Mean Rainfalls and Numbers of Rainy Days
Owerri Area

Station		J	F	M	A	M	J	J	A	S	O	N	D	Total
Owerri	/1	23	47	121	198	268	302	360	301	419	281	75	23	2,418
	/2	2	4	7	12	16	17	19	19	19	17	3	2	137
Umudike	/1	19	58	124	236	255	285	271	277	328	257	65	18	2,192
	/2	1	4	9	14	16	20	21	23	23	19	5	2	157
Okigwi	/1	25	48	83	147	230	255	266	220	311	229	51	15	1,878

/1 Average monthly rainfalls in mm
Owerri station (Meteorological service) 1907-1962, 1973-1976
Umudike station 1934-1963, 1972-1976
Okigwi station 1936-1966

/2 Average numbers of rainy days in day
Owerri station 1973-1976
Umudike station 1972-1976

Table 1.2 Monthly Mean Rainfalls and Numbers of Rainy Days
Auchi Area

Station		J	F	M	A	M	J	J	A	S	O	N	D	Total
Auchi	/1	6	20	64	138	164	178	180	134	189	136	20	7	1,236
	/2	1	2	6	9	9	12	15	12	12	9	2	1	90
Irrua	/1	11	20	96	155	196	229	226	195	310	201	30	11	1,694

/1 Average monthly rainfalls in mm
Auchi station 1961-1976
Irrua station 1952-1976

/2 Average numbers of rainy days in day
Auchi station 1961-1976

Table 1.3 Data of Other Meteorological Factors Owerri Area

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Monthly Mean Temperature in °C - Maximum /1	32	33	33	32	31	30	29	29	29	30	31	32	31
Monthly Mean Temperature in °C - Mean /1	26	28	27	27	27	26	25	25	26	26	27	26	26
Monthly Mean Temperature in °C - Minimum /1	20	22	22	22	22	22	22	22	22	22	22	20	22
Monthly Mean Relative Humidity in % /1	71	77	77	81	82	84	86	86	84	82	81	71	80
Monthly Mean Sunshine Hours /1	5.9	5.6	5.1	5.8	5.5	4.6	2.9	2.5	2.7	3.8	5.4	5.9	4.6
Monthly Mean Wind Speed in km/day /1	91	114	117	108	100	113	113	132	127	111	87	92	109
Monthly Mean Piche Evaporation in mm /1	4	3	4	3	2	2	2	2	2	2	3	4	3
Monthly Mean Class A Pan Evaporation in mm /2	3.3	3.2	3.9	3.3	2.8	1.9	1.5	2.0	2.7	3.1	2.3	2.9	2.7

Note: /1 (1972-1976) Station: Umudike

/2 (1976) Station: Umudike

Table 1.4 Data of Other Meteorological Factors, Auchi Area

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Monthly Mean Temperature in °C /1	23	26	27	26	26	25	24	24	24	25	25	22	25
Monthly Mean Relative Humidity in %	55	64	69	72	80	77	80	80	76	81	74	61	72
Monthly Mean Relative Humidity in %	77	80	83	83	84	85	88	88	88	88	85	81	84
/2													
Monthly Mean Relative Humidity in %	61	61	65	72	78	78	82	78	82	81	73	76	74
/4													
Monthly Mean Sunshine Hours Benin Nifor	6.1	6.4	5.6	6.0	6.1	5.0	4.2	3.3	3.4	4.8	6.8	6.8	5.4
/5													
Monthly Mean Sunshine Hours Lokaja	7.2	7.8	7.4	6.9	7.1	6.1	5.3	4.3	5.3	6.6	8.3	7.8	6.6
/5													
Monthly Mean Wind Speed in km/day	88	132	112	111	86	66	103	88	71	58	47	49	84
/2													
Monthly Mean Class A Pan Evaporation in mm	6.2	6.9	7.2	6.9	5.8	4.6	3.7	3.5	4.0	3.6	4.5	4.9	5.2
/2													

Note: /1 (1974-1976) Station : Irrua
/2 (1976) Station : Warrake
/3 (1974-1975) Station : Benin Nifor
/4 (1974-1975) Station : Lokaja
/3 Data Period: 1951-1960, 1971-1975

Fig. 1.1 Nigeria : Climatic Zoning

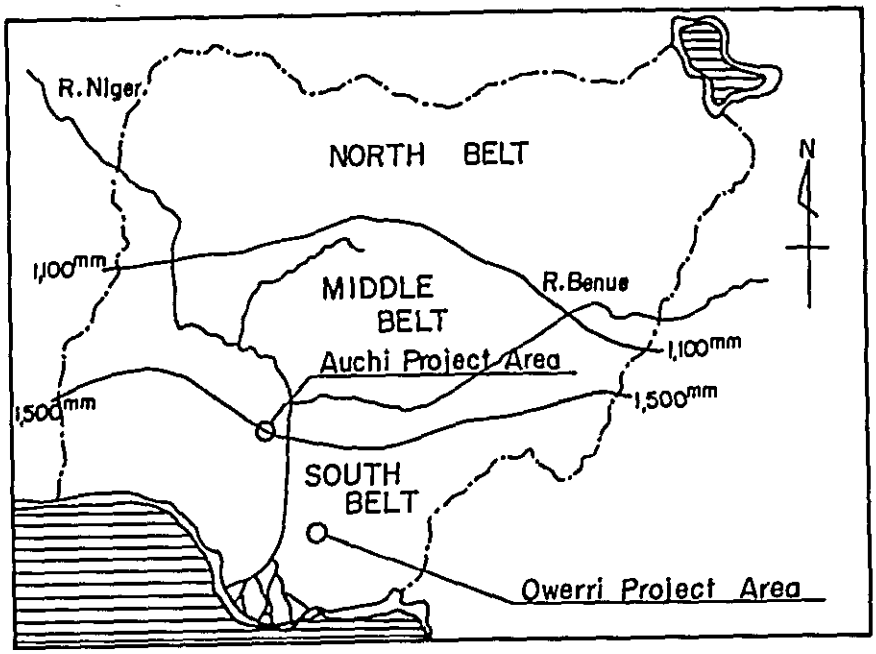


Fig. 1.2 Monthly Mean Rainfall and Numbers of Rainy Days.

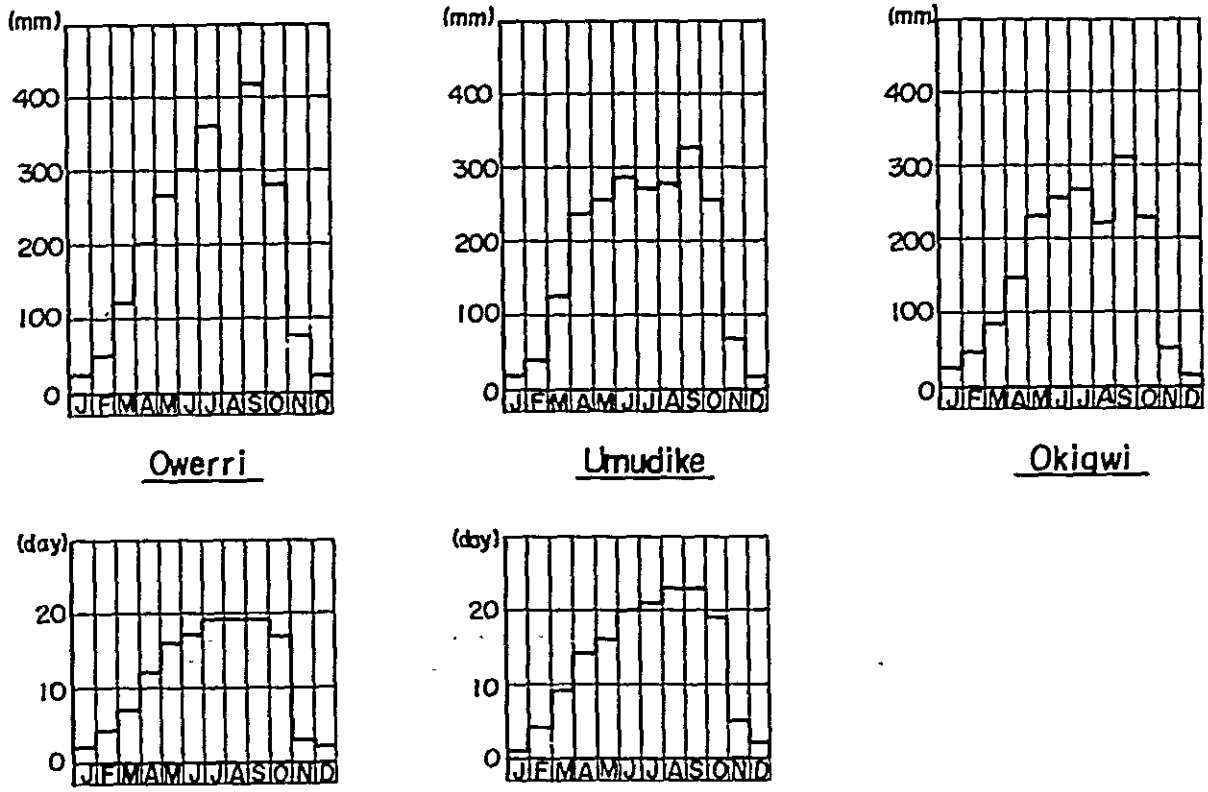


Fig.I.3 Probability Distribution of the Annual Total Rainfall, Owerri Area.

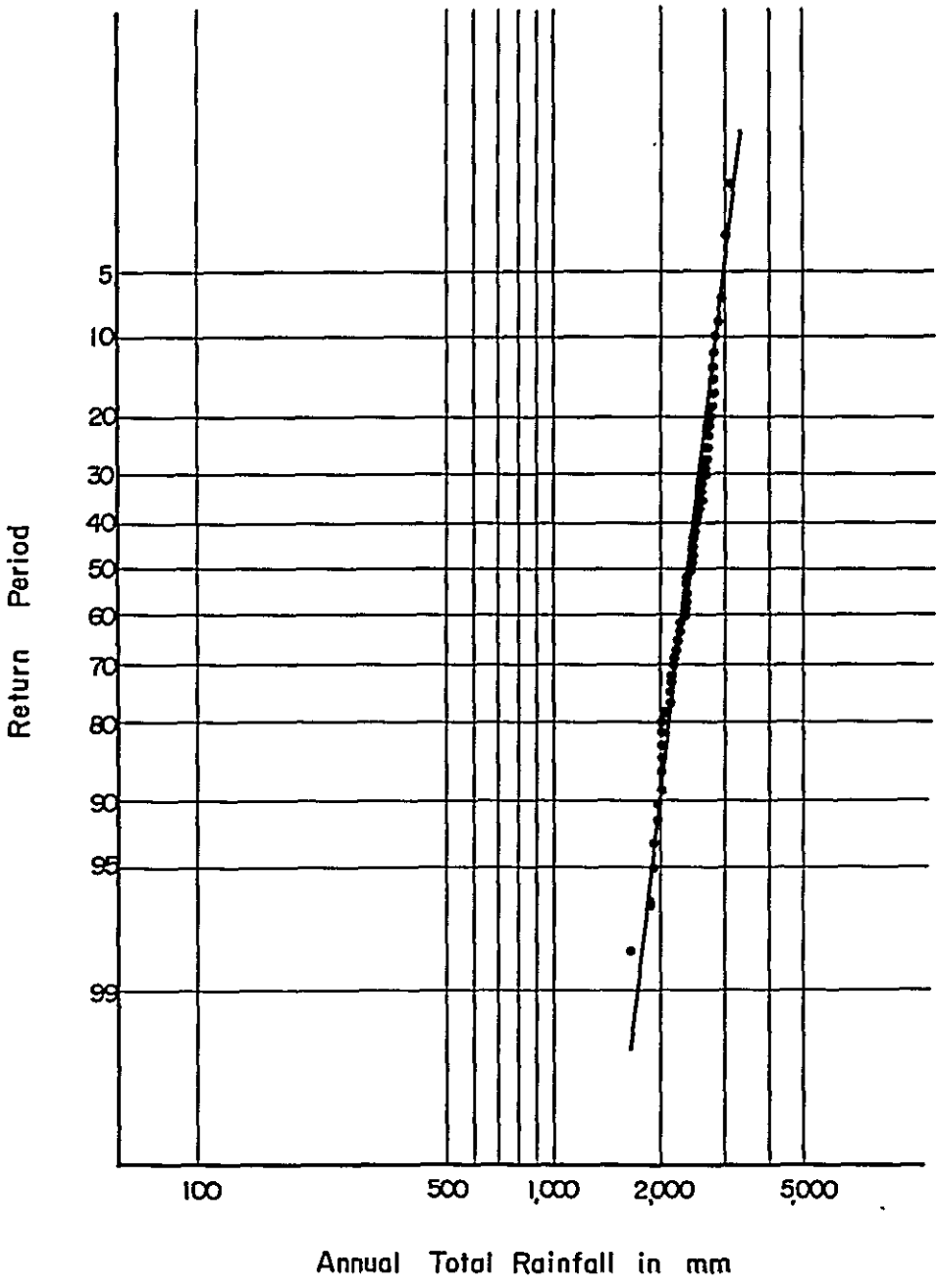


Fig. I.4 Design Monthly Rainfall, Owerri Area

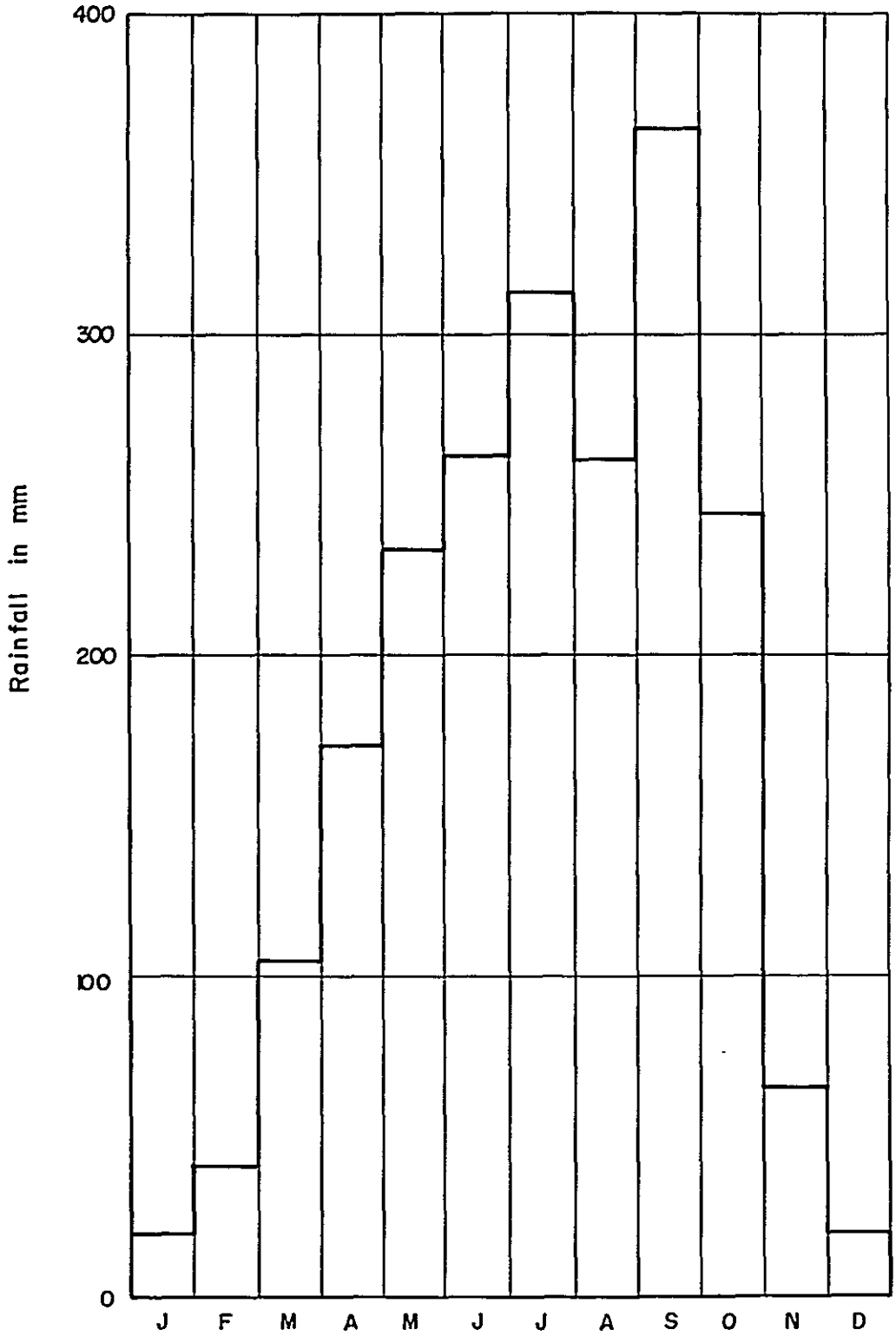


Fig. I.5 Probability Distribution of the Dailly Rainfall, Owerri Area.

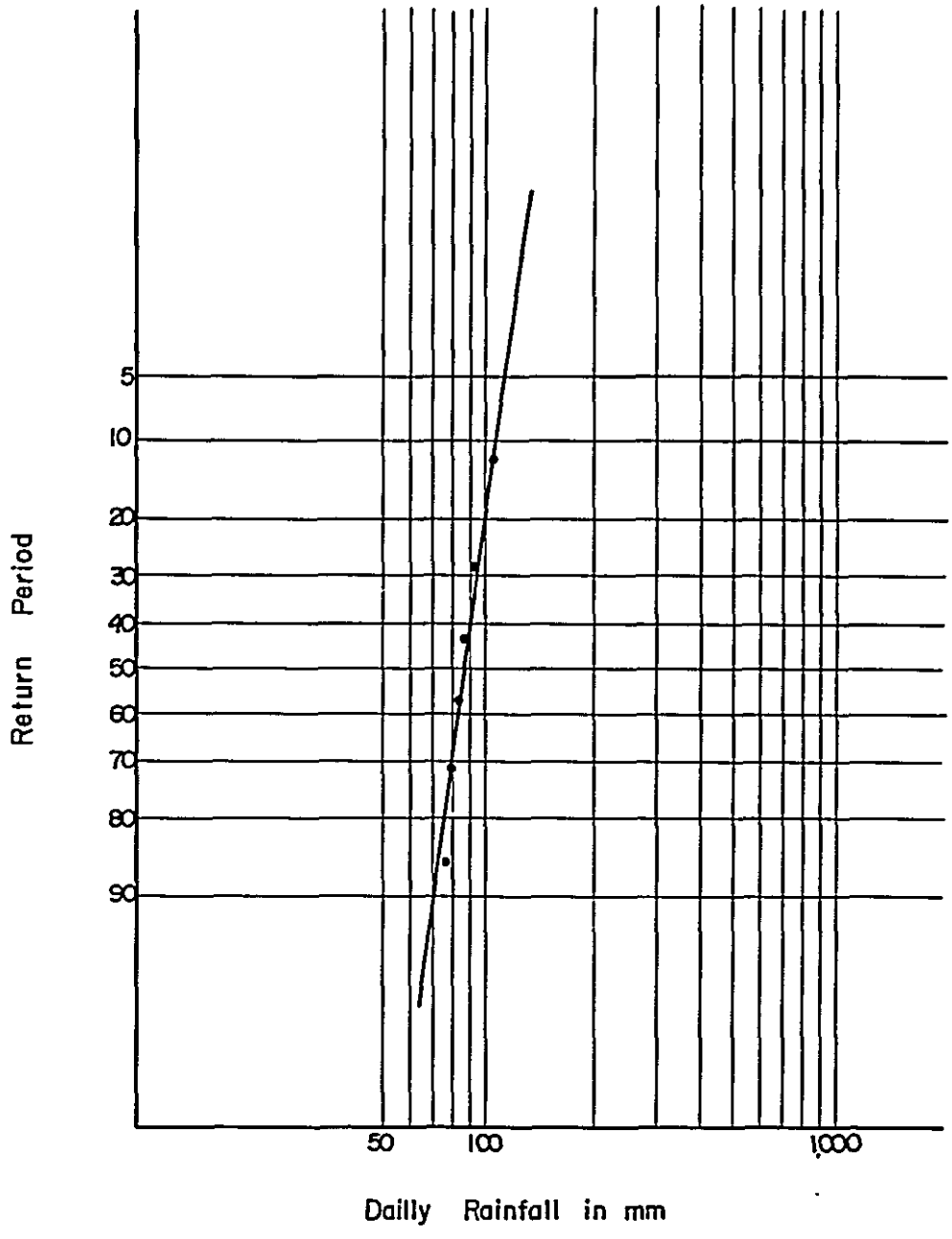
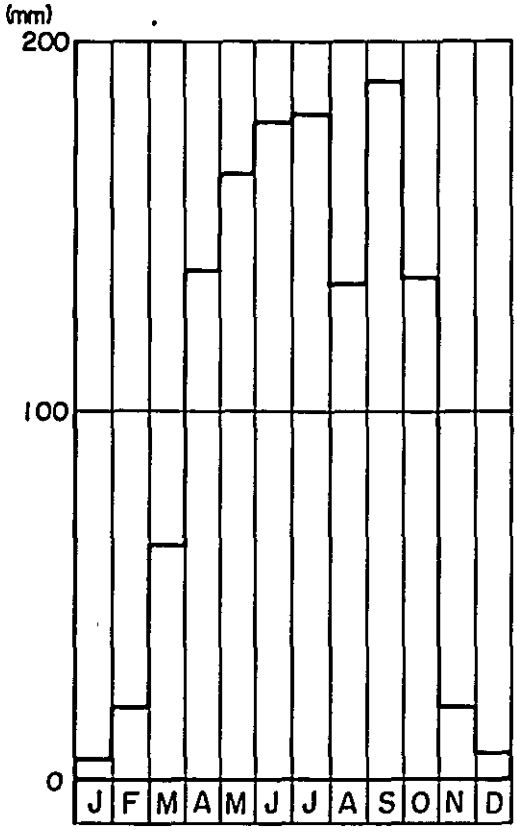
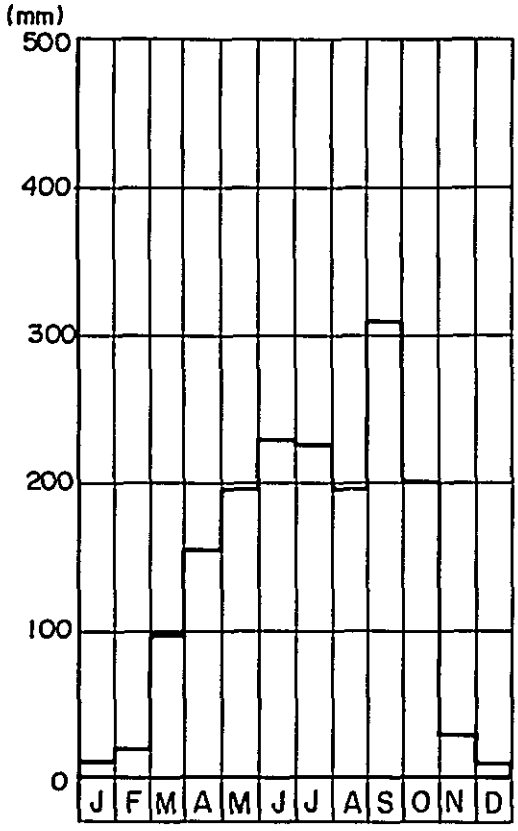


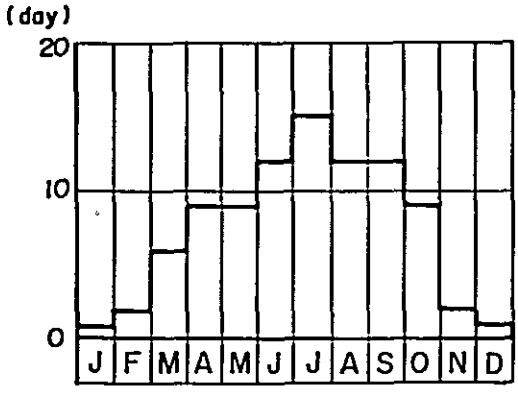
Fig.I.6 Monthly Mean Rainfall and Numbers of Raing Days



Auchi



Irrua



Auchi

Fig.I.7 Probability Distribution of the Annual Total Rainfall, .Auchi Area

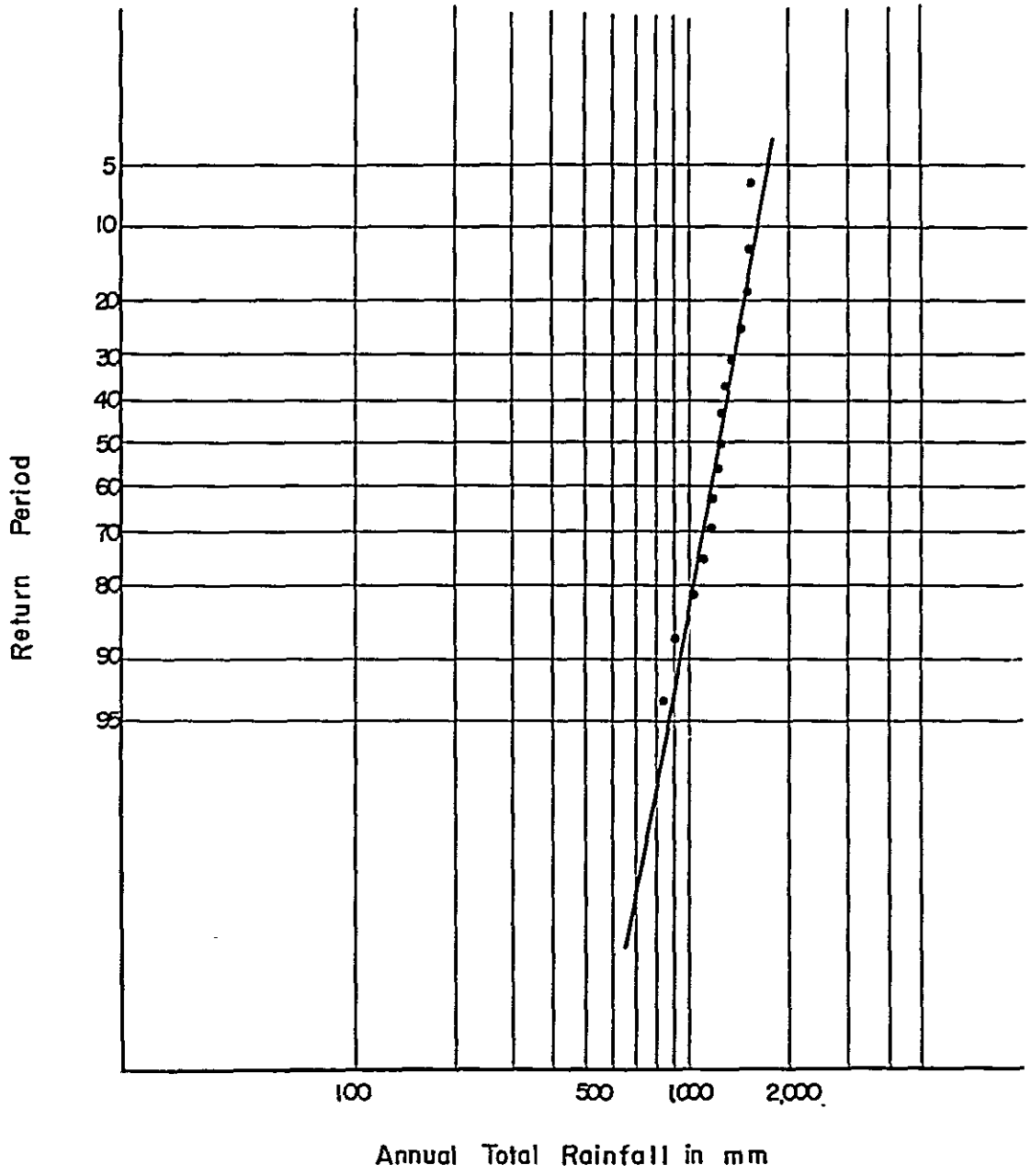


Fig..I. 8 Design Monthly Rainfall, Auchi Area

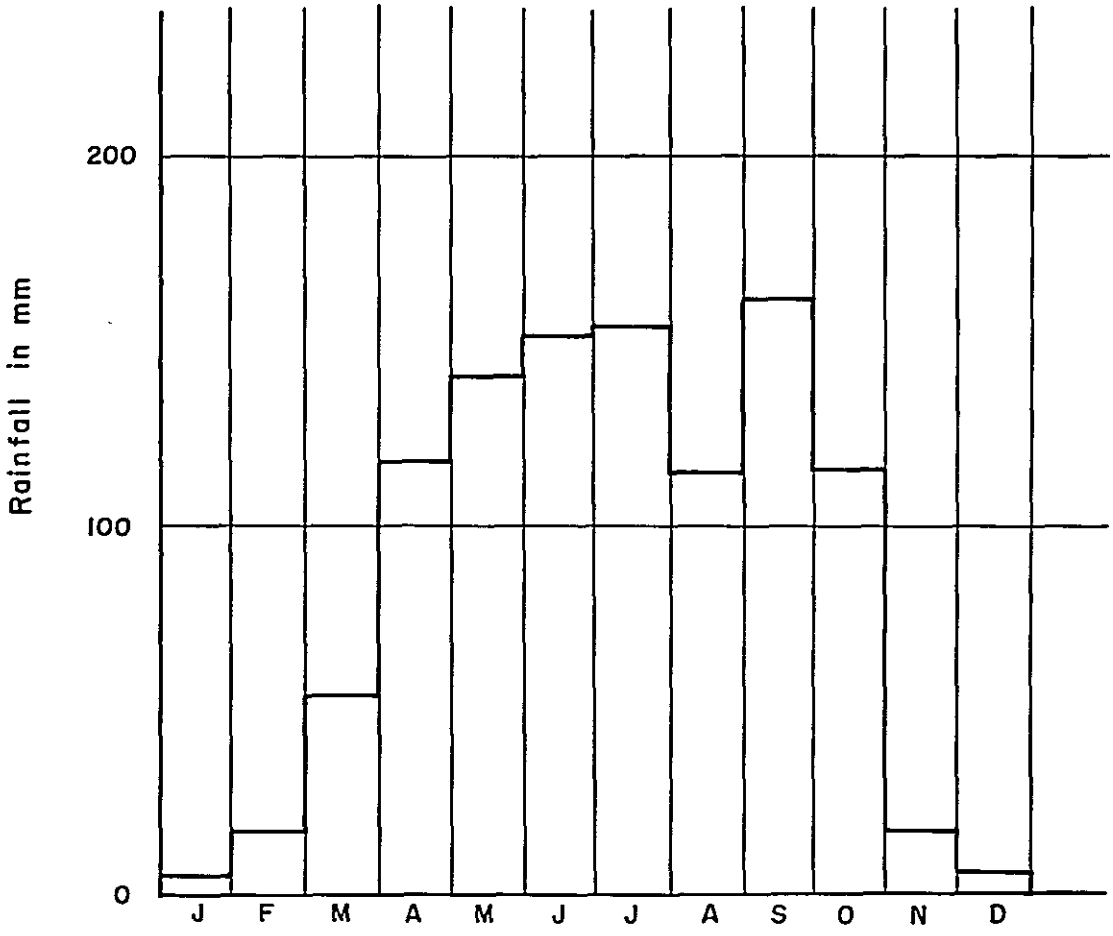
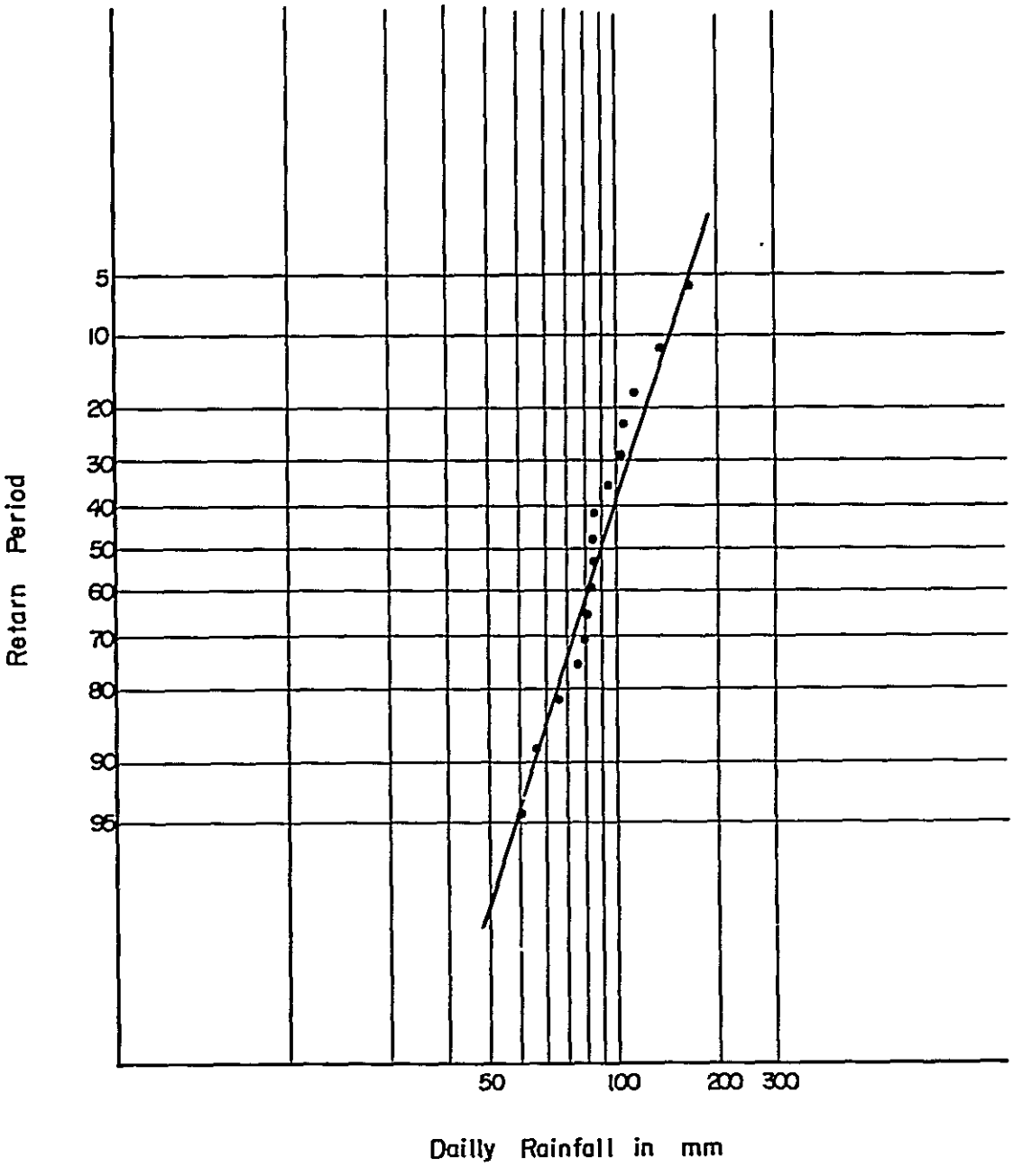


Fig.1.9 Probability Distribution of the Dailly Rainfall, Auchi Area.



2. HYDROLOGY

2.1 Hydrology of Oramirukwa River

2.1.1 River and Basin

The Oramirukwa river, water source of the Owerri Project is originated in the plateau around Okwele (about El 120m), flows to south-ward crossing the Owerri-Umuahia and the Owerri-Aba highways, and pours into the Otamiri river which is one of the tributaries of the Imo river. On the way it is joined by the Okitankwo river immediately after it crosses the Owerri-Umuahia highway. The features of the river course are summarized as follows. (Refer to Fig. 2.1)

- Catchment area : 630km^2 at the proposed intake site, including catchment area of the Okitankwo river.
- Length : The Oramirukwa river, about 40 km
  The Okitankwo river, about 45 km
- Bed slope : About 1:1,000 on an average at the proposed intake site.
- Vegetation : Scrubs.

The water level gauging has been carried out at the crossing point with the Owerri-Umuahia highway (near Azara Egbelu village. Catchment area: 330 km^2) since 1973 by MANR, Imo State.

The record shows that the river keeps perennial flow of about 5.0 m^3/sec in the rainy season and about 2.5m^3/sec in the dry season. In coincidence with the seasonal rainfall pattern, the discharge begins to increase generally in April, attains to peak in October, and decreases to minimum in March. The maximum flood ever happened is reported to be about 150m^3/sec according to the information from nearby inhabitants.

2.1.2 Monthly Mean Discharge

1) Observed Discharge

The record of the water level at the Azara Egbelu station has been cllected and the river discharge has been measured several times during the present field survey period.

Based upon these actual discharge measurements, the rating curve at the gauging point has been drawn as shown in Fig. 2.2, and the water level record has been converted to the discharge as tabulated in Table 2.1.

2) Annual Run-off Coefficient

Using the specific discharge at the Azara Egbelu station, the discharge of the proposed intake site has been calculated. In the dry season, the Okitankwo river has never been streamed according to the field survey of this stage and the information from nearby inhabitants. The converted discharge of the proposed intake site is shown in Table 2.2.

Based on this converted discharge and the simultaneous rainfalls, the run-off coefficient of the river at the intake site has been calculated as follows.

Period	Rainfall (mm)	Run-off (mm)	Annual run-off coefficient(%)
April, 1973 - March, 1974	2,335	389.7	16.7
April, 1974 - March, 1975	2,397	324.2	13.5
April, 1975 - March, 1976	2,272	330.5	14.5
		Average	14.9

For the sake of comparison, the annual run-off coefficients obtained from the other rivers in Nigeria and Ghana are cited as shown below.

River	Catchment Area(km^2)	Rainfall (mm)	Run-off (mm)	Annual run-off coefficient(%)	Gauging Period From	To
Otamiri /1	3,100	2,476	646	26	April,1959	March,1960
Obina /2	424	1,170	177.6	15.2	April,1973	March,1974
Pra /3	20,746	1,600	288	18	1944	1965
Tano /3	10,334	1,397	154	11	1944	1965
Ankobra /3	4,274	1,880	338	18	1944	1965
Densu /3	1,612	1,473	162	11	1948	1965
Ayensu /3	725	1,575	299	19	1948	1965

/1 Cited from Imo River Basin Pre-Feasibility Report, by ENPLAN GROUP, October 1974.

/2 Cited from Uzo-Uwani Pioneer Irrigation Project, by Nippon Koei, January 1975.

/3 Cited from Preliminary Report on Comprehensive Development Project of Water Resources in South Western Ghana, by Nippon Koei, Janaury 1967.

Taking these features in view, the annual run-off coefficient of the Oramirukwa river is assumed to be 15%.

3) Estimate of Monthly Mean Discharge in the Design Drought Year

Dry season discharge

The following table shows the cumulative monthly rainfall and the actual discharge of the river in the dry season from November to March during the period when the discharge data are available.

	November		December		January		February		March	
	R/1	Q/2	R/1	Q/2	R/1	Q/2	R/1	Q/2	R/1	Q/2
1973/1974	2,182	4.72	2,219	4.03	2,219	3.50	2,249	3.26	2,360	3.12
1974/1975	2,253	4.24	2,253	3.95	2,253	3.75	2,313	3.81	2,397	3.83
1975/1976	1,854	3.94	1,877	2.99	1,877	2.65	2,019	2.82	2,272	3.03

/1 R: Cumulative monthly mean rainfall from April to this month, in mm

/2 Q: Monthly mean discharge of this month, in m^3/sec

Based upon these figures, the relation between the cumulative rainfall and the dry season discharge is shown in Fig. 2.3, which indicates that there exists a district corelation between them and that the dry season discharge can be estimated by multiplying the cumulative rainfall by the ratio obtained from the figure. The dry season discharge under the design drought condition is, therefore, estimated by applying the above ratio to the design drought monthly rainfall. The result of the estimate is summarized as below.

Month	R (mm)	Q (m^3/sec)
November	1,914	3.65
December	1,934	3.15
January	1,954	2.90
February	1,999	2.75
March	2,100	2.65

Rainy season discharge

The simple estimation method applied to the estimate of the dry season discharge is found to be unapplicable to the estimate of the rainy season discharge owing to the non-existence of the distinct corelationship between the rainfall and the discharge. Analyses are made from several approaches, and as the result the following method is adopted finally:

- To separate the rainy season discharge into the surface flow and the base flow and to assume that the base flow is kept constant during the rainy season;
- To let the base flow be represented by the discharge in November in view of the actual flow record of the river and;
- To let the total surface flow during the rainy season be distributed to each of the months according to the monthly discharge distribution pattern in the design drought condition.

From Fig. 2.4, the monthly discharge distribution pattern in the design drought condition is assumed to be represented by the one in 1973, and the ratio of the monthly surface discharge to the total surface discharge during the whole rainy season is culculated as follows.

	J	F	M	A	M	J	J	A	S	O	N	D
Q/1	4.14	3.79	3.61	8.00	7.52	9.83	9.43	13.84	13.88	13.59	4.72*	4.03
Q'/2	-	-	-	3.28	2.80	5.11	4.71	9.12	9.16	8.87	-	-
Q/3	-	-	-	7.6	6.5	11.9	10.9	21.2	21.3	20.6	-	-

/1 Q: Actual discharge in 1973 (m^3/sec)

/2 Q': Discharge excluding baseflow (m^3/sec)
(Baseflow*: 4.72 m^3/sec)

/3 C: Ratio of monthly surface discharge to total surface discharge in rainy season (%)

On the other hand, the annual total runoff in the design drought year is calculated at: 2,100mm (annual total rainfall) x 15% (runoff coefficient) = 315mm. Total of the base flow in the rainy season and the dry season discharge is estimated at 167.5mm. Balance of 147.5mm corresponds to the total surface flow in the rainy season. It is distributed to each month using the ratio obtained above. The result of the estimate is summarized as follows.

	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
C /1	7.6	6.5	11.9	10.9	21.2	21.3	20.6	-	-	-	-	-
Q1/2	11.2	9.6	17.6	16.1	31.3	31.5	30.4	-	-	-	-	-
Q2/3	2.72	2.26	4.28	3.79	7.36	7.66	7.15	-	-	-	-	-
QB/4	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.15	2.90	2.75	2.65
Q /5	6.37	5.91	7.93	7.44	11.01	11.31	10.80	3.65	3.15	2.90	2.75	2.65

/1 C: Distribution ratio (%)

/2 Q1: Calculated surface discharge (mm)

/3 Q2: Calculated surface discharge (m^3/sec.)

/4 QB: Baseflow (m^3/sec.)

/5 Q: Estimated monthly mean discharge (m^3/sec.)

2.1.3 Flood Discharge

No data on flood discharge has been available at the proposed intake site. Therefore, the data of the other rivers are referred as shown in Table 2.3 to 2.4 and Fig. 2.5 to 2.8.

The features of these river basins are considered to be almost the same as those of the Oramirukwa river basin. Based upon these figures, the peak flood discharge at the intake site has been estimated as below.

Probable Peak Flood

Probability (%)	20	2	1
Peak Flood (m^3/sec)	115	150	160

As stated previously, the maximum flood ever happened is reported to be about 150m^3/sec according to the information from nearby inhabitants. It coincides fairly with the peak flood discharge estimated above. Probability of occurrence of the peak flood discharge for the headworks planning has been decided at 2% or once in fifty years.

2.2 Hydrology of Orle-Edion River

2.2.1 River and Basin

The Orle and Edion rivers are originated in the Basement Complex highlands (about El. 600m) in the vicinity of Igara, flow first in a southerly direction for about 55km and 40km respectively, join together near Auchi-Irrua highway, and then run to an easterly direction for about 50km to its confluence with the Niger river near Alegbette. In the downstream reach, it is joined by the Ojo river which is the proposed water source for the Auchi project. Total catchment of the basin is about 2,200km^2 which is subdivided into the following subcatchments: (Refer to Fig. 2.9)

Orle river at Edion confluence:	620km^2	
Edion river at Orle confluence:	700km^2	
Orle after confluence with Edion:	880km^2	including the Ojo river of 240km^2
Total	2,200km^2	

The Ojo river has a catchment area corresponding to 27% of the lower catchment of the Orle river after amalgamation of Edion. The length of the river from its origin to the proposed intake site is about 25km and the longitudinal gradient is about 1:100. The catchment area is covered almost by dense forests.

There esists no previous water level gauging in the Orle and Edion basins.

2.2.2 Monthly Mean Discharge

There exist no previous river gauging of the Orle-Edion basin, except rough flow measurements carried out in November, 1975 by the British Appraisal Mission/1. Based upon the measurements and information from local residents, the Mission gives the following estimate:

	Flow in November 1975	Estimated Minimum Flow (March)
Upper Orle River	1.4 m^3/sec	0.6 m^3/sec
Edion river at Orle confluence	1.0 m^3/sec	0.7 m^3/sec
Lower Orle near Niger	4.0 m^3/sec	2.3 m^3/sec
Obe river (Catchment area 240 km^2)	0.6 m^3/sec	0.3 m^3/sec

During the field survey period of this stage, the discharge of the Ojo river has been measured continuously at the intake site. The record shows that the discharge is about 0.6 m^3/sec in the beginning of January, about 0.4 m^3/sec in mid-January and about 0.3 m^3/sec in the early February. These figures coincide fairly with the previous estimation by the British Mission.

The monthly mean discharge for the purpose of planning has been calculated by applying the same procedure taken for the Oramirukwa river. Due to the paucity of data, realistic estimate is hardly possible. There remains much to be clarified based on continuous discharge measurements.

Based on the available data, it is assumed that the minimum monthly discharge in the dry season is 0.6 m^3/sec in November and 0.3 m^3/sec in March, decreasing constantly during the dry season. As regards the discharge in the rainy season, the design drought rainfall is used, and applying the same distribution ratios as those for the Owerri project, it is estimated as below. The annual total runoff under the design drought condition is 157mm and the surface flow in the rainy season is 69mm.

/1 Refer to "Report of the Orle Basin Appraisal Mission" by Ministry of Overseas Department, England in 1976.

	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
C /1	7.6	6.5	11.9	10.9	21.2	21.3	20.6	-	-	-	-	-
Q1/2	6.72	5.75	10.53	9.65	18.76	18.85	18.23	-	-	-	-	-
Q2/3	0.62	0.52	0.97	0.86	1.68	1.75	1.63	-	-	-	-	-
QB/4	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.43	0.36	0.30
Q /5	1.22	1.12	1.57	1.46	2.28	2.35	2.23	0.60	0.50	0.43	0.36	0.30

/1 C: Distribution ratio (%)

/2 Q1: Calculated surface discharge (mm)

/3 Q2: Calculated surface discharge (m^3/sec.)

/4 QB: Baseflow (m^3/sec.)

/5 Q: Estimated monthly mean discharge (m^3/sec.)

2.2.3 Flood Discharge

No data on flood discharge are available. From the trace of the river bank, the flood ever happened has been estimated to be about 70 m^3/sec. On the other hand, from Fig. 2.6 to 2.8, the probable peak flood in other regions are estimated as below.

Probable Peak Flood

Probability (%)	20	2	1
Peak Flood (m^3/sec)	65	80	90

Based upon these, the peak flood discharge for the planning of the headworks has been decided at 80 m^3/sec or 2% of the occurrence probability.

Table 2.1 Monthly Mean Discharge at Azara Egbelu Station

(Unit: m^3/sec)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Mean
1973	4.14	3.79	3.61	4.19	3.94	5.15	4.94	7.25	7.27	7.12	4.72	4.03	5.01
1974	3.50	3.26	3.12	3.58	3.95	4.57	4.67	4.43	4.86	4.96	4.24	3.95	4.09
1975	3.75	3.81	3.83	4.00	4.83	4.79	4.17	5.28	5.08	5.84	3.94	2.99	4.36
1976	2.65	2.82	3.03	2.89	3.51	5.16	4.22	3.41	4.43	6.82	4.58	2.90	3.96
Mean	3.51	3.42	3.40	3.67	4.06	4.92	4.50	5.09	5.41	6.19	4.37	3.47	4.36

Catchment Area: 330 km^2

Table 2.2 Converted Monthly Mean Discharge of Intake Site

(Unit: m^3/s)

Year	J	F	M	A	M	J	J	A	S	O	N	D
1973	4.14	3.79	3.61	8.00	7.52	9.83	9.43	13.84	13.88	13.59	4.72	4.03
1974	3.50	3.26	3.12	6.83	7.54	8.72	8.92	8.46	9.28	9.47	4.24	3.95
1975	3.75	3.81	3.83	7.64	9.22	9.14	7.96	10.08	9.70	11.15	3.94	2.99
1976	2.65	2.82	3.03	5.52	6.70	9.85	8.06	6.51	8.46	13.02	4.58	2.90

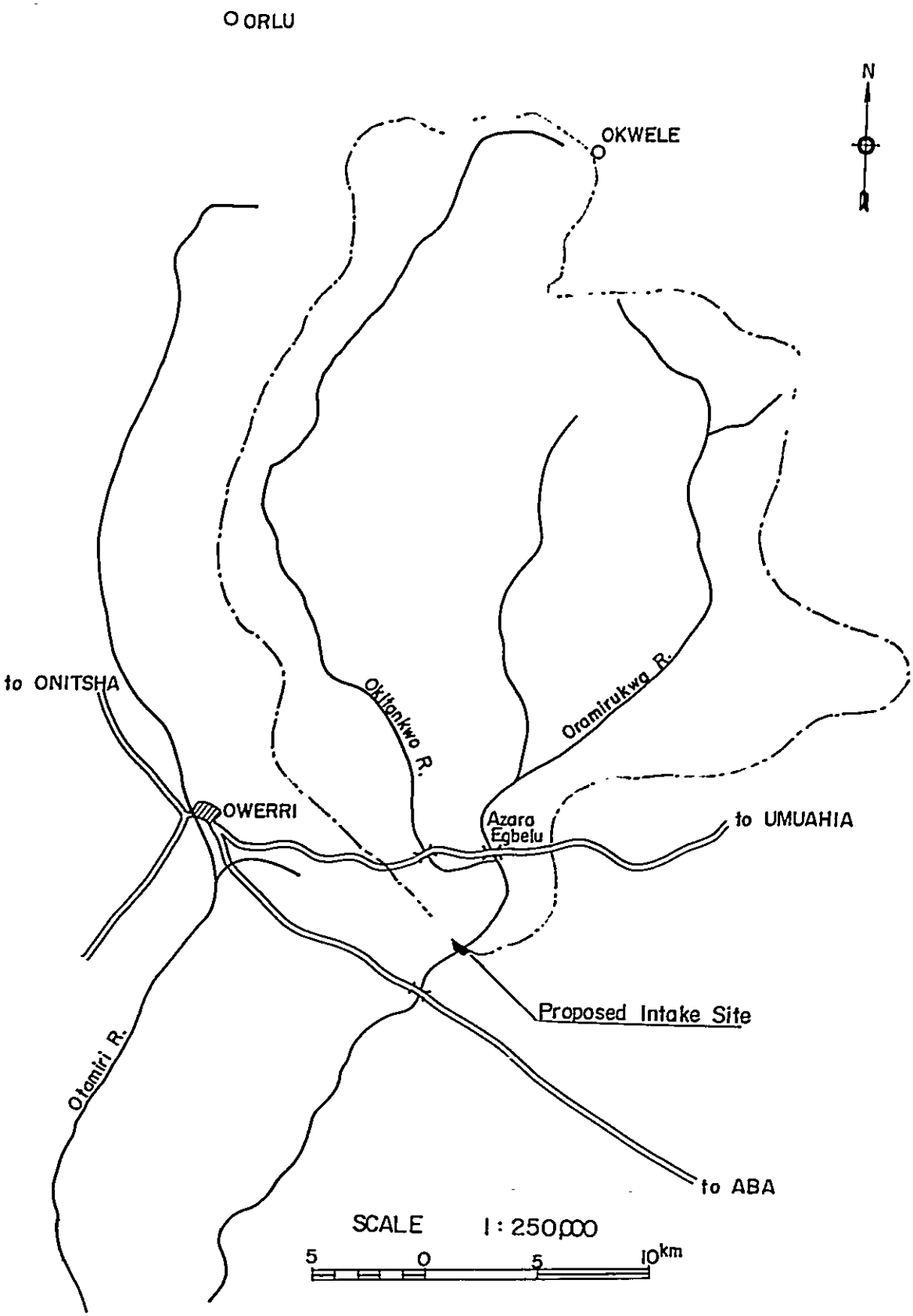
Table 2.3 Observed Maximum Flood and Probability of Flood in Nigeria

River & Station	Catchment area in sq. km	Available data	Observed max flood in m^3/s	Data	Probable peak flood 5 Years'	50 Years'	100 Years'
NIGER RIVER							
Idah	423,000	1955-1975	26,790	Oct. 6 1969	24,500	28,000	30,000
ANAMBRA RIVER							
Ifite-Ogwari	7,800	1964-1974	874	Oct. 15 & 16 1964	870	1,020	1,030
OBINA RIVER							
Adani bridge	554	1963-1966	47	Aug. 6 1965	51	71	76

Table 2.4 Observed Maximum Flood and Probability of Flood in Ghana

River & Station	Catchment area in sq. km	Available data	Observed max flood in m^3/s	Data	Probable peak flood in m^3/s		
					50 years'	50 years'	100 years'
TANO RIVER							
Wiawso	7,407	1957-1965	510	Oct.31 1963	334	595	600
Jomuro	10,334	1956-1965	518	July 3 1959	453	597	612
Alenda-Warf	15,747	1956-1965	442	July 11 1959	428	484	490
ANKOBRA RIVER							
Bepo	1,127	1955-1964	292	June 20 & 21 1958	170	269	272
Tarkwa	1,194	1955-1964	272	July 31 1963	244	382	388
Prestea	4,274	1955-1965	446	July 28 1960	396	515	521
PRA RIVER							
Mfensi	1,453	1950-1963	82	Oct. 19 1960	74	110	113
Kade	2,126	1959-1964	283	Aug. 6 & 7 1962	136	150	153
Oda	3,287	1955-1964	402	July 2 1961	311	402	408
Mampong	363	1951-1964	68	June 25 1955	53	84	85
Brenasi	2,106	1955-1964	147	Oct. 25 1960	116	153	156
Assin-Praso	9,347	1957-1965	668	Oct. 10 1963	651	906	934
Twifu-Praso	20,746	1943-1965	1,331	Oct. 12 & 13 1963	1,019	1,416	1,453
Daboasi	22,758	1954-1965	1,271	Oct. 10 1963	1,104	1,416	1,444
AYENSU RIVER							
Oketsew	725	1960-1965	149	July 25 1960	125	266	272
VOLTA RIVER							
Pwalagu	56,980	1950-1965	1,982	Sept.16 1962	1,869	2,549	2,568
Senchi	393,913	1936-1958	14,158	1917	8,778	15,574	16,140
AMISA RIVER							
Manso	370	1955-1964	57	June 12 1964	53	74	75
Mankesim	1,251	1955-1965	515	June 25 1962	113	224	232
NKWA RIVER							
Ochiso	914	1956-1964	348	July 24 1961	207	374	3,880
Ekotsi	1,445	1959-1964	176	July 24 1961	110	255	263

Fig. 2.1 Oramirukwa River Basin



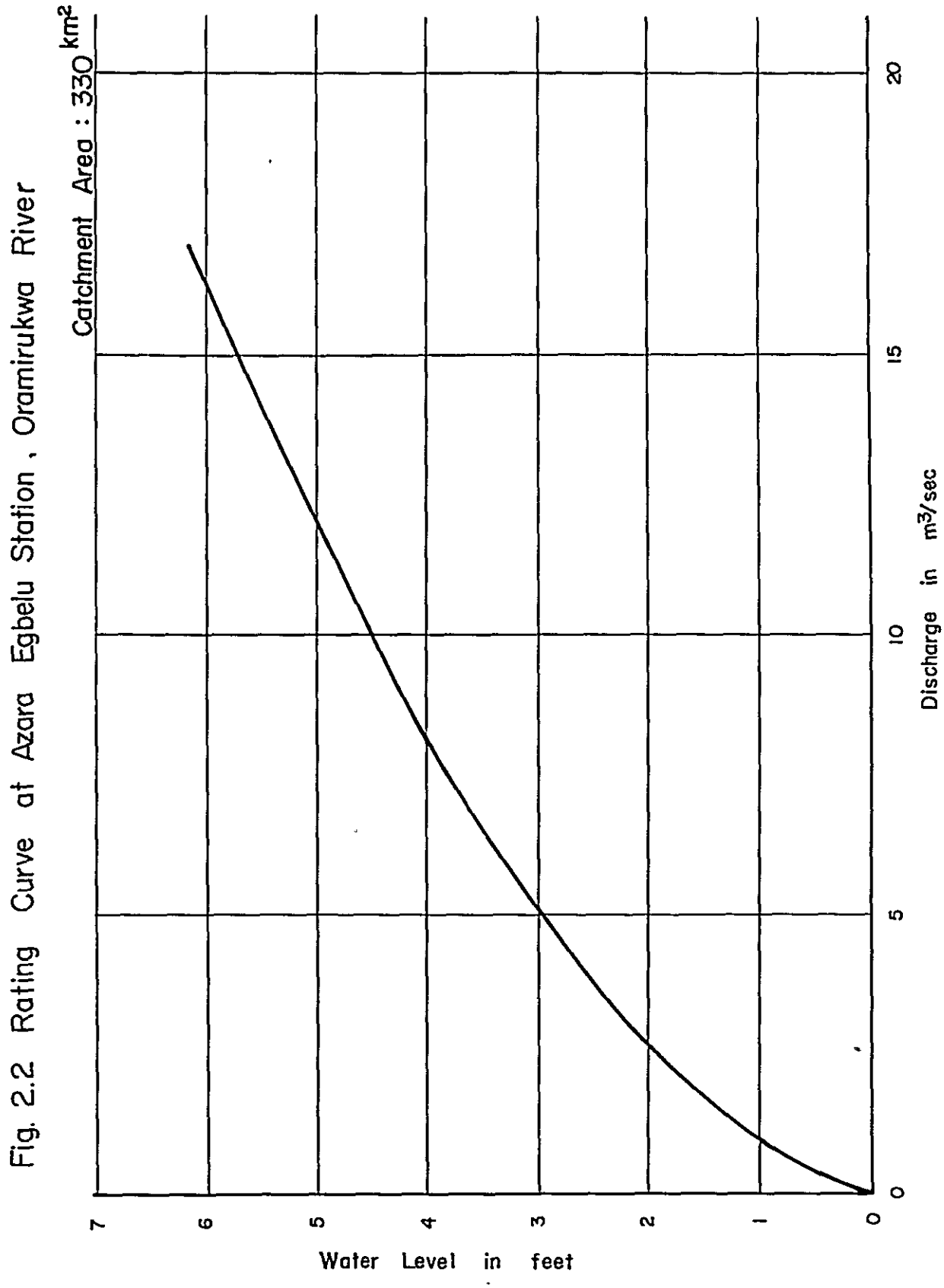


Fig. 2.2 Rating Curve at Azara Egbelu Station, Oramirukwa River

Fig. 2.3 Relation between Discharge and Cumulative Rainfall, Oramirukwa River.

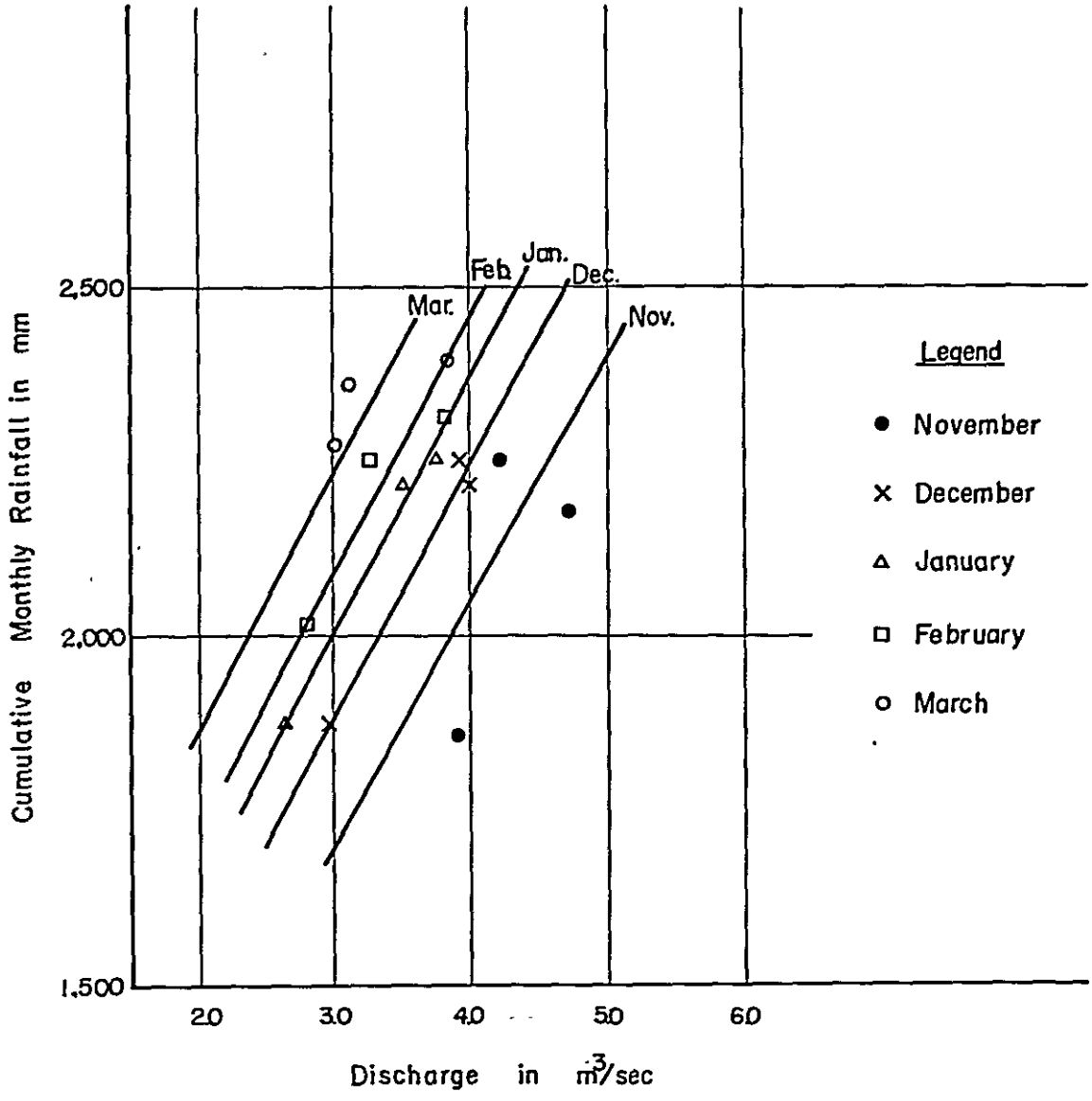
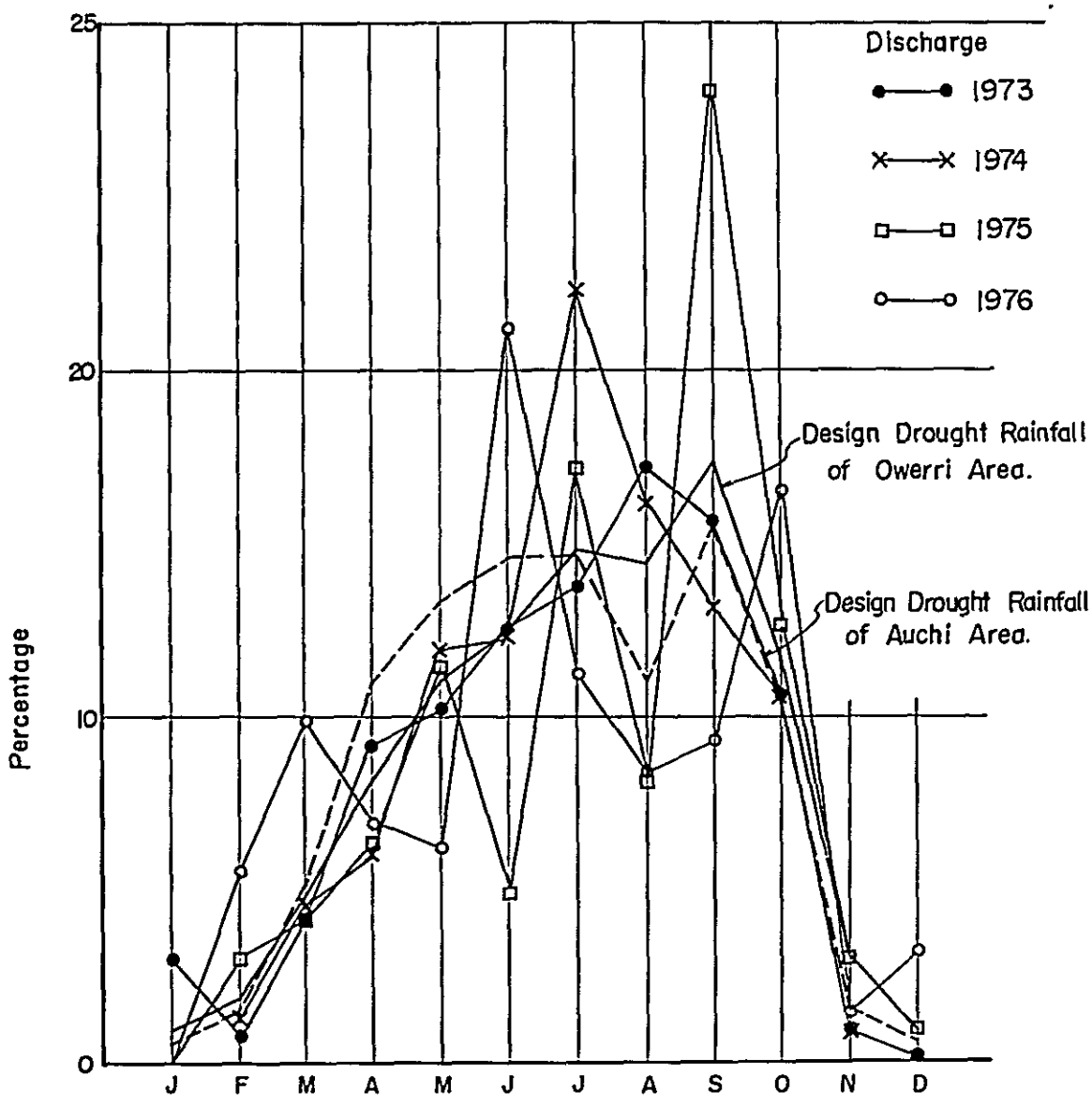


Fig. 2.4 Distributions of Rainfall and Discharge.



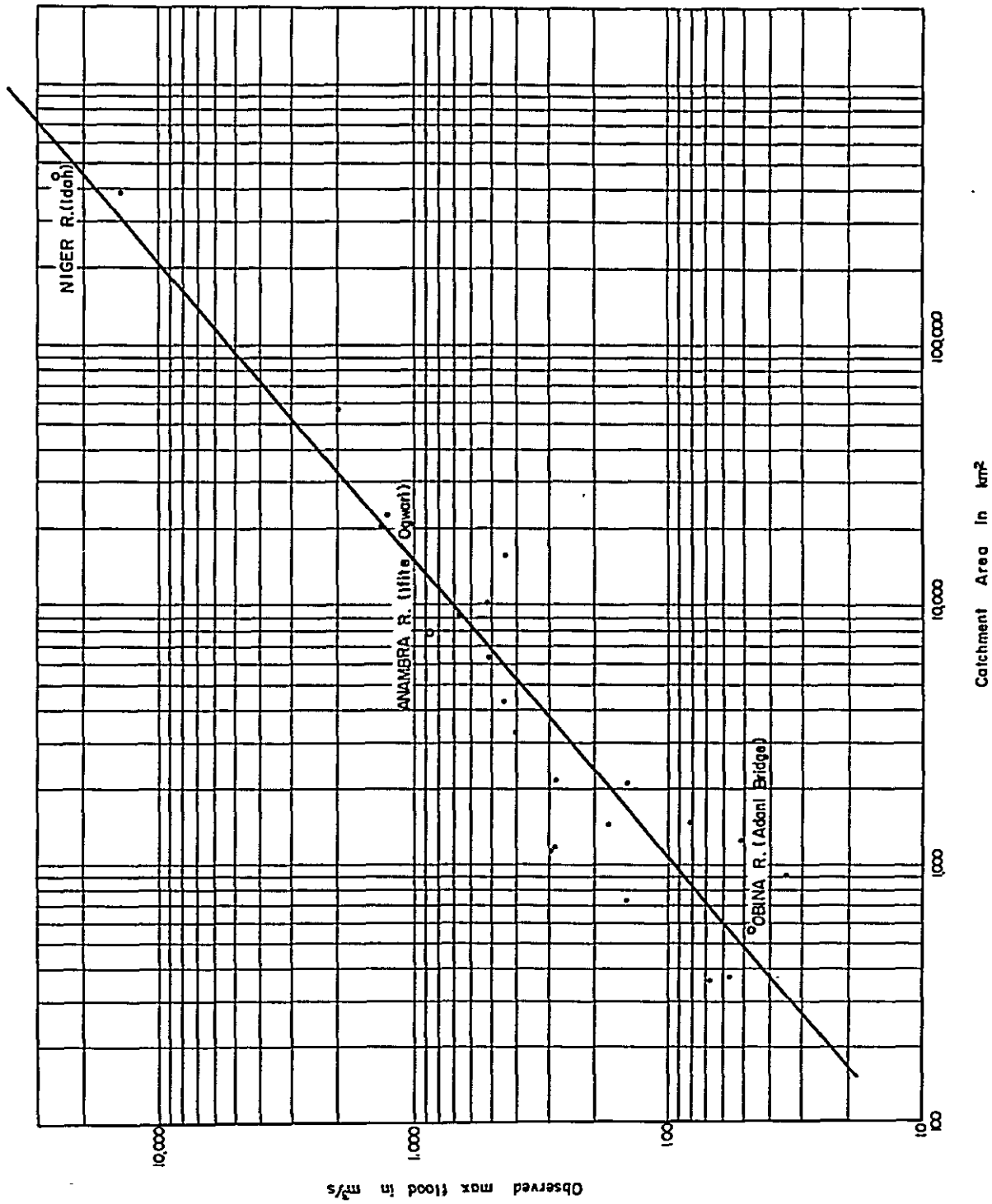


Fig. 2.5 Regional Relation of Peak Flood, Observed Max. Flood.

Fig. 2.6 Regional Relation of Peak Flood
5 Years' Flood.

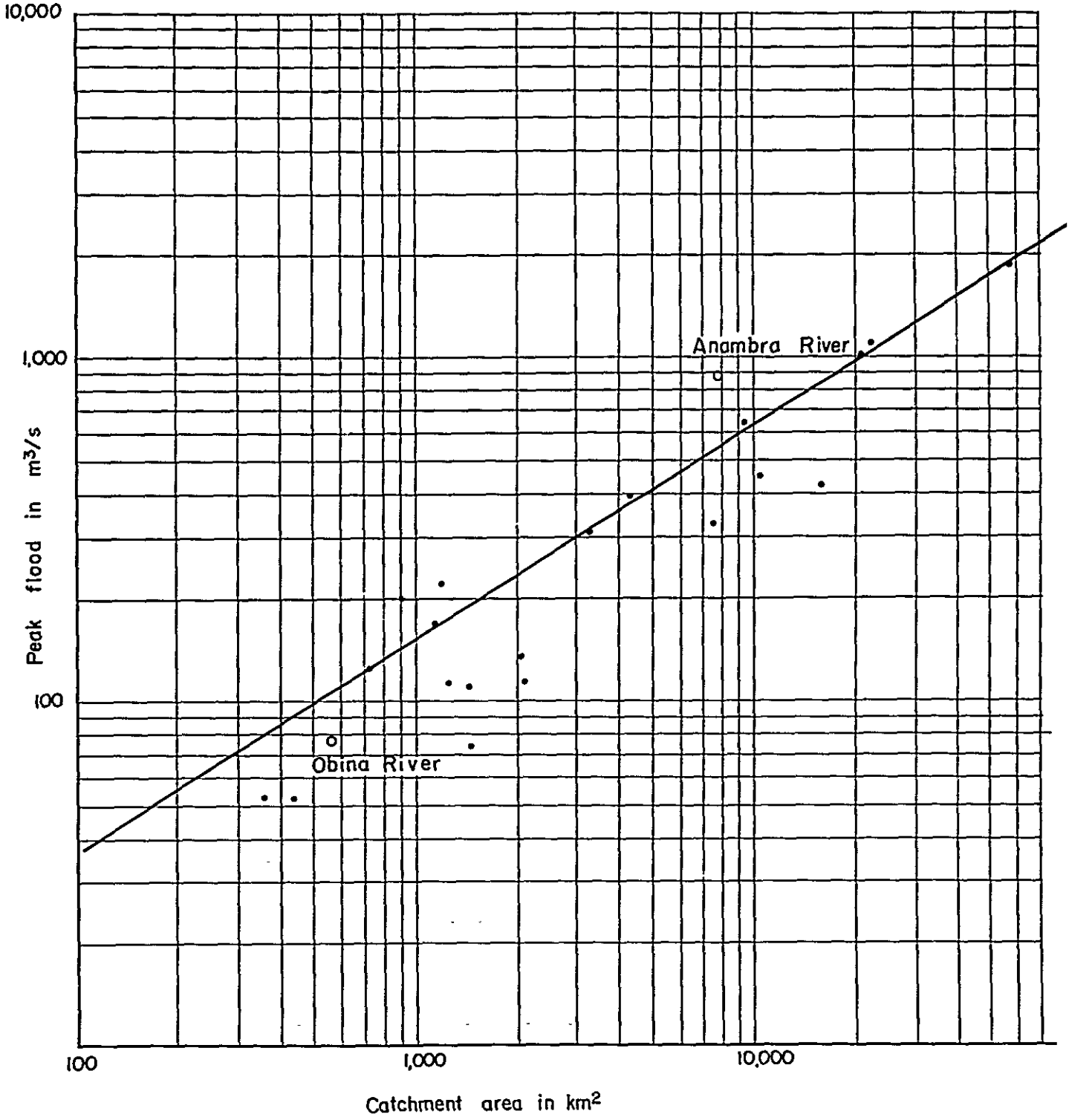


Fig. 2.7 Reigonal Relation of Peak Flood
50 Years' Flood.

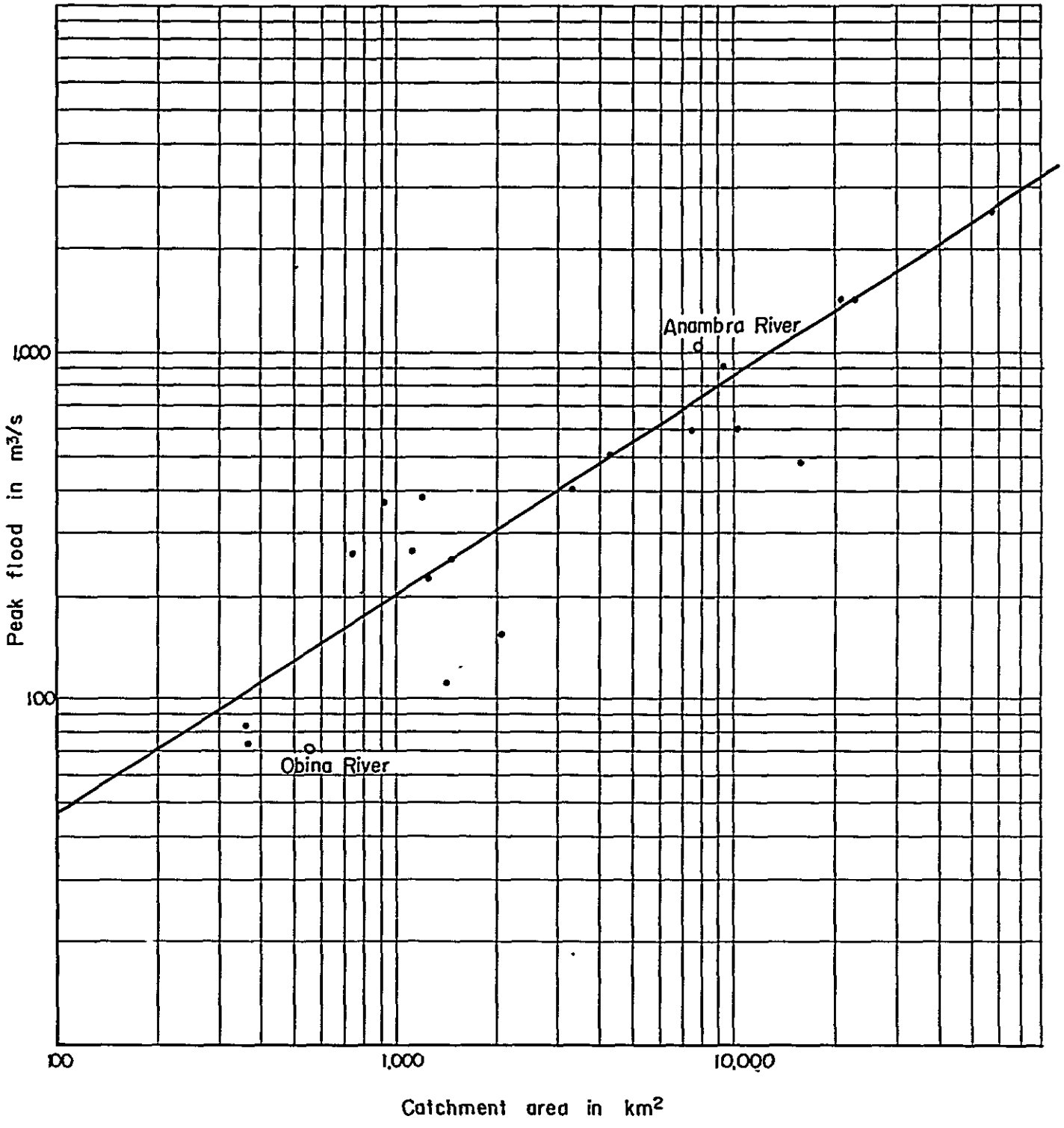


Fig. 2.8 Regional Relation of Peak Flood.
100 Years' Flood.

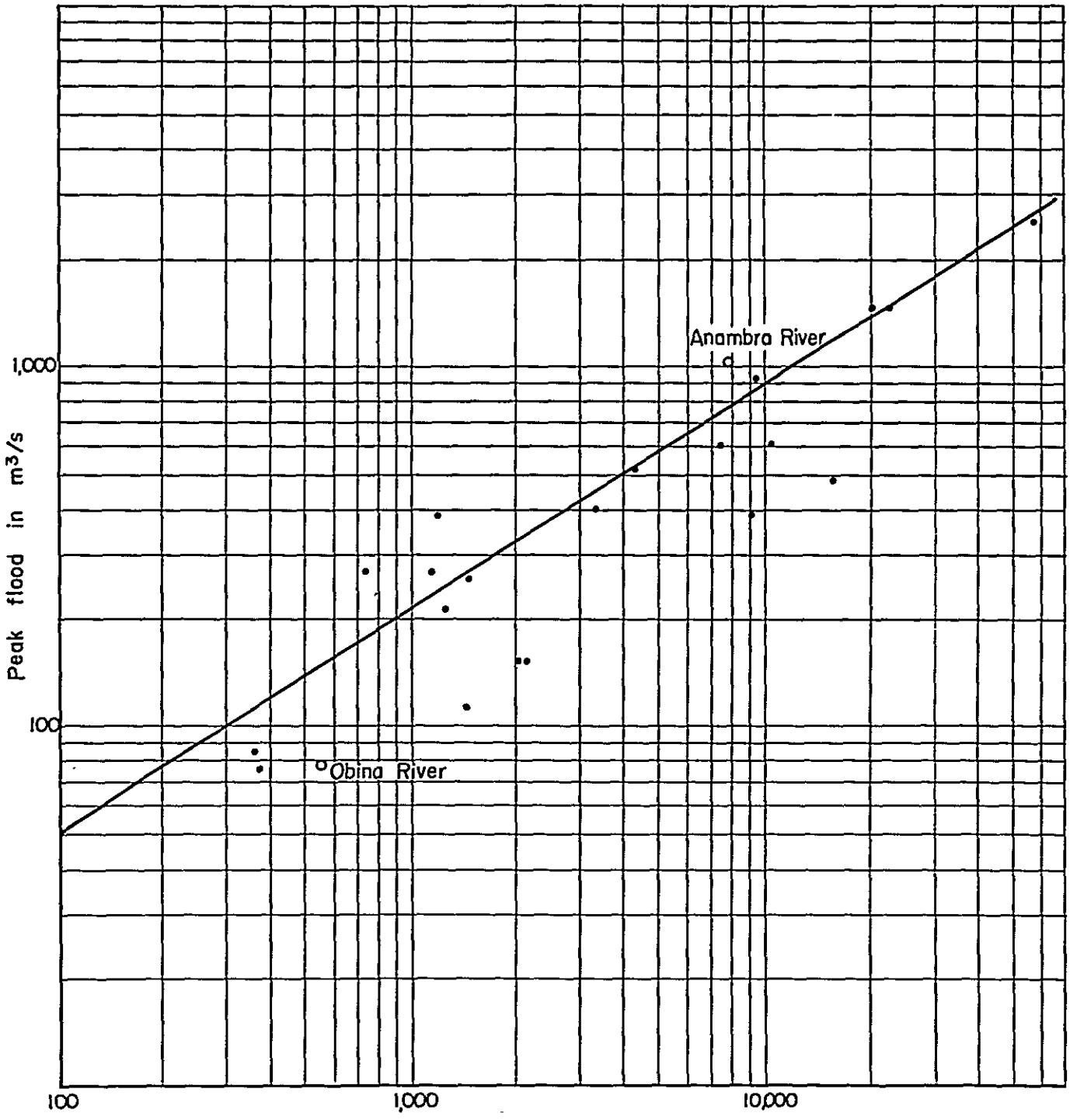
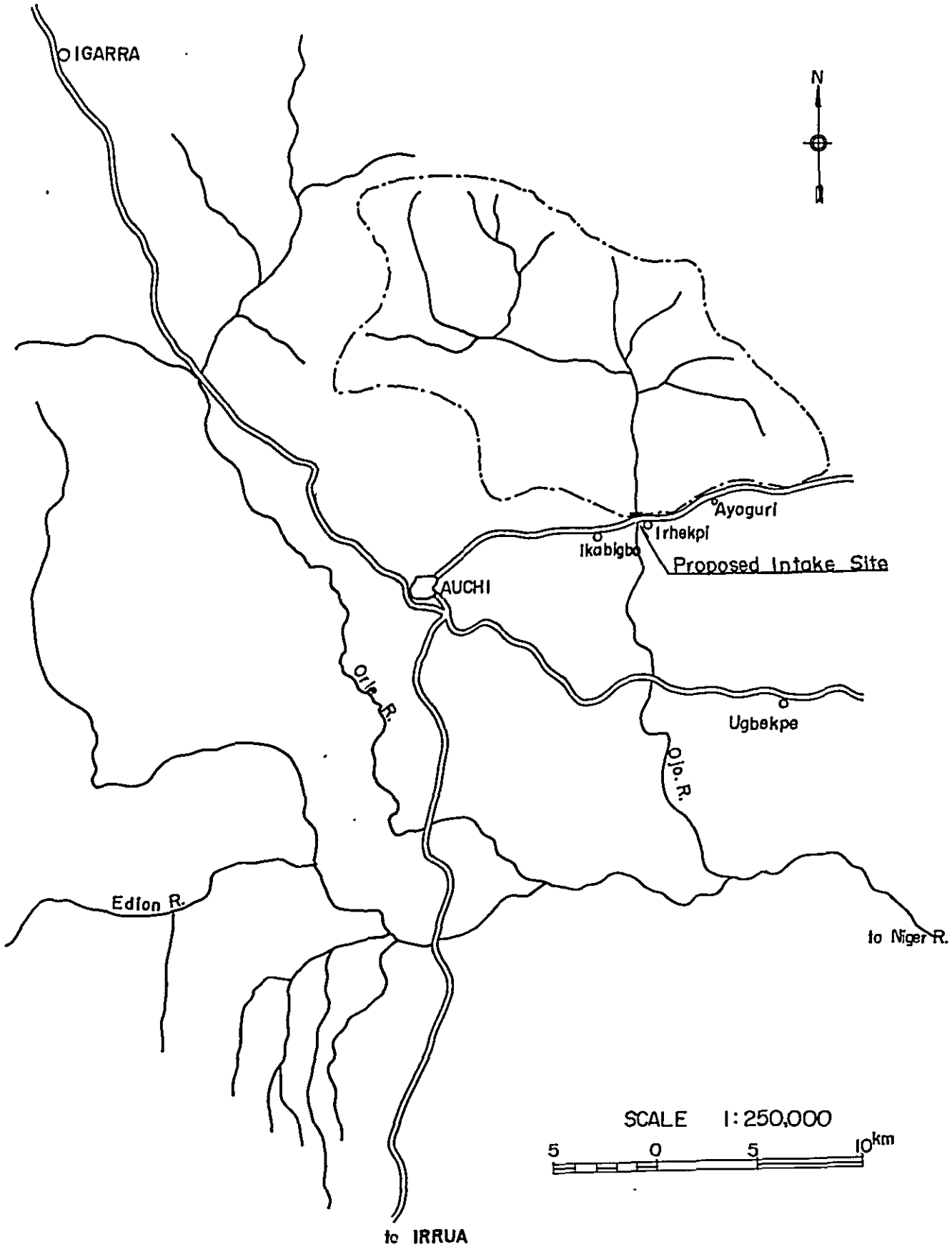


Fig.2.9 Orle - Edion River Basin



3. SOIL AND GEOLOGY

3.1 Soil and Land Capability

3.1.1 Introduction

The soil study in Nigeria has been carried out on a large scale by D'Hoore, J.L. and other soil scientists as follows.

(1) D'Hoore, J.L: Soil Map of Africa 1 to 5,000,000, Explanatory Monograph, C.C.T.A: Lagos, 1964.

(2) Soil Survey Unit of Ministry of Agriculture (Commission for Technical Co-operation in Africa) Eastern Nigeria: Eastern Nigeria Soils with a scale of 1: 2,000,000, 1963.

(3) E.N. Mgbemena: Some soil of the coastal sand area of eastern Nigeria. Soil Survey Bulletin No. 1 Soil Survey Unit, Federal Department of Agriculture, UMUDIKE, 1975.

(4) E.N. Mgbemena: Report on the advisory soil survey at NKALAGU/ EZILLO State Farm.
Soil Survey Bulletin No. 2. Soil Survey Unit Federal Department of Agriculture, UMUDIKE, 1975.

They have established a C.C.T.A system of classification for Nigeria. Their survey covers the soils in the Bendel state and Imo state, however, it does not sufficiently reach to our project areas. For this reason, the soil survey of this present survey aims at identifying major soil groups and their distribution and at examining the adaptability of each soil for the proposed irrigated rice development project, refering to the said soil maps.
This chapter presents the procedure of the survey, descriptions on the main features of the major soils, and new soil maps and land capability maps.

3.1.2 Procedure of Soil Survey

The field survey was carried out over the area of about 4,600 ha of the Owerri Project and about 6,000 ha of the Auchi Project areas by using the topography map of 1/50,000 scale. The soil profiles were observed in pits dug at the rate of one per 250 ha and described according to the standards defined in the Soil Survey Mannual of the United States Department of Agriculture. Some of them were modified, however, in compliance with recent experiences of soil study in Japan. The pits were dug to a depth of about one meter.

33 pits were dug out and 10 soil samples were taken in total from the representative soil horizons.

These soil samples were sent to the Nigeria University of Nsukka to be analized. The items checked at the analysis were PH value, total carbon, nitrogen, cation exchange capacity, exchangeable base (Ca, Kg, K, Na), available P_2O_5, particle size distribution analysis, specific gravity. The results are shown in Table 3.1 and 3.2, respectively.

3.1.3 Soil Classification and Main Features of the Major Soils

Most soils prevalent in the project area have much been weathered through lateritic soil formation process under tropical climatic condition, topographical condition, parent materials, and vegetation.

In the light of the morphological characteristics and the results of laboratory tests, soils in the Auchi area are classified into four great soil groups, namely, Latosols, Lateritic Soils with plinthite, Alluvial Soils, and Regosols. On the other hand, soils in the Owerri area is classified into Latosols of the great soil group, only.

Latosols of the Auchi area are further divided into two Soil Types, Loamy Soil Type and Clay Loam Soil Type.
On the other hand, Latosols of the Owerri area are divided into two Soil Types, namely, Sandy Loam Soil Type and Loamy Soil Type.

Latosols (Auchi Area)

The Latosols mainly extend over the northern part of the surveyed area, topographically, on the mild hilly region.

Total area of the Latosols is 4,230 ha equivalent to 68.6% of the surveyed area.

The horizon sequence of the Latosols soil is A1/A3/B1/B2, in general.

These soil have characteristic of dark color (7.5 YR 4/6 to 2.5Y 4/6) in surface soil and are red color (10R 4/6 to 10R 3/6) in subsoil. The structure of the A horizon is granular structure or weakly developed crumb structure. The B horizon has weakly developed subangular blocky structure and the structure becomes coarse blockly according to the soil depth. The texture of the soil is clay loam to loamy throughout the profile.

As far as chemical and physical properties are concerned, PH values range between 5.5 and 6.7 for H_2O and between 4.2 and 6.7 for N-KCl solution. But the PH values show low values in the B horizon of the soils. Cation exchange capacity shows about 12 milligrams equivalent per 100 grams of soils throughout the profile. The exchangeable base content is so low that base saturation degree shows low degree and its value decreases with depth.

The humus content is relatively low and shows 0.6% to 1.3% of the surface soil. The specific gravity shows 2.3 to 2.6 throughout the profile.

Latosols of the Auchi area are further divided into two Soil Types, Loamy Soil Type and Loamy and Clay Loam Soil Type depending on texture throughout the profile. The permeability of soil is different for each of these types.

The soils of Loamy Soil Type group cover an area of 3,970 ha equivalent to 64.4% of the total surveyed area of the Auchi area.

A typical profile of Loamy Soil Type observed at Egboto and Ugbekpe is shown in Table 3.3 and 3.4.

The soils of Clay Loam Soil Type group cover an area 260 ha equivalent to 4.2% of the surveyed area of the Auchi area.

A typical profile of Clay Loam Soil Type observed at Ugbekpe is described in Table 3.5.

Latosols (Owerri area)

Soils of the Owerri area extend over quite gently sloping land on the coastal plain. The coastal plain sands of parent material is formed of a group of grey gritty clays and coarse, angular and pebbly, current-bedded sands. They are the youngest bed.

Soils of the Owerri area is classified into Latosols of great soil group, only. Total area of the Latosols is 4,600 ha equivalent to 100% of the surveyed area of the Owerri area.

The sequence of these soil is A1/A3/B1/B2, in general. A horizon (surface soil) is dark reddish brown to dull reddish brown (5YR 3/3 to 2.5YR 4/4). The structure of A horizon is weakly developed granular structure to crumb structure. The color of B horizon (subsoil) is reddish brown (5YR 4/6 to 5YR 4/8), in general. The structure of B horizon (subsoil) is weakly developed granular structure or subangular blocky structure.

With regard to chemical and physical properties, soils of this group have PH values ranging between 4.1 and 5.0 for H_2O and between 3.5 and 3.9 for N-KCl solution throughout the profile. But PH shows lower values, where the CaO content is low. The PH values are lower than that of Latosols of the Auchi area. The cation exchange capacity is very low ranging from 7.8 to 19.0 milli-equivalent per 100 grams of soil. The base saturation degree shows less than 10%, where the exchangeable base shows very low values. The humus content on the surface soil (A horizon) is about 2.0% which decreases in proportion to depth. The specific gravity shows about 2.4.

These Latosols are further divided into two soil types, Sandy Loam Soil Type and Loamy Soil Type according to the texture of the profile.

The soils of the Loamy Soil Type extend over mainly central part between the Otamiri river and the Oramirukwa river.

Total area of Sandy Loam Soil Type is 2,300 ha or 50% of the total surveyed area of the Owerri area.

The typical profile of these Latosols, Sandy Loam Soil Type observed at Obeke, Eziobo and Ihiagwa is described in Table 3.6, 3.7 and 3.8.

On the other hand, total area of Loamy Soil Type is 2,300 ha equivalent to 50% of the total surveyed area of the Owerri area.

The typical profile of Loamy Soil Type observed at Okolochi and Umuikeo is described in Table 3.9 and 3.10.

Latosols of both project areas are classified into Oxisol Orthox according to 7th approximation of U.S.D.A.

Most of these soils are used at present for shifting farming and forest. The effective solum of these soils is very deep.

In the light of soil features, Latosols are suitable for the irrigated rice development agriculture under the proper farming practices including application of chemical fertilizers and manure, especially, proper application of nitrogen and phosphate fertilizers, proper irrigation and drainage system.

Lateritic Soil with Plinthite

Lateritic Soil with Plinthite is formed in the lowland in the Auchi area along small streams which have high groundwater table in the wet season.

One of the most important factors in the formation of these soils is the seasonal saturation with water. Due to the poor water absorbing capacity as a consequence of the sandiness and shallowness of the soil, the soils are saturated with water in the wet season. The conditions are similar to those of pseudo-gley formation, a process which is thought to be transitional stage in plinthite formation.

Lateritic soil with plinthite is classified into Oxisol Aquox according to 7th approximation of U.S.D.A.

The soils of this group cover an area of 1,440 ha, equivalent to 23.4% of the total surveyed area of the Auchi area.

The horizon sequence of this soils is A1/A3/Bg/Cim. in general.

The thickness of A horizon is about 40cm. A horizon is brown to orange (7.5YR4/3 to 7.5YR6/6). The structure of A horizon is medium developed to crumb or subangular blocky structure. The B horizon

has medium developed subangular blocky structure.
The B horizon which has iron mottling is bright brown (7.5YR 5/8) clay. Also many manganese concretions are found in this horizon. The C horizon is plinthite horizon due to iron and manganese concretion.

With regard to chemical and physical properties, soil of this group have PH value between 7.2 and 5.3 for H_2O and between 3.7 and 6.5 for N-KCl throughout the soil profile. A_1 horizon shows high value of 7.2 for H_2O and 6.5 for N-KCl only. The cation exchange capacity throughout the profile shows between 17.4 and 25.4 milligram equivalent per 100 grams of soils. The base saturation degree shows low value between 12 and 28%. The humus content of A horizon shows about 2.5% and its value decreases with depth. The specific gravity is between 2.25 and 2.39.

In the light of these soil features, Lateritic Soil with Plinthite have no agricultural potentiality for the irrigated rice development agriculture.

A typical profile of Lateritic Soil with plinthite observed at Ugbekpe in the Auchi area is described in Table 3.11.

Alluvial Soil

The soils of this group extend over the low land in the Auchi area below about EL 60m and formed of fluvial deposits along the river. In general, Alluvial Soil extening over the southern part of the surveyed area has developed from alluviums overlying sandy material.

Alluvial Soils is classified into Entisol Fluvent according to 7th approximation of U.S.D.A.

Generally this soil is in mature with no morphological characteristics. The sequence of this soil is A1-1/A1-2/C.

The thickness of A horizon is about 20cm in general. A horizon (surface soil) is brownish black to reddish gray (10YR 3/2 to 2.5YR 4/1). The soil texture is sandy throughout the profile. The structure is weakly developed consisting of granular structure throughout the profile.

As far as chemical and physical properties are concerned, the PH values range between 5.5 and 6.4 in H_2O and between 4.4 and 5.9 in N-KCl solution. The content of humus is relatively low and shows about 1% for the surface soil. Cation exchange capacity shows between 13.9 and 15.4 milligram equivalent per 100 grams of soils. The base saturation degree shows medium degree of about 30% for surface soil and its value decreases with depth. The specific gravity shows between 2.30 and 2.62.

This soil is featured by high infiltration and high permeability owing to sandy texture throughout the profile.

In the light of soil features, Alluvial Soil is moderately suitable to the irrigated rice development agriculture under the proper farming practices including application of chemical fertilizers and manure, proper irrigation and drainage system, and provisions of proper counter measures against high infiltration and high permeability.

The typical profile of this Alluvial Soil is shown in Table 3.12.

Regosol

Regosol is observed to exist on the bank of the Ojo river in the Auchi area. Regosol is classified into Inceptisol Ochrept according to 7th Approximation of U.S.D.A. The soils of this group cover an area of 490 ha, equivalent to 8.0% of the total surveyed area of the Auchi area.

The horizon sequence of this soil is A1-1/A1-2/C1/C2, in general.

The thickness of A horizon is about 30cm. C horizon is formed of gravel material of Mesozoic (Upper cretaceous) sand stone. A horizon is dull brown to bright reddish brown (7.5YR 5/4 5YR 5/6). The structure of A horizon (surface) is weakly developed to subangular blocky structure. C horizon is non texture and structureless, consisting only of gravel horizon.

Owing to these features, Regosol has no agricultural potentiability for the irrigated rice development agriculture. The typical profile of this Regosol is described in Table 3.13.

3.1.4 Land Capability

Based on the result of the soil survey and topography survey, the land in the project area is classified into four classes, namely, I, II, III and IV in accordance with modified classification of the standard of the Ministry of Agriculture and Forestry in Japan.

Class I. Very Suitable for Irrigated Rice Farming

Land that is suitable for rice paddy without the necessity of special developement for management practices. This soil has no special limitations or hazards.
This land extends over the area of Latosols of the Auchi area and Latosol Sandy Loam Soil Type of the Owerri area. The land of this class occupies 4,230 ha or 68.8% of the surveyed area of Auchi and 2,300 ha or 50% of the surveyed area of Owerri.

Class II. Suitable for Irrigated Rice Farming

Land is suitable for rice paddy with the application of simple but special development and management practices.

This has moderate hazards and limitations.
This land develops over the area of Latosols, Sandy Loam Soil Type of the Owerri area occupying 2,300 ha or 50% of the surveyed area.

Class III. Moderately Suitable for Irrigated Rice Farming

Land that is suitable for rice paddy but needs application of special development and management practices. This land is liable to servere hazards and limitations. The land of this class extends over the area of Alluvial Soil. This land is excluded from the project area.

Class IV. Unsuitable for Irrigated Rice Farming

Land that is of limited or questionable suitability for paddy because of very severe hazards, limitations and quite difficult special management practices. This land extends over the area of Lateritic Soil with plinthite and Regosol. The land of this class occupies 1,930 ha or 31.4% of the surveyed area of the Auchi area.

3.2 Geology

3.2.1 General

Amidst the stable shield of Paleozoic to Pre-Cambrian metamorphic rocks in the middle-southern part of Nigeria, develops two belts of Cretaceous sedimentary facies, i.e. the Benue Trough trending northeast to southwest nearly along the Benue river and the Middle Niger Basin trending northwest to southeast along the River Niger in the part upstream from the confluence of the Benue river. These two belts join in the north of Enugu and stretch south toward the coastal plain developing around the downstream Niger river. The Cretaceous formations, consisting of sandstones and shales, mildly dip southwards being covered in the southern area by thick Tertiary deposits, i.e. the Imo Shale Group, the Bende Ameki Group where sand predominates, and the Coastal Plain Sand, in chronological order and in the order of distribution of the exposures from north to south.

3.2.2 Geology in the Owerri Area

The Owerri Project area is situated among the extensive zone of the Coastal Plain Sands, which are composed of reddish brown unconsolidated sandy loam of Oligocene-Pleistocene. Permeability of the sandy loam is estimated to be within the order of 10^{-4} in cm/sec. In the proposed intake weir site on the Oramirukwa river, a wide marshy alluvial bed with about 180 m of width is formed in a flat valley. The alluvial deposits consists of, from the surface downwards, (1) 1.35 m thick grey soft mud, (2) 0.6 m thick grey dense sandy loam and (3) underlying sand which is dense and coarser to the lower part. The sandy loam in the item (2) is deemed to have enough strength for foundation of low earth embankment. The sand in (3) at about 2 m of depth will be usable as foundation for the low concrete structure, in which the expected allowable bearing strength is estimated approximately 8 ton/m^2. On the other hand, the sand being highly pervious, a protective measure against leakage such as blanket work is necessary. However, the existing coverings of less pervious sandy loam and mud are deemed to have fairly good blanket effect if rise of water level is kept within only a few meters. Care should be taken not to disturb those coverings in the course of construction work. Generally it should be noticed that high damming-up will imply abrupt increase of cost because the problem of foundation stability and leakage becomes so severe that far deeper foundation will have to be looked for. The geological profile of the intake weir site is illustrated in Fig. 3.5.

3.2.3 Geology in the Auchi Area

The Auchi Project area is situated on an east-west trending belt of the upper Cretaceous Coal Measures, which are composed of thick cross-bedded sandstones and shales. On the northern boundary about 7 km north from Auchi, these sedimentary rocks are terminated abutting on the exposures of quartzbiotite schists, gneiss and granites of the Basement Complex. On the other hand, those sedimentary rocks are covered by the Tertiary Imo Shale Group in the area more than 7 km south from Auchi. The proposed intake weir site on the Ojo river is located in the shale zone of the upper Cretaceous Coal Measures. Depth of foundation rock is approximately 1 to 1.5 m under the river bed and within 4 m on the slopes on both banks. Stiff clay, which is the product from weathering of shale, existing on the right slope covered by thin talus and the sandy loam on the left slope can be used as foundation of a low earth embankment, with about 1.5 m of excavation. Concrete structure should be placed on the foundation rock. The sandy loam on the left bank is deemed usable for embankment material. The geological profile of the intake weir site is illustrated in Fig. 3.6.

Table 3.1 Results of Soil Analysis
(Owerri Area)

Description	Origin	Specific Gravity	Mechanical Analysis				pH		ORG. Matter			Exchangeable Bases						
			% Clay	% Silt	% F.S.	% C.S.	H_2O	KCl	% C	% O.M.	% N	Na me	K me	Ca me	Mg me	CEC me	% SAT.	Kg P/hectare
OWERRI NO.	2 - 1	2.43	10	4	20	66	5.0	3.6	1.20	2.07	.116	.15	.10	0.3	0.1	14.7	2	94.6
" "	2	2.34	12	2	20	66	4.3	3.9	.66	1.14	.066	.18	.12	0.1	0.1	11.5	3	143.4
" "	3	2.48	16	4	19	61	4.8	3.9	.33	.57	.035	.13	.08	0.2	0.1	7.8	7	168.8
" "	4	2.43	18	2	20	60	4.8	3.9	.27	.47	.028	.11	.06	0.2	0.2	9.9	9	129.4
" "	3 - 1	2.43	10	6	18	66	4.3	3.7	1.11	1.91	.104	.13	.10	0.7	0.2	13.1	9	159.0
" "	2	2.40	14	6	19	61	4.3	3.8	.69	1.19	.060	.14	.08	0.5	0.4	14.9	8	168.8
" "	3	2.54	20	2	20	58	4.5	3.9	.42	.72	.042	.12	.06	0.3	0.4	14.8	5	168.8
" "	4	2.36	20	6	16	58	4.5	3.8	.27	.47	.031	.14	.10	0.5	0.2	12.3	8	134.0
OWERRI NO	7 - 1	2.38	10	10	18	62	4.8	3.9	1.20	2.07	.111	.15	.14	1.5	0.1	19.0	10	104.4
" "	2	2.30	14	2	21	63	4.3	3.8	.75	1.29	.071	.16	.13	0.7	0.5	15.9	9	204.0
" "	3	2.45	20	4	12	64	4.7	3.5	.66	1.14	.053	.15	.12	0.5	0.5	13.5	9	99.5
OWERRI NO	9 - 1	2.44	6	6	16	72	4.1	3.6	.87	1.50	.118	.15	.12	0.6	0.1	12.6	8	164.2
" "	2	2.69	12	4	19	65	4.3	3.8	.54	.93	.053	.14	.10	0.6	0.1	18.7	-	139.3
" "	3	2.44	18	2	17	63	4.6	3.8	.36	.62	.038	.16	.12	0.5	-	-	-	154.3
" "	4	2.44	20	2	15	63	4.7	3.9	.24	.41	.028	.20	.13	0.5	0.2	10.2	10	114.5
OWERRI NO	12 - 1	2.48	10	6	14	70	4.2	3.5	.84	1.45	.067	.15	.08	0.5	0.1	16.3	5	154.3
" "	2	2.51	14	2	22	62	4.5	3.7	.69	1.19	.062	.17	.10	0.5	0.3	14.9	7	129.4
" "	3	2.53	16	2	15	67	4.6	3.8	.36	0.62	.034	.14	.08	0.4	0.1	11.1	6	159.0
" "	4	2.53	20	2	18	60	4.5	3.8	.30	.52	.032	.15	.08	0.6	0.2	10.9	9	238.9

Table 3.2 Results of Soil Analysis
(Auchi Area)

Description		Origin	Specific Gravity	Mechanical Analysis				pH		ORG. Matter			Exchangeable Bases						
				% Clay	% Silt	% F.S.	% C.S.	H_2O	KCl	% C	% O.M.	% N	Na me	K me	Ca me	Mg me	CEC me	% SAT.	Kg P/hectare
AUCHI	NO	10 - 1	2.59	2	2	50	46	6.4	5.9	0.54	.93	.061	0.10	.16	3.0	1.6	15.4	32	65.0
"	"	2	2.62	2	2	55	41	5.5	4.5	.30	..52	.018	.07	.06	0.4	0.2	10.9	7	49.7
"	"	3	2.30	2	2	52	44	5.5	4.4	.15	.26	.012	.08	.06	0.3	0.5	13.9	7	14.9
	NO	13 - 1	2.60	10	2	64	24	6.7	6.1	.42	.72	.090	.16	.27	5.4	1.7	13.7	55	139.3
"	"	2	2.55	10	2	51	37	6.3	5.6	.33	.57	.046	.09	.08	1.9	1.9	10.5	38	114.5
"	"	3	2.60	34	6	34	26	5.7	4.4	.24	.41	.041	.08	.08	1.5	1.2	12.1	24	139.3
"	"	4	2.46	32	6	32	30	5.5	4.3	-	-	-	.09	.08	1.4	0.9	11.6	21	154.3
"	"	15 - 1	2.36	12	2	43	43	5.8	5.2	.60	1.031	.064	.12	.15	2.7	1.1	12.1	34	154.3
"	"	2	2.53	10	2	44	44	5.9	5.1	.33	.57	.027	.17	.10	0.7	0.1	5.2	21	114.5
"	"	3	2.35	36	10	32	26.	5.6	4.4	.15	.26	.045	.21	.12	1.0	0.7	12.7	16	104.4
"	"	4	2.41	38	10	27	25	5.5	4.2	.18	.31	.025	.15	.12	0.8	1.0	15.6	13	104.4
"	NO	18 - 1	2.54	12	0	48	40	6.1	5.6	1.14	1.97	.078	.14	.17	2.0	1.1	17.3	20	104.4
"	"	2	2.38	20	8	34	38	4.8	3.8	.24	.41	.034	.09	.06	0.1	0.5	11.4	16	49.7
"	"	3	2.40	24	8	37	31	4.8	3.9	.15	.26	.032	.14	.10	0.2	0.7	10.8	11	154.3
"	"	4	2.30	36	6	30	26	5.0	4.3	.18	.31	.032	.15	.08	0.9	0.9	15.7	13	179.2
"	NO	19 - 1	2.39	26	20	37	17	7.2	6.5	1.50	2.59	.137	.22	.58	3.5	2.6	25.0	28	228.6
"	"	2	2.39	32	18	38	12	5.3	3.7	.33	.57	.083	.18	.12	0.5	1.3	18.0	12	124.3
"	"	3	2.36	34	28	41	7	5.5	3.9	.24	.41	.042	.21	.13	0.3	2.1	18.2	15	139.3
"	"	4	2.25	30	12	28	30	5.5	3.9	.18	.31	.031	.23	.12	0.5	2.1	17.4	17	143.4

Table 3.3 Descriptions on Typical Profile of Loamy Soil Type (1)

a) Profile Number: No.13 (Auchi)

b) High Category Classification: Latosol, Loamy Soil Type
(Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 3 February, 1977

d) Location: 2 km east from Egbeto

e) Topography and Elevation: Undulated, 95 m

f) Land Use: Secondary bush

g) Parent material: Weathering material of Mesozoic (Upper Cretaceous) sand stone and shale

h) Drainage: Good Drainage

Profile Description

A_1 0 - 10 cm	Brown (7.5YR 4/6), loamy; little humus contents; granular structure; many fine roots; non sticky, non plastic; slightly loose; (Hardness 26); boundary diffuse.
A_3 10 - 24 cm	Dull reddish brown (5YR 4/4), loamy; weakly developed granular structure; non sticky, non plastic; (Hardness 29) boundary slightly clear.
B_1 24 - 50 cm	Red (10YR 4/6), loamy to clay loam; weakly developed subangular blocky structure; when dry slightly sticky and plastic; (hardness 29); boundary slightly clear.
B_2 50 - 115cm +	Red (10R 4/8), loamy to clay loam; weakly developed subangular blocky structure; when dry slightly sticky and plastic; when wet strongly sticky and plastic.

Table 3.4 Descriptions on Typical Profile of Loamy Soil Type (2)

a) Profile Number: No.15 (Auchi)

b) High Category Classification: Latosl, Loamy Soil Type
(Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 3 February, 1977

d) Location: 1.5 km west from Ugbekpe

e) Topography and Elevation: Flat, 90 m

f) Land Use: Secondary bush

g) Parent Material: Weathering material of Mesozoic (Upper Cretaceous) sand stone and shale

h) Drainage: Good Drainage

Profile Description

A_1	0 - 15 cm	Dull reddish brown (5YR 4/4), loamy; little humus contents; many fine roots; weakly developed crumb structure; slightly loose; non sticky, non plastic; (Hardness 25); boundary diffuse.
A_3	15 - 32 cm	Reddish brown (2.5YR 4/6), loamy; weakly developed granular structure; non sticky, non plastic; (Hardness 25); boundary slightly clear.
B_1	32 - 68 cm	Red (10YR 4/6), loamy to clay loam; weakly developed subangular blocky structure; slightly sticky and plastic; (Hardness 29); boundary diffuse.
B_2	68 - 110 cm +	Dark red (10R 3/6), loamy to clay loam; developed subangular blocky structure; when dry slightly sticky and plastic; when wet strongly sticky and plastic; (Hardness 26).

Table 3.5 Descriptions on Typical Profile of Clay Loam Soil Type

a) Profile Number: No.18 (Auchi)

b) High Category Classification: Latosol, Clay Loam Soil Type
(Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 5 February, 1977

d) Location: 2.5 km south from Ugbekpe

e) Topography and Elevation: Flat, 65 m

f) Land Use: Mariand plantation

g) Parent Material: Weathering material of Mesozoic (Upper Cretaceous) sand stone and shale

h) Drainage: Good Drainage

Profile Description

A_1	0 - 13 cm	Dark brown (7.5YR 3/3), clay loam; medium humus contents; many fine roots; loose; porous; non sticky, non plastic; (Hardness 15); boundary clear.
A_3	13 - 30 cm	Dull reddish brown (5YR 5/4), clay loam; granular structure; many fine roots; slightly compact; (Hardness 29); boundary slightly clear.
B_1	30 - 50 cm	Reddish brown (5YR 4/6), clay loam; weakly developed subangular blocky structure; slightly compact; when dry non sticky and plastic; (Hardness 32); boundary diffuse.
B_2	50 - 110 cm +	Reddish brown (2.5YR 4/8), clay loam; developed subangular blocky structure; when wet strongly sticky and plastic; very compact; (Hardness 33).

Table 3.6 Descriptions on Typical Profile of Sandy Loam Soil Type (1)

a) Profile Number: No.2 (Owerri)

b) High Category Classification: Latosol, Sandy Loam Soil Type (Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 13 January, 1977

d) Location: 2.5 km south from Obebe

e) Topography and Elevation: Undulated, 64 m

f) Land use: Secondary bush

g) Parent Material: Weathering material of coastal plain sand

h) Drainage: Good Drainage

Profile Description

A_1 0 - 16 cm	Dark reddish brown (5YR 3/3), sandy loam; medium humus contents; weakly developed granular to crumb structure; non sticky, non plastic; many fine roots; loose; (Hardness 10); boundary diffuse.
A_3 16 - 32 cm	Dark reddish brown (5YR 3/4), sandy loam; granular structure; slightly loose; non sticky, non plastic; (Hardness 20); boundary slightly clear.
B_1 32 - 62 cm	Reddish brown (5YR 4/6) sandy loam; granular structure; slightly compact; non sticky, non plastic; (Hardness 23); boundary diffuse.
B_2 62 - 135 cm +	Reddish brown (5YR 4/8), sandy loam; granular structure; very compact; non sticky, non plastic; (Hardness 30).

Table 3.7 Descriptions on Typical Profile of Sandy Loam Soil Type (2)

a) Profile Number: No.9 (Owerri)

b) High Category Classification: Latosol, Sandy Loam Soil Type (Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 8 January, 1977

d) Location: 2 km south from Eziobo

e) Topography and Elevation: Flat. 56 m

f) Land use: Secondary bush (Main UBUBA Shrub)

g) Parent Material: Weathering material of coastal plain sand

h) Drainage: Good Drainage

Profile Description

A_1 0 - 14 cm	Dull reddish brown (25YR 4/4), sandy loam; developed granular structure; many fine roots; loose; non sticky, non plastic; (Hardness 16); boundary diffuse.
A_3 14 - 29 cm	Bright reddish brown (5YR 5/6), sandy loam; developed granular structure; slightly loose; non sticky, non plastic; (Hardness 14); boundary slightly clear.
B_1 29 - 52 cm	Reddish brown (2.5YR 4/6), sandy loam; developed granular structure; medium compact; non sticky, non plastic; (Hardness 22); boundary diffuse.
B_2 52 - 140 cm +	Reddish brown (2.5YR 4/8), sandy loam; developed granular structure; non sticky, non plastic; compact; (Hardness 27).

Table 3.8 Descriptions on Typical Profile of Sandy Loam Soil Type (3)

a) Profile Number: No.12 (Owerri)

b) High Category Classification: Latosol Sandy Loam Soil Type (Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 7 January, 1977

d) Location: 1 km east from Ihiagwa

e) Topography and Elevation: Flat, 66 m

f) Land use: Secondary bush

g) Parent Material: Weathering material of coastal plain sand

h) Drainage: Good Drainage

Profile Description

A_1 0 - 12 cm	Dark reddish brown (5YR 3/3), sandy loam; medium humus contents; weakly developed crumb structure; loose; non sticky, non plastic; (Hardness 8); boundary diffuse.
A_3 12 - 30 cm	Reddish brown (5YR 4/8), sandy loam; developed granular structure; slightly loose; non sticky, non plastic, (Hardness 18); boundary slightly clear.
B_1 30 - 60 cm	Reddish brown (2.5YR 4/6), sandy loam; developed granular structure; slightly compact; non sticky, non plastic; (Hardness 27); boundary diffuse.
B_2 60 - 120 cm +	Reddish brown (2.5YR 4/8), sandy loam; developed granular structure; compact; when dry non sticky and plastic; (Hardness 27).

Table 3.9 Descriptions on Typical Profile of Loamy Soil Type (1)

a) Profile Number: No.13 (Owerri)

b) High Category Classification: Latosol Loamy Soil Type (Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 14 January, 1977

d) Location: 3.5 km east from Okolochi

e) Topography and Elevation: Flat, 63 m

f) Land use: Secondary bush

g) Parent Material: Weathering material of coastal plain sand.

h) Drainage: Good Drainage

Profile Description

A_1	0 - 16 cm	Dark reddish brown (5YR 3/4), loamy, little humus contents; weakly developed crumb structure; slightly loose; non sticky, non plastic; many fine roots; boundary diffuse.
A_3	16 - 34 cm	Reddish brown (5YR 4/6), loamy; weakly developed granular structure; slightly loose; non sticky, non plastic; (Hardness 24); boundary slightly clear.
B_1	34 - 60 cm	Bright reddish brown (5YR 5/8), loamy; weakly developed granular structure; slightly compact; non sticky, non plastic; (Hardness 29); boundary diffuse.
B_2	60 - 150 cm +	Reddish brown (2.5YR 4/6), loamy; developed granular structure; non sticky, non plastic; slightly compact; (Hardness 28).

Table 3.10 Descriptions on Typical Profile of Loamy Soil Type (2)

a) Profile Number: No.7 (Owerri)

b) High Category Classification: Latosol Loamy Soil Type
(Probably Oxisol Orthox in revised 7th Approximation)

c) Date of Examination: 8 January, 1977

d) Location: 4 km west from Umuskea

e) Topography and Elevation: Flat, 54 m

f) Land use: Secondary bush

g) Parent material Weathering material of coast plain sand

h) Drainage: Good Drainage

Profile Description

A_1 0 - 13 cm	Dark reddish brown (5YR 3/3), sandy loam; medium humus contents; granular structure; many fine roots; loose; non sticky, non plastic; (Hardness 10); boundary diffuse.
A_3 13 - 28 cm	Dark reddish brown (5YR 3/4), sandy loam; granular structure; slightly loose; non sticky, non plastic; (Hardness 12); boundary slightly clear.
B_1 28 - 56 cm	Reddish brown (2.5YR 4/6), sandy loam to loam; granular structure; slightly compact; non sticky, non plastic; (Hardness 25); boundary diffuse.
B_2 56 - 120 cm +	Dark reddish brown (2.5YR 3/6), sandy loam to loamy; weakly developed subangular blocky structure; slightly sticky and plastic; compact.

Table 3.11 Descriptions on Typical Profile of Lateritic Soil with Plinthite

a) Profile Number: No.19 (Auchi)

b) High Category Classification: Lateritic Soil with Plinthite (Probably Oxisol Aquox in revised 7th Approximation)

c) Date of Examination: 6 February, 1977

d) Location: 3.25 km south from Ugbekpe

e) Topography and Elevation: Plat, 60 m

f) Land use: Secondary bush

g) Parent Material: Weathering material of Mesozoic (Upper Creataceous) sand stone and shale

g) Drainge: Good Drainage

Profile Description

A_1 0 - 15 cm	Brown (7.5YR 4/3), clay loam to clay; developed crumb structure; many fine roots; slightly compact; when wet strongly sticky and plastics (Hardness 33); boundary diffuse.
A_3 15 - 42 cm	Orenge (7.5YR 6/6), clay; weakly developed subangular blocky structure; developed mottles (iron and manganese); medium sticky and plastic; (Hardness 31); boundary diffuse.
B_g 42 - 80 cm	Dull brown (7.5YR 6/3), clay; gleisation; strongly developed mottles (bright brown 7.5YR 5/8, iron and manganese); developed subangular blocky structure; medium sticky and plastic; (Hardness 28); boundary sharply clear.
C_{im}80 - 120cm +	Dull reddish brown (2.5YR 4/4); plinthite horizon

Table 3.12 Descriptions on Typical Profile of Alluvial Soil

a) Profile Number: No.10 (Auchi)

b) High Category Classification: Alluvial Soil
(Probably Entisol Fluvent in revised 7th Approximation)

c) Date of Examination: 5 January, 1977

d) Location: 1 km east from Odame

e) Topography and Elevation: Flat, 60 m

f) Land use: Secondary bush, Compared of apare grass (Gumba, Enphatoevm)

g) Parent Material: Recent alluvial deposits (sand)

h) Drainage: Good Drainage when dry season

Profile Description

A_{1-1}	0 - 11 cm	Brownish black (10YR 2/3), sandy; medium humus content; granular structure; non sticky, non plastic; very loose; many fine roots; (Hardness 14); boundary diffuse.
A_{1-2}	11 - 24 cm	Reddish gray (2.5YR 4/1), sandy; little humus content; granular structure; very loose; non sticky, non plastic; (Hardness 17); boundary diffuse.
C	24 - 100 cm +	Grayish yellow brown (10YR 6/2), sandy; granular structure; weakly developed iron mottles; (Hardness 15)

Table 3.13 Description on Typical Profile of Regosol

a) Profile Number: No.12 (Auchi)

b) High Category Classification: Regosol
(Probably Inceptisol Ochrept in revised 7th Approximation)

c) Date of Examination: 2 February, 1977

e) Topography and Elevation: Flat to undulated. 95 m

f) Land use: Secondary bush but under cocoa plantation

g) Parent Material: Mesozoic (Upper Cretaceous) sand stone and shale

h) Drainage: Good Drainage

Profile Description

A_{1-1}	0 ~ 17 cm	Dull brown (7.5YR 5/4), loamy; weakly developed subangular blocky structure; many fine roots; non sticky, non plastic; (Hardness 19); boundary diffuse.
A_{1-2}	17 - 32 cm	Bright reddish brown (5YR 5/6), loamy, weakly developed subangular blocky structure; non sticky, non plastic (Hardness 177; boundary clear.
C_1	37 - 72 cm	Orange (5YR 6/6), gravel horizon ; non texture, structureless; gravel of sand stone (diameter 5 - 6 cm); Very compact: (Hardness 27 cm); boundary no clear
C_2	72 - 120 cm +	Orange (5YR 6/8), gravel horizon; gravel of sand stone (diameter 2 - 5 cm); very hard; (Hardness 28).

Fig. 3.1 Soil Map of the Owerri Project Area

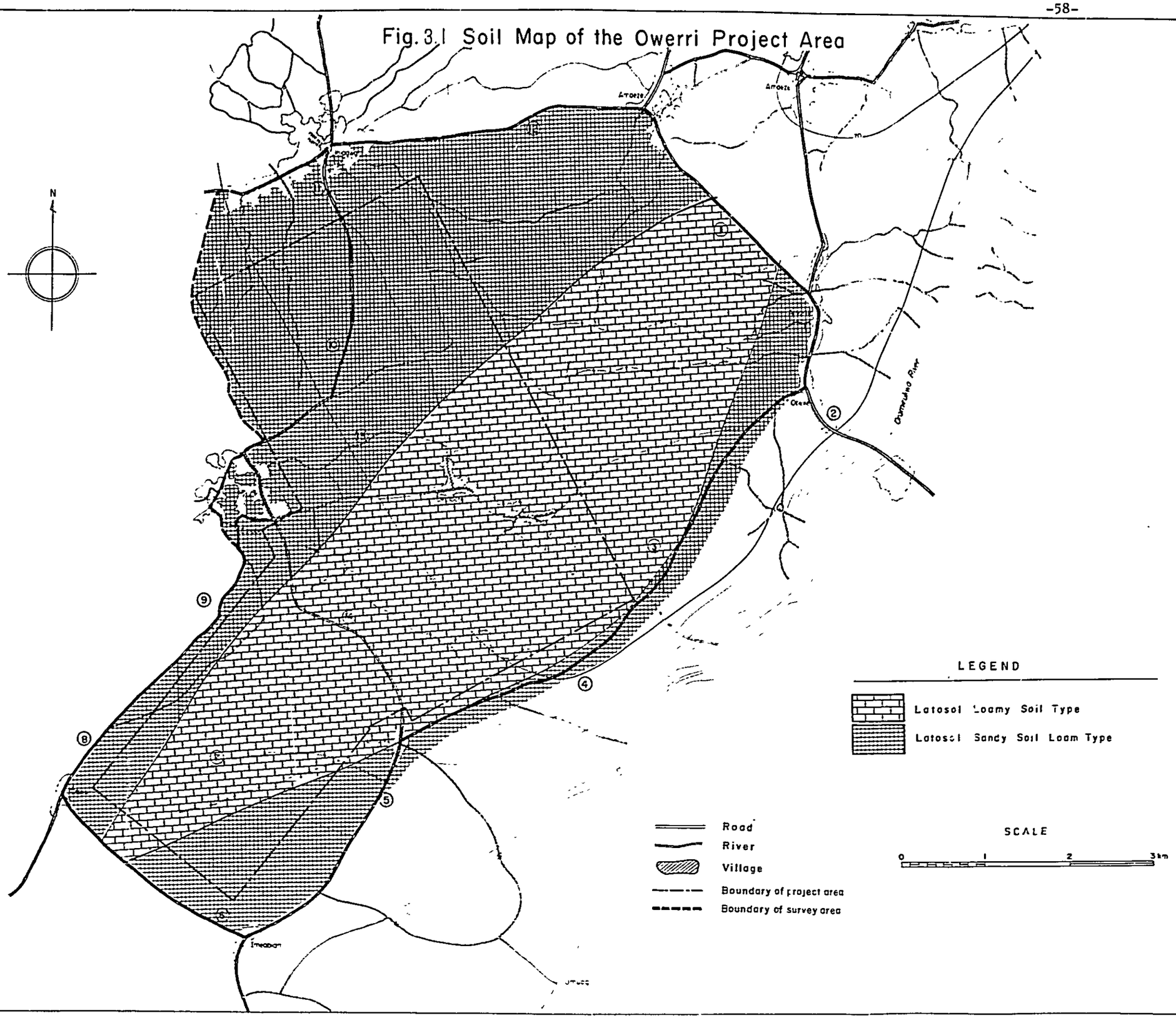


Fig. 3.2 Soil Map of the Auchi Project Area

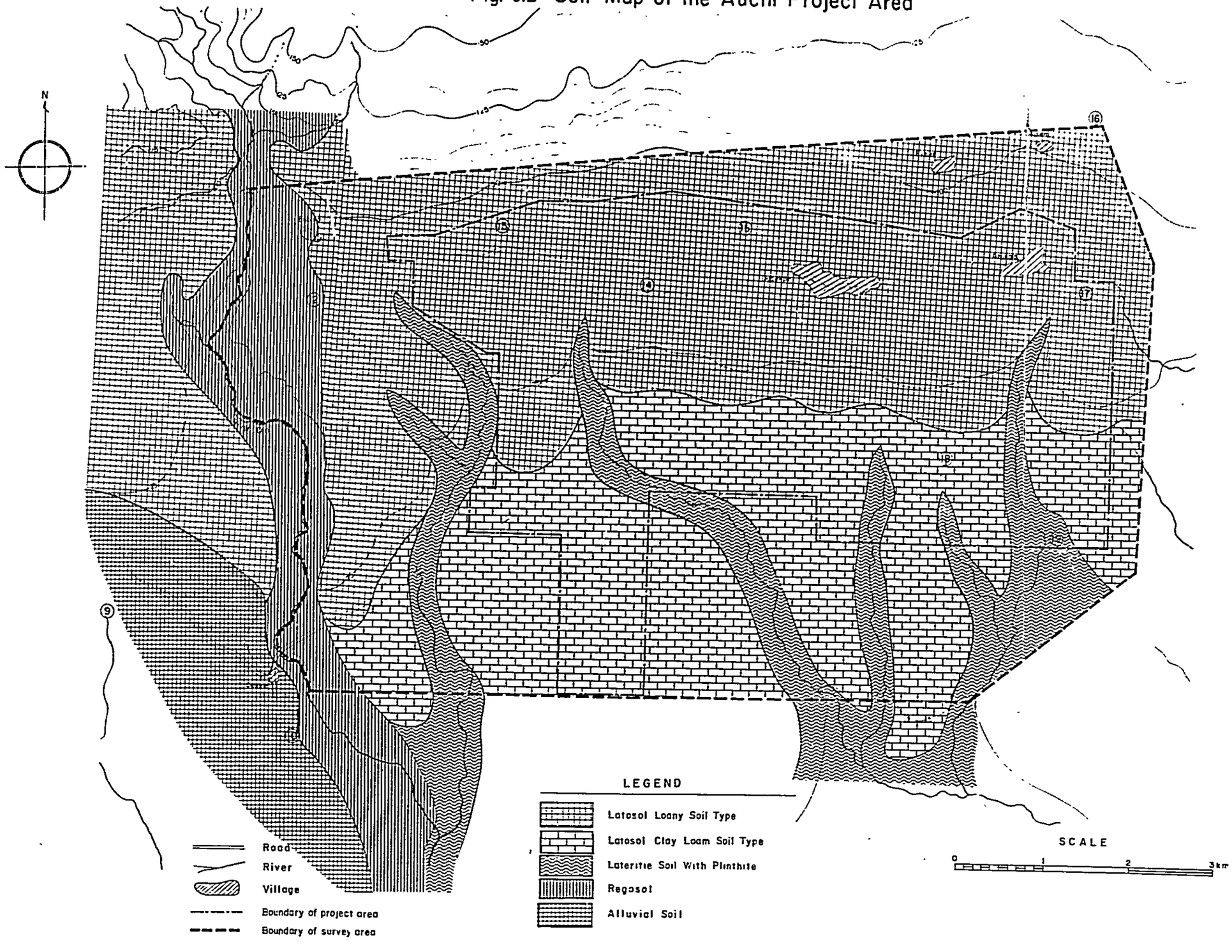


Fig. 3.3 Land Capability Map in the Owerri Project Area

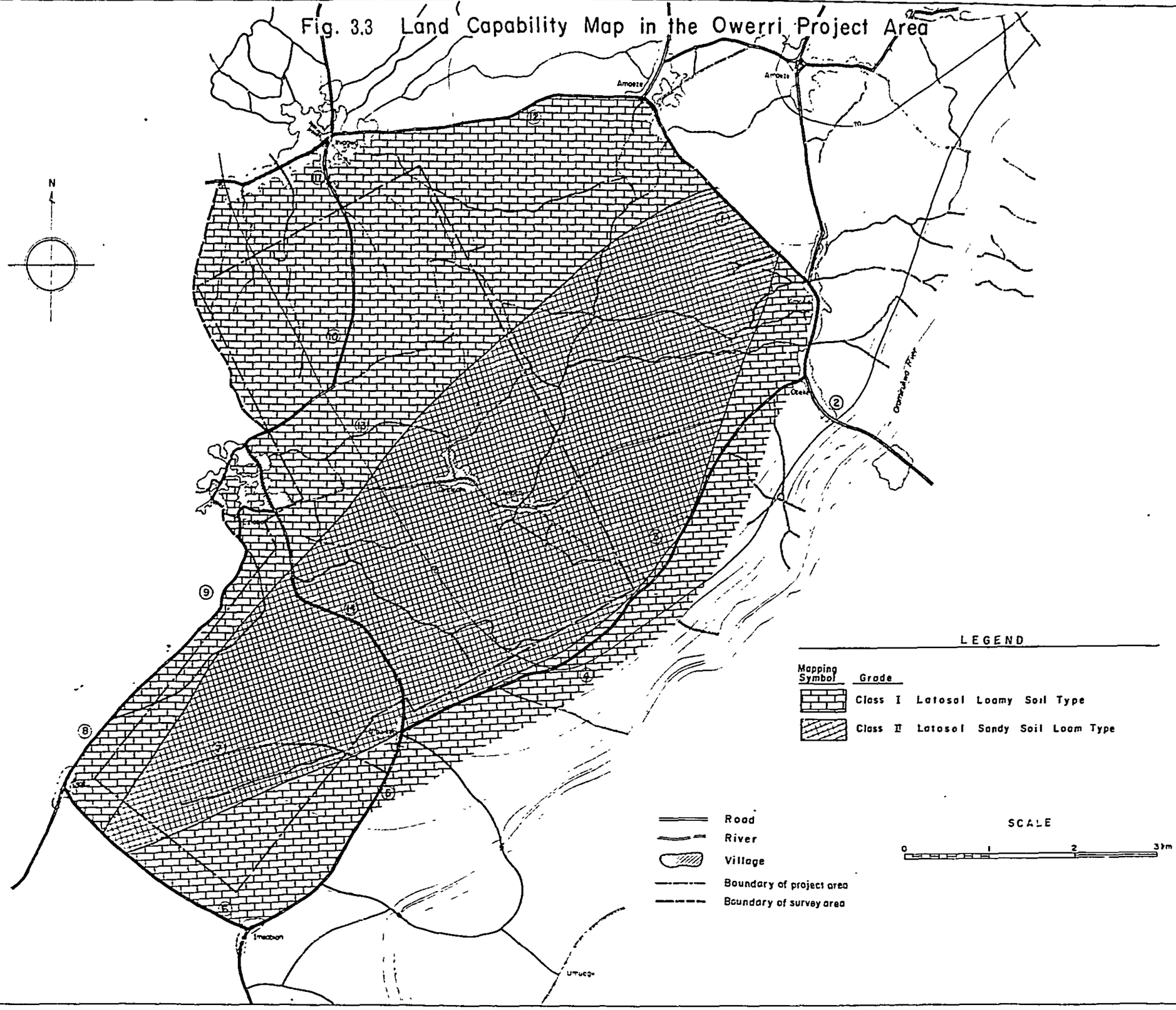
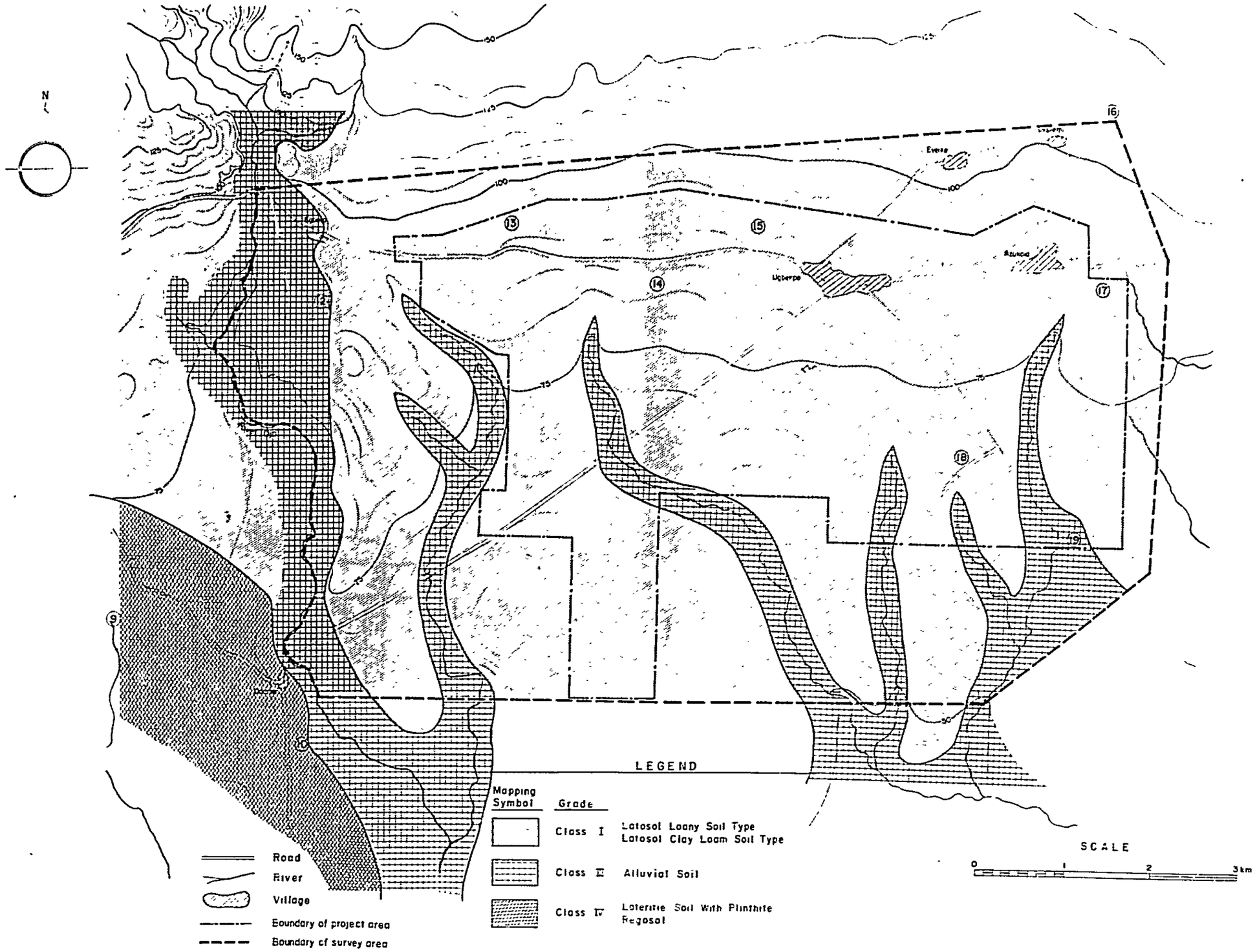


Fig. 3.4 Land Capability Map in the Auchi Project Area



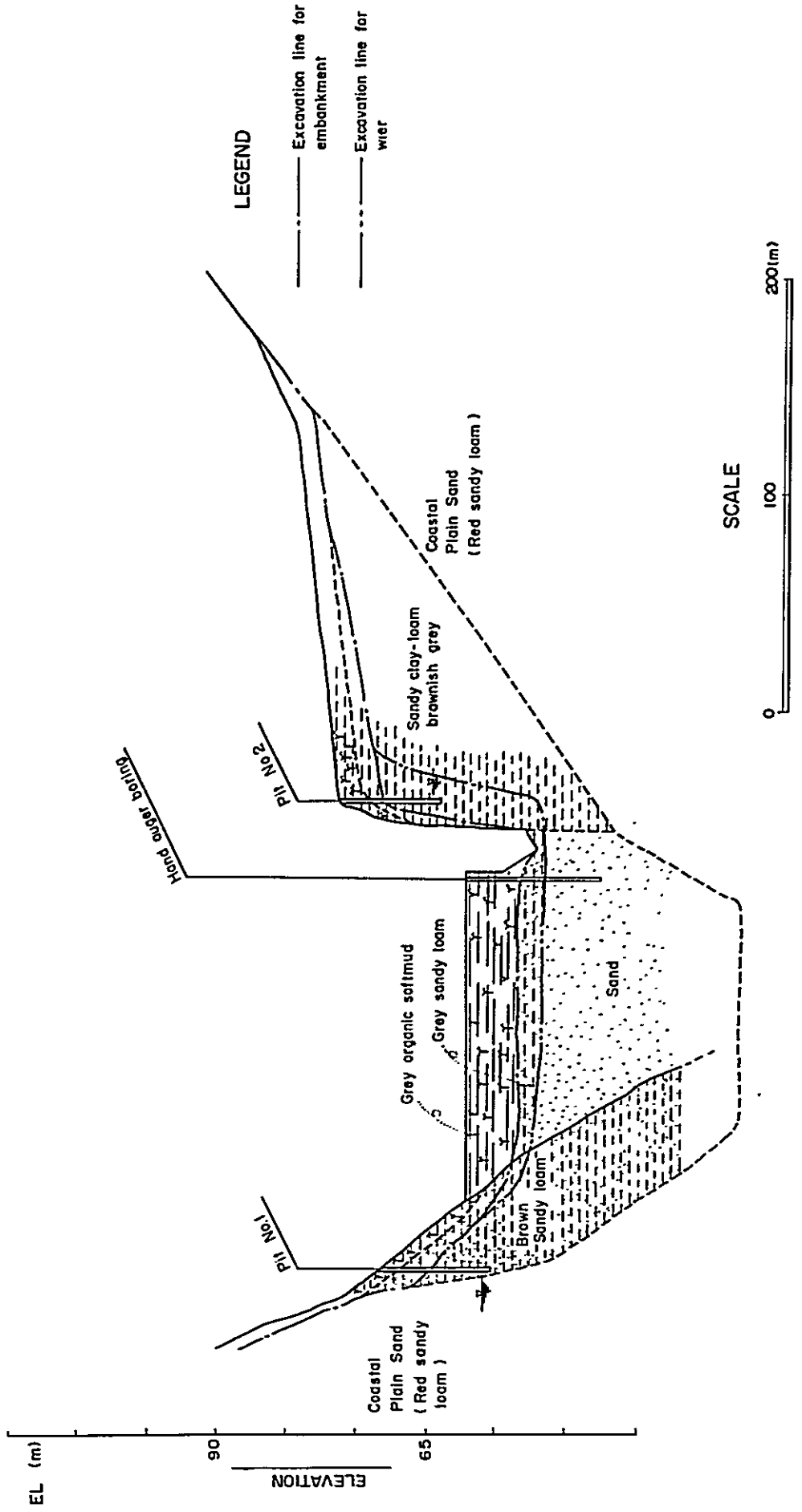
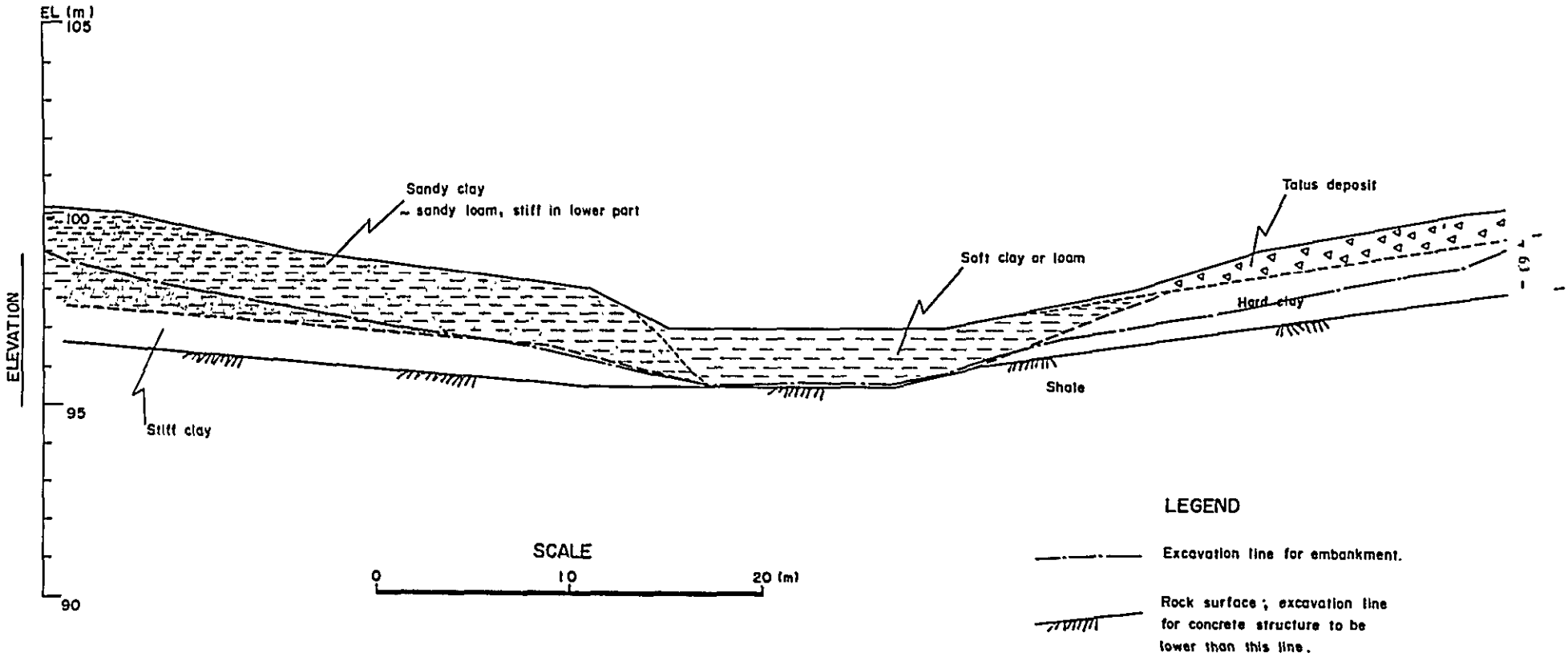


Fig.3.5 Geological Profile of the Intake Site for Owerri

Fig.3.6 Geological Profile of the Intake Site for Auchi



4. PRESENT AGRICULTURAL SETTING

4.1 Socio-Economic Background

The Owerri Project area is located in the south-western corner of the Imo State about 10 km south of Owerri, capital city of the State. The project area covers the land of about 2,600 ha extending south-west between the Oramirukwa river and Otamiri river. To the north of the area Federal highway A-6 runs from Owerri to Aba and further to Port Harcourt. Near the southern boundary of the area, there exists state border with the adjacent state of Rivers State.

The Owerri Project area is relatively densely populated area. The population including 6 villages in the project or adjacent to project is about 6,400 with its population density of 250 per km^2. Agriculture is the mainstay of the local economy and about 90% of the working population is estimated to be engaged in agricultural production.

With respect to land tenure system, most of the land are held by the community or the kindred and privately owned land is quite limited. According to the farm survey conducted during our recent survey, about 70% of the land is owned by the kindred and around 20% by the community while residual some 10% is held by private. The land is allocated to member farmers every season depending on their capabilities. Average farm size in the Owerri Project area is about 1.0 ha. Their farm lands are generally fragmented and different plots are widely scattered.

The Auchi Project area is situated in the northern part of the Bendel State about 20 km east of Auchi, capital city of the Estsako Local Government Area of the State. From the Benin City, capital of the State, the project area is located with the distance of about 70 km. The project area covers the land of about 2,850 ha situated in the east bank of the Ojo river, one of the tributaries of the Orle river. The area is relatively flat bounded by the hilly plateau to the north and lowland inundated annually by the flood of the Orle river to the south. In the northern part of the area, there runs a provincial road from west to east connecting Auchi to Agnebode with a distance of 45 km.

The area is sparsely polulated compared with the Owerri Project area. Total population of the area is about 2,000 with the population density of 70 per km^2. The population is centered around the northern area along the provincial road and there is no residential quarters in the south. As in case of the Owerri Project area, most of the working population are engaged in agriculture.

All the land in the Auchi Project area is held by the community excepting very limited area of private holding for farmers' living quarters. Allocation of the land for agricultural production is made each crop season by the community. The size of the allocated land is determined depending on their capacities. Average farm size is relatively large and about 1.5 ha of the land is cultivated by one farm family. Land fragmentation is the characteristic of the land tenure system in the area and the distance from one plot to one plot for one-farmer can be 3 to 4 km.

4.2 Land Use

The present land use in the Owerri and the Auchi Project areas is estimated on the basis of aerophotos and field survey. Results of the survey are summarized into the following table and Fig. 4.1 to Fig. 4.2.

Land Categories	Owerri Project Area		Auchi Project Area	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
1) Village, roads and other non-agricultural land	30	1	30	1
2) Cultivated land	720	28	220	10
3) Scrub and grassland	1,460	56	660	21
4) Light forest	390	15	1,940	68
Total	2,600	100	2,850	100

Owerri Project Area

The Owerri Project area is well developed area in terms of agricultural production with its favourable topographical condition and abundant working population. In the area, about 84% is allocated for the land for shifting cultivation, 15% is allocated for light forest and the residual 1% is allocated for non-agricultural land such as villages and roads.

The light forest area surrounds the villages and is located around Okolochi village and east part of Eziobo village. The forest consists of mainly palm tree supplemented by rubber and other citrus trees. The density of the forest is not so high.

The area for villages is very small since most of the village compounds are excluded from the project area. The Okolochi village which is wholy included in the project area is situated in north-eastern part of the project area.

Out of 2,180 ha which is under shifting cultivation 720 ha or 28% of the total project area is now cultivated for agricultural production. Residual 1,460 ha or 56% of the project area remains fallow and now categorized into scrub and grassland. From the ratio of the cultivated land to the land in fallow, the interval of the shifting cultivation is estimated to be 3-year.

Main crops harvested in the cultivation area are cassava, yam, maize and cocoyam supplemented by vegetables such as melon and beans. Rice is not planted in the project area.

Auchi Project Area

The project area is less developed area in terms of the land use. Most of the area is covered with forest or light forest which occupies about 1,940 ha or 68% of the total area. For shifting cultivation about 880 ha is allocated in which 220 ha is now cultivated for agricultural production and other 660 ha remains fallow. Villages, roads and other non-agricultural land dominates 30 ha or only 1% of the project area.

As illustrated in Fig. 4.2, southern part of the area is covered with forest, density of which is relatively high in the Auchi area. The villages are found only along the provincial road located in the northern part of the project area. The land used for shifting cultivation is located western part of Ugbekpe village and around Azukala and Ugbekpe villages. The interval of the shifting cultivation is estimated at 4-year from the present land use map.

Major crops cultivated in the project area are rice, cassava, yam and maize supplemented by beans, potatoes and vegetables.

4.3 Cropping Pattern and Farming Practices

Shifting cultivation is a common practice both in the Owerri and Auchi Project areas for maintaining soil fertility with the fallow period of 3 to 4 years. Method of cultivation is essentially traditional from the stage of land preparation, planting to harvesting. Except the usage of cutlass and hoe no agricultural machines or tools are applied for agricultural production. Furthermore, animal power is generally not available in the project areas due to tsetse fly and other diseases and all the works are carried out by manpower.

Mixed cropping is the predominant cultivation system in both areas with root crops such as yam, cassava and cocoyam being grown on raised mounds and other crops (mainly maize) planted on the

side of or between the mounds. Rice is generally planted as a sole crop.

As shown in Fig. 4.3 to Fig. 4.4, cropping callendar of the Owerri Project area is almost same as that of the Auchi Project area. But, the seeding time for yam and cassava is slightly earlier (one to two months) in the Owerri Project area than that in the Auchi Project area due to the different cultivation condition. Main features of the crops and the farming practices are explained below.

Cassava

Cassava is an important food crop grown throughout the Owerri and the Auchi Project areas. The root of cassava is used for human food and utilized mainly as "garri" by grating, fermentation and frying. The cultivation become more popular and the production has increased due to easiness of the cultivation on any type of soil condition and relatively low labor requirement.

Varieties: Main varieties cultivated in the project areas are local varieties such as Nwangoye, Okotorowa, Udukanana, Okupon, Karagba and Dalejoro. Improved varieties such as 60447, 53101 and 60506 are partly planted.

Cultivation method: Cassava is cultivated under the mixed cropping with yam and maize. The spacing is generally 0.7 - 1.5 m^2 per stand. In the Owerri Project area cassava is planted from May to July and harvested from April to October in the next year. Total growth period spans from 11 months to 18 months. In the Auchi Project area, it is planted from April to May and harvested during the months between March and August in the next year. Total growth period is about 11 month to 17 months.

Farm inputs: Seedlings are planted with the rates of 9,000 stalks per hectare both in the Owerri and the Auchi project areas. Fertilizer and agro-chemicals are not applied generally. Labour requirement for the cultivation is estimated at about 210 man-days per hectare.

Yam

Yam is another most important crop as food-stuff in the two project areas. However, the crop is decreasing in its importance mainly due to the decreasing soil fertility, much labor requirement and high transport cost. Yam is cultivated in rich soils and the cultivation requires well-drained heavy loam and about 1,000 to 1,800 mm of annual rainfall. Much of the products are consumed by the farmers family with some residuals finding the outlet in the local markets.

Varieties: Main species cultivated in the project areas are White yam, Water yam, Yellow yam, Trifoliate yam and Aerial yam.

Cultivation method: Yams are generally intercropped with maize and cassava. The spacing is 0.7 - 1.5 m^2 per stand and 0.4 - 0.6 m^2 for seed production. Seed yam is usually planted in mounds on the newly cleared soil and sometimes in ridges. In the Owerri Project area, yam is planted from March to April and harvested from September to December. Total growth period spans from about 6 months to 7 months. In the Auchi project area, it is planted from January to March and harvested from July to November. Total growth period is usually from 6 months to 8 months.

Farm inputs: Seed rate is about 2,700 kg/ha both in the Owerri and the Auchi project areas. Fertilizer and agro-chemicals are not applied generally. Labour requirement for the cultivation is about 480 man-days per hectare.

Rice

Rice is planted in the alluvial plains in the Niger and Benue river basins. While there is no cultivation of rice in the Owerri Project area, rice is largely grown in the Auchi Project area located in the Etsako Division, which is noted for rice growing area in Bendel State. Mainly upland rice is cultivated as a principal cash crop for farmers in the area.

Varieties: Major varieties cultivated in the project area are local varieties such as Agbede-short, Agbede-long and Ekpoma and OS-6 as improved varieties.

Cultivation method: Rice is generally planted as a sole crop in the Auchi Project area. The cultivation method is dependent on the onset of the rainy season and seeding period fluctuates from year to year. In the normal year, rice is planted at the beginning of the rainy season from the middle of March to the end of May and harvested from the early of August to the middle of October. The Seeding method is "direct sowing", and the harvesting is carried out by ear plucking by hand. Total growth period is about 4.5 months.

Farm inputs: Seed rate is about 50 kg/ha. Application of fertilizer and agro-chemicals is quite limited. Labour requirement for the cultivation is about 220 man-days/ha at present level.

Maize

Maize is a common crop which is cultivated by almost every farmer in the project areas although it is very small quantities. Maize is often planted under mixed cropping with yam, cassava and sometimes rice. Most of the product is for domestic use and consumed almost entirely by the farmers family.

Varieties: Main varieties used are Western yellow, FARZ 6 (Diacol) and FARZ 23 as the improved varieties and Lagos white as the local variety.

Cultivation method: Maize is planted from the middle of March to the middle of May and harvested from the middle of July to the middle of September. Total growth period is about 4 months.

Farm inputs: The seed rate is about 23 kg/ha and the labour requirement is 100 man-days/ha. Fertilizer and agro-chemicals are not generally used.

Cocoyam

Cocoyam is generally planted under mixed cropping with other crops. Although cocoyam is commonly planted around farm house in the Owerri Project area, it is not popular in the Auchi Project area.

Varieties: The most popular varieties are Ede oyibo and Ede okporo.

Cultivation method: For the cultivation of cocoyams high humidity throughout growth period and good soil are required. It is planted from the middle of March to the middle of June and harvested from the end of October to the middle of January in the next year. The growth period is 7.5 months to 10 months.

Farm inputs: The seed rate is 1,000 kg/ha. Similar to cassava, yam, etc., fertilizer and agro-chemicals are not applied generally. The labour requirement is about 200 man-days/ha.

4.4 Agricultural Production

Unit yield and products

Unit yields for major food crops are estimated on the basis of the collected data from the regional agricultural offices, MANR and Federal Office of Statistics. The estimated yields are also studied and checked by the current farm survey. The results of the estimate are shown in Table 4.1 to Table 4.2.

The yields are generally low partly due to the application of unimproved varieties and partly due to lack of fertilizer application and plant protection against pests and diseases. The low yield is also attributable to uncontrolled water supply subject to uneven distribution of the rainfall.

Total products are 5,400 tons of cassava, 1,680 tons of yam, 192 tons of maize and 220 tons of cocoyam in the Owerri Project area while 900 tons of cassava, 292 tons of yam, 120 tons of rice and 77 tons of maize are produced in the Auchi Project area. Most of the food crops are produced mainly for self-consumption and about one quarter of the products are sold at the market.

Livestock

Livestock breeding is not popular both in the Owerri Project area and the Auchi Project area. Only a few small stocks such as sheep, goats and poultry are kept by most of the farmers mainly for their consumption. Since there is few large livestock such as cattle and horse in the project areas due to tsetse fly and other animal diseases, there is no integration of crop and livestock farming.

There are no reliable statistics on livestock holding in the project area but number of livestock held per farm family is estimated as follows:

No. of Livestock held per Farm Family

(Nos)

Kind of Livestocks	Owerri Project Area	Auchi Project Area
Fowls	18.6	16.1
Pig	0.5	2.2
Goat	3.1	2.1
Sheep	-	2.2

Source: "Report on Rural Economic Survey 1973/74" Government of East Central State, Nigeria
"Report of An Agricultural Sample Survey of the Midwestern State of Nigeria 1969/1970" Ministry of Economic Development and Reconstruction.

4.5 Farm Economy

The farm economy both in the Owerri Project area and the Auchi Project area is, in general, based on root and cereal crops with supplementary income derived from tree crops. As mentioned in the preceding section, agricultural production is directed mainly to self-consumption of farmers and some surplus is sold at the market.

Average farm size is about 1.0 ha and 1.5 ha for the Owerri Project area and the Auchi Project area respectively. The size of the farm family is 6 to 7 persons in the Owerri and the Auchi Project areas in which about 3 adults are included. Agricultural production is a task mainly for men except for cassava production, which is cultivated by woman.

On the basis of the results of the farm survey, farm budgets in the two project areas are prepared for a typical farmer holding 1.0 ha and 1.5 ha as shown in Table 4.3 to Table 4.4. Comments on the farm economy are briefly made as follows.

Gross income

Gross incomes of typical farmer in the Owerri and the Auchi project areas are estimated at ₦883 and ₦1,116 respectively. Farmers get their incomes mainly from farming activities which produce cassava, yam, maize, rice, cocoyam and tree crops. In terms of contribution to the gross income, cassava and yam are the important source for the farmers both in the Owerri and the Auchi project areas. But, taking into account the volume consumed by farmers themselves, most of the cash incomes are gained from yam and maize in the Owerri Project area, while yam and rice are the main cash income in the Auchi Project area. In addition, farmers get their income from selling tree crops such as palm oil, citrus and vegetables, which amounts to ₦65 and ₦95 for the Owerri Project area and the Auchi Project area respectively.

There is some opportunity for getting incomes from non-farm activity such as off-farm labor and trade, but these incomes are negligibly small in both areas and excluded in the budgets.

Gross outgo

Farming expenses are estimated at ₦88 and ₦183 for the Owerri Project area and the Auchi Project area respectively. The expenses consist of the cost for seed and, hired labour charge. The farming expenses account for about 11-18% of the gross income gained from the food crops.

Living expenses include the cost for food and other costs such as clothes, education, health and daily consumption goods etc. In the calculation of living expenses, family consumption of the self-produced products are costed at current prices.

Living expenses of the typical farmer in the Owerri and the Auchi project areas are estimated at ₦781 and ₦841 respectively. High ratio of food expenditure to total living expenditure is a characteristic of the consumption pattern both in the Owerri and the Auchi Project areas.

Net reserve

Net reserves of the typical farmer are estimated at ₦14 and ₦92 respectively as shown in the typical farm budget. The net reserves are negligibly small, which indicates that the agricultural production in the project areas is mainly for self-consumption and the farm economy is on the subsistence level.

4.6 Marketing and Institutions

4.6.1 Marketing and Processing

Marketable surplus of the food crops is brought to the local market by farmers. The local markets exist in most of the village and are opened daily, every four days or every eight days depending on the volume of traded goods. Most of the food crops are traded in the form of raw materials except cassava which is graded by grating machine and sold mainly in the form of grain. Rice is sold both in the form of paddy and milled rice. For getting milled rice, paddy is, in general, parboiled and milled at privately owned mills.

Major export crops such as palm oil, cocoa and coffee are purchased by the Marketing Board which is responsible for collecting these crops through the Licenced Buying Agents at the fixed prices. The agricultural products produced under the sponsorship of the state are purchased and processed by Agricultural Development Corporation (ADC) in Imo State and by Bendel Food Production Board in Bendel State.

With respect to processing facilities, there are a few cassava grating machines in each village in both project areas. Two private rice mills with very limited processing capacity exist in the Auchi Project area, while no rice mill in the Owerri Project area. Most of the agricultural products produced by farmers are storaged in and around farmer's house and there is no special storage facilities in the project areas.

Marketing and processing facilities are barely sufficient for present production in the project areas, but improvement of processing and storage facilities is required for stabilizing prices of agricultural products and raising farm income.

4.6.2 Agricultural Institutions

The Ministry of Agriculture and Natural Resources (MANR) of the states is responsible for agricultural development including forestry, fisheries and livestock. The Ministry of Works is responsible for civil works, while the Ministry of Trade, Industry and Cooperatives provides agricultural credit. Nigerian Agricultural Bank (NAB) is also in charge of providing agricultural credit for individual farmers and cooperative societies.

MANR is responsible for agricultural extension service and research. The extension services are being provided through the divisional Agricultural Officers (AO) of MANR, who are stationed at Local Government Agricultural Office, under whom, an Agricultural Superintendent (AS) is in charge of the extension service for each zone in the Local Government Area together with an Agricultural Assistant (AA). There are several Field Overseers (FO) who are engaged in daily contact with farmers for providing the services under the responsibility of AA.

There are about 13 extension workers (excluding FO) in the Owerri Local Government Area, Imo State, out of which one to two are presently engaged in the Owerri Project area. About 26 extension workers (including FO) are now in charge of the Etsako Division, Bendel State, of which two are involved in the Auchi Project area. Primary activity of the extension worker is to assist farmers to obtain inputs such as improved variety, fertilizer and chemicals and also to give an advisory services. However, the number of the extension worker is not sufficient and the extension services have not been satisfactory partly due to the shortage of staffs and finance both in the Owerri Project and the Auchi Project areas.

Various agricultural credit schemes have been introduced through MANR in collaboration with the Ministry of Trade, Industry and Cooperatives and NAB both in Imo State and Bendel State. But, most of them have not been operated successfully and little institutional credit has been utilized by farmers in the project areas partly because of poor management and partly because of insufficient financial resources.

Agricultural cooperative activity has been promoted by the Ministry of Trade, Industry and Cooperatives as well as MANR. In the project areas both in Imo and Bendel States, a few Farmers Multipurpose Cooperative Societies have been established on the village level. Actually, the ratio of the participation of farmers is very low; less than 5% of the farmers involved and the activity of the cooperatives is quite limited mainly for getting credit. This is caused by the present land tenure system and shortage of manpower and finance.

Table 4.1 Present Agricultural Production (Owerri Project Area)

Kind of Crops	Cultivated Area (ha)	Unit Yield (t/ha)	Products (t)
Cassava	720	7.5	5,400
Yam	240	7.0	1,680
Maize	320	0.6	192
Cocoyam	70	3.1	220
Others /1	110	-	-

Remarks: /1 Include melon, beans, vegetables, etc.

Table 4.2 Present Agricultural Production (Auchi Project Area)

Kind of Crops	Cultivated Area (ha)	Unit Yield (t/ha)	Products (t)
Cassava	120	7.5	900
Yam	40	7.3	292
Rice	100	1.2	120
Maize	70	1.1	77
Others /2	20	-	-

Remarks: /1 Include beans, groundnuts, potatoes, vegetable. etc.

Table 4.3 Present Typical Farm Budget
(Owerri Project Area)

	Cult. Area (ha)	Unit Yield (t/ha)	Total Yield (t)	Unit Price (₦/t)	Total Value (₦)
Average Farm Size		(1.0 ha)			
I. Gross Income					
1. Food Crops					
Cassava	0.8	7.5	6.64	63	418.32
Yam	0.2	7.0	1.40	232	324.80
Maize	0.3	0.6	0.18	184	33.12
Cocoyam	0.1	3.1	0.31	136	42.16
(Sub-total)					(818.40)
2. Tree crops and others					65
Total Gross Income					883.40
II. Gross Outgo					
1. Farming expenses					
Seed					52
Hired labor					36
(Sub-total)					(88)
2. Living expenses					
Food consumption /1					601
Other living expenses					180
(Sub-total)					(781)
Total Gross Outgo					869
III. Net Reserve					14.4

/1 Includes the value of the food crops which are produced by farmers themselves.

Table 4.4 Present Typical Farm Budget
(Auchi Project Area)

	Cult.Area (ha)	Unit Yield(t/ha)	Total Yield (t)	Unit Price(₦/t)	Total Value (₦)
Average Farm Size		(1.5 ha)			
I. Gross Income					
1. Gross Income					
Cassava	0.7	7.5	5.25	63	330.75
Yam	0.25	7.3	1.83	232	424.56
Paddy	0.5	1.2	0.6	308	184.8
Maize	0.4	1.1	0.44	184	80.96
(Sub-total)					(1,021.07)
2. Tree crops and others					95
Total Gross Income					1,116.07
II. Gross Outgo					
1. Farming expenses					
Seed					78
Hired labor					105
(Sub-total)					(183)
2. Living expenses					
Food consumption/1					647
Other living expenses					194
(Sub-total)					(841)
Total Outgo					1,024
III. Net Reserve					92.07

/1 Includes the value of the food crops which are produced by farmers themselves.

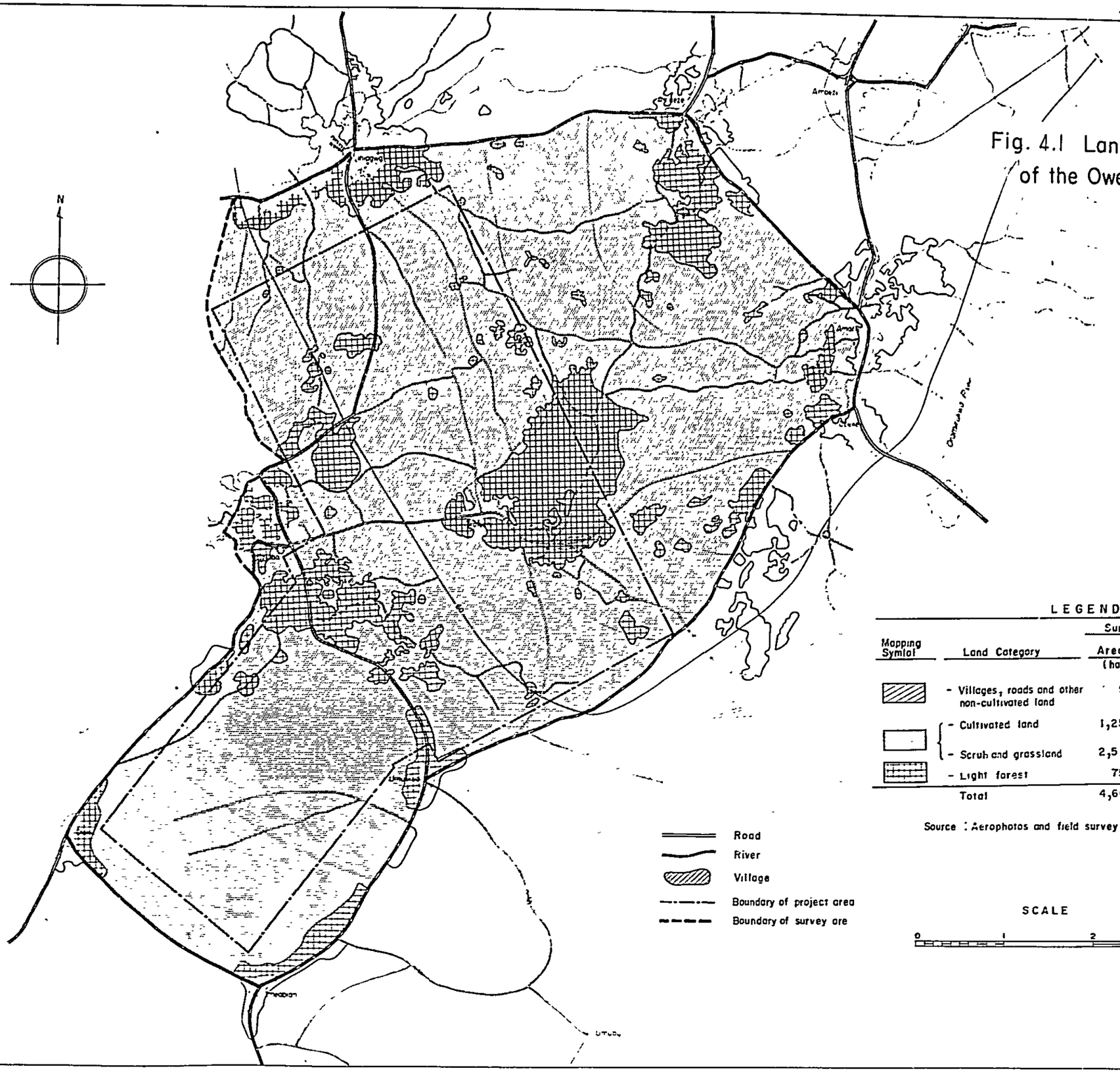


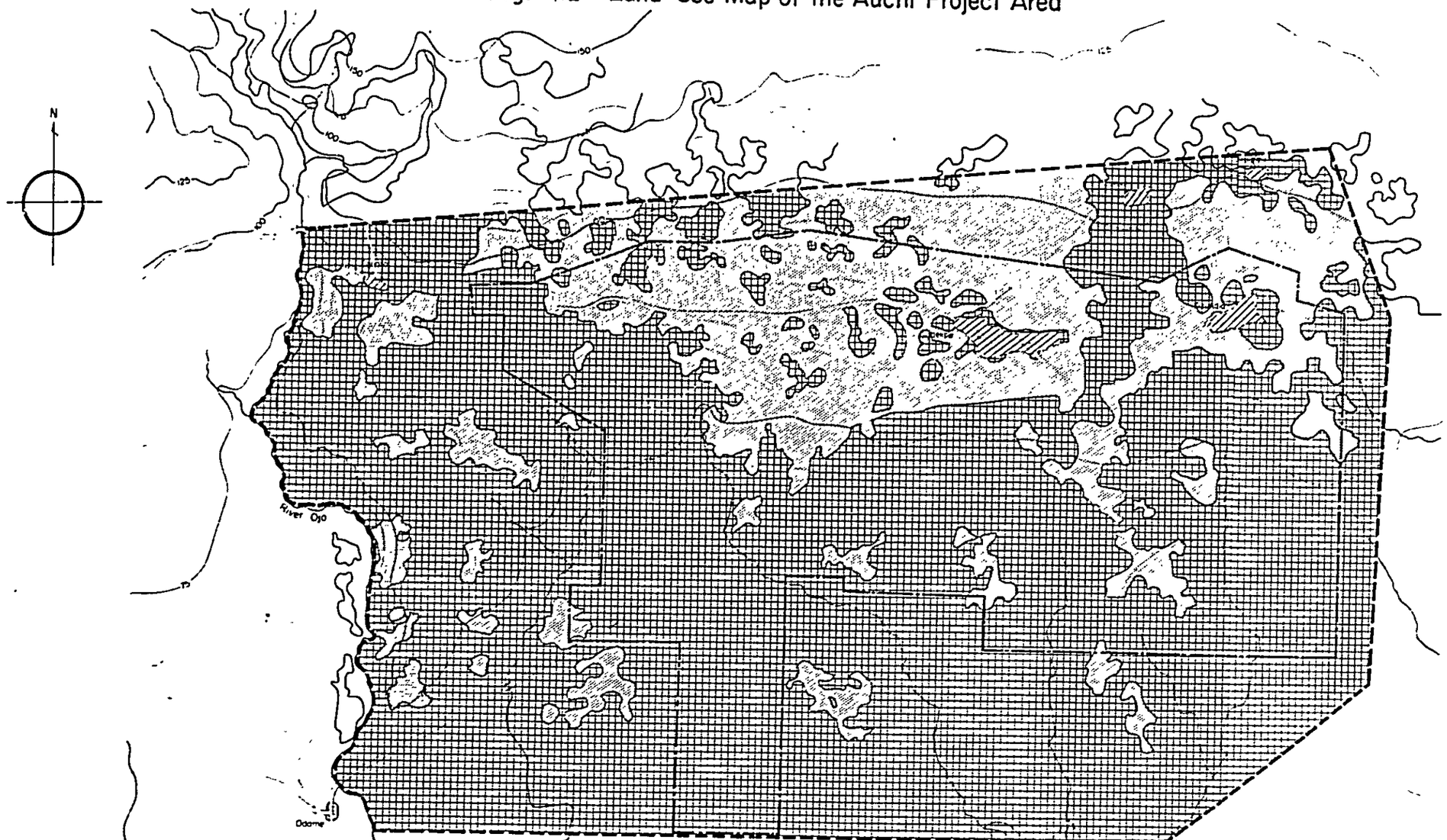
Fig. 4.1 Land Use Map of the Owerri Project Area

LEGEND

Mapping Symbol	Land Category	Survey Area Area (ha)	Survey Area Proportional Extent (%)	Project Area Area (ha)	Project Area Proportional Extent (%)
	- Villages, roads and other non-cultivated land	90	2	30	1
	- Cultivated land	1,250	25	720	28
	- Scrub and grassland	2,510	57	1,460	56
	- Light forest	750	16	390	15
	Total	4,600	100	2,600	100

Source : Aerophotos and field survey

Fig. 4.2 Land Use Map of the Auchi Project Area



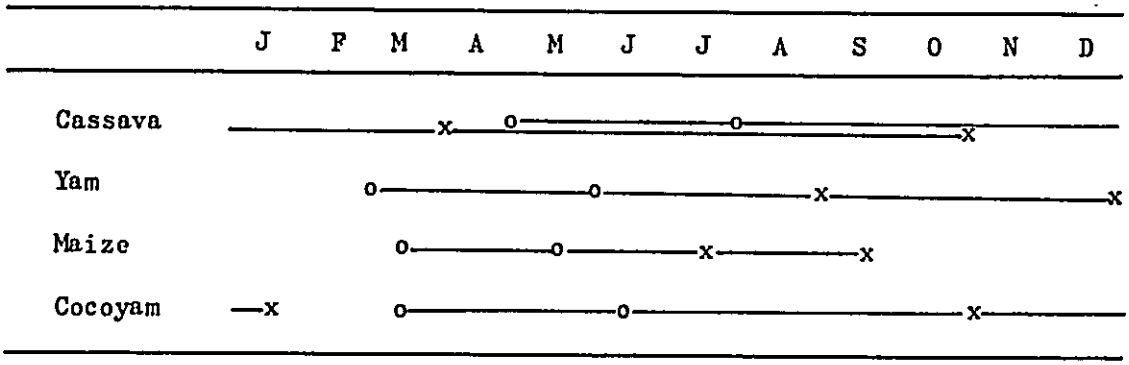
LEGEND

Mapping Symbol	Land Category	Survey Area Area (ha)	Survey Area Proportional Extent (%)	Project Area Area (ha)	Project Area Proportional Extent (%)
	- Villages, roads and other non-cultivated land	40	1	30	1
	- Cultivated land	380	6	220	8
	- Scrub and grassland	1,150	19	660	23
	- Light forest	4,590	74	1,940	68
	Total	6,160	100	2,850	100

Source : Aerophotos and field survey

Fig. 4.3 Typical Cropping Calendar of the Major Crops

(Owerri Project Area)



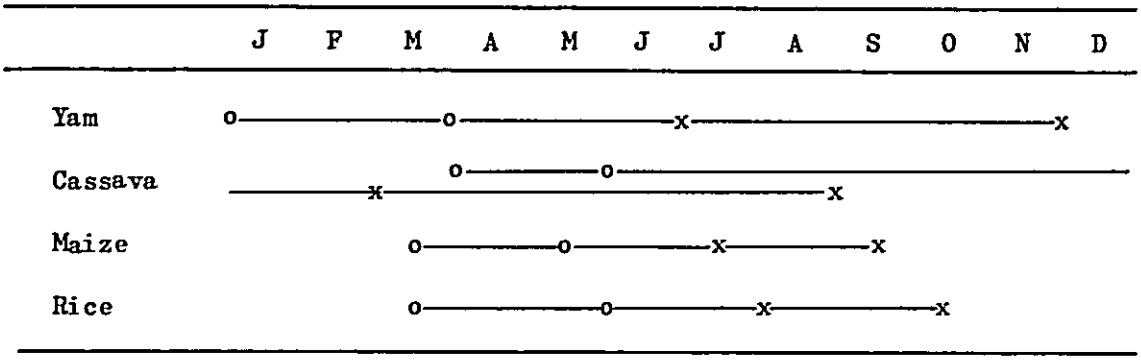
Remarks: o——o Seeding period

x——x Harvesting period

Source : Data from Regional Agricultural Office and farm survey

Fig. 4.4 Typical Cropping Calendar of the Major Crops

(Auchi Project Area)



Remarks: o——o Seeding period

x——x Harvesting period

Source: Data from Regional Agricultural Office and farm survey

5. AGRICULTURAL DEVELOPMENT PLAN

5.1 General

As explained in the preceding chapter, present agricultural production in the project areas is conducted by using traditional cultivation method. The agricultural activity is characterized by its low productivity and self-consumption and the farm economy is on the subsistence level.

For improving these situation and increasing food crop production, agricultural development plan is formulated both for the Owerri Project area and the Auchi Project area. Both projects aim to increase rice production by introducing irrigation farming. Rice is selected as the most appropriate crop in the project area in due consideration of the economy of the production, the existing potential demand for the crop and marketability.

Irrigation facilities will be constructed covering 2,100 ha each for both projects, where mechanized farming is to be practiced from the view points of their early realization of the project, efficient operation and management and reduction of the peak labor requirement for farmers. The projects will be operated by estate farm plus small holder in which estate farm is expected to play a nuclear farm for the small holder area. In the Owerri Project, 1,015 ha is allocated for the estate farm and the residual 1,085 ha for the small holder, while 1,800 ha is allocated for the estate farm and the residual 300 ha for the small holder in the Auchi Project.

Upon completion of the project works, about 2,100 ha of the land will be turned into irrigated land both for the Owerri and the Auchi Projects, on which intensive land use will be made possible. In the Owerri Project area, complete double cropping of rice will be introduced on the whole area, while the cropping ratio of the dry season paddy will be only 30% in the Auchi Project area due to the limited available water from the Ojo river. Through the application of improved seeds, fertilizer and agro-chemicals the productivity of rice is expected to increase to 5.0 t/ha of paddy in the small holder area and 4.5 t/ha of paddy in the estate farm at their full development stage for both projects. Total annual production of paddy will attain about 20,000 tons and 12,400 tons in the Owerri Project and the Auchi Project respectively.

5.2 Proposed Land Use

Through the project construction works including paddy field construction and irrigation facilities, land use of the project areas is expected to change considerably as explained below.

Owerri Project area

In the Owerri Project area, all the scrub and grass land (1,460 ha) and a part of the light forest (190 ha) will be reclaimed, while the area for village, roads and other non-agricultural land will remain as it is. Total cultivable area will become about 2,470 ha dominating about 95% of the area, out of which 2,100 ha is allocated for the irrigable area and the remaining 370 ha for the irrigation facilities and farm road network. The light forest will decrease to 100 ha or only 4% of the total area.

Auchi Project area

Most of the light forest and all the scrub and grass land will be reclaimed, while the land for the village, roads and other non-agricultural land will remain as it is. For the irrigable area, 2,100 ha is allocated and for the irrigation facilities and farm roads 370 ha is allocated. As the results, the area for the light forest will decrease to 350 ha or 12% of the total area.

Irrigated paddy production will be introduced for all the irrigable area of 2,100 ha. Traditional food crops such as yam, cassava, cocoyam and maize will not be cultivated in the irrigable areas in view of most economical land use. These traditional crops will be planted around the village and the area outside the project area under rainfed condition for home consumption.

Proposed land use for the Owerri Project area and the Auchi Project area is presented in the following table.

Table 5.1 Proposed Land Use

Land Categories	Owerri Project Area		Auchi Project Area	
	Area	Proportion	Area	Proportion
	(ha)	(%)	(ha)	(%)
Irrigated cultivation land	2,100	81	2,100	74
Irrigation facilities and farm roads	370	14	370	13
Villages	30	1	30	1
Light forest	100	4	350	12
Total	2,600	100	2,850	100

5.3 Proposed Cropping Pattern

5.3.1 Selection of Crops

In the irrigation development plan, rice is selected as the most suitable crop for the irrigated farming from the following view points.

i) Profitability of rice

High profitability of rice production under irrigated farming is proved by crop benefit cost calculation. It is also confirmed through farmers interview that they have sufficient incentives to produce rice as much as possible.

ii) High potential demand for rice

Although per capita consumption of rice is only 7 kg at present, the demand is considered to be higher potentially. In the future, the demand is expected to grow considerably in proportion to the income increase and change in the dietary preference from root crops to rice.

iii) Long durability

Rice will be kept in storage for relatively long time and good for market operation.

5.3.2 Proposed Cropping Pattern

Proposed cropping patterns for the Owerri Project and the Auchi Project are determined in the manner that the planting area will be maximized within the constraints of the available water from the rivers. Climatic and soil conditions are also carefully considered for introducing mechanized farming. Due to the different climatic condition, the proposed cropping pattern of the Owerri Project is different from that of the Auchi Project.

Owerri Project area

The proposed cropping pattern consists of complete double crops of paddy intercropped with green manure as illustrated in Fig. 5.1.

Wet season paddy will be planted from the middle of June to September and harvested from the middle of October to January. Dry season paddy will be planted about one month after the harvest of the wet season paddy and harvested from March to June. The design growing period applied in the cropping pattern is 125 days including seedling. Following the harvest of the dry season paddy, green manure will be planted for improving organic contents of soils and maintaining the expected high yield.

Since the Owerri Project area has relatively much rainfall, the proposed cropping calendar is set in such a way that the harvesting will be conducted in the month with relatively little rainfall for introducing harvester most efficiently.

Through the introduction of the complete double cropping of paddy on the irrigated area of 2,100 ha, cropping intensity will reach 200%.

Auchi Project area

The proposed cropping pattern in the Auchi Project area consists of 2,100 ha of wet season paddy and 600 ha of dry season paddy intercropped with green manure as presented in Fig. 5.2.

Wet season paddy will be planted from April to June and harvested in August to October. Dry season paddy will be planted in September and December and harvested in January and April. Since the available water from the Ojo river is quite limited in the dry season, the area of the dry season paddy is only 600 ha or about 30% of the total irrigable area though the cropping calendar is adjusted to utilize the available water at its maximum extent. Due to the limited rainfall, harvesting by using harvester will not find any difficulty in the Auchi Project even for the rainy season harvest. Green manure will be planted widely both after the wet season paddy and dry season paddy for improving organic contents of soils.

Cropping intensity of the Auchi Project will be about 130% which is considerably lower compared with that of the Owerri Project.

5.4 Proposed Farming Practices and Operation

5.4.1 General

Farm operation of the two projects is characterized by mechanized farming from the stage of land preparation to harvest and mill process. The mechanized farming is recommended to be introduced from the following view points:

i) Efficient operation and management of the estate farm;

ii) Reduction of peak labor for paddy cultivation on the small holder area and increase cultivation area per farmer;

iii) Demonstration effect of the mechanized farming to the region; and

iv) Early realization of the expected increase in paddy production in the whole project area most efficiently.

Since both projects include farm lands of the small farmers already settled, the Owerri and Auchi Project will be operated by estate farm and small holder. For determining the share of the estate farm and small holder area, economic scale both for the estate farm and farm size per one farm family is taken into consideration. In due consideration of the farm budget, labor requirement and the available manpower per farmer, 1.2 ha is proposed to be the optimum farm size per farmer.

For the Owerri Project, the size of the small holder area is determined to be 1,085 ha, almost same as that of the estate farm (1,015 ha) due to high population density in the area. But, for the Auchi Project, most of the land (1,800 ha) will be allocated to the estate farm and only about 15% (300 ha) to the small holder as present cultivation land is small with less farmers.

5.4.2 Proposed Farming Practices

Different farming practices will be applied for the operation of the estate farm and small holder area both in the Owerri and Auchi Projects. In order to utilize the manpower at the maximum extent, the mechanization will be limited to partial operation mainly for land preparation and harvesting to rice milling in the small holder area, while complete mechanization will be practiced in the estate farm. The proposed farming practices both for the estate farm and the small holder area are illustrated in Fig. 5.3 to Fig. 5.4, which are briefly explained below.

Estate farm

Direct sowing method will be principally adopted for the estate farm for reducing the labor requirement for transplanting. But, in the early stage of the project and in the pilot scheme area, transplanting will be precticed partially for training farmers. The cultivation practices of the direct sowing area as follows:

1) Land preparation

Weed cutting and burning: Weed cutting will be made by using mower attached to 40PS class tractor. The weed will be burned after cutting.

Plowing and harrowing: Before 10 to 15 days of seeding, the paddy field will be plowed once up to about 25 - 30 cm depth and harrowed twice. These works will be done every three-year by using 3-row plow and 20" x 24 harrow attached to the 60 PS class wheel type tractor.

Rotervating and puddling: The paddy field will be plowed to break down clods on the field by using rotervater attached to the 60 PS class wheel type tractor. Puddling work will be carried out in flooded condition by using puddling rake. The 60 PS class swampy type tractor will be used for this work.

2) Seed treatment and seeding

Seed will be sterilized by agro-chemicals prior to the seeding for protecting from fungi and facilitating regular sprouting. The seeds will be planted in shallow depth of about 2 cm with the seed rate of 100 kg/ha. Broad caster attached to the 60 PS swampy type tractor will be employed for seeding operation.

3) Fertilizer application and plant protection

Fertilizer application: Design volume of fertilizer per ha in 200 kg of compound fertilizer and 129 kg of urea.

The application schedule of fertilizer will be as follows:

Basic-dressing (puddling time)	;	Compound fertilizer 200 kg/ha
First top-dressing (about 3 weeks after seeding)	;	Urea 43 kg/ha
2nd top-dressing (panicle formation stage)	;	Urea 43 kg/ha
3rd top-dressing (heading stage)	;	Urea 43 kg/ha

Triple super phosphate and potassium will be applied at puddling time as basic dressing. Broad caster attached to the 60 PS class swampy type tractor will be used for the basic dressing. The first, second and third top-dressings will be done by manpower.

Application of herbicide: Weeding will be done 3 times, namely, at about 4 days before seeding and 2 weeks and 5 weeks after seeding by applying herbicides such as Saturn, Stam, etc. Swath sprayer attached to the 60 PS wheel type tractor is employed for this operation.

Application of insecticide: Insecticides such as Dimecron and γ-BHC will be applied against stem-borer and leaf-hopper. Design volume of the insecticide is 3 ℓ/ha. Application of insecticide will be carried out 3 times. First application of insecticide will be 4 weeks after seeding, the second application will be 7 weeks after seeding and the third application will be at heading stage. Insecticides will be applied by swath sprayer attached to the 60 PS class wheel type tractor.

Application of fungicide: Application of fungicide will be carried out for protecting from plant diseases. The application will be made once at the panicle formation stage with the design volume of 30 kg/ha. Self-propelled type cluster will be employed for this operation.

4) Water control

Since water requirement for paddy cultivation is different from stage to stage of the production, water control is the essential farming practice for ascertaining the expected high yield. In due consideration of effective use of the available irrigation water, water control is made by the staff of the estate farm in the following manner.

Seeding - about 1 week after seeding	;	Shallow water
Sprouting	;	Water drained
The period of about 1 week after sprouting	;	Deep water
Most active tillering stage	;	Shallow water with intermittent irrigation
Neck-node differentiation period up to panicle formation period	;	Drying practice
Panicle formation period up to full ripening period	;	Shallow water with intermittent irrigation
Full ripening period to harvest	;	Water drained

5) Harvesting and transportation

Harvesting will be conducted by the seld-propelled type combine. The harvested paddy will be transported to the rice mill by trailer attached to the 40 PS class wheel type tractor.

Small holder area

In the small holder area, transplanting method will be applied for ensuring the expected high yield steadily utilizing the family labor force at the maximum extent. Farm mechanization will be introduced in the stage of land preparation, agro-chemicals application and harvesting. The machinery services will be provided by the estate farm, the cost of which will be paid to the estate farm as machinery charges by the farmers in the small holder area.

1) Nursery preparation: Area of the nursery bed is designed to be 400 m^2 per hectare or 1/25 of paddy field, and the nursery period will be about 20 days. Seed rate to be applied is 35 kg per ha.

2) Land preparation: Land preparation will be conducted in the same way as applied in the estate farm. Machinery services will be provided by the estate farm and farmers in the project area will be engaged in the work as assistant laborer.

3) Transplanting: Transplanting will be carried out by manpower using mainly their family labors. Labour requirement for the transplanting is estimated at 50 mandays/ha. The recommended planting density is one seedling per 30 cm x 15 cm. Seedling will be transplanted to the main paddy field in shallow depth and the density per hill is three.

4) Fertilizer application and plant protection: Fertilizer application will be conducted only by manpower of the farm family in the small holder area. Design volume of the fertilizer is same as that of the estate farm. Labor requirement for the fertilizer application is estimated at 10 mandays/ha. The application will be carried out in the following manner corresponding to the growing stage.

Basic-dressing (transplanting time)	;	200 kg compound fertilizer
First top-dressing (about 2 weeks after transplanting)	;	43 kg urea
Second top-dressing (panicle formation stage)	;	43 kg urea
Third top-dressing (heading stage)	;	43 kg urea

Herbicide application will be made by manpower of farm family. The herbicides to be used are Saturn, Stam, etc.

Application will be made 3 times which include 2 times at puddling period and once about 3 weeks after transplanting. Design volume of the herbicide is 70 kg/ha and the labour requirement is estimated at 2 mandays/ha.

For the application of the insecticide and fungicide, self-propelled type duster and swath sprayer of the estate farm will be used. Design volume and application time for these agro-chemicals are almost same as that to be applied for the estate farm. Farmers in the project area will be engaged in the assistance for the chemical application by machinery. The estimated labor for the assistance work is about 2 man-days/ha.

5) Water control: Water control under the tertiary canals for the irrigated paddy will be conducted by farmers themselves. Water control for the main and secondary canals will be carried out by the estate farm. The water control will be implemented in the following manner.

Rooting stage	; Deep water
Most tillering stage	; Shallow water with intermittent irrigation
Neck-node differentiation stage up to panicle formation stage	; Drying practice
Panicle formation stage up to full ripening stage	; Shallow water with intermittent irrigation
Full ripening period up to harvest	; Water drained

6) Harvesting and transportation: Harvesting of paddy will be made by the estate owned self-propelled type combine. Farmers will be involved in the work as assistant laborers. The harvested paddy will be transported to the rice mill by trailer attached to the 40 PS class wheel type tractor.

5.5 Farm Inputs and Farm Machineries

Required farm inputs and farm machineries for executing the farm operation stipulated above are estimated on the basis of the collected data for the similar projects in Nigeria and experience in Japan.

5.5.1 Farm Inputs

1) Selection of varieties

The varieties to be applied for the project will be TOS103 and BG90-2, which are determined on the basis of the experimental results conducted by IITA and Uzo Uwani Pioneer Project, Anambra State. The selection was carried out from the view points of resistance to lodging, growth period, yield and disease tolerance. These varieties are short-culmed of between 60 - 70 cm and proved to be highly resistant to lodging, which is one of the most important characteristics for introducing harvesting machine. The growth period of the varieties are medium ranging from 110 to 125 days which give room to adjust the cropping pattern to harvest in the dry season or relatively less wet season. These varieties have another favorable features such as strong disease tolerance and resistance to insect as well as high yield.

These varieties will be tested together with other promising varieties on the pilot scheme area. Most optimum varieties in the project area will be finally selected through this testing and experiment.

2) Farm inputs

The design volume of the farm inputs is estimated both for the estate farm and the small holder area as summarized in the following table and the detailed application schedule is presented in Fig. 5.3 to Fig. 5.4.

Table 5.2 Proposed Farm Inputs per Ha

Farm Inputs		Estate Farm (Direct Sowing)	Small Holder Area (Transplanting)
1) Seed	(kg/ha)	100	35
2) Fertilizer			
Compound fertilizer/1	(kg/ha)	200	200
Urea/2	(kg/ha)	129	129
3) Agro-chemicals			
Fungicide/3	(kg/ha)	30	30
Insecticide/4	(ℓ/ha)	3	3
Herbicide			
Solution/5	(ℓ/ha)	30	-
Granule/6	(kg/ha)	-	70

/1 : N: 15%, P: 15%, K: 15%
/2 : 46% of N
/3 : Hinosan, etc.
/4 : Dimecron, γ-BHC, etc.
/5 : Preforan, Stam, etc.
/6 : Saturn, Stam, etc.

With respect to the application of fertilizer, basic elements of fertilizer particularly nitrogen and phosphate are required to be supplied as the basic fertilizer. The growth of paddy is vigorous during early and medium stages because of considerable rooting activity of rice under the condition of the high soil temperature. However, the growth tends to become dissipated in the later stage. It is, therefore, recommended to apply heavy top-dressing of urea in the period of panicle formation and heading stage.

Considerable amount of agro-chemicals will be applied since the damages caused by plant diseases and insects are expected to increase with the introduction of the irrigated paddy cultivation using fertilizer. Weed control will also be emphasized for ensuring to get the high yield.

The design volume of the farm inputs will be confirmed through the field trials and experiments in the pilot scheme.

3) Labor requirement

(Estate farm)

Although the estate farm will be operated mainly by machineries, the proposed farming practices will still require considerable manpower. The labor requirements per year for the operation of the estates are estimated at about 287,000 mandays and 117,000 mandays for the Owerri Project and the Auchi Project respectively. These requirements will be provided by about 120 permanent laborers and about 24,600 mandays of seasonal laborers for the Owerri Project area and 80 permanent laborers and 35,000 mandays of seasonal laborers for the Auchi Project.

(Small holder area)

Farm labor requirement for cultivating 1.2 ha of paddy field is estimated at 252 mandays and 210 mandays for the Owerri Project and the Auchi Project respectively as shown in Table 5.3. Assuming that 3 adult workers are available per family, labor shortage will not occur except the transplanting period. The shortage is not substantial and will be supplemented by hired laborer or neighboring farmers through mutual collaboration.

5.5.2 Farm Machineries

Selection of the type of machinery and the estimate of the required number are made upon in due consideration of the climatic and soil conditions of the project area referring to the similar experience around the project area.

The proposed type of machinery for each farm operation is shown in Fig. 5.3 to Fig. 5.4 and the estimated number of machineries is presented in Table 5.4.

For the efficient operation and maintenance of the farm machineries, a workshop will be constructed for each of the two projects. The workshop will be equipped with necessary machineries and equipment and managed by Farm Machinery Department of the Project Office.

5.6 Rice Mill and Storage Facilities

At present, there is no reliable processing and storage facilities for rice both in the Owerri Project area and the Auchi Project area. Upon completion of the projects, about 20,000 tons of paddy will be produced in the Owerri Project and 12,400 tons of paddy in the Auchi Project annually. For processing, keeping in good quality and marketing them on favourable conditions, it is necessary to install rice mill and storage facilities.

Major function of the rice mill are drying, parboiling and milling. The process of the milling is divided into five sections, namely, receiving and clearing section, drying section, storage section, parboiling section and milling section. These processes are briefly illustrated in Fig.5.5. The proposed processing system includes a storage between the drying section and parboiling section so that major equipment can be operated efficiently. Required capacity of the rice mill is estimated assuming that workable days of the rice mill are 300 days per year and the operation hour is 16 hours per day. Number of rice mills to be installed will be 3 with the milling capacity of 1.5 t/hr each and 1.0 t/hr each for the Owerri Project and the Auchi Project respectively. Milling efficiency will be raised to about 70% from the present 50-60% at the local mill.

Storage facilities will be installed in the project areas in order to keep the milled rice in high quality and sell the products at favorable market price. The capacity of the storage facilities will be 7,000 tons and 6,700 tons of rice for the Owerri Project and the Auchi Project.

Details of the rice mill and the storage facilities are presented in Table 5.5.

5.7 Anticipated Yield

Under the future condition with project, the productivity of paddy is expected to increase considerably through extensive use of inputs, expansion of introduced farming technics and effective water management. Based on the experimental data of the similar project in Anambra State and IITA, average unit yields are expected to attain 4.5 t/ha for the estate farm (direct sowing) and 5.0 t/ha for the small holder area (transplanting) at the full development stage. (Results of the experiment in Anambra State are shown in Table 5.6) From the experience in Japan and the

experimental data of the similar project in Anambra State, the yield of direct sowing is assumed to be about 10% less than that of transplanting.

The yield of paddy will increase gradually corresponding to the increase of land productivity and will attain the expected yield in the 5th year for the estate farm and 7th year for the small holder area after completion of the irrigation facilities. Though intensive extension services will be provided for the small holder area, it is expected to take longer time for attaining the target yield than the estate farm since the farmers in the area are not accustomed to irrigated farming. The yields during the build-up period are presented in the following table.

Anticipated Unit Yield of Paddy

Item	Build-up Period						
	1st	2nd	3rd	4th	5th	6th	7th
Direct sowing (Estate farm)	2.5	3.0	3.5	4.0	4.5	4.5	4.5
Transplanting (Small holder area)	3.0	3.4	3.8	4.1	4.4	4.7	5.0

Anticipated productions of rice for the Owerri Project and Auchi Project are estimated by multiplying the anticipated unit yield with the future cultivation area, which are presented in Table 5.7 and 5.8.

The anticipated production of rice is estimated at about 20,000 tons in the Owerri Project area and 12,400 tons in the Auchi Project area at the full development stage.

5.8 Pilot Scheme

5.8.1 General

As explained above, the Owerri Project and the Auchi Project include the estate farm and small holder area. The farmers and extension workers in the project areas are not accustomed to the irrigated farming since there is no irrigation facilities in and around regions. Particularly, the farmers in the Owerri Project area have never practiced rice cultivation. Furthermore, farm mechanization have not prevailed in the region and farmers in the project areas have no experience in mechanized farming.

In both states, agricultural research has been carried out in the experiment stations in Umudike, Badeggi and other institutions. Their efforts, however, are directed mainly to the traditional crops such as cassava, yam, cocoyam, etc. Systematic research and experiments have not yet been made regarding rice.

Under these situation, it is indispensable to establish a pilot scheme in the proposed project area from the earliest stage for the successful operation of the projects. The primary objectives of the pilot scheme are 1) training and demonstration of mechanized farming to project staff, extension workers and farmers to be involved in the small holder area, 2) agronomic research on rice cultivation, and 3) multiplication of seeds. The pilot scheme will be managed by Production Department and Extension Department of the Project Office.

5.8.2 Location and Scale of the Pilot Scheme

In view of the early operation of the pilot scheme, the sites are proposed at north-east corner of the project area for the Owerri Project and north-west part below the provincial road of the project area for the Auchi Project. For both pilot scheme areas, irrigation will be provided from the early stage of the project construction and the operation will start from 1980 and 1979 for the Owerri Project and the Auchi Project respectively.

The size of the pilot scheme will be 50 ha for both projects which will be allocated to each function as described below.

	Owerri Project	Auchi Project
Agricultural research	2 ha	2 ha
Seed multiplication	20 ha	18 ha
Training & demonstration	28 ha	30 ha
Total	50 ha	50 ha

5.8.3 Scope of Work

Proposed scope of work in the pilot scheme will be as follows:

1) Agricultural research

For improving the variety and increasing crop yield with optimum input costs, following agronomic research will be conducted in the pilot scheme.

a) Variety test,

b) NPK test,

c) Trial and test for optimum fertilizer requirement,

d) Trial for optimum planting density, and

e) Weed control test.

2) Seed multiplication

Seed multiplication farm will be established in the pilot scheme area, which will provide required amount of improved rice seeds for sustaining the expected high yield in the whole project area. The seeds to be multiplied by this farm will be distributed both to the estate farm and the farmers in the small holder area.

3) Training and demonstration

The projected large scale mechanized farming under irrigation involves staffs of the estate farm, farmers in the project area and extension workers.

Since the development of the estate farm and extension of the irrigated farming to the small holder area are indispensable for the successful implementation of the project, the staffs of the estate farm, farmers and the extension workers will be trained intensively in various fields of mechanized rice cultivation by learn-by-doing method in the pilot scheme. The training will be repeated and continued until they acquire necessary technics and knowledge for the rice cultivation.

Schedule for the construction and operation of the pilot scheme is illustrated in Fig. 8.1 and Fig. 8.2.

Table 5.3 Labour Requirement for the Cultivation of 1.2 Ha (Small Holder Area)

(Unit: Manday)

	Cultivated Area (ha)	J	F	M	A	M	J	J	A	S	O	N	D	Total
Owerri Project Area														
Rainy season paddy	1.2	3	-	-	-	-	-	3	37	58	9	7	9	126
Dry season paddy	1.2	30	56	16	7	10	6	-	-	-	-	-	1	126
Total		33	56	16	7	10	6	3	37	58	9	7	10	252
Workable days /1		27	22	23	19	19	18	20	18	17	17	24	26	250
Family labour force /2		81	66	69	57	57	54	60	54	51/3	51	72	78	750
Auchi Project Area														
Rainy season paddy	1.2	-	-	-	-	-	13	76	15	8	8	6	-	126
Upland paddy	1.2	80	7	5	12	-	-	-	-	-	-	-	32	136
Total		80	7	5	12	-	13	76	15	8	8	6	32	262
Workable days /1		27	18	25	21	21	20	22	23	20	23	25	27	272
Family labour force /2		81	54	75	63	63	60	66/3	69	60	69	75	81	816

/1: Workable days exclude national holiday, sunday and rainy days.

/2: Average number of available family labour force is assumed to be 3 persons per household.

/3: This shortage of labour force would be supplemented by hired labour or in collaboration with other farmers.

Table 5.4 Required Farm Machinery

Description		Owerri Project (Nos.)	Auchi Project (Nos.)
1) Tractor and combine			
- Wheel type tractors	60PS class	30	27
- Wheel type tractors	40PS class	40	27
- Crawler type tractors	60PS class	5	3
- Crawler type tractors	40PS class	5	3
- Self-propelled type combines	100PS class	20	16
2) Other equipment and attachment			
- Disc plows	26" x 3	5	7
- Disc harrows	20" x 24	4	5
- Rotavators	1.8 - 2.0 m	28	20
- Broad casters	350 ℓ	9	7
- Swath sprayers	400 ℓ	16	16
- Dusters	35 kg	6	5
- Puddling rakes	3.0 m	9	6
- Rear-mounted mowers	1.8 - 2.0 m	8	6
- Dump trailers	2-ton	25	20
- Trucks	6-ton	5	5
- Tool bars	3.0 m	10	10
- Float wheels		20 (set)	15 (set)
3) Spare parts		L.S.	L.S.
4) Service tools and equipments		L.S.	L.S.

Table 5.5 Main Features of Rice Mill and Storage Facilities

Main Features	Owerri Project			Auchi Project		
	Unit Capacity	Nos.	Total Capacity	Unit Capacity	Nos.	Total Capacity
1) Receiving equipment Paddy cleaners, receiving bins, etc.	3.5 t/hr	3	10.5 t/hr	3 t/hr	3	9 t/hr
2) Drying equipment Paddy dryers, tempering bins, etc.	10 t/hr	3	30 t/hr	10 t/hr	3	30 t/hr
3) Parboiling equipment Receiving hopper, soaking and steaming tanks, dryers, etc.	1 t/hr	3	3 t/hr	0.6 t/hr	3	1.8 t/hr
4) Milling equipment Rice milling unit, packing unit, etc.	1.5 t/hr	3	4.5 t/hr	1 t/hr	3	3 t/hr
5) Storage equipment Storage silos, aeration system, etc.	1,000 t	5	5,000 t	1,000 t	5	5,000 t
6) Power supplying plant Control panel, wiring materials, diesel generators.	200 KVA	3	600 KVA	200 KVA	3	600 KVA

Table 5.6 Results of Variety Trial in Anambra State

Variety	Unit Yield	Duration of Growth	Culm Length	Pamicle Length	Resistant to Blast Diseases
	(ton/ha)	(days)	(cm)	(cm)	
Juma 1	7.5	128	130.2	28.2	R
AA83	7.3	143	166.3	25.8	R
IR1516	6.5	123	85.9	24.2	R
ROK5	6.5	133	140.0	25.8	MS
IR2053-473	6.4	137	83.2	25.2	R
BG90-2	6.4	125	70.8	30.1	R
IR8	6.3	125	74.3	22.8	MR
TOS 103	6.2	110	63.2	27.8	R
C.J.5.2	6.2	145	158.0	27.8	MR
TOX7-4	6.1	120	122.9	27.3	MR
IR20	6.1	136	87.0	25.5	S
IR2035-730-3	6.1	152	84.6	26.3	R
FRRS-CR-162	6.0	122	96.5	28.1	MR
IR2035-263-3-3	6.0	122	96.5	28.1	MR
TOS4346	5.9	115	76.3	25.2	MR
ROK7	5.8	135	125.1	29.2	MS
IR2031	5.8	136	103.7	24.8	MR
Taichung 65	5.1	119	93.6	22.8	MR
OS6	4.7	109	133.4	31.9	R
Sasanisiki	6.4	120	71.9	20.4	MR
IR22	4.5	119	84.0	25.1	S
Kosihikari	4.5	101	-	-	R

Source: Uzo Uwani Rice Development Project, Anambra State

R: Resistant, MR: Moderately Resistant, MS: Moderately Susceptive

S: Susceptive

Table 5.7 Rice Production Programme in the Owerri Project Area

Year	Estate Farm			Small Holder Area			Total Harvested Area	Total Paddy Production	Rice Production /1
	Harvested Area	Unit Yield	Paddy Production	Harvested Area	Unit Yield	Paddy Production			
	(ha)	(t/ha)	(t)	(ha)	(t/ha)	(t)	(ha)	(t)	(t)
1980	450	2.5	1,125	-	-	-	450	1,125	788
1981	1,510	3.0	4,530	-	-	-	1,510	4,530	3,171
1982	2,030	3.5	7,105	1,110	3.0	3,330	3,140	10,435	7,305
1983	2,030	4.0	8,120	2,170	3.4	7,378	4,200	15,498	10,849
1984	2,030	4.5	9,135	2,170	3.8	8,246	4,200	17,381	12,167
1985	2,030	4.5	9,135	2,170	4.1	8,897	4,200	18,032	12,622
1986	2,030	4.5	9,135	2,170	4.4	9,548	4,200	18,683	13,078
1987	2,030	4.5	9,135	2,170	4.7	10,199	4,200	19,334	13,534
1988 & after	2,030	4.5	9,135	2,170	5.0	10,850	4,200	19,985	13,990

/1 Milling rate: 70%

Table 5.8 Rice Production Programme in the Auchi Project Area

Year	Estate Farm			Small Holder Area			Total Harvested Area	Total Paddy Production	Rice Production /1
	Harvested Area (ha)	Unit Yield (t/ha)	Paddy Production (t)	Harvested Area (ha)	Unit Yield (t/ha)	Paddy Production (t)	(ha)	(t)	(t)
1980	1,010	2.5	2,525	-	-	-	1,010	2,525	1,768
1981	1,630	3.0	4,890	-	-	-	1,630	4,890	3,423
1982	2,180	3.5	7,630	-	-	-	2,180	7,630	5,341
1983	2,200	4.0	8,800	450	3.0	1,350	2,650	10,150	7,105
1984	2,200	4.5	9,900	500	3.4	1,700	2,700	11,600	8,120
1985	2,200	4.5	9,900	500	3.8	1,900	2,700	11,800	8,260
1986	2,200	4.5	9,900	500	4.1	2,050	2,700	11,950	8,365
1987	2,200	4.5	9,900	500	4.4	2,200	2,700	12,100	8,470
1988	2,200	4.5	9,900	500	4.7	2,350	2,700	12,250	8,575
1989 & after	2,200	4.5	9,900	500	5.0	2,500	2,700	12,400	8,680

/1 Milling rate: 70%

Fig. 5.1 Proposed Cropping Pattern

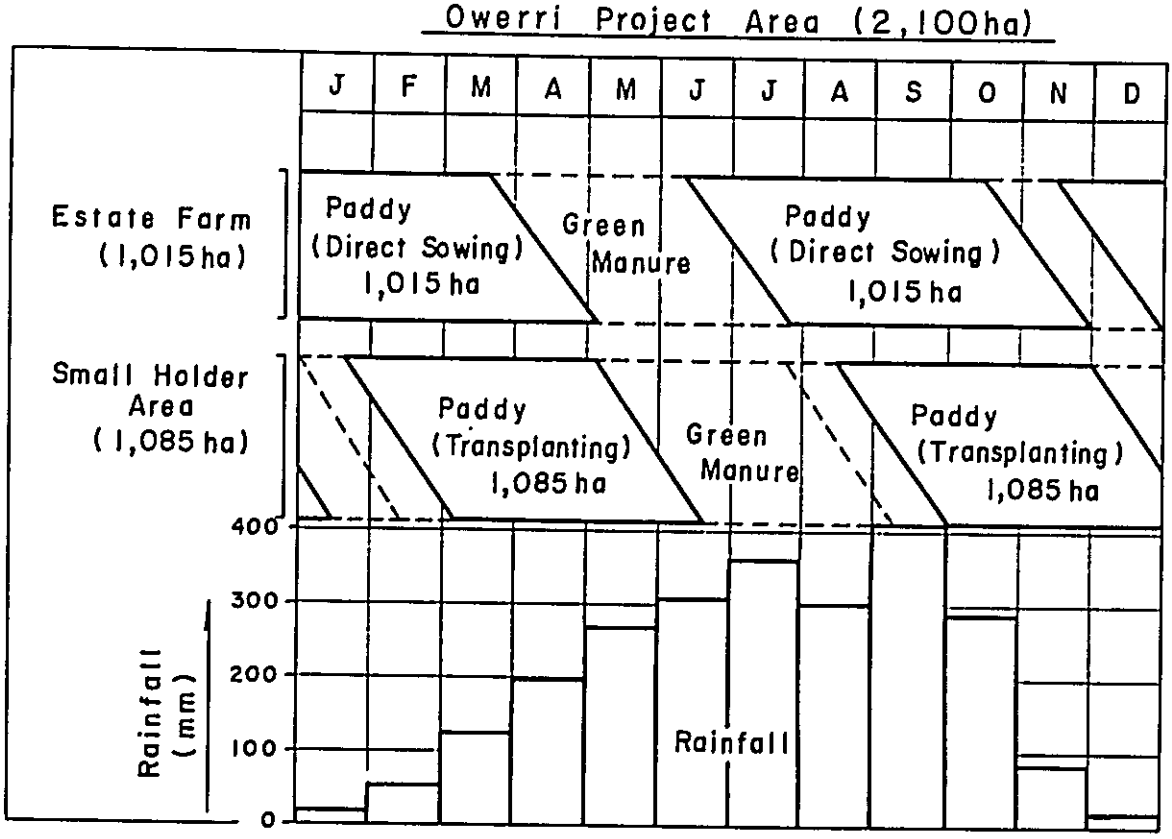


Fig. 5.2 Proposed Cropping Pattern

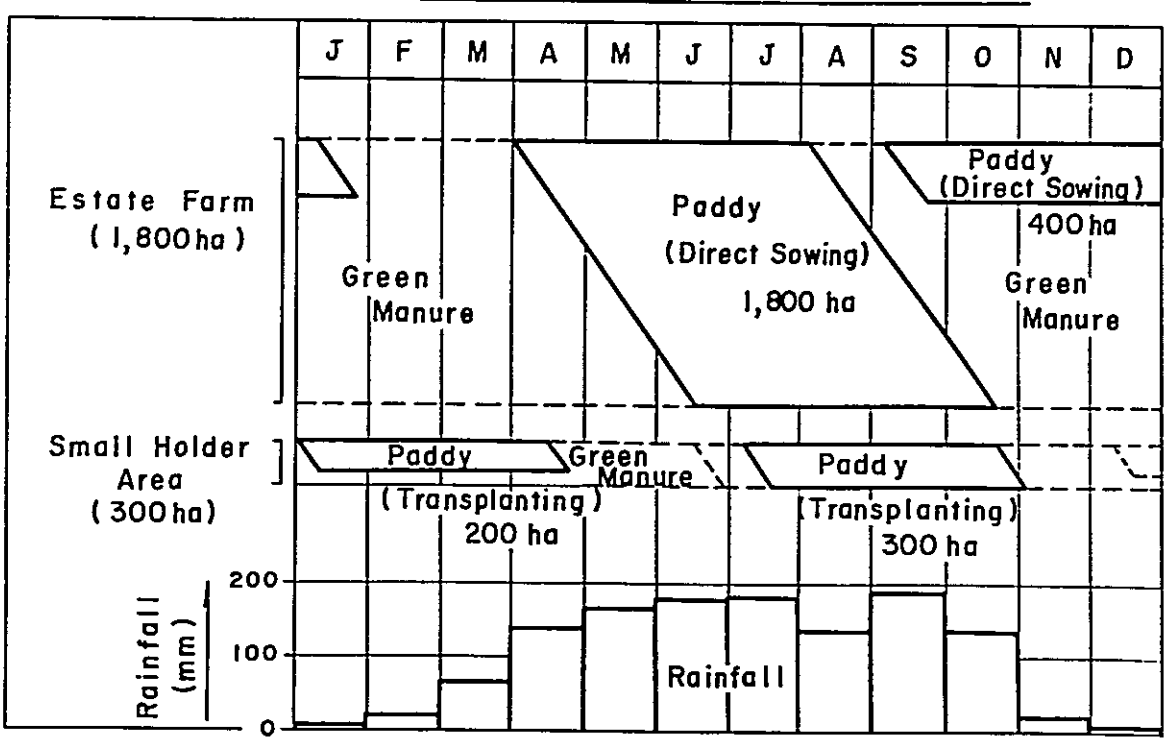
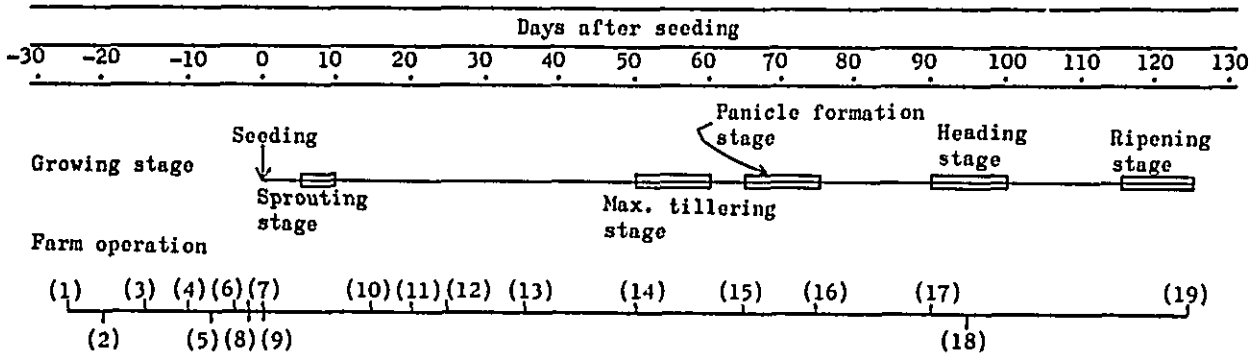
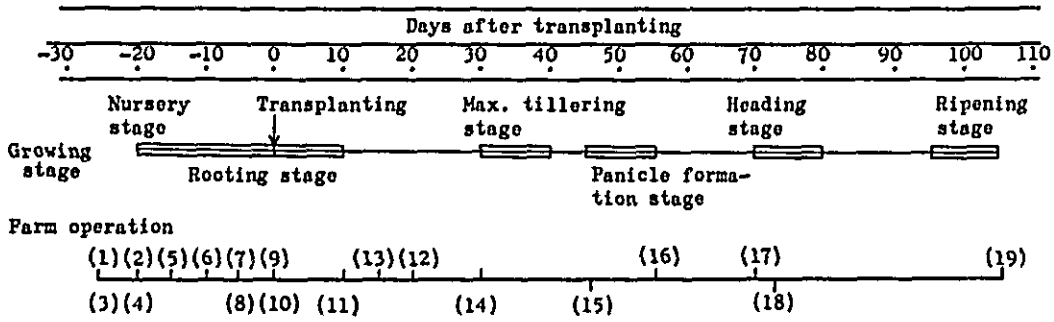


Fig.5.3 Proposed Farming Practices (Estate Farm)



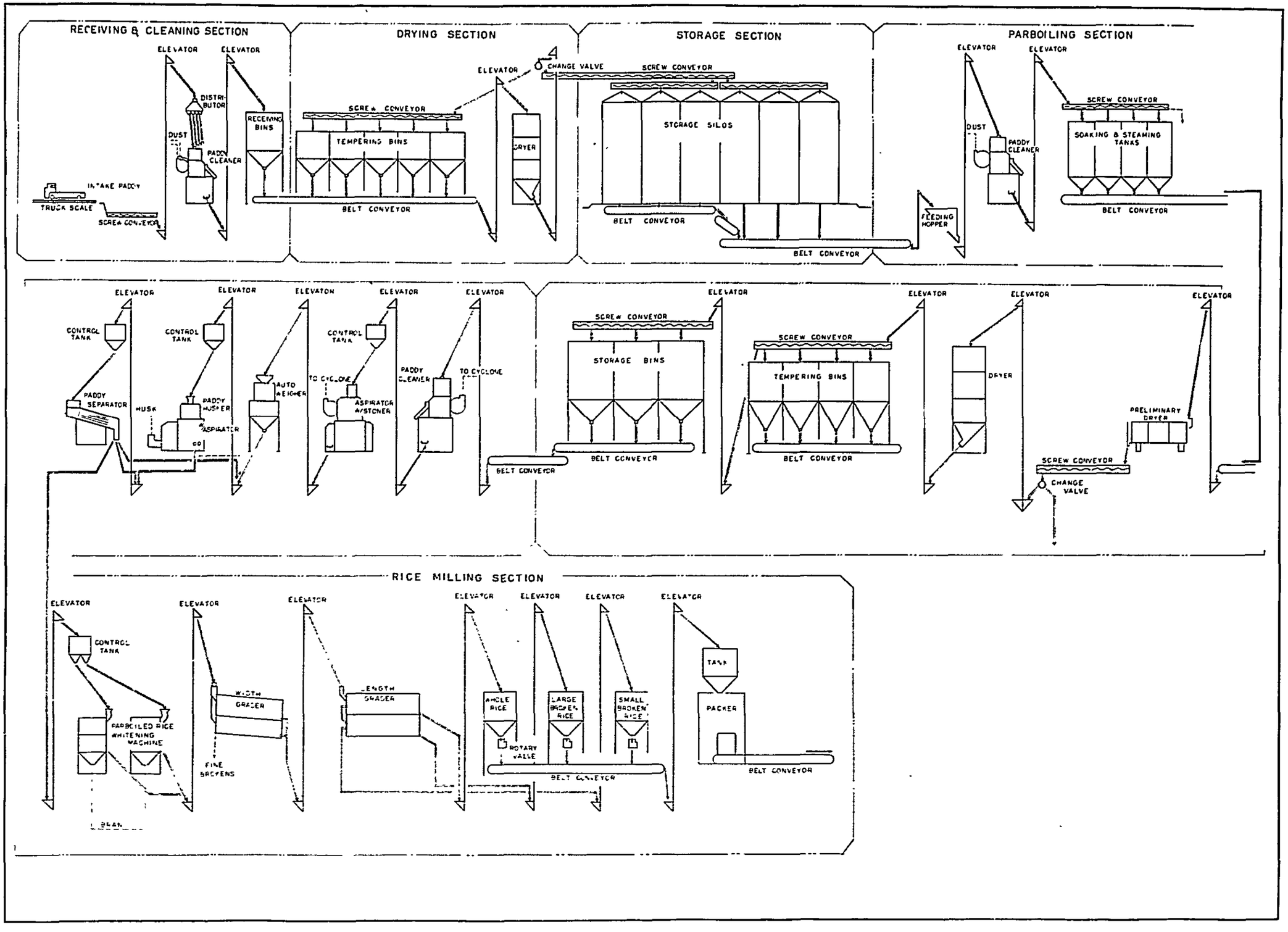
Operation Items	Operation Method	Attachment	Farm Inputs	Remarks
1) Cutting of used	40PS class tractor	Mower		
2) Burning	Man-power	-		
3) Plowing & harrowing	60PS class tractor	Disc Plow & disc harrow		First year 3 years interval
4) Rotavating		Rotavator		
5) Puddling	40PS class tractor	Puddling rake		
6) 1st application of herbicide	"	Swath sprayer	Herbicide: 10ℓ/ha	
7) Seed treatment	Man-power	-	Fungicide: 6g	
8) Basal dressing	40PS class tractor	Broad caster	Compound fertilizer (15:15:15): 200kg/ha	
9) Seeding	"	Broad caster	Seed: 100kg/ha	
10) 2nd application of herbicide	"	Swath sprayer	Herbicide: 10ℓ/ha	
11) 1st top-dressing	Man-power	Truck	Urea(46%): 43kg/ha	
12) 1st application of insecticide	40PS class tractor	Swath sprayer	Insecticide: 1ℓ/ha	
13) 3rd application of herbicide	"	Swath sprayer	Herbicide: 10ℓ/ha	
14) 2nd application of insecticide	"	Swath sprayer	Insecticide: 1ℓ/ha	
15) 2nd top-dressing	Man-power	Truck	Urea(46%): 43kg	
16) Application of fungicide	Self-propelled	Duster	Fungicide: 30kg/ha	
17) 3rd application of insecticide	40PS class tractor	Swath sprayer	Insecticide: 1ℓ/ha	
18) 3rd top-dressing	Man-power	Truck	Urea(46%): 43kg/ha	
19) Harvesting	Self-propelled 40PS class tractor	Combine Dump trailer	Rice Bag: 60sheet/ha	

Fig.5.4 Proposed Farming Practices (Small Holder)



Operation Items	Operation Method	Attachment	Farm Inputs	Remarks
1) Cutting of weed	40PS class tractor	Mower		
2) Burning	Man-power	-		
3) Preparation of nursery bed	60PS class tractor	Potavator		
4) Seed treatment	Man-power	-	Seed: 35kg/ha Pungicide:6g/ha	
5) Plowing & harrowing	60PS class tractor	Disc plow & disc harrow		First year & 3 years interval
6) Rotavating		Rotavater		
7) Puddling	40PS class tractor	Puddling rake		
8) Basal dressing	Man-power	-	Compound fertilizer (15:15:15): 200 kg/ha	
9) Transplanting	"	-		
10) 1st application of herbicide	"	-	Herbicide: 40 kg/ha	
11) 1st top-dressing	"	-	Urea (46)%: 43 kg/ha	
12) 2nd application of herbicide	"	-	Herbicide: 30 kg/ha	
13) 1st application of insecticide	40PS class tractor	Swath sprayer	Insecticide: 1ℓ/ha	
14) 2nd application of insecticide	"	Swath sprayer	Insecticide: 1ℓ/ha	
15) 2nd top-dressing	Man-power	-	Urea (46%): 43kg/ha	
16) Application of fungicide	Self-propelled	Duster	Fungicide: 30kg/ha	
17) 3rd application of insecticide	40PS class tractor	Swath sprayer	Insecticide: 1 ℓ/ha	
18) 3rd top-dressing	Man-power	-	Urea (46%): 43 kg/ha	
19) Harvesting	Self-propelled 40PS class tractor	Combine Dump trailer	Rice bag: 70 sheet/ha	

Fig.5.5 FLOW CHART OF RICE MILL



6. IRRIGATION PLAN

6.1 General

For sustaining the year-round rice culture proposed in the proceding chapter, establishment of systematic irrigation and drainage networks in the areas is needed indispensably to cope with the climatic conditions which is characterized by the existence of distinct rainy and dry season.

The irrigation system will consist of a simple run-of-river type intake weir on the nearby river, conveyance and distribution canals comprising a head race, main and secondary canals, tertiary and supply canals. All the canals will be of earth type from the economic viewpoint.

The drainage system will cover the whole areas with an adequate density to ensure the introduction of the optimum water management and the mechanized farming. The system will comprise collector and field drains which have the capacity to drain excess water on the paddy field within one and a half days.

In addition to these facilities, provision of an adequate farm road system will also be needed. The existing roads in both project areas are, in general, cart roads and footpath and all-weather passage of agriculture machinery is hardly possible. The new road system will consist of main and branch roads and they will have an adequate width and strength for passage of the proposed farming machinery.

6.2 Irrigation Water Requirement

6.2.1 General

Irrigation water requirement consists of consumptive use of water for crops, percolation, puddling water requirement, and conveyance and application losses. Most desirable way to determine the consumptive use of water for crops is that based on the actual measurement in the field over a long period. Since the data are not available in these project areas, the consumptive use of water has been estimated.

In this study, the irrigation water requirements for the project has been estimated through the following procedure:

1) Estimation of potential evapotranspiration;

2) Calculation of the consumptive use of water for the crop;

3) Assessment of percolation rate and the water requirement for puddling work;

4) Estimation of effective rainfall and deduction of it from the amounts obtained in the above items 2) and 3); and

5) Assessment of irrigation water requirement dividing the results of item 4) by the overall irrigation efficiency.

6.2.2 Potential Evapotranspiration

1) Estimation Method

Several method of estimating the evapotranspiration have been compared in order to select the most suitable method. Three methods e.g. (a) Radiation, (b) Penman and (c) Hargreaves have been compared under the same climatic conditions using the data at Umudike Station shown in Table 6.1 and Fig. 6.1.

It is shown clearly that the Penman method tends to bring higher values in comparison to the class A pan values, whereas the values estimated by the Radiation and Hargreaves methods coincide fairly with the class A pan values. Since the Radiation method gives slightly higher values than the Hargreaves method, it is adopted in this planning for the sake of safety. For each of these methods, procedures of the estimation are explained in Appendix-2.

2) Result of Estimation

The Radiation method has been applied to the Owerri and Auchi Project areas. In the Owerri Project area, the climatic data are taken from the average monthly record at the Umudike station as shown in Table 6.2. In the Auchi Project area, however, necessary climatic data can not be available from the stations in and around the area and some of them are supplemented by the data from other stations which have similar climatic conditions. The data used are shown in Table 6.3.

The estimation of the potential evapotranspiration has been carried out as shown in Tables 6.4 and 6.5. The following table gives a summary of the results.

Potential Evapotranspiration (mm/day)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Owerri Project	3.3	3.6	3.5	3.7	3.5	3.0	2.5	2.4	2.6	2.9	3.3	3.3
Auchi Project	3.6	4.3	4.3	3.9	3.8	3.4	3.1	2.9	3.0	3.4	3.8	3.8

6.2.3 Consumptive Use of Water for Paddy

1) Crop Coefficient

The crop coefficient is diversified according to the kind of crops, growing stage of plant, cultivation method and etc. Crop coefficient for paddy has been estimated both for the transplanting and the direct sowing methods based on the following formula.

$$kc = ku \left(\frac{K}{Ku}\right)$$

where kc = crop coefficient

ku = crop consumptive unit factor as given in Fig. 6.2 and Fig. 6.3

Ku = periodical crop consumptive unit factor:

- Transplanting : Ku = 0.78
- Direct sowing : Ku = 0.85

K = periodical crop factor

$$K = 0.7 + \alpha W$$

α = variety coefficient (Indica 0.08)

W = paddy production in ton/ha

The crop coefficient of paddy has been estimated respectively for the transplanting and direct sowing methods as illustrated in Fig. 6.4 and Fig. 6.5. It is tabulated on a half month basis as below.

Crop Coefficient of Paddy

Growing Stage (day)	0-15	15-30	30-45	45-60	60-75	75-90	90-105
Transplanting	1.07	1.01	1.13	1.24	1.28	1.17	-
Direct Sowing	0.85	1.05	1.19	1.27	1.29	1.26	1.13

2) Consumptive Use of Water

Comsumptive use of water for paddy can be obtained by multiplying the potential evapotranspiration estimated in Chapter 6.2.2 by the crop coefficients. Consumptive use of water thus calculated is shown in each of the calculation is shown in each of the calculation tables of the irrigation water requirement for the projects.

6.2.4 Puddling Watre Requirement and Percolation

1) Puddling Water Requirement

The quantity of water required for the puddling work before transplanting or direct sowing of paddy consists of water depth above soil surface after puddling and difference in soil moisture before and after puddling. The amount varies from place to place subject to such factors as farming practices, porosity of soil, ground water table, method of puddling, etc. In view of these factors, the puddling requirement is assumed as follows.

Puddling Requirement (Unit: mm)

	Dry season	Wet season
Transplanting	120	100
Direct sowing	90	90

2) Percolation

The rate of percolation in the field is governed by the ground water table as well as the texture and structure of soils and, in most cases, it fluctuates during the irrigation period. Since realistic forecast on fluctuation of ground water table after commencement of paddy cultivation is hardly possible, the percolation rate is assumed to be 3 mm/day in dry season and 2 mm/day in wet season taking into account the soil structure and experiences in other similar projects.

6.2.5 Effective Rainfall

The effective rainfall for paddy cultivation in these project areas is estimated by applying the daily water balance method, using the following assumptions:

1) Rainfall less than 5 mm/day is ineffective;

2) If, in the process of calculation, water depth exceeds 80 mm, the excess beyond 80 mm is ineffective; and

3) Evapotranspiration and deep percolation are 6 mm/day and 3 mm/day, respectively.

The daily rainfall data used are for the period of 4 years at the Alavan station in the Owerri Project and of 16 years at the Auchi station in the Auchi Project. The results of the calculation are shown in Tables 6.6 and 6.7.

6.2.6 Diversion Water Requirement

The diversion water requirement is estimated by dividing the values obtained through the preceding procedures by the irrigation efficiency taking into account the application and conveyance losses. The irrigation efficiency is assumed to be 65% in this study. The following table shows the total diversion water requirement for the projects. The result of the calculations are shown in Table 6.8 for the Owerri Project and Table 6.9 for the Auchi Project. Based on these tables, the diversion requirements are estimated in Tables 6.10 and 6.11.

Diversion Requirement (m^3/sec)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Owerri Project	1.6	2.5	1.4	0.5	0.1	0.2	0.4	0.2	0.4	0	1.5	1.5
Auchi Project	0.3	0.3	0.2	0.6	0.9	0.8	1.1	1.1	0.5	0.3	0.6	0.4

As shown in the above table, the peak monthly diversion requirements e.g. 2.5 m^3/sec (1.19 ℓ/sec/ha) and 1.1 m^3/sec (0.52 ℓ/sec/ha) occur in February in the Owerri Project and in July and August in the Auchi Project. These diversion requirements are calculated on the monthly mean basis, therefore, they are multiplied by about 1.2 and 1.4 respectively in order to decide the design capacities of the irrigation facilities. The calculated peak design discharges are 3.0 m^3/sec (1.43 ℓ/sec/ha) and 1.5 m^3/sec (0.71 ℓ/sec/ha) for the Owerri Project and for the Auchi Project respectively.

6.3 Headworks

6.3.1 Headworks for the Owerri Project

1) Site Conditions

The proposed weir site is selected at a point about 4 km upstream from the bridge of the Owerri-Aba highway over the Oramirukwa river in due consideration of the ground surface elevation of the proposed irrigation area. At the site, the river has a width of about 20 m and its flood plain extends with a width of about 180 m. The average gradient of the river bed is about 1 : 1,000 at the site.

As stated in Chapter 3.2, the river bed is broadly constituted by the top soil and the underlying alluvial layer. The top soil is composed of grey organic soft mud with a depth of

about 1.5 m. The underlying alluvial deposits are constituted of grey sandy loam and sand. The bearing strength of these deposits will be enough for supporting the embankment of a few meters high.

The design flood discharge is estimated to be 150 m^3/sec in Chapter 2.1.

2) Diversion Weir

In view of the geological condition of the river bed, the floating type concrete gravity weir will be constructed. The crest evevation will be El. 67.5 m, and the weir will be 5.5 m high and 45 m long. In the right end of the weir, a scouring sluice with 1 set of gate, 1.5 m wide and 2.2 m high, will be provided so that the deposited sand can be flashed down. The scouring gate will be operated by man power.

The elevation of the operation deck is to be fixed at El. 72.8 m in consideration of the flood water level of El. 69 m. The length of the downstream apron is estimated at 16 m. The stone protection will be provided in the downstream of the apron for about 5 m against scouring of the river bed. For preventing increase of the seepage under the weir, the natural blanket, 10 m long and 1 m thick, will be placed in the upstream of the weir by compacting the backfilled top soil.

3) Embankment

Embankment will be needed for both sides of the weir. The right side embankment is for keeping intake water level and consists of low dike of 250 m long and 3 m high at maximum. The left side embankment is for closing the river and has a length of 207 m and a height of 6 m at maximum. The crest elevation of these embankments is to be fixed at El. 70.0 m.

4) Intake Structures

The intake structures will be constructed on the right bank with an intake water level of El. 67.35 m and an inflow water depth of 1 m. The intake gates will consist of 2 sets of sluices, each 2.0 m wide and 1.5 m high, which will be operated by man power. The intake discharge is estimated at 3 m^3/sec at maximum.

6.3.2 Headworks for the Auchi Project

1) Site Conditions

The weir site is selected in the Ojo river just upstream of the bridge of the road running through Ikabigbo and Ayoguri to take water within the shortest distance from the project area. At the site, the river is about 35 m wide and 2.5 m deep. The longitudinal gradient of the river bed is 1 : 350 on an average.

Geological condition of the site is described in Chapter 3.2. The depth to foundation rock is approximately 1 m in the river course and within 4 m in both banks of the river. The surface soil of the left bank consists of sandy loam which is deemed to be suitable as embankment materials. The surface soil of the right bank includes stiff clay, which is residuum of shale and can be used as the foundation of low embankment if properly stripped. The design flood discharge is estimated at 80 m^3/sec in Chapter 2.2.

2) Diversion Weir

The fixed type concrete gravity weir with a crest elevation of El. 100.0 m and 21 m long and 5.5 m high, will be constructed across the river on the solid foundation rock. In the left end of the weir, one set of sand scouring sluice, 1.5 m wide and 3.2 m high, will be installed. It will be operated by man power. The elevation of the operation deck will be at El. 104.3 m. The apron will be constructed in the down stream of the weir with a length of 16 m.

3) Intake Structures

The intake structures will be constructed on the left bank, just upstream of the weir. The maximum intake discharge is 1.5 m^3/sec and the proposed intake water level is El. 99.85 m with an inflow water depth of 1 m. The intake gate will consist of 1 set of sluice gate, 2 m wide and 1.5 m high, which will be operated by man power.

6.4 Irrigation Canals and Related Structures

6.4.1 Layout of Irrigation Canals

The general layout of the proposed canal system is shown in Dwg. No. 01 and 02 , for the Owerri and Auchi Projects respectively.

The head race is for conveying irrigation water from the intake structures to the project area and irrigation water is delivered to the tertiary canals through main or secondary canals. The tertiary canals are diverted from the secondary canals with approximate intervals of 500 m supplying water to the irrigation unit of 30-80 ha. Distribution of water within the unit will be made by the supply canals to be branched off from the tertiary canals with an interval of 225 m.

The length of irrigation canals for the Owerri and Auchi Projects are estimated as follows.

Total Length of Irrigation Canals (km)

Name of canal	Owerri Project	Auchi Project
Head race	16.8	11.74
Main canal	-	7.00
Secondary canal	11.40	18.57
Tertiary canal	50.56	46.10
Supply canal	219.00	219.00

6.4.2 Preliminary Design of Irrigation Canals

The preliminary design of the canals has been made based on the basic design criteria summarized in Table 6.12.

Depending on this criteria, monograph for the hydraulic calculation of canals is prepared as shown in Fig. 6.6. The canals are classified into the following types. The typical section is illustrated in Fig. 6.7.

Type of canal	B/1	Max. d/2	Fb/3
A	2.50	1.67	0.55
B	1.75	1.17	0.50
C	1.50	1.00	"
D	1.25	0.83	0.45
E	1.00	1.00	"
F	0.75	0.75	0.40
G	0.50	0.50	0.35
H	0.30	0.30	0.30

/1 B: Canal bottom width in m

/2 d: Water depth in m

/3 Fb: Freeboard in m

The schematic diagram are shown in Fig. 6.8 and 6.9.

According to the type, lengths of the canals are estimated as follows.

Type of canal	Owerri Project (km)	Auchi Project (km)
A	16.38	-
B	-	11.74
C	4.95	1.85
D	0.50	-
E	2.00	3.41
F	3.00	5.01
G	34.55	13.80
H	235.95	266.60
Total	297.33	302.41

6.4.3 Design of the Related Structures

The canals run across the rivers, streams, and roads. Accordingly, many related structures such as flumes, culverts, and cross drains will be needed. In addition to these structures, turnouts, checks and spillway structures will also be needed to distribute water or secure the rational water management. In case of the Auchi Project, the slope of the ground surface is rather steep so that a number of drops will be necessary. Required number of these structures is summarized below.

Structure	Owerri Project (Nos)	Auchi Project (Nos)
1. Flume	-	2
2. Culverts	208	198
3. Cross drain	153	105
4. Turnout	432	483
5. Spillway	3	8
6. Drop	-	50

The flumes are needed in the head race for the Auchi Project where the head race traverses the steep cliffs of the Ojo river, they will be of rectanglar type with a dimension of 1.5 m x 2.0 m x 200 m, made of cast-in-situ concrete.

To construct canals across roads, either culverts or bridges are needed. It is estimated roughly that in case the canal width is less than 15 m, culverts are more economical than bridges. Since the width of the canals for both projects is less than 10 m, culverts are adopted as the crossing structures.

The culverts will consist of precast concrete pipes and inlet and outlet boxes made of cast-in-situ concrete. Size of the precast concrete pipes varies from ϕ1,200 mm to 300 mm in accordance with the discharge. In case that necessary diameter is more than 1,200 mm, rectangular type of cast-in-situ concrete box will be constructed. The length of the culverts is 14 m and 11 m respectively for crossing the main and branch roads.

Cross drains are for conducting the flow of streams and drains under the bottom of the irrigation canals, and will consist of either precast concrete pipes or cast-in-situ concrete. The dimensions of these cross drains will vary from ϕ1,000 mm to ϕ300 mm for the precast concrete type and from 2.5 m x 2.5 m to 1.5 m x 1.5 m for the cast-in-situ concrete type.

Turnouts are provided for diverting water from canal to canal. The following three types of turnouts are proposed.

Type	Descriptions	Location
A	Regulated by stoplog without check gate	Tertiary canal to supply canal
B	Regulated by sluice gate with check gate	Secondary canal to tertiary canal
C	Regulated by sluice gate with check gate and broad crested measuring weir	Secondary canal to tertiary canal, Main canal or head race to secondary canal

For the purpose of keeping the canal from overflowing, a number of spillways are necessary. Side overflow type spillway will be generally adopted because of its simplicity.

Attached to some of these side spillways, the whole discharge wasteway will also be constructed to drain the canal completely for the inspection or maintenance. This combination type of spillway (Type-A) will be constructed just downstream of the intake structures on the head race, and on each secondary canal for the Owerri Project and on main canal for the Auchi Project. The side overflow type spillway (Type-B) will be constructed on each of secondary canals for the Auchi Project.

The slope of the ground surface of the Auchi Project area is fairly steep with an average inclimation of about 1 : 100. On the other hand, longitudinal slope of the canal is required to be more gentle in order to keep the velocity within the allowable limit. Therefore, many drops are needed in order to adjust the height of difference between ground surface and water surface. The design fall will be in the range of 0.6 m to 1.3 m. Drops are needed only for the Auchi Project.

6.5 Drainage Canals and Related Structures

6.5.1 Layout of Drainage Canals

The proposed drainage system will consist of collector and field drains to be constructed, and utilization of existing natural depressions and streams. The existing depressions and streams will serve as the main drainage canals. The drained water from every plot of paddy field will discharge into field drains and, further, into the collector drains. The layout of the drainage system is shown in Dwg. No. 01 and 02. The total length of the drains are as follows.

Name of Drain	Owerri Project (km)	Auchi Project (km)
Collector Drain	26.0	31.8
Field Drain	110	105

6.5.2 Design of Drainage Canal

The design drainage requirement is decided so as to drain the excess water on paddy fields within 36 hours. The excess water is assumed to be caused by the maximum daily rainfall of 100 mm and 122 mm, respectively for the Owerri Project and the Auchi Project. These maximum daily rainfalls are estimated on the occurrence probability of once in five years. The schematic diagram of the drainage canals is shown in Fig. 6.10 and 6.11.

All the drainage canals have trapezoidal section with a side slope of 1 : 1.5. The longitudinal slope of the drain is decided based on the same criteria as used for the irrigation canal. The typical section of the drainage canals is illustrated in Fig. 6.12.

6.5.3 Design of the Related Structures

1) Culvert

Culverts are needed at the crossing points of the drainage canals with roads. The type of the culverts for the drainage canals is entirely the same as that for the irrigation canals. Necessary number is 50 and 105, respectively for the Owerri Project and for the Auchi Project.

2) Drop

A number of drops will also be required on the drains, especially in the Auchi Project. The design height of fall will vary from 0.4 m to 1.5 m in accordance with topography. The type of drop is the same as that for the irrigation canal, and necessary number will be 13 and 59, respectively for the Owerri Project and the Auchi Project.

6.6 Farm Road

6.6.1 Road Layout

The proposed road system consists of two types of roads, i.e., main road and branch road. Main road will run along the main and the secondary irrigation canals and serve as the main artery in the area and connecting lines between villages. While, the branch road will be laid along the tertiary and supply irrigation canals and used mainly for farming purposes.

As shown in DWG. 01 and 02, all the project areas will be covered by the proposed road net works with an average grid interval of 225 m x 500 m.

Total length of the roads is estimated as follows.

	Owerri Project (km)	Auchi Project (km)
Main road	20	23.4
Branch road	150	155

6.6.2 Typical Sections of the Roads

The typical sections of the main road and the branch road are shown in Fig. 6.13.

The main road will have an effective width of 7 m with laterite pavement of 30 cm thick. The effective width of the branch road is 5 m with laterite pavement of 20 cm thick. The total width will be 10 m in the main road and 7 m in the branch road, and the road surface will be inclined to both sides with a slope of 3% for the sake of drainage.

6.7 Layout of Paddy Field

A typical layout of paddy field proposed for the project is presented in Fig. 6.14.

The smallest irrigation unit, which is to be commanded by one supply canal, will consist of 12 and 16 plots of paddy field respectively for the Owerri and Auchi Projects.

Size of the plot is decided at 40 m x 100 m for the Owerri Project and at 30 m x 100 m for the Auchi Project taking into consideration the slope of the ground surface, water management workability of agricultural machinery, size of land holding by farmers, and etc.

The land surface of the Owerri Project area is rather flat with an average slope of 1 : 500 and hence, the size of the plot is decided mainly from the viewpoints of water management and the size of land holding by farmers, whereas the size of the plot for the Auchi Project is decided mainly in view of the topographic features that the slope of the land surface is rather steep with an average inclination of 1 : 100.

Table 6.1 Climatic Data at Umudike Station (1976)

Latitude : 5°29'N

Altitude : 120m

Month	Temperature t	Relative humidity RH	Sunshine hour N	n	n/N	Wind velocity U2
	(°C)	(%)	(hrs)	(hrs)		(Km/day)
Jan.	25.9	69	11.8	5.6	0.47	109
Feb.	26.9	83	11.9	5.4	0.45	129
Mar.	27.3	81	12.0	5.3	0.44	118
Apr.	27.2	83	12.2	4.5	0.37	118
May	26.9	83	12.3	5.4	0.44	111
Jun.	25.8	85	12.4	4.1	0.33	131
Jul.	24.2	88	12.3	1.6	0.13	164
Aug.	24.3	87	12.3	1.8	0.15	162
Sep.	25.6	84	12.1	2.6	0.21	148
Oct.	25.8	88	12.0	2.9	0.24	139
Nov.	26.2	82	11.9	4.4	0.37	105
Dec.	27.3	73	11.5	5.4	0.46	106

Table 6.2 Climatic Data at the Umudike Station (1972-1976)

Latitude : 5°20'N

Altitude : 60m

Month	Temperature t	Relative humidity RH	Sunshine hour N	n	n/N	Wind velocity .U2
	(°C)	(%)	(hrs)	(hrs)		(Km/day)
Jan	26	71	11.8	5.9	0.50	91
Feb	28	77	11.9	5.6	0.47	114
Mar	27	77	12.0	5.1	0.43	117
Apr	27	81	12.2	5.8	0.48	108
May	27	82	12.3	5.5	0.45	100
Jun	26	84	12.4	4.6	0.37	113
Jul	25	86	12.3	2.9	0.24	113
Aug	25	86	12.3	2.5	0.20	132
Sep	26	84	12.1	2.7	0.22	127
Oct	26	82	12.0	3.8	0.32	111
Nov	27	81	11.9	5.4	0.45	87
Dec	26	71	11.8	5.9	0.50	92

Table 6.3 Climatic Data at Auchi Station

Latitude : 7°00'N

Altitude : 60m

Month	Temperature /1 t	Relative humidity /2 RH	Sunshine hour N	Sunshine hour n /3	n/N	Wind velocity /2 U2
	(°C)	(%)	(hrs)	(hrs)		(Km/day)
Jan.	23	55	11.7	6.6	0.56	88
Feb.	26	64	11.9	7.1	0.60	132
Mar.	27	69	12.0	6.5	0.54	112
Apr.	26	72	12.2	6.5	0.53	111
May	26	80	12.5	6.6	0.53	86
Jun.	25	77	12.5	5.6	0.45	66
Jul.	24	80	12.4	4.8	0.39	103
Aug.	24	80	12.3	3.8	0.31	88
Sep.	24	76	12.1	4.2	0.35	71
Oct.	25	81	11.9	5.7	0.48	58
Nov.	25	74	11.8	7.6	0.64	47
Dec.	22	61	11.7	7.3	0.62	49

/1 : Irrua govt. farm 1974-1976

/2 : Warrake govt. farm 1976

/3 : Mean value between Benin Nifer and Lokoja met. station (1951-1960, 1971-1975)

Table 6.4 Calculation Sheet for Radiation Method in Owerri Project

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Date													
1. Latitude	5.3°	5.3											
2. Altitude	60m	60											
3. Sunshine,	n/N	0.50	0.47	0.43	0.48	0.45	0.37	0.24	0.20	0.22	0.32	0.45	0.50
4. Temparature,	t(°C)	26	28	27	27	27	26	25	25	26	26	27	26
5. Relative humidity,	RH(%)	71	77	77	81	82	84	86	86	84	82	81	70
6. Wind velocity, U2(Km/day)		91	114	117	108	100	113	113	132	127	111	87	92
W.Rs = W.Ra(0.25 + 0.50n/N)													
7. W (Refer to Appendix 2)		0.75	0.77	0.76	0.76	0.76	0.75	0.74	0.74	0.75	0.75	0.76	0.75
8. Ra (")		14.0	14.8	15.4	15.4	15.1	14.6	14.8	15.2	15.3	15.0	14.3	13.8
9. (0.25 + 0.50n/N)		0.50	0.49	0.47	0.49	0.48	0.44	0.37	0.35	0.36	0.41	0.48	0.50
10. Item7 x Item8 x Item9(mm/day)		5.25	5.58	5.50	5.73	5.51	4.82	4.05	3.94	4.13	4.61	5.22	5.18
Ept = a + b.W.Rs													
11. a (Refer to Appendix 2)		-0.3											
12. b (")		0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
13. Item11 + Item12 x Item10	(mm/day)	3.32	3.55	3.50	3.65	3.50	3.03	2.49	2.42	2.55	2.88	3.30	3.27

Table 6.5 Calculation Sheet for Radiation Method in Auchi Project

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Date													
1. Latitude	7.0°	7.0											
2. Altitude	60m	60											
3. Sunshine,	n/N	0.56	0.60	0.54	0.53	0.53	0.45	0.39	0.31	0.35	0.48	0.64	0.62
4. Temparature,	t(°C)	23	26	27	26	26	25	24	24	24	25	25	22
5. Relative humidity,	RH(%)	55	64	69	72	80	77	80	80	76	81	74	61
6. Wind velocity,	U2(Km/day)	88	132	112	111	86	66	103	88	71	58	47	49
W.Rs = W.Ra(0.25 + 0.50n/N)													
7. W (Refer to Appendix 2)		0.70	0.75	0.76	0.75	0.75	0.74	0.73	0.73	0.73	0.74	0.74	0.71
8. Ra (")		13.8	14.7	15.4	15.5	15.2	14.9	15.0	15.3	15.3	14.9	14.1	13.5
9. (0.25 + 0.50n/N)		0.53	0.55	0.52	0.52	0.52	0.48	0.45	0.41	0.43	0.49	0.57	0.56
10. Item7 + Item8 + Item9	(mm/day)	5.12	6.07	6.09	6.05	5.93	5.29	4.93	4.58	4.80	5.40	5.95	5.37
Ept = a + b.W.Rs													
11. a (Refer to Appendix 2)		-0.3											
12. b (")		0.76	0.76	0.76	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.76
13. Item11 + Item12 + Item10	(mm/day)	3.59	4.31	4.33	3.87	3.79	3.35	3.10	2.86	3.01	3.43	3.81	3.78

Table 6.6 Monthly Effective Rainfall (mm) for Paddy in Owerri Project

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1973	77	21	95	211	239	268	234	221	277	213	23	23	1,902
1974	0	27	111	141	248	284	305	278	206	240	32	0	1,872
1975	0	56	82	124	220	93	341	147	337	197	55	23	1,675
1976	0	139	230	172	135	367	269	194	208	239	37	81	2,071
Mean	19	61	130	162	211	235	287	210	257	222	37	32	1,880
20% chance of drought	0	15	55	123	140	200	230	145	190	195	22	9	1,244
Actual /1	19	62	137	168	231	309	375	315	374	289	38	35	2,352
Percentage	0	24	40	73	61	65	61	46	51	67	58	26	53

/1 Average for 4 years (1973 - 1976) at Alavan station

Table 6.7 Monthly Effective Rainfall (mm) for Paddy in Auchi Project

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1960	0	51	55	236	116	242	57	184	174	171	47	15	1,348
1961	11	0	20	213	81	144	190	0	325	76	0	0	1,060
1962	0	0	76	221	137	136	87	31	127	149	33	0	997
1963	12	26	70	278	72	177	188	182	166	215	0	21	1,407
1964	0	12	40	131	241	156	140	24	195	88	0	32	1,059
1965	10	23	91	76	162	111	228	240	149	71	0	0	1,161
1966	11	7	57	75	286	267	184	208	113	121	0	0	1,329
1967	0	9	85	145	94	281	113	58	———	NA	———		
1968	46	0	46	72	225	198	191	198	290	96	36	6	1,404
1969	0	38	92	180	126	145	151	138	85	185	68	0	1,208
1970	NA	NA	98	94	128	111	50	29	176	51	10	0	
1971	0	0	66	69	238	179	239	94	316	118	37	0	1,356
1972	0	0	83	99	179	137	———	———	NA	———	———		
1973	———	———	———	———	———	NA	———	———	———	———	———	———	
1974	0	0	0	80	159	134	140	104	157	197	0	0	971
1975	0	16	43	113	189	125	240	28	183	102	9	21	1,069
1976	0	106	53	113	152	75	105	108	82	188	31	0	1,013
Mean	6	19	61	137	162	164	154	108	181	131	19	7	1,149
20% chance of drought	0	3	41	85	103	120	95	32	110	78	5	0	679
Actual /1 rainfall	6	20	64	138	164	178	180	134	189	136	20	7	1,236
Percentage	100	15	64	62	63	67	53	24	58	57	25	14	55

/1 Average for 16 years (1960 - 1976) at Auchi station

* NA = Data are not available.

Table 6.8a Irrigation Water Requirement of the Owerri Project

Description	Jun.	Jul.		Aug.		Sep.		Oct.		Nov.
Schematic Cropping Calender		Estate Farm Paddy (Direct Sowing) 1,015 ha						Drain		
A. Consumptive Use of Water										
(1) Crop Coefficient (kc)	0.85	1.05	1.19	1.27	1.29	1.26	1.13			
		0.85	1.05	1.19	1.27	1.29	1.26	1.13		
			0.85	1.05	1.19	1.27	1.29	1.26	1.13	
				0.85	1.05	1.19	1.27	1.29	1.26	1.13
(2) Average Crop Coefficient (kc)	0.85	0.92	1.00	1.10	1.21	1.26	1.25	1.21	1.21	1.13
(3) Potential Evapotranspiration mm	46	39	39	38	38	39	39	45	45	50
(4) Consumptive Use of Water(2)x(3)mm	39	36	39	42	46	49	49	54	54	57
B. Percolation mm	30	30	30	30	30	30	30	30	30	45
C. Effective Rainfall mm	100	115	115	73	73	95	95	98	98	11
D. (A) + (B) - (C) mm	0	0	0	0	3	0	0	0	0	91
E. Crop Intensity to Total Area	1/6	3/6	5/6	1	1	1	1	5/6	3/6	1/6
F. Other Water Requirement mm	30	30	30	-	-	-	-	-	-	-
G. Net Water Requirement (D)x(E)+(F) mm	30	30	30	0	3	0	0	0	0	15
H. Unit Water Requirement (G)/E/1 mm	46	46	46	0	5	0	0	0	0	23
" " " ℓ/s/ha	0.35	0.35	0.35	0	0.04	0	0	0	0	0.18
I. Irrigation Water Requirement m^3/sec	0.35	0.35	0.35	0	0.04	0	0	0	0	0.18

/1 : Irrigation efficing "E" is 0.65.

Table 6.8b Irrigation Water Requirement for the Owerri Project

Description	Nov.	Dec.		Jan.		Feb.		Mar.		Apr.	May
Schematic Cropping Calender		Estate Farm Paddy (Direct Saving) 1,015 ha						Drain			
A. Consumptive Use of Water											
(1) Crop Coefficient (kc)	0.85	1.05	1.19	1.27	1.29	1.26	1.13				
		0.85	1.05	1.19	1.27	1.29	1.26	1.13			
			0.85	1.05	1.19	1.27	1.29	1.26	1.13		
				0.85	1.05	1.19	1.27	1.29	1.26	1.13	
(2) Average Crop Coefficient (kc)	0.85	0.92	1.00	1.10	1.21	1.26	1.25	1.21	1.17	1.13	
(3) Potential Evapotranspiration mm	50	51	51	52	52	50	50	55	55	55	
(4) Consumptive Use of Water(2)x(3)mm	43	47	51	57	63	63	63	67	64	62	
B. Percolation mm	45	45	45	45	45	45	45	30	30	30	
C. Effective Rainfall mm	11	4.5	4.5	0	0	7.5	7.5	28	28	62	
D. (A) + (B) - (C) mm	77	88	92	102	108	101	101	679	66	30	
E. Crop Intensity to Total Area	1/6	3/6	5/6	1	1	1	1	5/6	3/6	1/6	
F. Other Water Requirement mm	30	30	30	-	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E) mm	43	74	107	102	108	101	101	58	33	5	
H. Unit Water Requirement (G)/E mm	66	114	165	157	166	15	155	89	51	8	
" " " ℓ/s/ha	0.51	0.88	1.27	1.21	1.28	1.20	1.20	0.69	0.39	0.06	
I. Irrigation Water Requirement m^3/sec	0.51	0.88	1.27	1.21	1.28	1.20	1.20	0.69	0.39	0.06	

Table 6.8c Irrigation Water Requirement for the Owerri Project

Description	Jan.	Feb.		Mar.		Apr.		May		Jun.
Schematic Cropping Calender		Small Holder Paddy (Transplanting) 1,085 ha						Drain		
A. Consumptive Use of Water										
(1) Crop Coefficient (kc)	1.07	1.01	1.13	1.24	1.28	1.17				
		1.07	1.01	1.13	1.24	1.28	1.17			
			1.07	1.01	1.13	1.24	1.28	1.17		
				1.01	1.01	1.13	1.24	1.28	1.17	
(2) Average Crop Coefficient (kc)	1.07	1.05	1.06	1.10	1.17	1.22	1.23	1.21	1.17	
(3) Potential Evapotranspiration mm	52	50	50	55	55	55	55	55	55	
(4) Consumptive Use of Water mm	56	53	53	61	64	67	68	67	64	
B. Percolation mm	45	45	45	30	30	30	30	30	30	
C. Effective Rainfall mm	0	7.5	7.5	28	28	62	62	70	70	
D. (A) + (B) - (C) mm	101	91	91	63	66	35	36	27	24	
E. Crop Intensity to Total Area	1/6	3/6	5/6	1	1	1	5/6	3/6	1/6	
F. Other Water Requirement mm	40	40	40	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F) mm	57	86	116	63	66	35	30	14	4	
H. Unit Water Requirement (G)/E mm	88	132	178	97	102	54	46	22	6	
" " " ℓ/s/ha	0.68	1.02	1.37	0.75	0.79	0.42	0.35	0.17	0.05	
I. Irrigation Water Requirement m^3/sec	0.75	1.12	1.51	0.83	0.87	0.46	0.39	0.19	0.06	

Table 6.8d Irrigation Water Requirement for the Owerri Project

Description	Aug.	Sep.		Oct.		Nov.		Dec.		Jan.
Schematic Cropping Calender		Small Holder Paddy (Transplanting) 1,085 ha						Drain		
A. Consumptive Use of Water										
(1) Crop Coefficient (kc)	1.07	1.01	1.13	1.24	1.28	1.17				
		1.07	1.01	1.13	1.24	1.28	1.17			
			1.07	1.01	1.13	1.24	1.28	1.17		
				1.07	1.01	1.13	1.24	1.28	1.17	
(2) Average Crop Coefficient (kc)	1.07	1.05	1.06	1.10	1.17	1.22	1.23	1.21	1.17	
(3) Potential Evapotranspiration mm	38	39	39	45	45	50	50	51	51	
(4) Consumptive Use of Water(2)x(3)mm	41	41	41	50	53	61	62	62	60	
B. Percolation mm	30	30	30	30	30	45	45	45	45	
C. Effective Rainfall mm	73	95	95	98	98	11	11	4.5	4.5	
D. (A) + (B) - (C) mm	0	0	0	0	0	95	96	103	101	
E. Crop Intensity to Total Area	1/6	3/6	5/6	1	1	1	5/6	3/6	1/6	
F. Other Water Requirement mm	33	33	33	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F) mm	33	33	33	0	0	95	80	52	17	
H. Unit Water Requirement (G)/E/1 mm	51	51	51	0	0	146	123	80	26	
" " " l/s/ha	0.39	0.39	0.39	0	0	1.13	0.95	0.62	0.20	
I. Irrigation Water Requirement, m^3/sec	0.43	0.43	0.43	0	0	1.24	1.05	0.68	0.22	

/1 Irrigation efficiency "E" is 0.65.

Table 6.9a Irrigation Water Requirement for Auchi Project

Description	Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.
Schematic Cropping Calender	Estate Farm Paddy (Direct Sowing) 1,800 ha — Drain												
A. Consumptive Use of Water													
(1) Crop Coefficient (kc)	0.85	1.05	1.19	1.27	1.29	1.26	1.13						
		0.85	1.05	1.19	1.27	1.29	1.26	1.13					
			0.85	1.05	1.19	1.27	1.29	1.26	1.13				
				0.85	1.05	1.19	1.27	1.29	1.26	1.13			
					0.85	1.05	1.19	1.27	1.29	1.26	1.13		
						0.85	1.05	1.19	1.27	1.29	1.26	1.13	
(2) Average Crop Coefficient (kc)	0.85	0.92	1.00	1.06	1.11	1.17	1.22	1.23	1.23	1.21	1.17	1.13	
(3) Potential Evapotranspiration mm	58	58	59	59	51	51	48	48	45	45	45	45	
(4) Consumptive Use of Water(2)x(3)mm	49	53	59	63	57	60	59	59	55	54	53	51	
B. Percolation	30	30	30	30	30	30	30	30	30	30	30	30	
C. Effective Rainfall mm	43	43	52	52	60	60	48	48	16	16	55	55	
D. (A) + (B) - (C) mm	36	40	37	41	27	30	41	41	69	68	28	26	
E. Crop Intensity to Total Area	1/10	3/10	5/10	7/10	9/10	1	1	9/10	7/10	5/10	3/10	1/10	
F. Other Water Requirement mm	18	18	18	18	18	-	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F) mm	22	30	37	47	42	30	41	37	48	34	8	3	
H. Unit Water Requirement(G)/E/1 mm	34	46	57	72	65	46	63	57	74	52	12	5	
" " " l/s/ha	0.26	0.35	0.44	0.56	0.50	0.35	0.49	0.44	0.57	0.40	0.09	0.04	
I. Irrigation Water Requirement m^3/sec	0.47	0.63	0.79	1.01	0.90	0.63	0.88	0.79	1.03	0.72	0.16	0.07	

/1: Irrigation efficience "E" is 0.65.

Table 6.9b Irrigation Water Requirement for Auchi Project

Description		Sep.		Oct.		Nov.		Dec.		Jan.
Schematic Cropping Calender		Estate Farm Paddy (Direct Sowing) 400 ha							Drain	
A. Consumptive Use of Water										
(1) Crop Coefficient (kc)		0.85	1.05	1.19	1.27	1.29	1.26	1.13		
			0.85	1.05	1.19	1.27	1.29	1.26	1.13	
(2) Average Crop Coefficient (kc)		0.85	0.92	1.12	1.23	1.28	1.29	1.20	1.13	
(3) Potential Evapotranspiration	mm	45	45	53	53	57	57	59	59	
(4) Consumptive Use of Water (2) x (3)	mm	38	41	59	65	73	74	71	67	
B. Percolation	mm	30	30	30	30	45	45	45	45	
C. Effective Rainfall	mm	55	55	39	39	2.5	2.5	0	0	
D. (A) + (B) - (C)	mm	13	16	50	56	116	117	116	112	
E. Crop Intensity to Total Area		1/2	1	1	1	1	1	1	1/2	
F. Other Water Requirement	mm	90	-	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F)	mm	97	16	50	56	116	117	116	56	
H. Unit Water Requirement(G)/E	mm	149	25	77	86	178	180	178	86	
" " "	ℓ/s/ha	1.15	0.19	0.59	0.66	1.37	1.39	1.37	0.66	
I. Irrigation Water Requirement	m^3/sec	0.46	0.08	0.24	0.26	0.55	0.56	0.55	0.26	

Table 6.9c Irrigation Water Requirement for Auchi Project

Description		Jul.		Aug.		Sep.		Oct.	Nov.
Schematic Cropping Calender		Small Holder Paddy (Transplanting) 300 ha						Drain	
A. Consumptive Use of Water									
(1) Crop Coefficient (kc)		1.07	1.01	1.13	1.24	1.28	1.17		
			1.07	1.01	1.13	1.24	1.28	1.17	
(2) Average Crop Coefficient (kc)		1.07	1.04	1.07	1.19	1.26	1.23	1.17	
(3) Potential Evapotranspiration		48	48	45	45	45	45	53	
(4) Consumptive Use of Water (2)x(3)	mm	51	50	48	54	57	55	62	
B. Percolation	mm	30	30	30	30	30	30	30	
C. Effective Rainfall	mm	48	48	16	16	55	55	39	
D. (A) + (B) - (C)	mm	33	32	62	68	32	30	53	
E. Crop Intensity to Total Area		1/2	1	1	1	1	1	1/2	
F. Other Water Requirement	mm	100	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F)	mm	117	32	62	68	32	30	27	
H. Unit Water Requirement(G)/E	mm	180	49	95	105	49	46	442	
" " "	ℓ/s/ha	1.39	0.38	0.73	0.81	0.38	0.35	0.32	
I. Irrigation Water Requirement	m^3/sec	0.42	0.11	0.22	0.24	0.11	0.11	0.10	

Table 6.9d Irrigation Water Requirement for Auchi Project

Description		Jan.		Feb.		Mar.		Apr.	May
Schematic Cropping Calender		Small Holder Paddy (Transplating) 200 ha					Drain		
A. Consumptive Use of Water									
(1) Crop Coefficient (kc)		0.77	0.95	1.09	1.15	1.15	1.07		
			0.77	0.95	1.09	1.15	1.15	1.07	
(2) Average Crop Coefficient (kc)		0.77	0.86	1.02	1.12	1.15	1.11	1.07	
(3) Potential Evapotranspiration		56	56	61	61	67	67	58	
(4) Consumptive Use of Water (2)x(3)	mm	43	48	62	68	77	74	62	
B. Percolation	mm	45	45	45	45	45	45	30	
C. Effective Rainfall	mm	0	0	1.5	1.5	21	21	43	
D. (A) + (B) - (C)	mm	88	93	105.5	111.5	101	98	49	
E. Crop Intensity to Total Area		1/2	1	1	1	1	1	1/2	
F. Other Water Requirement	mm	120	-	-	-	-	-	-	
G. Net Water Requirement (D)x(E)+(F)	mm	164	93	105.5	111.5	101	98	49	
H. Unit Water Requirement (G)/E	mm	252	143	162	172	155	151	95	
" " "	ℓ/s/ha	1.94	1.10	1.25	1.77	1.20	1.17	0.17	
I. Irrigation Water Requirement	m^3/sec	0.39	0.22	0.25	0.27	0.24	0.23	0.15	

Table 6.10 Diversion Water Requirement for the Owerri Project

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Estate Farm												
Paddy (Direct Sowing) 1,015 ha	1.21 1.28	1.20 1.20	0.69 0.39	0.06		0.35 0.35	0.35 0	0.04 0	0 0	0 0	0.18 0.51	0.88 1.27
Small Holder												
Paddy (Transplanting) 1,085 ha	0.75	1.12 1.51	0.83 0.87	0.46 0.39	0.19 0.06			0.43	0.43 0.43	0 0	1.24 1.05	0.68 0.22
Diversion Requirement	1.21 2.03 1.62	2.32 2.71 2.52	1.52 1.26 1.39	0.52 0.39 0.46	0.19 0.06 0.13	0 0.35 0.18	0.35 0.35 0.35	0 0.47 0.24	0.43 0.43 0.43	0 0 0	1.42 1.56 1.49	1.56 1.49 1.53
River Discharge	2.90	2.75	2.65	6.37	5.91	7.93	7.44	11.01	11.31	10.80	3.65	3.15

Table 6.11 Diversion Water Requirement for the Auchi Project

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Estate Farm												
Paddy (Direct Sowing) 1,800 ha				0.47 0.63	0.79 1.01	0.90 0.63	0.88 0.79	1.03 0.72	0.16 0.07			
Paddy (Direct Sowing) 400 ha									0.46 0.08	0.24 0.26	0.55 0.56	0.55 0.26
Small Holder												
Paddy (Transplanting) 300 ha							0.42 0.11	0.22 0.24	0.11 0.11	0.10		
Paddy (Transplanting) 200 ha	0.39 0.22	0.25 0.27	0.24 0.23	0.15								
Diversion Requirement	0.39 0.22 0.31	0.25 0.27 0.26	0.24 0.23 0.24	0.62 0.63 0.63	0.79 1.01 0.90	0.90 0.63 0.77	1.22 0.90 1.06	1.25 0.96 1.11	0.73 0.26 0.50	0.34 0.26 0.30	0.55 0.56 0.56	0.55 0.26 0.41
River Discharge	0.4	0.4	0.30	1.2	1.1	1.6	1.5	2.3	2.4	2.2	0.6	0.5

Table 6.12 Design Criteria of Irrigation Canals

1	Design discharge (ℓ/sec./ha)	Owerri Project.....1.43 Auchi Project.....0.71
2	Canal capacity	$Q = VA$, $V = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$ where Q = Discharge (m^3/sec.) V = Velocity (m/sec.) A = Flow area (m^2) n = Coefficient of roughness Earth canal.....0.03 Concrete structure....0.015 R = Hydraulic radius (m) I = Hydraulic gradient
3	Side slope	Head race, Main & Secondary canal...1:1.5 Tertiary & Supply canal.....1:1.0
4	Permissible max. velocity (m/sec.)	Earth canal.....0.6
5	B/d ratio B: Canal bottom width d: Water depth	$Q \geq 1.0$ (m^3/sec.).....1.5 $Q < 1.0$ (m^3/sec.).....1.0
6	Freeboad (Fb) (m)	$Fb = 0.05d + hv + 0.30$ where hv = Head of velocity (m)

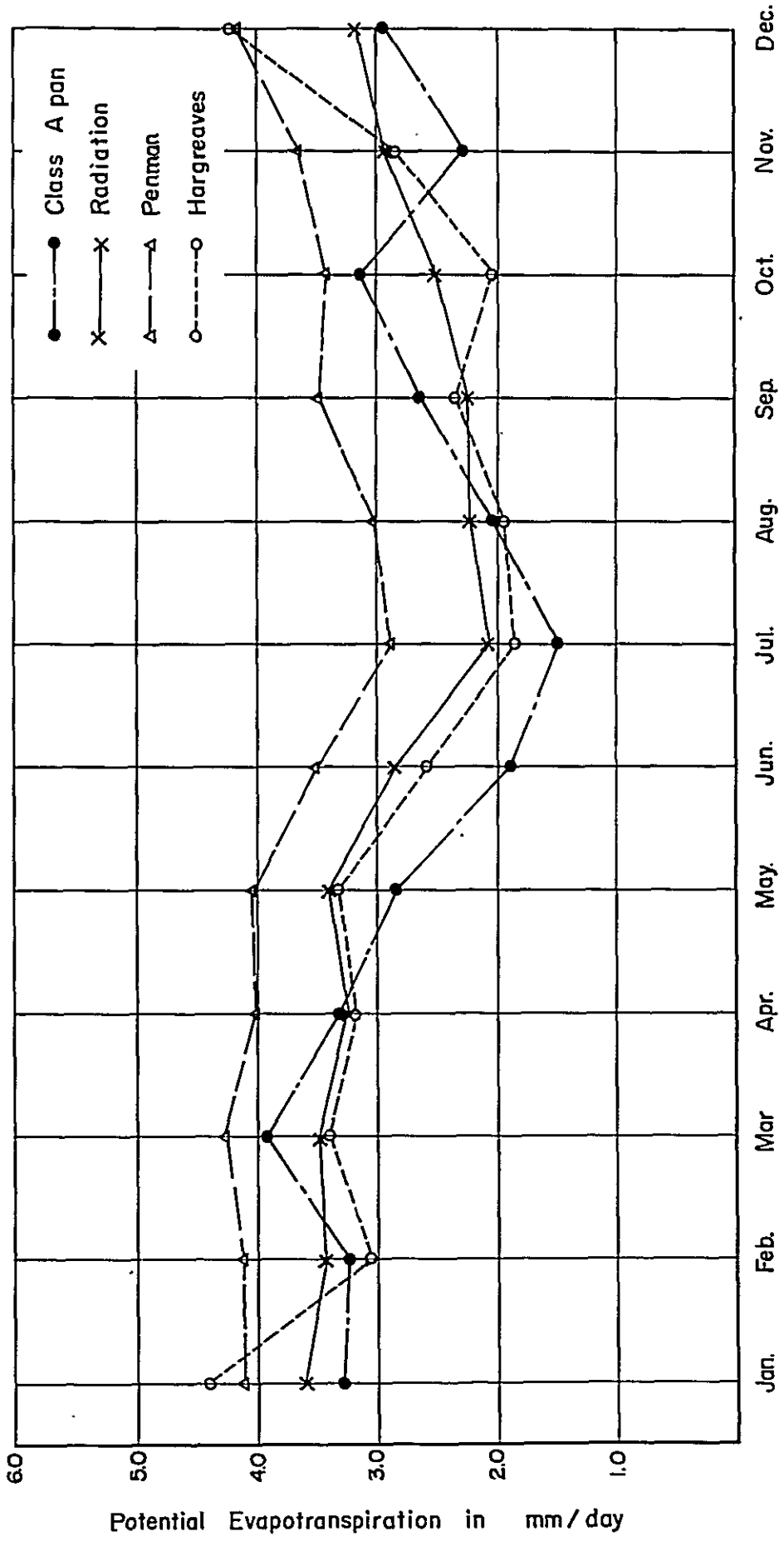


Fig. 6 I Comparison of Potential Evapotranspiration at Umudike Station (1976)

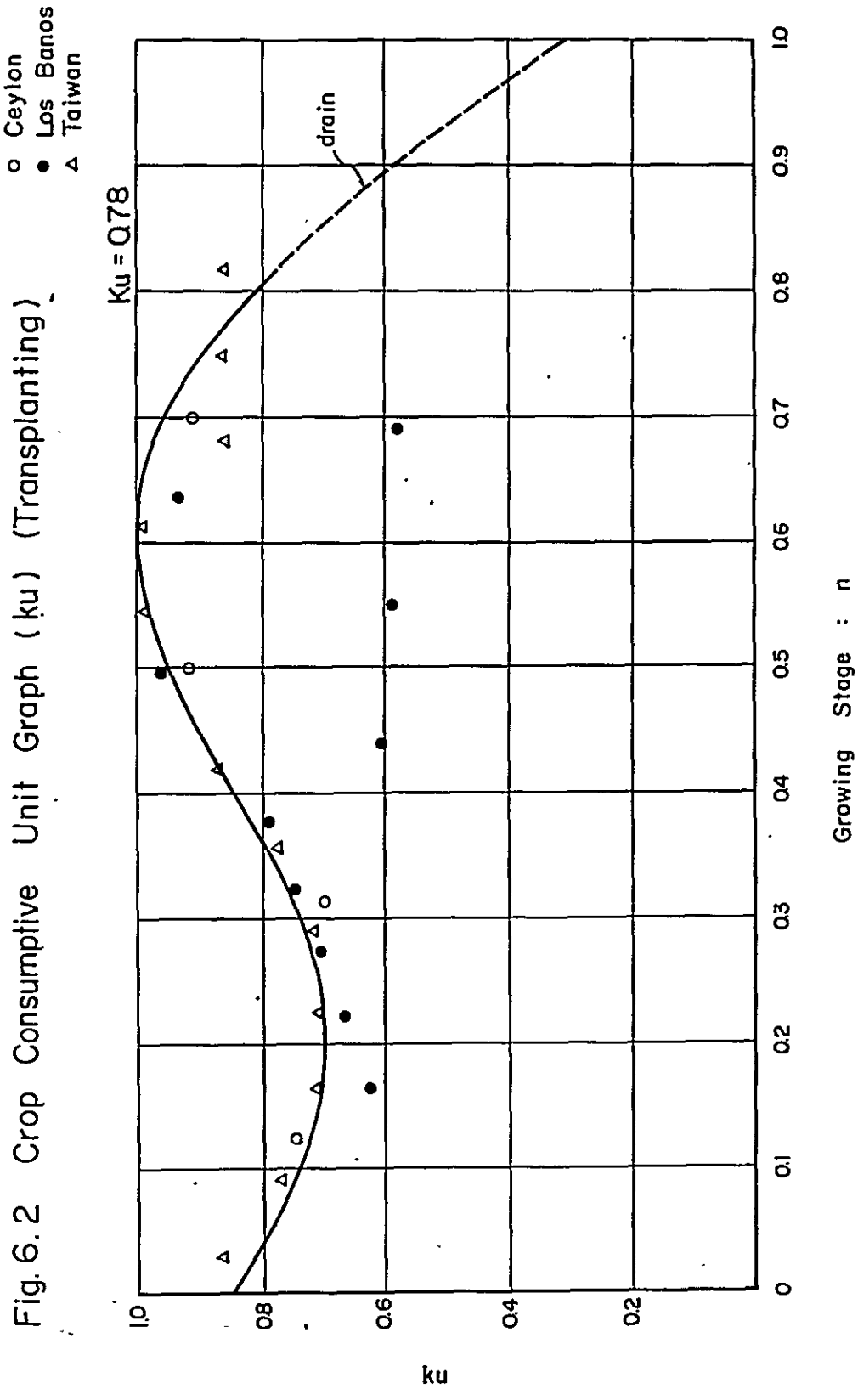


Fig. 6.2 Crop Consumptive Unit Graph (ku) (Transplanting)

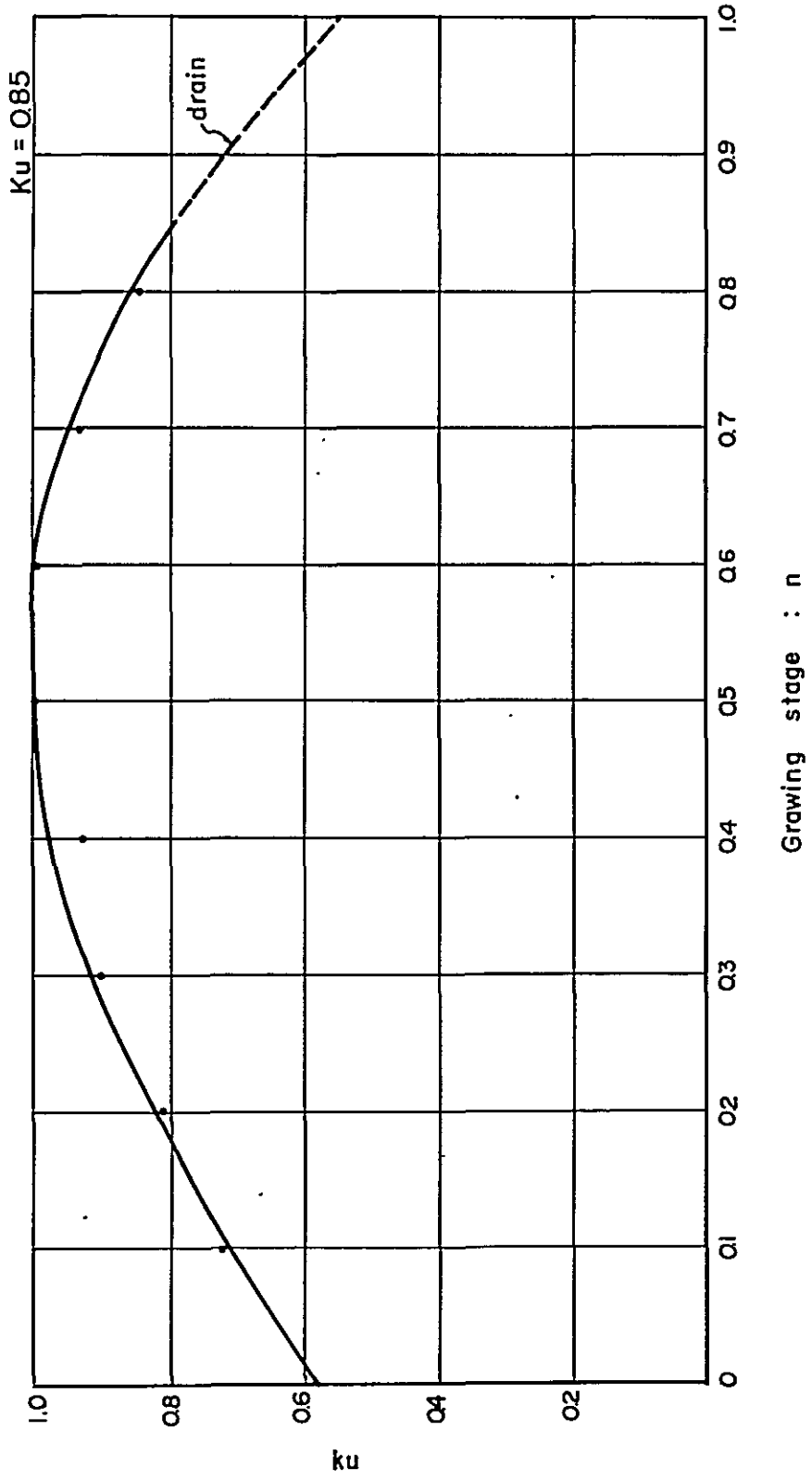


Fig. 6.3 Crop Consumptive Unit Graph (ku) (Direct Sowing)

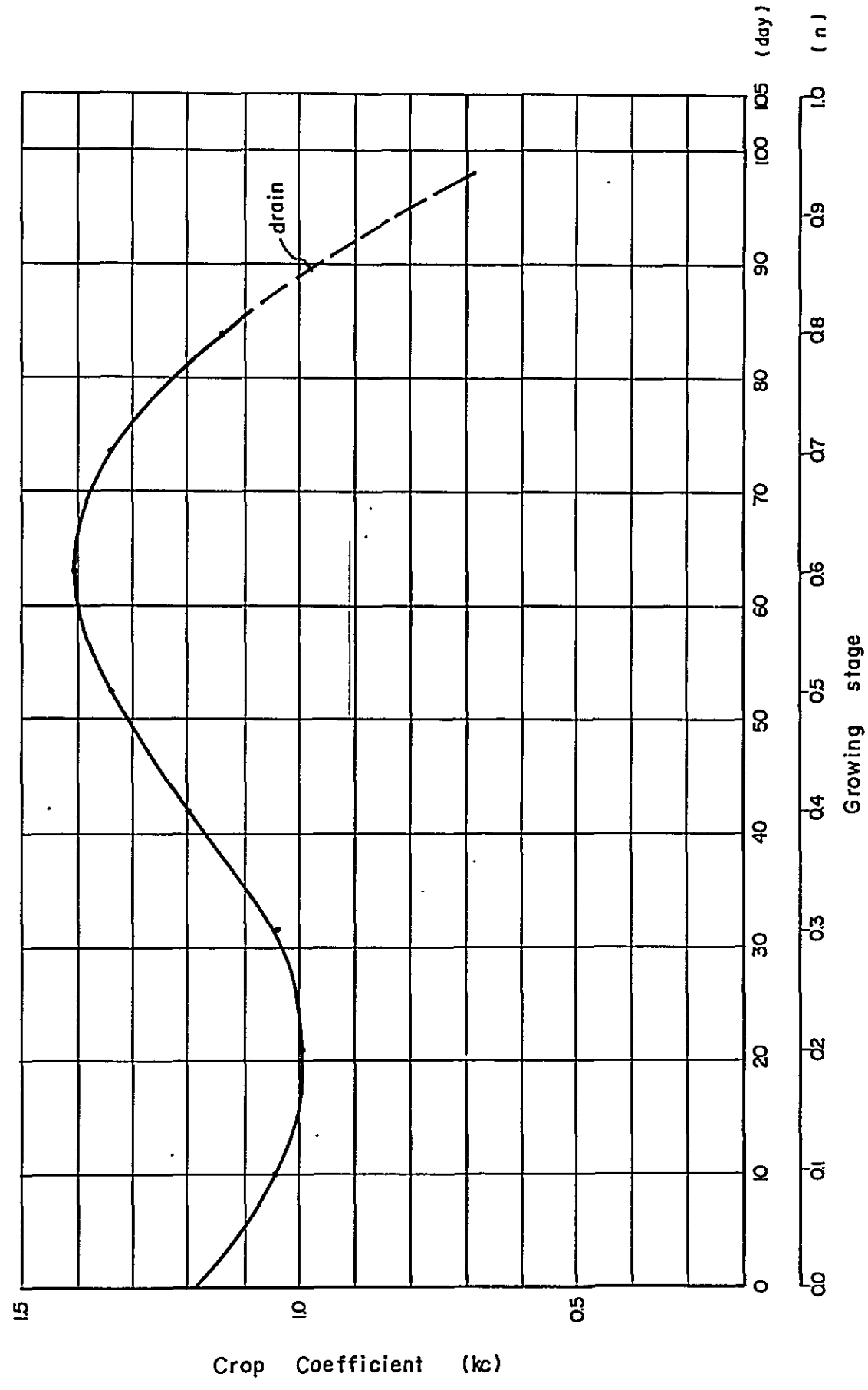


Fig. 6.4 Crop Coefficient for Paddy (Transplanting)

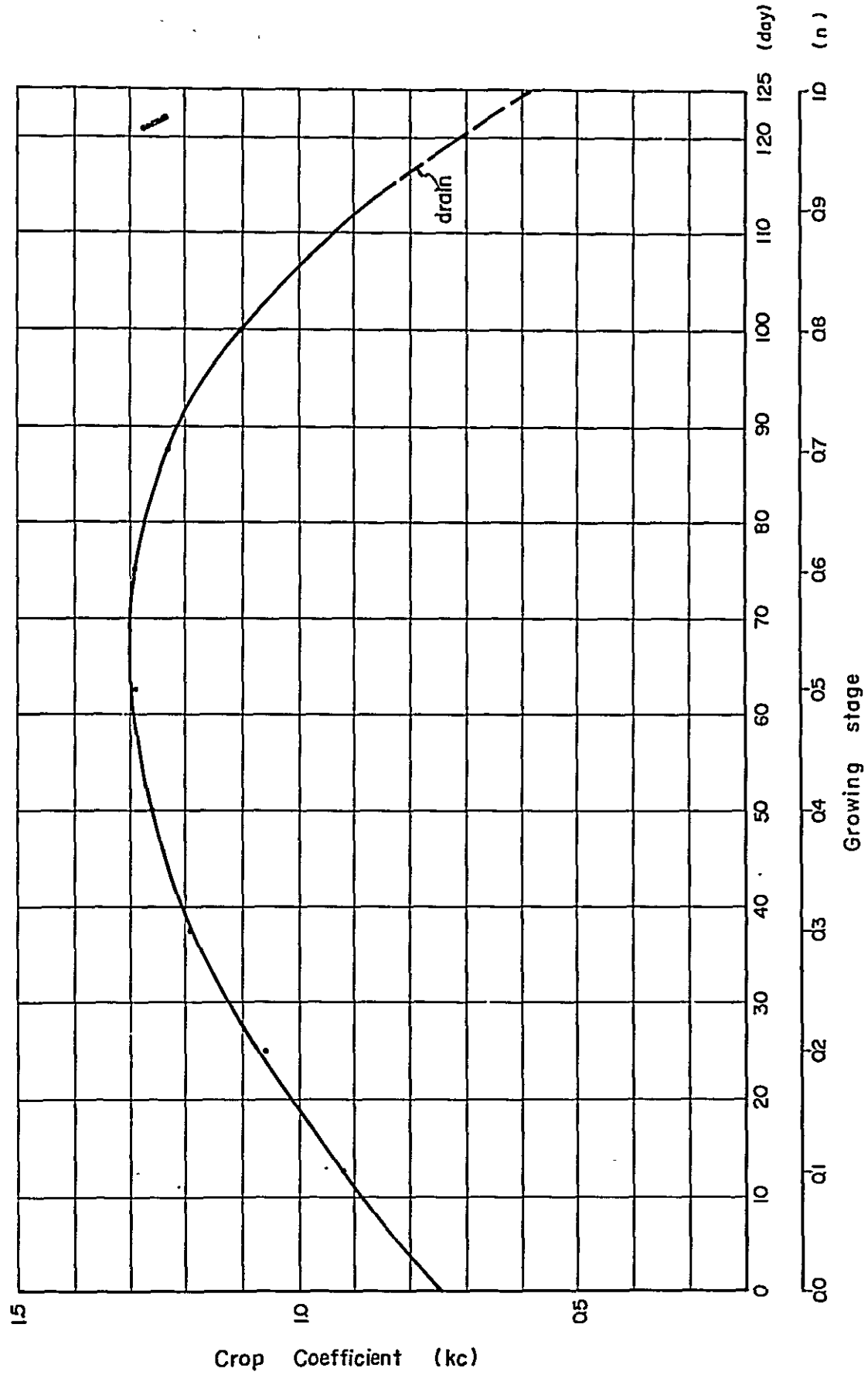
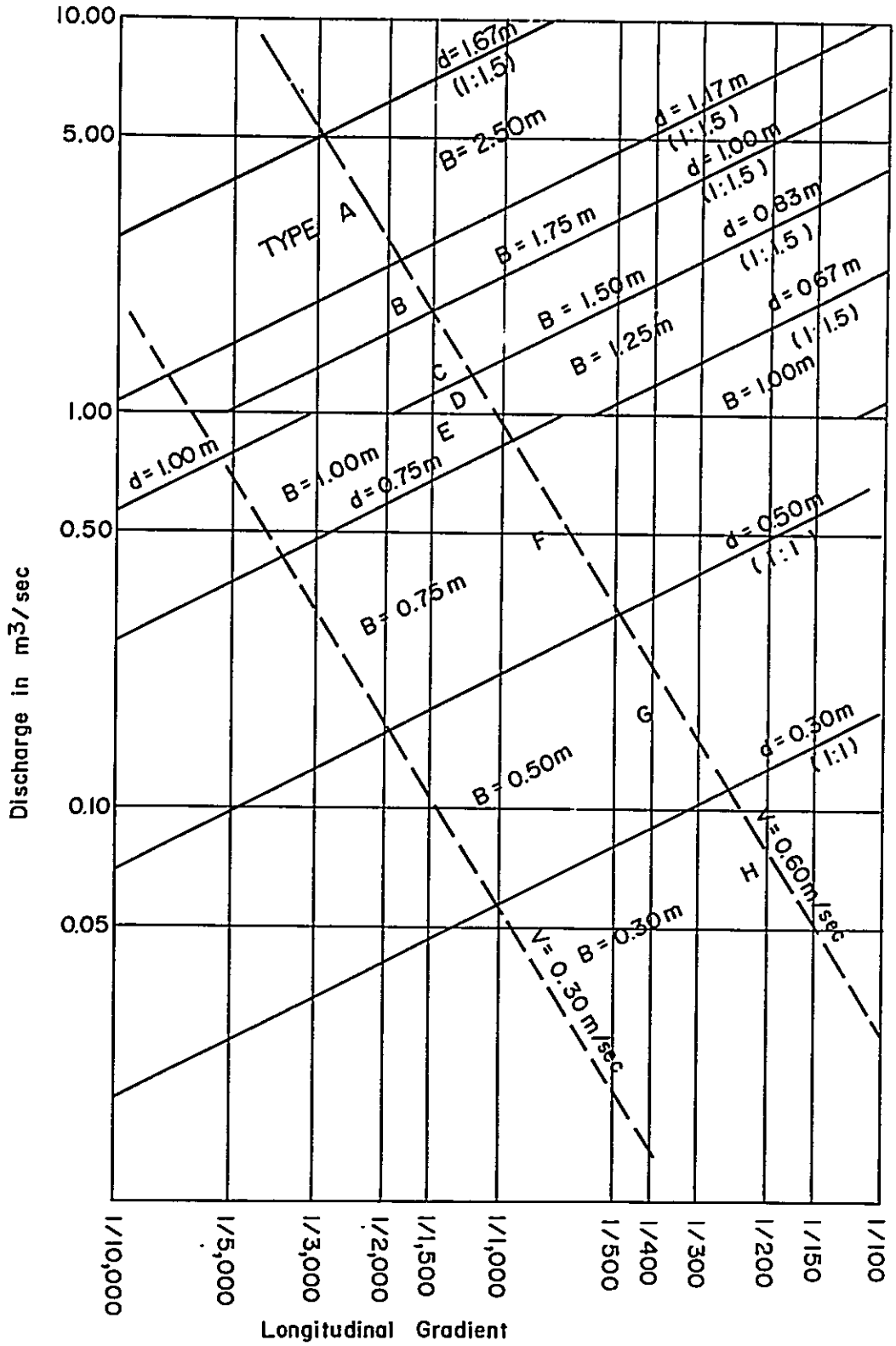


Fig. 6.5 Crop Coefficient for Paddy (Direct Sowing)

Fig.6.6 Classification of Canal Types

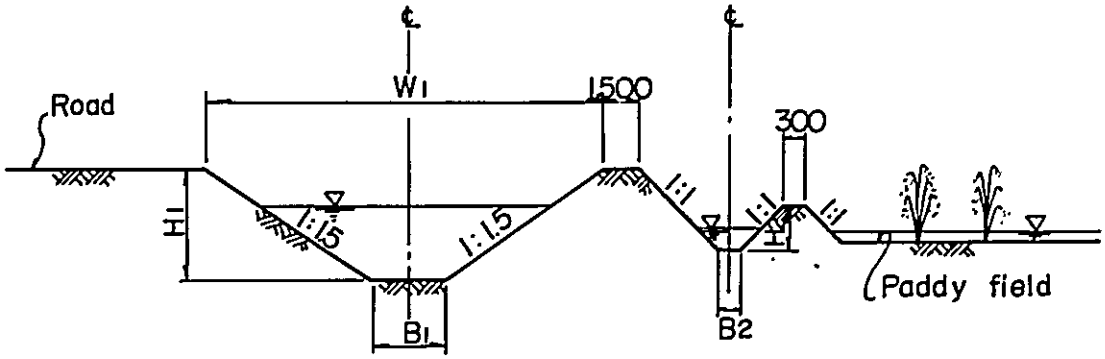


d : Water depth in m

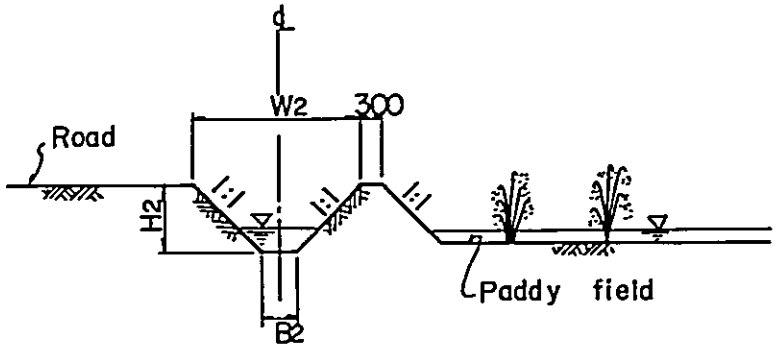
B : Canal bottom width in m

(1:1), (1:1.5) : Side slope.

Fig. 6.7 Typical Sections of Irrigation Canals



Main and Secondary Canal.



Tertiary and Supply Canal.

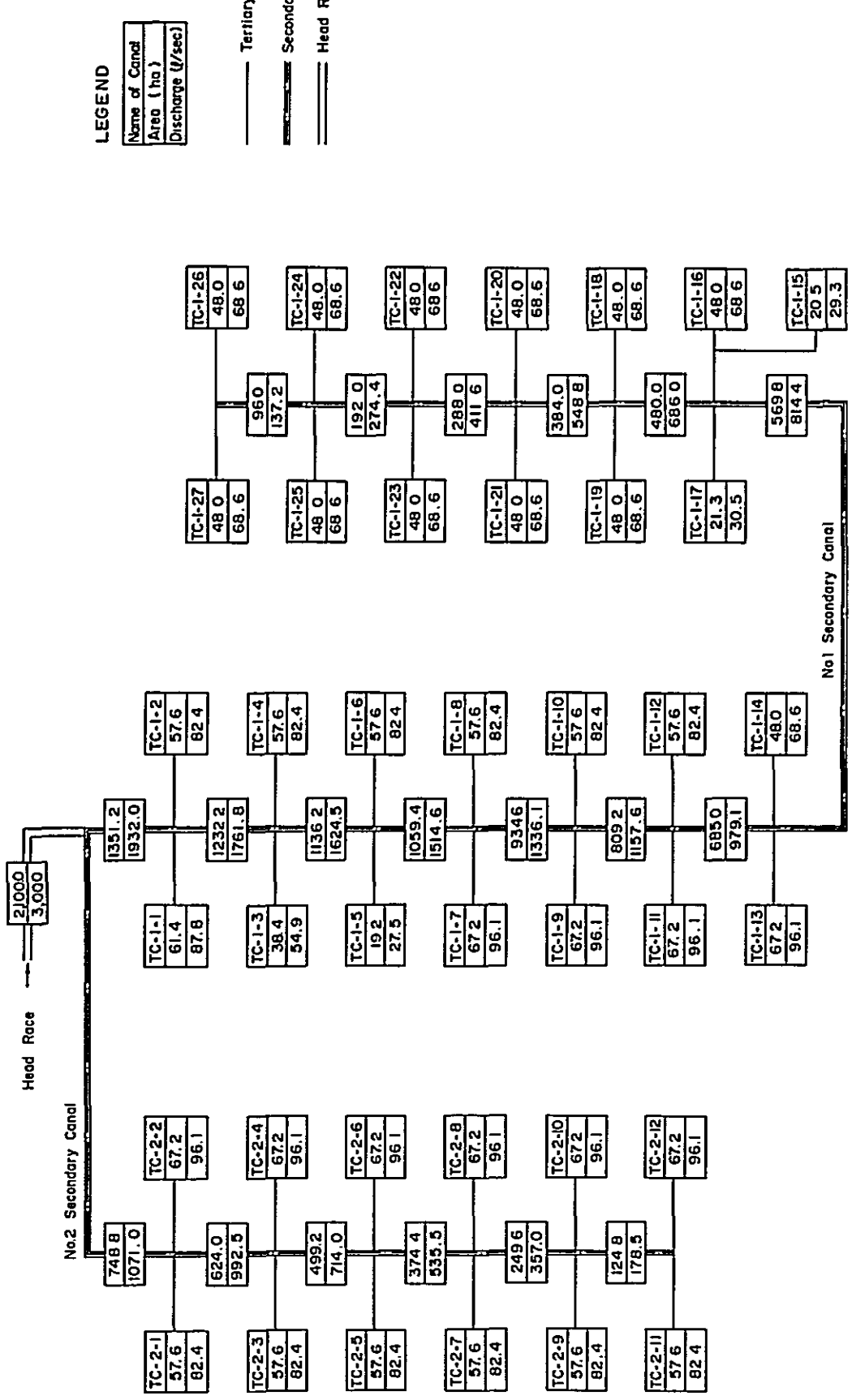
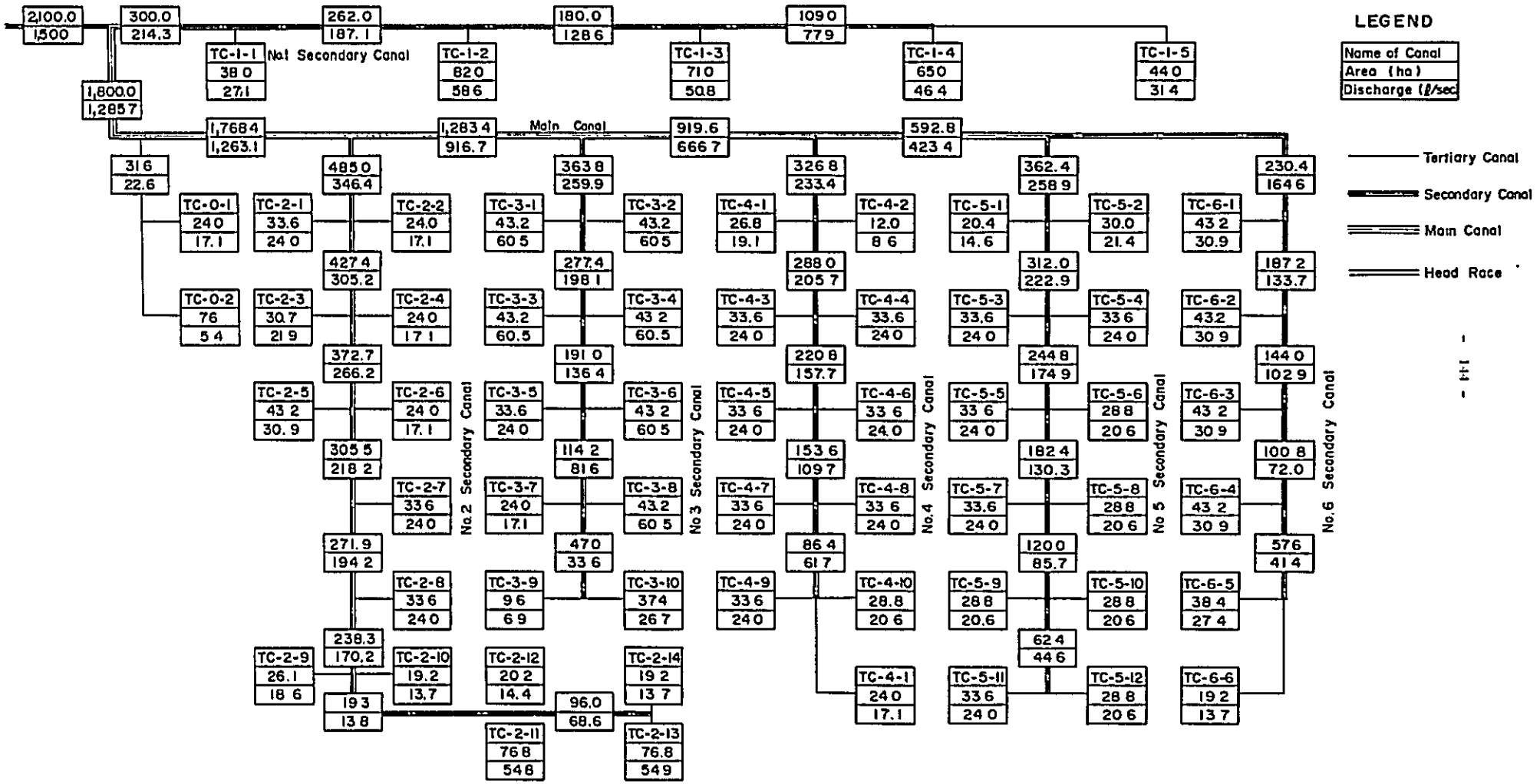


Fig.6.8 Irrigation System Diagram for Owerri Project

Fig. 6.9 Irrigation System Diagram for Auchi Project



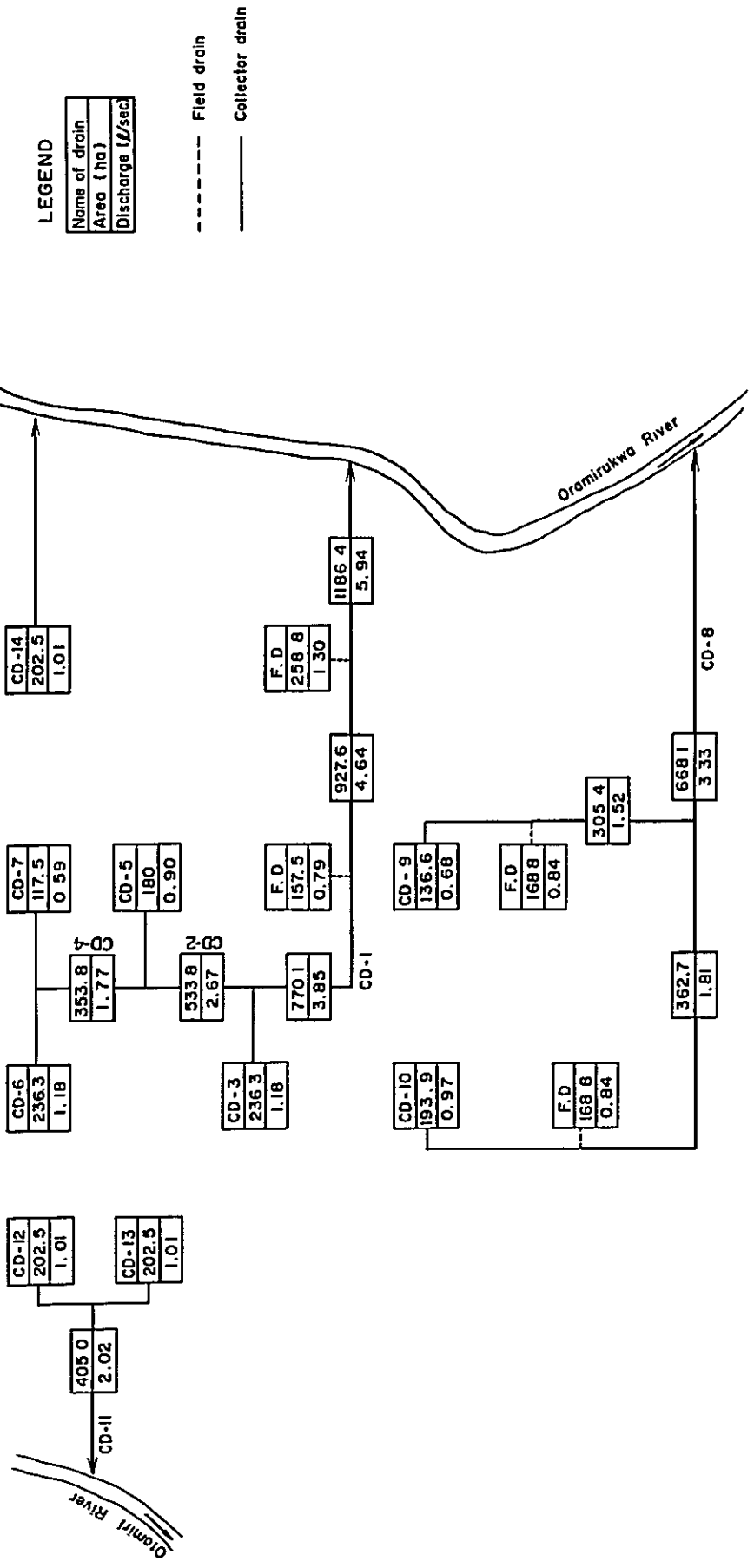


Fig. 6.10 Drainage System Diagram for Owerri Project

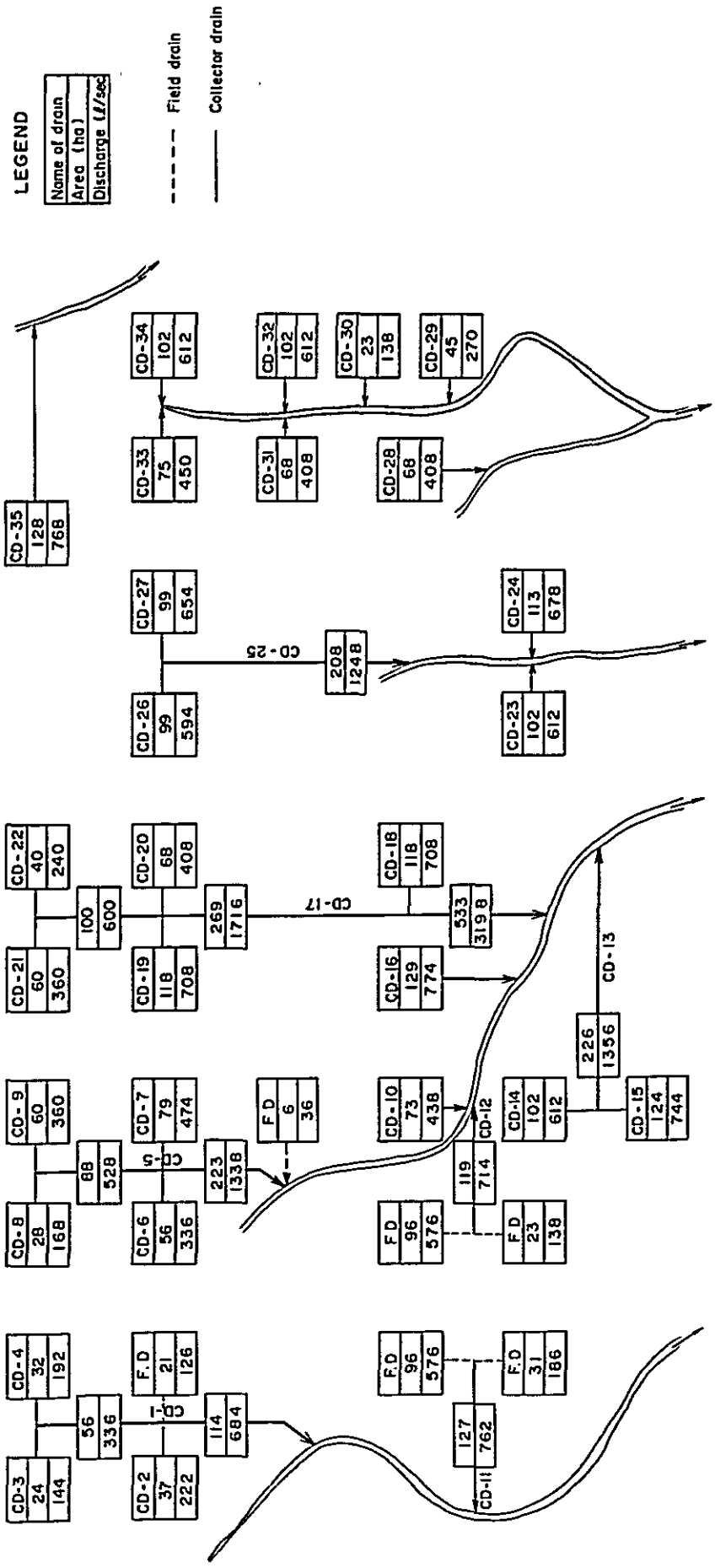
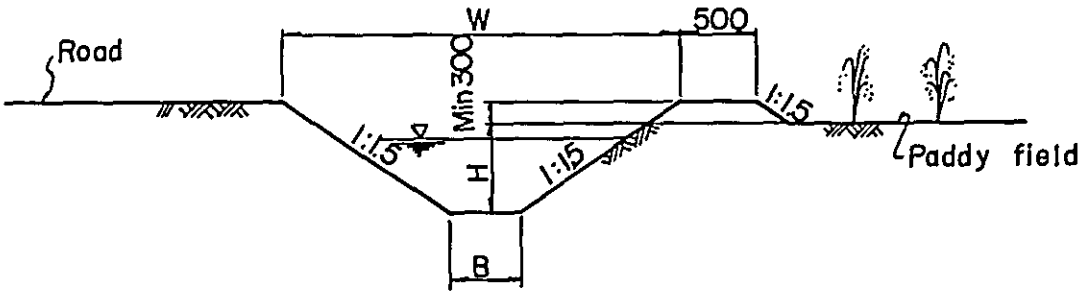
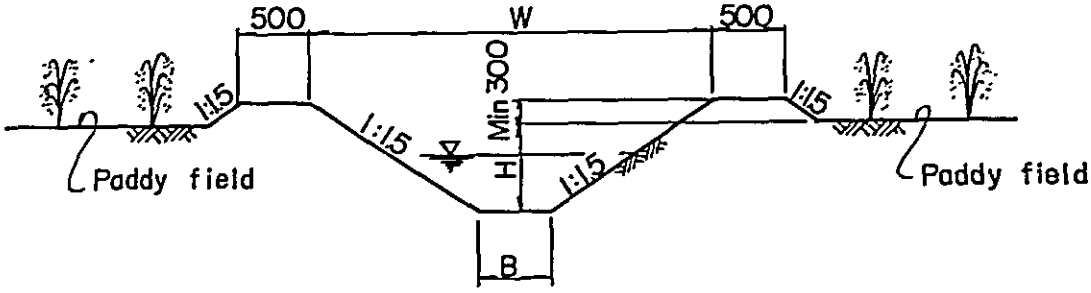


Fig. 6.11 Drainage System Diagram for Auchi Project

Fig. 6.12 Typical Sections of Drains.

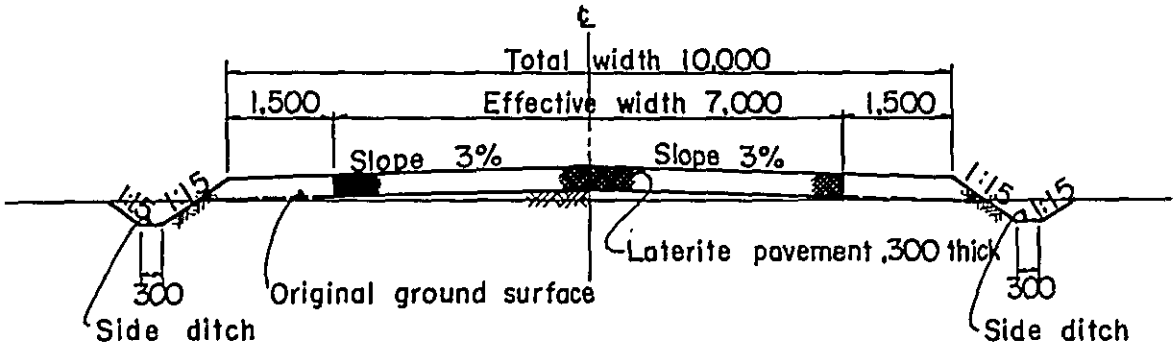


Collector Drain

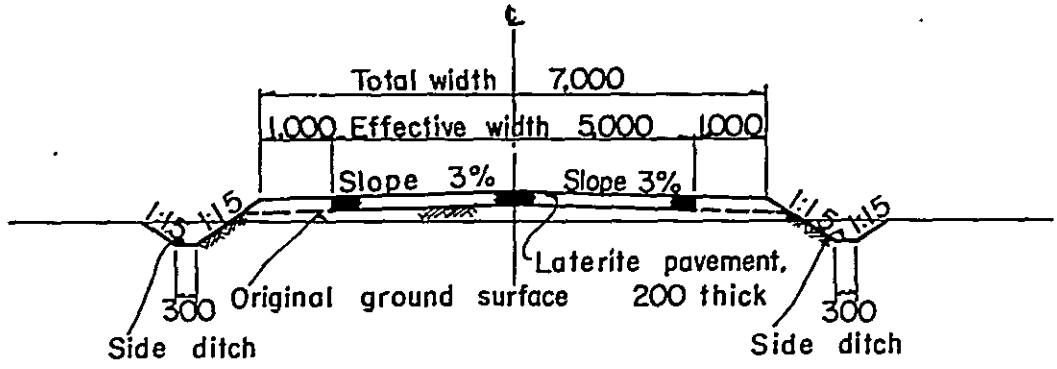


Field drain

Fig. 6.13 Typical Sections of Roads.

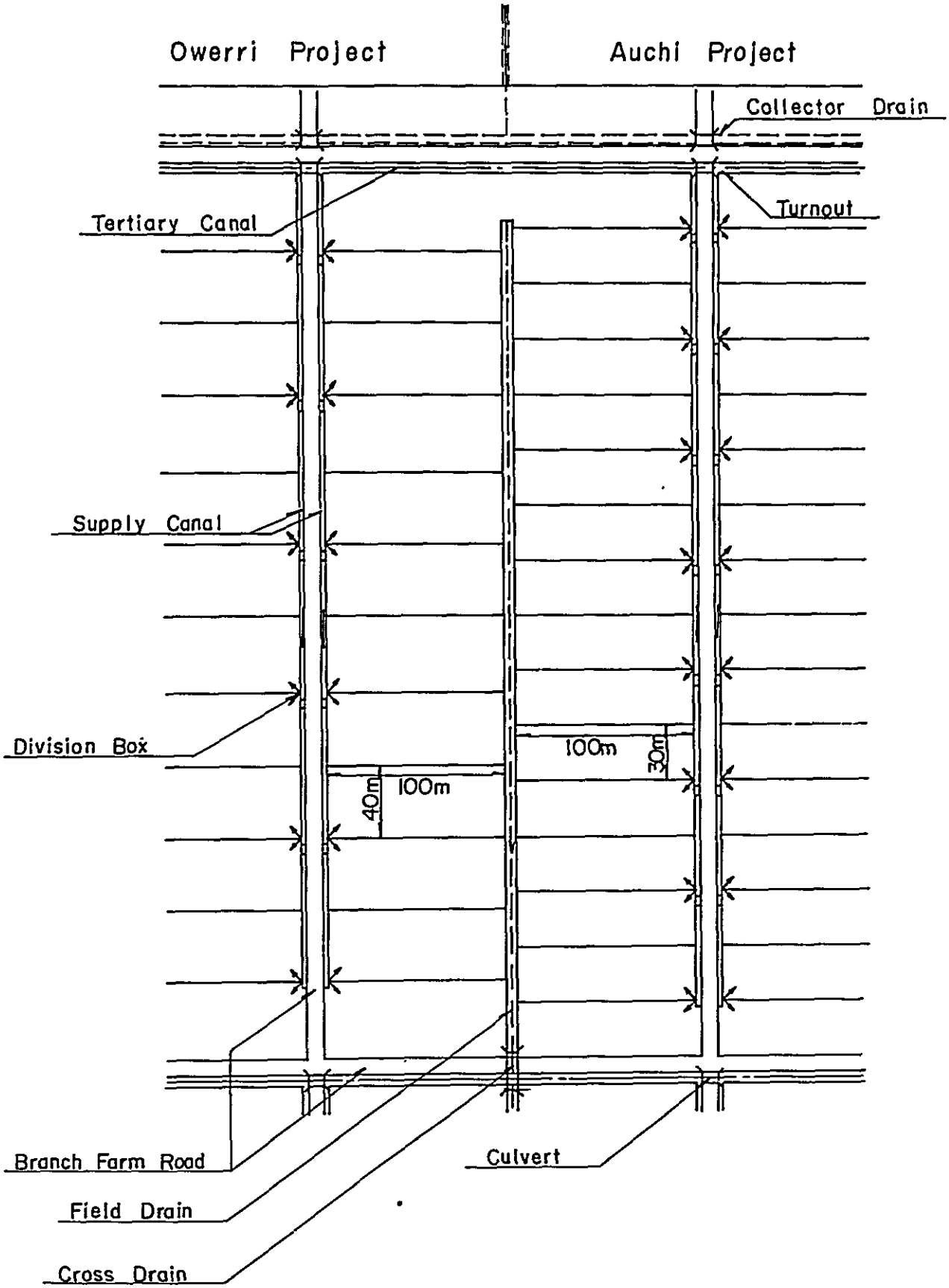


Main Road



Branch Road

Fig. 6.14 Typical Layout of Farm Unit



7. ORGANIZATION AND MANAGEMENT

7.1 General

For the smooth operation and successful accomplishment of the development, it is essential to establish efficient organizations responsible for the execution of the project construction and its operation and maintenance. Referring to the similar projects in Nigeria and experience in Japan, following organization is proposed as an example.

In order to establish the executing organizations, Project Coordination Committees will be firstly installed in the State level or Federal level. The Project Coordination Committee will be in charge of the necessary arrangements for the establishment of the executing organization and of giving advice and supervisory services for the operation.

The project executing organization to be established through the necessary arrangement and coordination of the Project Coordination Committee will be responsible for the project implementation including the estate and the small holder area from the stage of the construction to the operation and maintenance.

In the small holder area, farmers in the project area will be organized into Agricultural Cooperatives. Through the Agricultural Cooperative, agricultural extension services such as input supply and guidance of cultivation technics and machinery services will be provided from the estate farm. For coordinating the activity between the project executing organization and Agricultural Cooperative, Farm Operation Committee will be established. The overall organizations for the Owerri Project and Auchi Project are illustrated in Fig 7.1 and Fig. 7.2.

7.2 Project Coordination Committee

Prior to establish any project executing organizations, a Project Coordination Committee will be organized for the early realization of the project. The Committee will be responsible for establishing the overall policies, implementation planning. financial arrangement and coordination between various governmental organizations. The committee will consist of the members from the related Ministries and Authorities.

Another function of the Project Coordination Committee will be giving supervisory service and guidance to the project executing organization for the operation of the project.

7.3 Project Executing Organization

7.3.1 Owerri Project Office

1) Organization

For the execution of the project, an executing organization will be established in the project area under the guidance and necessary arrangements of the Project Coordination Committee. The executing organization, tentatively called Owerri Project Office, will be responsible for execution of the project construction and its operation and maintenance. The Project Office will have the following functions:

a) Construction of the irrigation and drainage facilities and road network for the whole project area including the estate farm and small holder area;

b) Installation of the rice mills and the related facilities;

c) Procurement of machineries and equipment required for the project;

d) Operation and maintenance of the irrigation and drainage facilities and road network;

e) Operation and maintenance of the rice mills and related facilities;

f) Operation and management of farm machineries and equipment;

g) Input procurement for cultivating paddy and management of the estate farm;

h) Extension services to the small holder farmers;

i) Farm input supply with necessary credit and providing machinery services to the small holder farmers;

j) Storage and marketing of the products including the products from small holder area; and

k) Accounting and administrations.

As summarized above, the Project Office will be responsible for the construction of the necessary irrigation and drainage facilities for the whole project area and mainly for the operation of the estate farm. However, the Project Office will also function for distributing agricultural inputs and providing machinery services and extension services for the irrigated paddy cultivation to the small holder area.

The machinery services to be provided by the estate farm will be mainly for land preparation and harvesting. Milling rice to be produced in the whole project area (including estate farm and small holder area) and marketing them will be another important functions of the Project Office.

As farmers in the Owerri Project area have no experience of rice cultivation and the extension services in the state are still insufficient to handle the large scheme, the extension services are, in particular, the important function of the Project Office. To pursue this object, extension workers and key farmers in the small holder area as well as staff of the estate will be trained intensively in the Pilot Scheme from the initial stage of the project implementation.

For executing the functions mentioned above, the Owerri Project Office, headed by Project Manager, will have six departments of Engineering, Production, Extension Services, Farm Machinery, Processing and Marketing and Administrative. Details of the function of each department are explained in Table 7.1.

2) Staffing and expatriate assistance

Number of staffs to be required for the implementation of the project is estimated on the basis of the collected data from the recent similar projects. Estimated total number of staffs at the full development stage is 321 including 8 specialists or senior engineers, 17 assistant staffs and 296 operators, administrative staffs and farm laborers. In addition to this, about 24,600 mandays of seasonal laborers will be employed for the farm operation. Number of the required staffs from 1978 to 1984 is shown in Table 7.2 together with their specialities.

Since there exists accute shortage of experienced personnel in the country, some specialist staffs will have to be recruited from abroad for the successful implementation of the project. Experts to be invited will be the specialist in the following fields.

Speciality	No. of personnel
Irrigation Engineer	1
Civil Engineer	1
Agronomist	1
Construction Machinery Engineer	1
Farm Machinery Engineer	1
Rice Mill Engineer	1
Extension Specialist	1
Accountant	1

7.3.2 Auchi Project Office

1) Organization

Under the guidance and necessary arrangements of the Project Coordination Committee, the Auchi Project Office (tentatively called) will be established in the project area. The function of the Project Office will be almost same as itemized in the function for the Owerri Project Office and be responsible for the construction of the project works and its operation and maintenance.

However, the function of the extension services will be less important in the area, since the Auchi Project will be operated mainly by estate farm and the small holder area is quite limited. Furthermore, the fact that the farmers in the Auchi Project area have some experience for paddy production will facilitate the extension of the rice cultivation more smoothly.

The organization of the Auchi Project Office will be almost same as that of the Owerri Project. The Auchi Project Office will be comprised of five departments; Engineering, Production, Farm Machinery Processing and Marketing and Administrative. Extension Department is excluded for the Auchi Project Office, where the extension services will be provided by the Production Department. Details of the function of each department are shown in Table 7.1.

2) Staffing and expatriate assistance

Estimated total number of staffs to be required for the implementation of the Auchi Project is 248 at the full development state, which include 8 specialists or senior engineers, 13 assistant staffs and 227 operators, administrative staffs and farm laborers. About 35,000 mandays of seasonal labor will be additionally required for the farm operation. Number of the required staffs is shown yearly in Table 7.3 together with their specialities.

As in case of the Owerri Project, some specialist staffs will have to be recruited internationally due to the shortage of the experienced personnel in the country. Experts to be invited will be as followes.

Speciality	No. of Personnel
Irrigation Engineer	1
Civil Engineer	1
Agronomist	1
Construction Machinery Engineer	1
Farm Machinery Engineer	1
Rice Mill Engineer	1
Accountant	1

7.4 Agricultural Cooperative

Agricultural Cooperative will be established organizing all the farmers to be involved in the small holder area both for the Owerri Project and the Auchi Project. The establishment of the farmers' cooperative organization aims to introduce mechanized irrigation farming smoothly into the small holder areas and to attain the expected increase in rice production most efficiently.

The Agricultural Cooperative will be established principally on the basis of the irrigation system in due consideration of the size of the village. In the Owerri Project area, about 40 - 60 farmers will be organized as a Farmers Cooperative Unit. The cultivated area to be included in one Farmers Cooperative Unit corresponds to the area which will be commanded by one tertiary canal.

About 19 Farmers Cooperative Units will be established in the Owerri Project area, which will be integrated into two Branch Agricultural Cooperatives. Commanding area by one Branch Agricultural Cooperative corresponds to the land to be covered by one secondary canal. The Branch Agricultural Cooperative will be further integrated into one Federated Agricultural Cooperative.

In the Auchi Project area, about 40 - 80 farmers will be organized into a Farmers Cooperative Unit. As in case of the Owerri Project, size of the cultivated land to be covered by one Farmers Cooperative Unit corresponds to the area which will be commanded by one tertiary canal. About 5 Farmers Cooperative Units will be established in the project area, which will be integrated into one Federated Agricultural Cooperative.

The proposed organizations of the Agricultural Cooperative both for the Owerri Project and the Auchi Project are briefly illustrated in Fig 7.3 to Fig 7.4.

The function of the Agricultural Cooperatives will include various services related to the irrigated farming as itemized as follow:

i) Irrigation water control under tertiary canal;

ii) Distribution of farm inputs such as seed, fertilizer and agricultural chemicals; and

iii) Promotion of joint cultivation.

As stipulated in the preceding section, extension services for irrigated rice cultivation will be provided through the Agricultural Cooperatives to the farmers in the project area. It is, therefore, considered that good coordination and cooperation between the Project Office and the Agricultural Cooperatives are the essential factor for the successful operation of the whole project.

To facilitate this function, a Farm Operation Committee will be established in each of the project areas. The Committee, headed by Project Manager of the Project Office as a chairman, will consist of department chiefs of the Project Office and representatives of the Federated Agricultural Cooperatives as its member.

Table 7.1 Function of the Departments for the Owerri Project Office and the Auchi Project Office

Organization	Function
Engineering Department	- Design and construction of the project works
	- Operation and maintenance of the irrigation and drainage facilities and road networks
	- Irrigation water control
Production Department	- Production control and farm management of the estate farm
	- Research work
	- Seed multiplication
	- Input procurement
Extension Department [1]	- Training of project staff extension workers, and farmers in the pilot scheme area
	- Input supply for small holders in the project area with necessary credit
	- Guidance on farming technics in the small holder area
Farm Machinery Department	- Operation and maintenance of construction machineries and agricultural machineries
	- Operation and management of the work shop
Processing & Marketing Department	- Operation and management of rice mill and and storage facilities
	- Collection and storage of farm products and marketing

- to be continued -

Organization	Function
Administrative Department	- General administration of the estate farm - Accounting and labor management - Collection of water charge and charges on machinery services from small holders

/1 The Extension Department will be excluded in the Auchi Project Office where the function will be provided through the Production Department.

Table 7.2 Required Number of Staffs of the Owerri Project Office

Item	1978	1979	1980	1981	1982	1983	1984 & after
1) Construction & Farm Operation							
Project Manager	1	1	1	1	1	1 (1)	1 (1)
Civil Engineer	1	1	1	1	1	0	0
Architect	1	1	1	0	0	0	0
Construction Machinery Engineer	1	1	1	1	1	0	0
Irrigation Engineer	1	1	1	1	1	1 (1)	1 (1)
Asst. Irrigation Engineer	1	2	2	2	2	2 (2)	2 (2)
Surveyer	6	6	6	6	6	0	0
Draftman	10	10	10	10	10	0	0
Field Overseer for Construction	5	15	15	8	8	0	0
Agronomist	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Agronomist	0	0	1 (1)	2 (2)	3 (3)	3 (3)	3 (3)
Farm Machinery Engineer	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Farm Machinery	0	0	1 (1)	2 (2)	3 (3)	3 (3)	3 (3)
Construction & Farm Machinery Operator	10	40	60 (20)	80 (50)	117 (87)	87 (87)	87 (87)
Driver	10	10	15	15	20	20 (20)	20 (20)
Mechanic	2	2	3	3	3	3 (3)	3 (3)
Permanent Labourer for Repair Shop	10	10	10	10	10	10 (10)	10 (10)

- to be continued -

Item	1978	1979	1980	1981	1982	1983	1984 & after
Electrician	1	1	1	1	1	1 (1)	1 (1)
Field Overseer for Farm	0	0	6 (6)	13 (13)	20 (20)	20 (20)	20 (20)
Farm Lebourer	0	0	32 (32)	76 (32)	120 (120)	120 (120)	120 (120)
Extension Specialist	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Extension Worker	0	0	4 (4)	4 (4)	4 (4)	4 (4)	4 (4)
Store Officer	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Storekeeper	0	0	1 (1)	2 (2)	2 (2)	2 (2)	2 (2)
2) Rice Mill & Storage Facilities							
Rice Mill Engineer	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Rice Mill Engineer Engineer	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Rice Mill Operator	0	0	5 (5)	10 (10)	10 (10)	20 (20)	20 (20)
Store Officer	0	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Storekeeper	0	0	3 (3)	3 (3)	3 (3)	3 (3)	3 (3)
3) Administration							
Accountant	1	1	1	1	1	1 (1)	1 (1)
Asst. Accountant	1	1	2	2	2	2 (2)	2 (2)
Administrative Office	1	1	1	1	1	1 (1)	1 (1)

- to be continued -

Item	1978	1979	1980	1981	1982	1983	1984 & after
Clerical Officer	1	1	2	2	2	2 (2)	2 (2)
Typist	1	1	2	2	2	2 (2)	2 (2)
Security Officer	2	4	4	6	6	6 (6)	6 (6)
Total	67	110	199	272	365	321	321

Note: Number in the parentheses is the number of the personnel to be required for the operation stage of the project.

Table 7.3 Required Number of Staffs of the Auchi Project Office

Item	1978	1979	1980	1981	1982	1983	1984 & after
1) Construction & Farm Operation							
Project Manager	1	1	1	1	1	1 (1)	1 (1)
Civil Engineer	1	1	1	1	1	0	0
Architect	1	1	1	0	0	0	0
Construction Machinery Engineer	1	1	1	1	1	0	0
Irrigation Engineer	1	1	1	1	1	1 (1)	1 (1)
Asst. Irrigation Engineer	1	2	2	2	2	2 (2)	2 (2)
Surveyer	6	6	6	6	6	0	0
Draftman	10	10	10	10	10	0	0
Field Overseer for Construction	5	15	15	8	8	0	0
Agronomist	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Agronomist	0	1 (1)	2 (2)	3 (3)	3 (3)	3 (3)	3 (3)
Farm Machinery Engineer	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Farm Machinery Engineer	0	1 (1)	2 (2)	3 (3)	3 (3)	3 (3)	3 (3)
Construction & Farm Machinery Operation	10	51 (11)	60 (20)	66 (36)	82 (52)	61 (61)	61 (61)
Driver	10	10	15	15	20	20 (20)	20 (20)
Mechanic	2	2	3	3	3	3 (3)	3 (3)
Permanent Labourer for Repair Shop	7	7	7	7	7	7 (7)	7 (7)

- to be continued -

Item	1978	1979	1980	1981	1982	1983	1984 & after
Electrician	1	1	1	1	1	1 (1)	1 (1)
Field Oversee for Farm	0	4 (4)	7 (7)	12 (12)	17 (17)	20 (20)	20 (20)
Farm Labourer	0	14 (14)	26 (26)	47 (47)	68 (68)	80 (80)	80 (80)
Extension Worker	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Store Officer	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Storekeeper	0	1 (1)	1 (1)	2 (2)	2 (2)	2 (2)	2 (2)
2) Rice Mill & Storage Facilities							
Rice Mill Engineer	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Asst. Rice Mill Engineer	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Rice Mill Operator	0	5 (5)	5 (5)	10 (10)	10 (10)	20 (20)	20 (20)
Store Officer	0	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Storekeeper	0	1 (1)	1 (1)	3 (3)	3 (3)	3 (3)	3 (3)
3) Administration							
Accountant	1	1	1	1	1	1 (1)	1 (1)
Asst. Accountant	1	2	2	2	2	2 (2)	2 (2)
Administrative Officer	1	1	1	1	1	1 (1)	1 (1)
Clerical Officer	1	2	2	2	2	2 (2)	2 (2)

- to be continued -

Item	1978	1979	1980	1981	1982	1983	1984 & after
typist	1	2	2	2	2	2 (2)	2 (2)
Security Officer	3	4	5	6	6	6 (6)	6 (6)
Total	65	155	188	223	270	248	248

Note: Number in the parentheses is the number of the personnel to be required for the operation stage of the project.

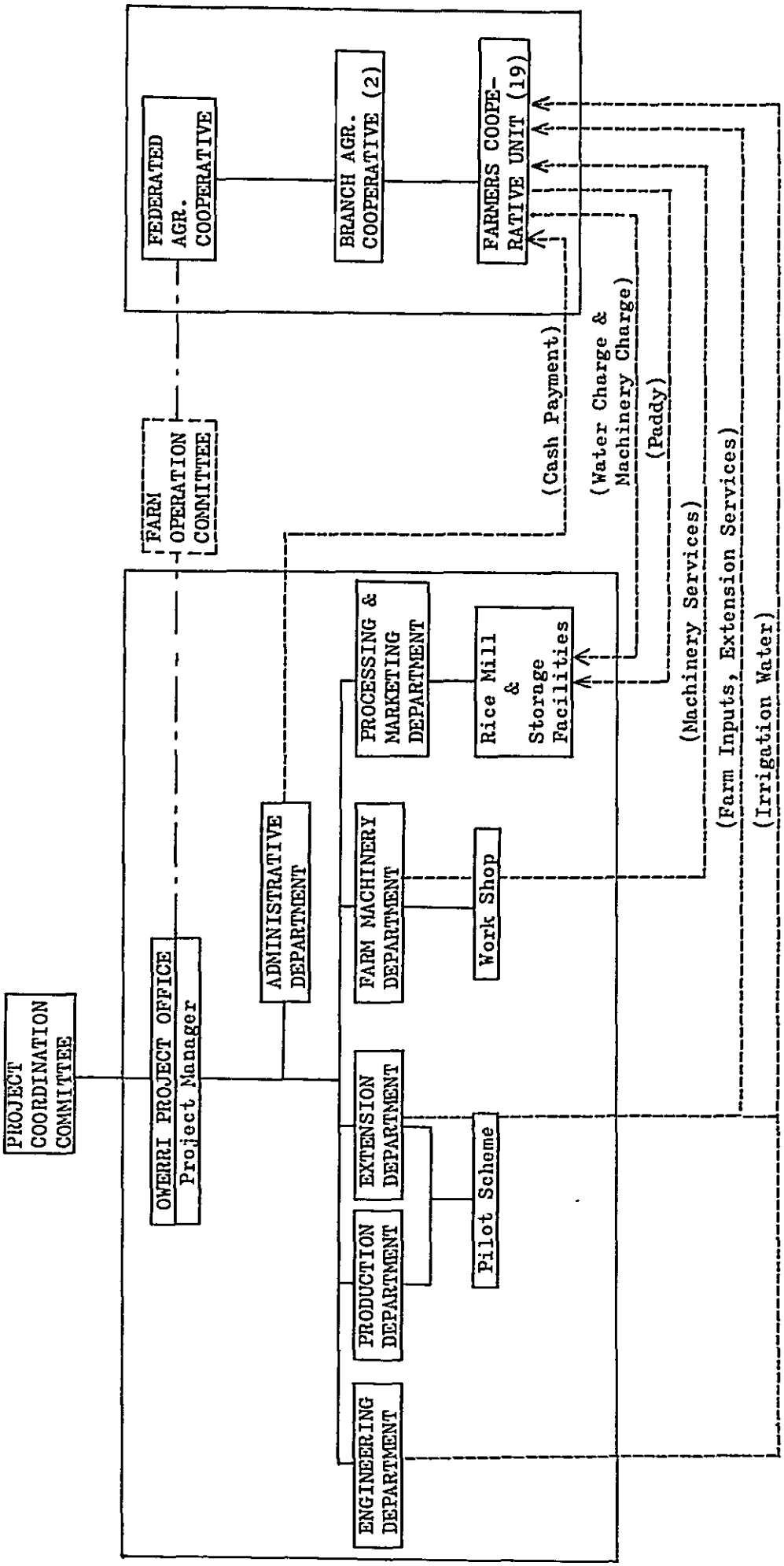


Fig. 7.1 Proposed Organization for Owerri Project

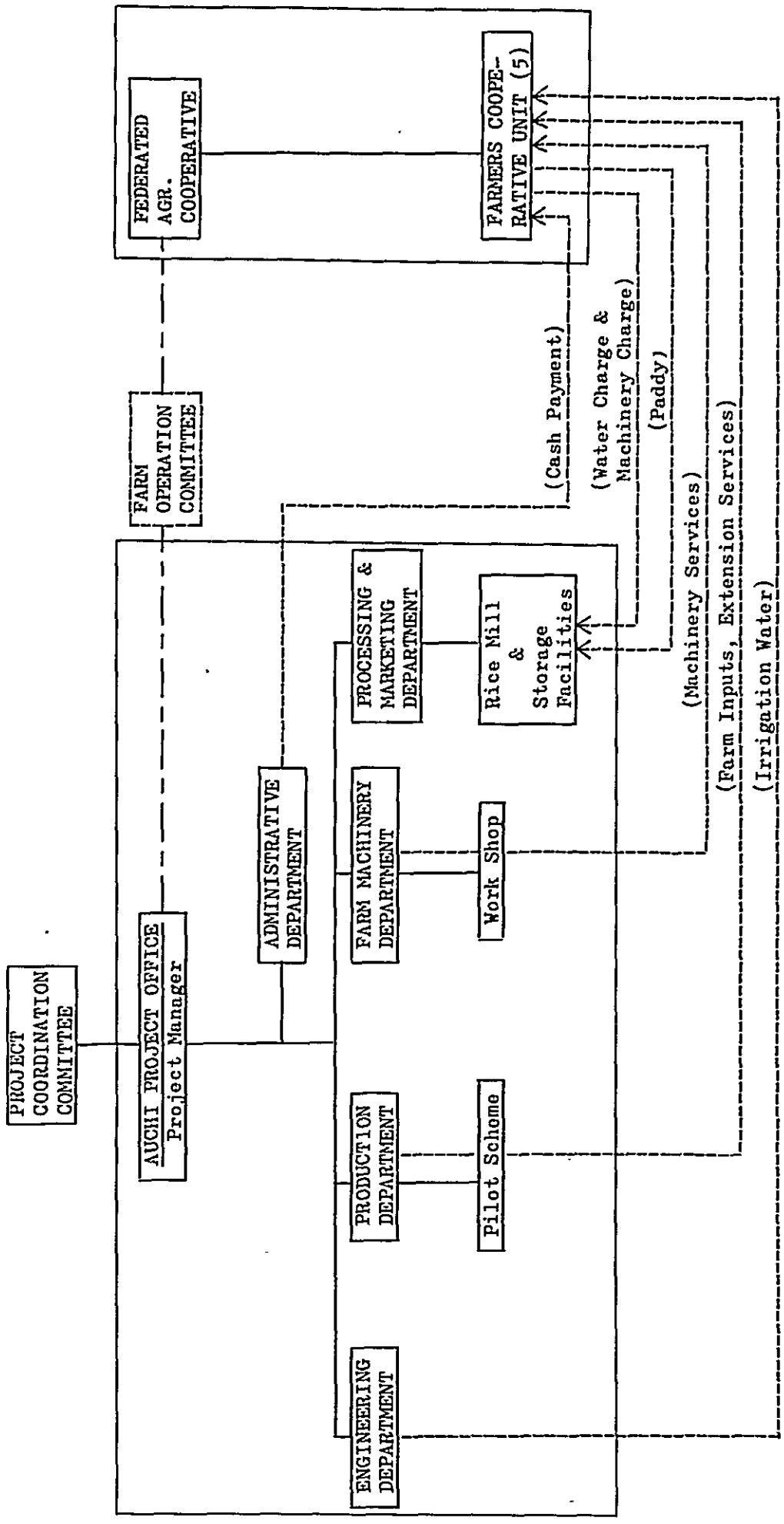
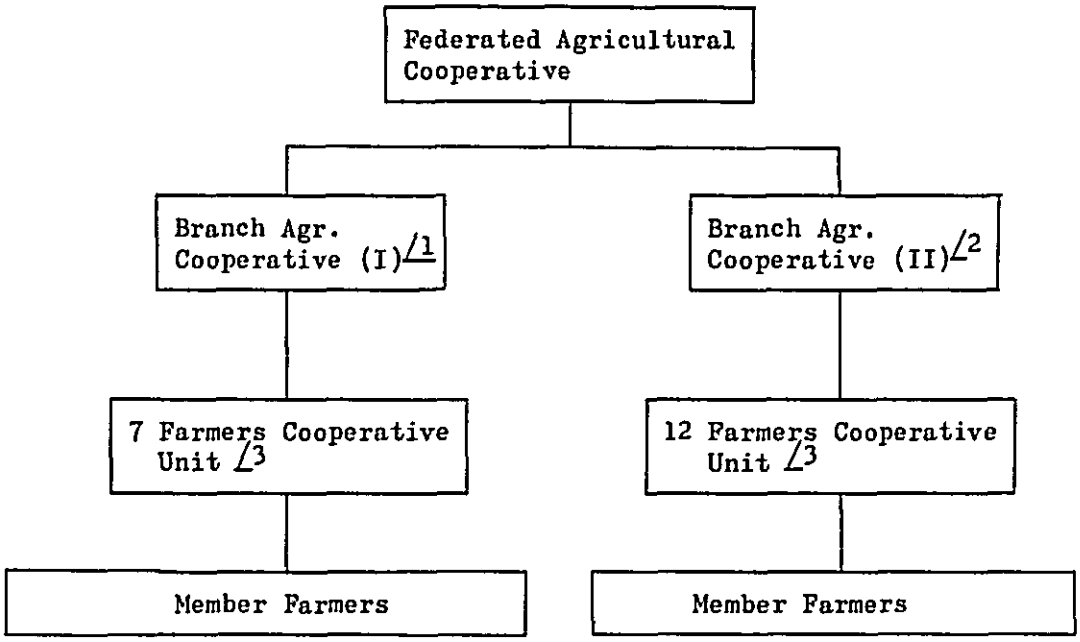


Fig. 7.2 Proposed Organization for Auchi Project

Fig. 7.3 Organization of Agricultural Cooperative for the Owerri Project

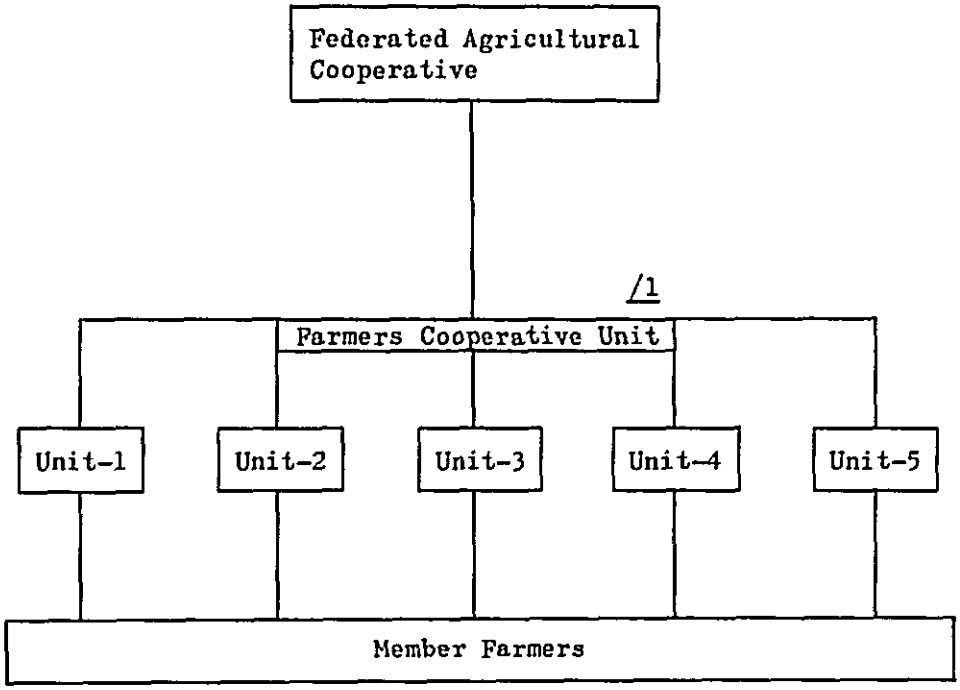


/1 The area covered by the Branch Agricultural Cooperative corresponds to the area to be commanded by No.1 Secondary Canal.

/2 The area covered by the Branch Agricultural Cooperative corresponds to the area to be commanded by No.2 Secondary Canal.

/3 The area covered by a Farmers Cooperative unit corresponds to the area to be commanded by one tertiary canal.

Fig. 7.4 Organization of Agricultural Cooperative for the Auchi Project



/1 The area covered by a Farmers Cooperative Unit corresponds to the area to be commanded by one tertiary canal.

8. IMPLEMENTATION SCHEDULE AND CONSTRUCTION PLAN

8.1 Implementation Schedule

The implementation schedule of the project is bar-charted in Fig. 8.1 and Fig. 8.2, respectively for the Owerri and Auchi Projects. It is prepared basing upon the following conditions:

(1) Mapping works of the project areas will be started in October 1977 upon arrival of the dry season and be finished in three months;

(2) Detail designs of the project works will follow the completion of mapping works and be finished in six months;

(3) In parallel with the detail designs, procurement of construction machinery and equipment will be started partially;

(4) Upon completion of the detail designs, construction of the project works will be started in succession and be completed in four and a half years;

(5) Except for minor on-farm structures, all the construction works will be executed by using construction machinery and equipment and;

(6) Workable days for the construction are 210 days per year for the Owerri Project and 275 days per year for the Auchi Project. /1

For both of the Owerri and Auchi Projects, commencement of construction of the project works will be in July 1977 and completion of the whole construction works will be at the end of December 1982. However, since the intake structures and head races will have been constructed and commissioned by May 1980 and by July 1979, respectively for the Owerri Project and the Auchi Project, partial operation will become possible for both projects after these times on. From the reclamation schedule and cropping pattern, the initial operation will be made on an area of 400 ha and 350 ha respectively for the Owerri and Auchi Projects including pilot scheme of 50 ha. Development of the operation will progress as follows.

(Unit: ha)

Year	Owerri Project	Auchi Project
1979	-	350
1980	400	660
1981	950	1,230
1982	1,820	1,780
1983	2,100	2,100

/1 Refer to Table 8.1.

8.2 Construction Plan

8.2.1 General

In view of unavailability of competent contractors for this kind of construction works, it is proposed that the project works be constructed on the force account basis of the project office to be established for each of the projects. As the mechanized construction of paddy field is still unfamiliar to Nigeria, technical guidance by well-experienced foreign experts will be necessary. Number of the experts to be required and their provisional scope of services are drafted in Appendix 1.

For both projects, major construction works consist of headworks for intake of irrigation water, irrigation and drainage canals, farm roads, paddy field of 2,100 ha, and rice mills. The works involve substantial amounts of earth-moving works in rather short construction periods. It is proposed, therefore, that construction machinery and equipment be used extensively. A list of the machinery and equipment to be required for the construction is shown in Table 8.2.

8.2.2 Construction Plan of the Owerri Project

Features of the major project works needed for the Owerri Project are outlined in Table 8.3. For each of them, the construction plan is explained briefly as follows.

i) Headworks for water intake

The main works comprise the constructions of a concrete fixed weir with the downstream apron, sand scouring sluice, intake structures, and right and left banks embankments. The construction will be done in two dry seasons from September 1978 to the end of March 1980.

The construction works will be carried out in two steps in accordance with the diversion procedure of the river water. In the first dry season in 1978/79, the diversion canal and coffer dams will be constructed and after the diversion of the river water the weir and related structures such as the apron, sand scouring sluice, and intake structures will be constructed. In the second dry season in 1979/80, the river water is diverted again by the conduits through the weir, and the embankment works will be executed. The embankment volume is estimated at about 32,000 m^3, of which materials will be available from the hill on the left bank.

ii) Irrigation canals

The irrigation canals consist of a head race of about 17 km, secondary canals of about 11 km, tertiary canals of about 51 km and supply canals of 219 km. In order to expedite the commencement of the project operation, major canals such as the head race and the secondary canals are scheduled to be completed in about twenty months from August 1978 to April 1980. Construction of the tertiary and supply canals will be made in four years from the beginning of 1979 to the end of 1982 keeping pace with the development schedule of the paddy field.

Mechanized construction method will be applied to the head race, secondary canals and a part of the tertiary canals, while most of the tertiary canals and supply canals are to be excavated by manpower.

Since the proposed major canal routes run almost in parallel with the existing roads construction can be started at any place. All the excavated soils will be used for the embankment materials of the canal dike and the inspection road.

iii) Drainage canals

The drainage canals consist of collector drains of 26 km and field drains of 110 km. Since the collector drains are to be laid in lowland and natural depressions, the excavation works will only be possible in the dry season. It is scheduled that these drains will be constructed in four dry seasons from 1979 to 1982 using mechanical power. The field drains are of rather minor ditches and the construction will be continued even in the rainy season using mainly manpower. It will span four years from the beginning of 1979 to the end of 1982 keeping pace with the construction schedule of the paddy field.

iv) Farm roads

Two types of farm roads are proposed e.g., the main farm road of 20 km and the branch farm road of 150 km. In order to facilitate easy access to work sites, these roads are scheduled to be constructed in the early stage of construction by the end of 1980.

All the roads are to run along the canals so that the excavated soils of canals will be used as the road bed. The laterite, which will be used for surfacing materials, will be available from nearby hills.

v) Paddy field

Paddy field construction needs an enormous amount of elaborate earth-moving works, vital to the successful implementation of the project. Full use of construction machinery will be made and 2,100 ha of total paddy field is scheduled to be reclaimed in four years from the beginning of 1979 to the end of 1982.
The yearly schedule of the reclamation will be 600 ha in 1980, 700 ha in 1981, and 800 ha in 1982. At the commencement of the partial operation proposed in May 1980, about 370 ha of paddy field will have been completed.

The paddy field construction works consist broadly of tree felling and removal of roots, terracing, minute levelling and plot border construction. All these works will be executed by mechanical power using mainly bulldosers of 21 - 15 ton class. The minute levelling works will have to be executed so that the ruggedness of the field surface may be kept within the range of ± 5 cm.

8.2.3 Construction Plan of the Auchi Project

An outline of the major project works is given in Table 8.3.

i) Headworks for water intake

The scale of the works is smaller than that for the Owerri Project and hence, the construction will be executed only in about one year mainly during the season of 1978/79.

The construction will start in August 1978 together with the construction of the intake structures on the left bank of the river. After that, the diversion canal will be excavated on the right bank of the river and with construction of coffer dams across the river, the river course will be diverted. Foundation excavation and concrete placing works for the weir and related structures will follow in succession, and upon the completion of these works, backfilling works of the diversion canal will be executed.

It is scheduled that all the works will be completed by the end of the dry season in 1978/79.

ii) Irrigation canals

The irrigation canals comprise a head race of about 12 km, main canal of 7 km, secondary canals of about 19 km, tertiary canals of about 46 km, and supply canals of 219 km.

In order to realize the early implementation of the project, construction of the head race will be carried out almost in parallel with the headworks construction. Construction of main and secondary canals will also be finished by the end of 1979. Construction of minor irrigation canals such as tertiary and supply canals will be made in four years from 1979 to 1982. The method to be applied to the construction is entirely the same as that for the Owerri Project.

iii) Drainage canals

Total length of the drainage canals is about 137 km comprising collector drains of about 32 km and field drains of 105 km. Similar to the drainage construction in the Owerri Project, the collector drains will be constructed in four dry seasons from 1979 to 1982, whereas construction of the field drains will be executed throughout the year for four years in parallel with the paddy field construction.

iv) Farm roads

The roads are classified into the main farm road of about 23 km and the branch farm road of 155 km. They will be completed by the end of 1979 and 1980, respectively. Surfacing materials such as gravels and laterites are easily available from the Ojo river and the hills around Auchi.

v) Paddy field

The total paddy field to be reclaimed is 2,100 ha which will be developed in four years from 1979 to 1982 with a rate of 525 ha per year. By the time of partial operation proposed in September 1979, about 300 ha of paddy field will have been constructed.

Table 8.1 Workable Days for Construction Works

Conditions for estimate

1)	Daily rainfall (mm)	0 - 4	5 - 15	16 - 30	Over 31
2)	Duration of rainfall(day)	0	0.5	0.5	1.0
3)	Waiting time after rain(day)	0	0.5	1.0	1.5

Owerri Project

1) Rainfall (Frequency/month)

Daily rainfall	J	F	M	A	M	J	J	A	S	O	N	D	Total
5 - 15 mm	-	1	1	3	5	5	7	6	6	6	1	-	41
16 - 30 mm	1	1	2	3	2	4	5	4	4	4	1	1	32
Over 31 mm	-	1	2	2	2	3	3	3	4	3	-	-	23
2) Duration of rains (day)	0.5	2.0	3.5	5.0	5.5	7.5	9.0	8.0	9.0	8.0	1.0	0.5	59.5
3) Waiting time (day)	1.0	3.0	5.5	7.5	7.5	11.0	13.0	11.5	13.0	11.5	1.5	1.0	87.0
4) Duration of suspension (day)	1.5	5.0	9.0	12.5	13.0	18.5	22.0	19.5	22.0	19.5	2.5	1.5	146.5
5) Workable days(day)	29	23	22	17	18	11	9	11	8	11	27	24 /1	210

Auchi project

1) Rainfall (Frequency/month)

Daily rainfall	J	F	M	A	M	J	J	A	S	O	N	D	Total
5 - 15 mm	-	1	2	3	3	3	4	4	4	3	1	-	28
16 - 30 mm	-	-	1	2	3	2	3	1	3	2	-	-	17
Over 31 mm	-	-	-	2	2	2	2	1	2	1	-	-	12
2) Duration of rains(day)	-	0.5	1.5	4.5	5.0	4.5	5.5	3.5	5.5	3.5	0.5	-	34.5
3) Waiting time (day)	-	0.5	2.0	6.5	7.5	6.5	8.0	4.5	8.0	5.0	0.5	-	49.0
4) Duration of Suspension(day)	-	1.0	3.5	11.0	12.5	11.0	13.5	8.0	13.5	8.5	1.0	4.0 /1	91.5
5) Workable days (day)	31	27	27	19	18	19	17	23	16	22	29	27	275

/1 Christmas holidays are considered.

Table 8.2 List of Construction Machinery and Equipment

	Machinery & Equipment	Required Number		
		Owerri	Auchi	Total
1.	Bulldoser 13 ton - 15 ton	2	2	4
2.	- " - 21 ton	8	7	15
3.	- " - 21 ton w/rake	2	3	5
4.	- " - 33 ton	2	2	4
5.	Backhoe 0.3 m^3	3	3	6
6.	- " - 0.6 m^3	2	2	4
7.	Crawler loader 1.3 m^3	1	1	2
8.	Motorgrader 9 ton	2	2	4
9.	Roadroller 8 - 10 ton	1	1	2
10.	Dump truck 6 ton	12	10	22
11.	Ordinary truck "	10	10	20
12.	Tractor crane 5 ton	1	1	2
13.	Tamping roller, 500 kg	2	1	3
14.	Tamping rammer, 80 kg	10	10	20
15.	Concrete mixer, 0.2 m^3	2	2	4
16.	- " - , 0.6 m^3	2	1	3
17.	Diesel generator 3.5 KVA	2	1	3
18.	Water tanker 2 m^3	1	1	2
19.	Fuel tanker 5 m^3	1	1	2
20.	Grease car	1	1	2
21.	100mm sub. pump	1	1	2
22.	Tractor shovel 0.6 m^3	2	2	4

Table 8.3 Features of Major Project Works

	Major project works	Unit	Owerri Project	Auchi Project
1.	Headworks			
	Concrete weir, length	m	42	45
	- " - , height	"	5.5	5.5
	- " - , volume	m^3	3,500	1,500
	Embankment	m^3	32,000	270
2.	Irrigation canals			
	Head race	km	16.4	11.7
	Main canal	"	-	7.0
	Secondary canal	"	11.4	18.6
	Tertiary canal	"	50.6	46.1
	Supply canal	"	219.0	219.0
3.	Drainage canal			
	Collector drain	km	26.0	31.8
	Field drain	"	110.0	105.0
4.	Farm road			
	Main farm road	km	20.0	23.4
	Branch farm road	"	150.0	155.0
5.	Paddy field construction	ha	2,100	2,100
6.	Rice mills	Nos.	3	3

Fig. 8. 1 Implementation Schedule for Owerri Project

Work Item	Unit	Quantity
1. Preparatory Works		
1.1 Topo. Mapping & D/D	LS	
1.2 Procurement of Equipment	"	
1.3 Land Acquisition	Ha	28
1.4 Access & Project Office	LS	
2. Head Works		
2.1 Clearing	m²	27,300
2.2 Excavation of Diversion Canal	m³	1,200
2.3 Coffering for Weir	"	500
2.4 Foundation Excavation for Weir	"	3,700
2.5 Concrete Works	"	3,500
2.6 Gate Installation	LS	
2.7 Coffering for Embankment	m²	1,200
2.8 Excavation for Embankment	"	9,300
2.9 Embankment for Left Bank	"	25,000
2.10 —"— for Right Bank	"	7,000
2.11 Plug for Diversion Conduit	"	15
3. Head Race	km	16.3
3.1 Stripping	m²	278,000
3.2 Excavation	m³	165,000
3.3 Embankment	"	116,000
3.4 Related Structures	LS	
4. Secondary Irrigation Canals	km	11.5
4.1 Stripping	m²	47,000
4.2 Excavation	m³	18,000
4.3 Embankment	"	25,000
4.4 Related Structures	LS	
5 Tertiary & Supply Canals	km	27.0
6. Drainage Canals	km	136.0
6.1 Collector Drains	"	26.0
6.2 Field Drains	"	110.0
7 Road		17.0
7.1 Main Road	"	2.0
7.2 Branch Road	"	15.0
8 Paddy Field Construction	Ha	2,100
9 Processing Storage & Workshops	LS	
10 Project Operation		
10.1 Pilot Scheme	Ha	50
10.2 Project Operation		
(a) Estate	"	1,015
(b) Small-Holder	"	1,085

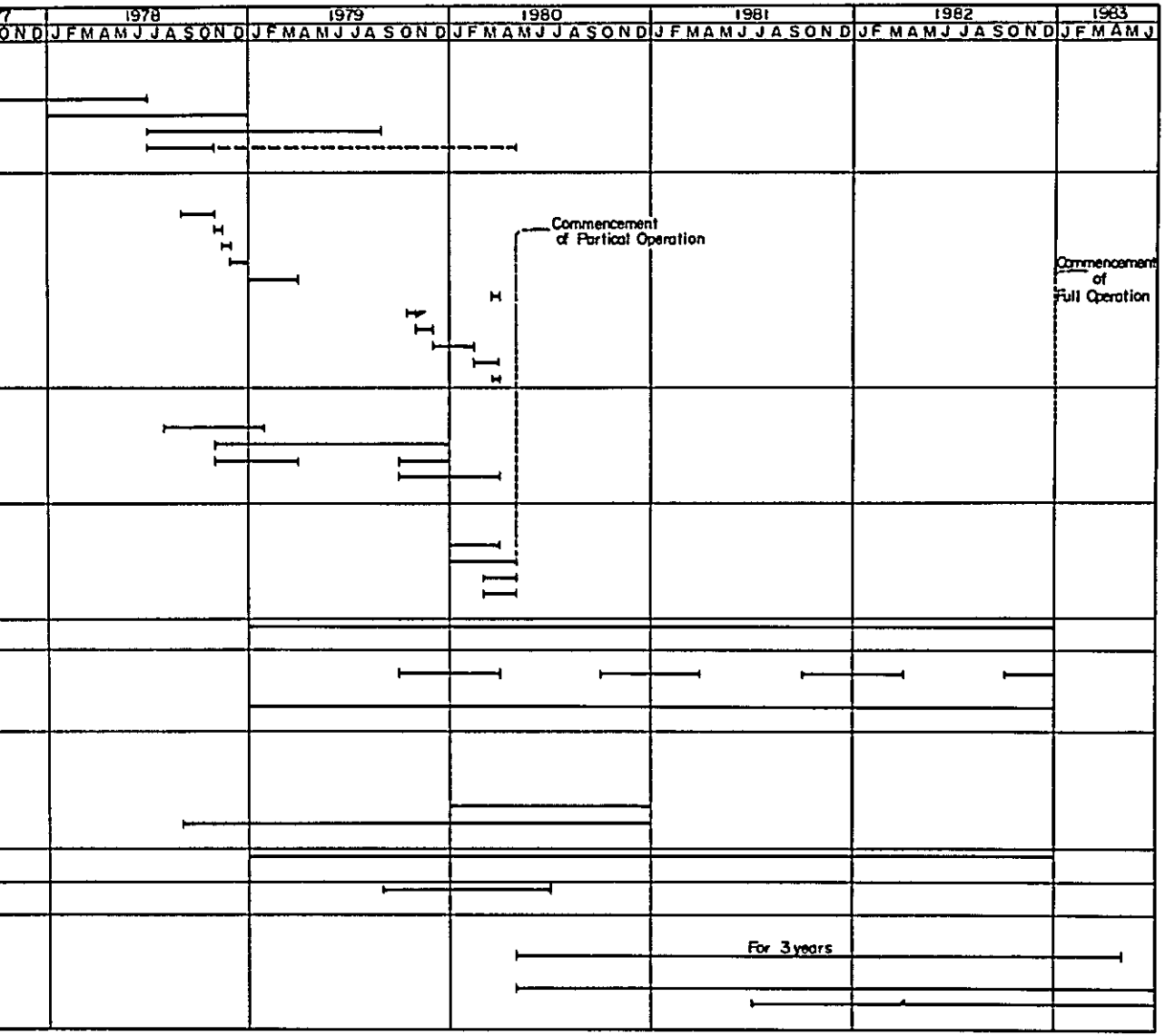
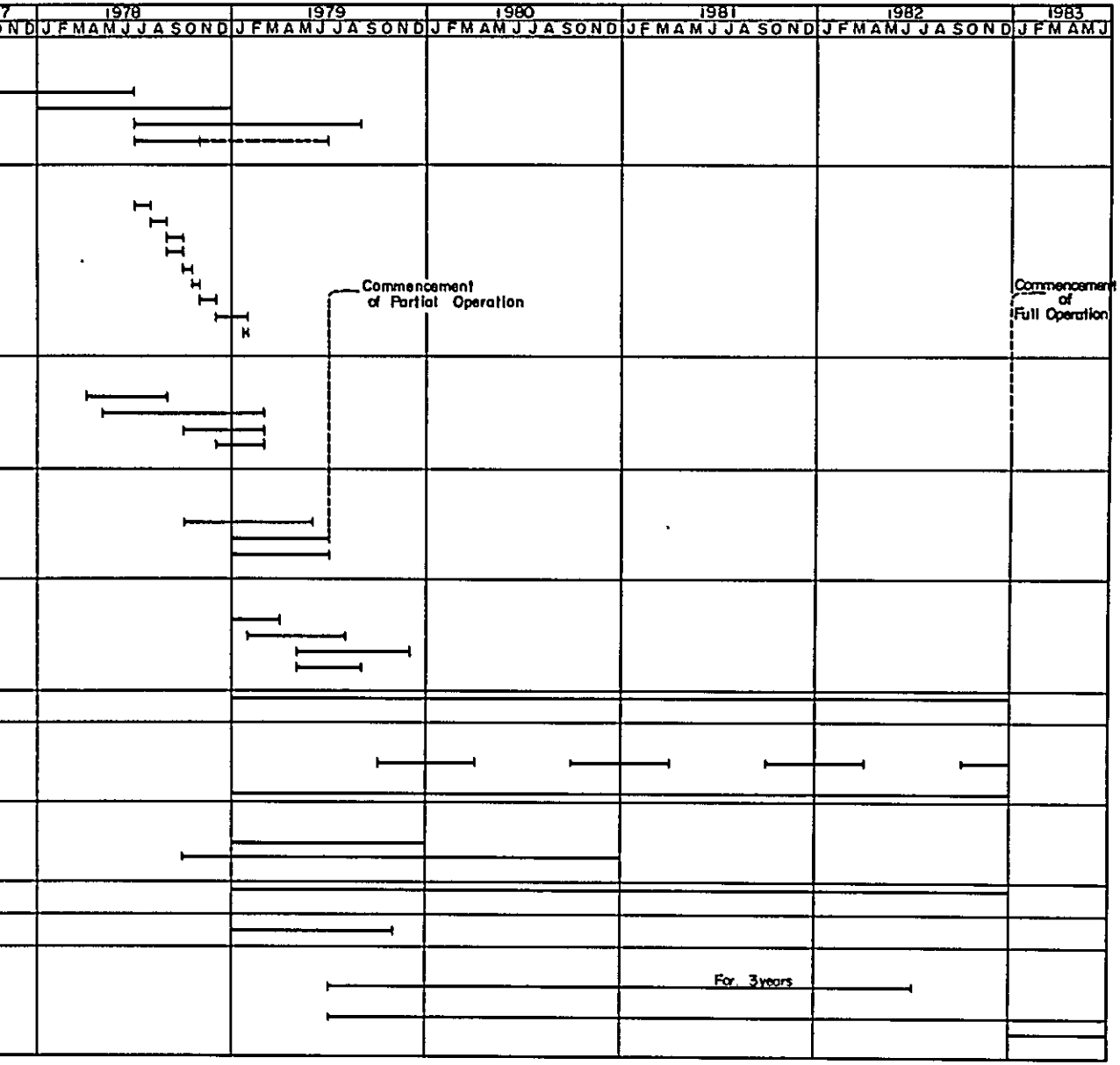


Fig. 8.2 Implementation Schedule for Auchi Project

Work Item	Unit	Quantity
1 Preparatory Works		
1.1 Topo Mapping & D/D	LS	
1.2 Procurement of Equipment	"	
1.3 Land Acquisition	Ha	14
1.4 Access & Project Office	LS	
2 Head Works		
2.1 Clearing	m²	520
2.2 Intake Str. Excavation	m³	440
2.3 —·— Concrete Works	"	500
2.4 —·— Embankment	"	270
2.5 Excavation of Diversion Canal	"	850
2.6 Coffering	"	600
2.7 Weir Foundation Excavation	"	1,000
2.8 —·— Concrete Works	"	1,100
2.9 Gate Installation	LS	
3 Head Race	km	11.7
3.1 Stripping	m²	139,000
3.2 Excavation	m³	95,000
3.3 Embankment	"	96,000
3.4 Related Structures	LS	
4 Main Irrigation Canal	km	7.0
4.1 Stripping	m²	58,000
4.2 Excavation	m³	27,000
4.3 Embankment	"	124,000
4.4 Related Structures	LS	
5 Secondary Irrigation Canals	km	17.9
5.1 Stripping	m²	43,000
5.2 Excavation	m³	75,000
5.3 Embankment	"	52,000
5.4 Related Structures	LS	
6 Tertiary & Supply Canals	km	27.0
7 Drainage Canals	"	
7.1 Collector Drains	"	
7.2 Field Drains	"	
8 Road	"	178.4
8.1 Main Road	"	23.4
8.2 Branch Road	"	155.0
9 Paddy Field Construction	Ha	2,100
10 Processing Storage & Workshops	LS	
11 Project Operation		
11.1 Pilot Scheme	Ha	50
11.2 Project Operation		
(a) Estate	"	1,800
(b) Small-Holder	"	300



9. COST ESTIMATE

9.1 General

The costs for the implementation of the Owerri Project and the Auchi Project are estimated on the basis of the preliminary design of the project works taking into account the construction method to be applied, productivity of labor and machineries with the following assumptions:

a) Major construction and farm machineries and materials such as steel, fertilizer and agro-chemicals are to be procured by international competition bidding;

b) Construction of the project works will be made by Force Account of the Government or project executing organization;

c) Compensation cost for the crops which are planted on the proposed head race area will be paid to farmers;

d) Physical contingency of the cost estimate is about 15% for the construction cost and 5% for the procurement cost of the machineries and equipment;

e) Price contingency applied in the estimate is: 1978; 7.5% 1979; 7.5%, 7.0% from 1980 onwards for foreign currency portion and 1978; 15%, 1979; 15%, 10% from 1980 onwards for local currency portion;

f) Price level for the cost estimate is principally mid-1977; and

g) All the conversion rate from US$ to ₦ is ₦1.0 = US$1.58.

9.2 Project Cost

The project cost consists of (i) cost for the civil works including land reclamation, (ii) cost for the processing and storage facilities including project office and its related facilities, and (iii) initial farm investment including procurement cost of agricultural machinery.

9.2.1 Construction Cost of Civil Works

Based upon the assumptions and conditions, mentioned above, construction cost of the civil works is estimated for each of the projects as shown in Tables 9.1 and 9.2. The estimated costs for the civil works are ₦12.65 million for the Owerri Project and

₦14.16 million for the Auchi Project. More detailed breakdown of the cost is given in Tables 9.3 and 9.4 for the Owerri and Auchi Projects, respectively. The breakdown of the cost for construction machinery is shown in Table 9.5. The cost for the engineering services includes the cost required for the detailed design and technical supervision during construction by foreign experts. Contingencies consist of physical contingency and provisions for price escalation, which are estimated on the conditions mentioned previously.

9.2.2 Construction Cost of Processing, Storage, Office Facilities

Cost required for construction of these facilities is estimated at ₦6.22 million and ₦5.49 million for the Owerri Project and Auchi Project respectively. Detailed breakdown is given in Tables 9.6 and 9.7 for the Owerri and Auchi Projects.

In the cost for the office and related facilities, the cost necessary for the related facilities of the pilot scheme is included.

9.2.3 Initial Farm Investment

The initial farm investment comprises the procurement cost of agricultural machinery and farming expenses required for the initial operation of the project. The estimated costs for the initial farm investment are ₦3.77 million for the Owerri Project and ₦3.27 million for the Auchi Project. Breakdown of the cost is given in Table 9.10.

9.2.4 Total Project Cost and Annual Disbursement Schedule

Total project costs for the Owerri Project and the Auchi Project are ₦22.64 million and ₦22.92 million respectively as summarized into tables 9.13 and 9.14.

These costs are broken down into the annual fund requirement in compliance with the implementation schedule of the projects. Tables 9.15 and 9.16 show the annual disbursement schedules of the cost for each of the Owerri and Auchi Projects.

9.3 Operation and Maintenance Cost

The operation and maintenance cost (OM cost) is needed annually after the commencement of the project operation. It comprises the costs for: (i) operation and maintenance of the irrigation and drainage facilities, and roads, (ii) maintenance of the project offices and their related facilities, and (iii) overhead and personnel expenses.

At the full operation stage of the project, annual OM cost is estimated in Table 9.17.

Table 9.1 Construction Cost of Civil Works for Owerri Project

(Unit: 10^3₦)

Work Item	Foreign currency	Local currency	Total
1. Preparatory works	-	26	26
2. Head works	63	91	154
3. Head race	125	372	497
4. Irrigation canals	133	1,261	1,394
5. Drainage canals	103	944	1,047
6. Roads	575	549	1,124
7. Reclamation	600	547	1,147
8. Construction machinery	2,290	-	2,290
Sub-total	3,889	3,790	7,679
9. Engineering services	770	570	1,340
10. Contingencies	1,021	2,610	3,631
Grand total	5,680	6,970	12,650

Table 9.2 Construction Cost of Civil Works for Auchi Project

(Unit: 10^3₦)

Work item	Foreign currency	Local currency	Total
1. Preparatory works	-	32	32
2. Head works	23	57	80
3. Head race	105	272	377
4. Irrigation canals	185	1,333	1,518
5. Drainage canals	96	1,259	1,355
6. Roads	607	575	1,182
7. Reclamation	896	889	1,785
8. Construction machinery	2,230	-	2,230
Sub-total	4,142	4,417	8,559
9. Engineering services	840	660	1,500
10. Contingencies	1,128	2,973	4,101
Grand total	6,110	8,050	14,160

Table 9.1 Detailed Breakdown of Construction Cost for Owerri Project

I. Preparatory Works

(Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Land Acquisition	ha	28	-	0	470	13,160	13,160
2. Access Road	m	5,500	-	0	1.95	10,730	10,730
3. Miscellaneous	L.S.					2,110	2,110
Total				0		26,000	26,000

II. Head Works for Owerri Project

(Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Clearing							
1.1 Forest clearing	ha	2.73	141	384.93	125	341.25	726.18
1.2 Miscellaneous	L.S.			15.07		58.75	73.82
(Sub-total)				(400)		(400)	(800)
2. Diversion canal & Coffer dam							
2.1 Excavation-E	m^3	1,150	0.34	391	0.30	345	736
2.2 Embankment-D	m^3	500	0.39	195	0.37	185	380
2.3 Miscellaneous	L.S.			114		30	144
(Sub-total)				(700)		(600)	(1,300)
3. Weir, Sand scouring & Intake							
3.1 Weir							
3.1.1 Excavation-E	m^3	3,000	0.34	1,020	0.30	900	1,920
3.1.2 Concrete-A	m^3	70	0.30	21	0.25	17.5	38.5
Concrete-B	m^3	3,100	0.07	217	1.65	5,115	5,332
Concrete-C	m^3	160	0.75	120	22	3,520	3,640
3.1.3 Reinforcement bar	Ton	20	410	8,200	30	600	8,800
3.1.4 Form for concrete	m^2	1,750	0.10	175	1.40	2,450	2,625
3.2 Sand scouring							
3.2.1 Excavation-E	m^3	100	0.34	34	0.30	30	64
3.2.2 Concrete-A	m^3	80	0.75	60	35	2,800	2,860
Concrete-B	m^3	50	0.75	37.5	30	1,500	1,537.5
Concrete-C	m^3	10	0.75	7.5	22	220	227.5
Mortar	m^3	1	-	0	34	34	34
3.2.3 Reinforcement bar	Ton	5	410	2,050	30	150	2,200
3.2.4 Form for concrete	m^2	330	0.10	33	1.40	462	495
3.2.5 Sluice gate 2.5m x 1.6m	Pc	1	-	0	205	205	205
3.2.6 Stoplog	m^3	1	-	0	26	26	26
3.2.7 Hoist-A	Pc	1	5,800	5,800	-	5,800	5,800
3.3 Intake							
3.3.1 Excavation-A	m^3	280	0.30	84	0.25	70	154
3.3.2 Excavation-B	m^3	310	0.07	21.7	1.65	511.5	533.2
3.3.3 Concrete-A	m^3	80	0.75	60	35	2,800	2,860
Concrete-C	m^3	10	0.75	7.5	22	220	227.5
Mortar	m^3	1	-	0	34	34	34
3.3.4 Reinforcement bar	Ton	4	410	1,640	30	120	1,760
3.3.5 Form for concrete	m^2	200	0.10	20	1.40	280	300
3.3.6 Sluice gate 2.0m x 1.5m	Pc	2	-	0	160	320	480
3.3.7 Stoplog	m^3	1	-	0	26	26	26
3.3.8 Hoist-A	Pc	2	5,800	11,600	-	0	11,600
3.4 Plug for Diversion Conduit							
3.4.1 Mortar	m^3	15	-	0	34	510	510
3.4.2 Stoplog	m^3	1	-	0	26	26	26
3.5 Miscellaneous	L.S.			1,691.8		1,937.5	3,629.3
(Sub-total)				(32,900)		(35,000)	(67,900)
4. Earth Dike							
4.1 Coffer dam							
4.1.1 Embankment-D	m^3	1,200	0.39	468	0.37	444	912
4.2 Earth Dike (Right)							
4.2.1 Excavation-A	m^3	900	0.30	270	0.25	225	495
4.2.2 Embankment-C	m^3	7,000	0.75	5,250	1.50	10,500	15,750
4.2.3 Sod facing	m^2	1,800	-	0	0.08	144	144
4.3 Earth Dike (Left)							
4.3.1 Excavation-E	m^3	8,400	0.34	2,856	0.30	2,520	5,376
4.3.2 Embankment-C	m^3	25,000	0.75	18,750	1.50	37,500	56,250
4.3.3 Sod facing	m^2	2,800	-	0	0.08	224	224
4.4 Miscellaneous	L.S.			1,406		3,443	4,849
(Sub-total)				(29,000)		(55,000)	(84,000)
Total				63,000		91,000	154,000

III. Head Race for Owerri Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Race							
1.1 Stripping	m^2	278,000	0.06	16,680	0.06	16,680	33,360
1.2 Excavation-C	m^3	165,000	0.07	11,550	1.40	231,000	242,550
1.3 Embankment-A	m^3	116,000	0.37	42,920	0.25	29,000	71,920
1.4 Sod facing	m^2	141,000	-	0	0.08	11,280	11,280
1.5 Miscellaneous	L.S.			3,850		15,040	18,890
(Sub-total)				(75,000)		(303,000)	(378,000)
2. Related Structures							
2.1 Spillway							
2.1.1 Concrete-A	m^3	15	0.75	11.25	35.0	525	536.25
Concrete-B	m^3	6	0.75	4.5	30.0	180	184.5
Concrete-C	m^3	2	0.75	1.5	22.0	44	45.5
2.1.2 Reinforcement bar	Ton	1.1	410	451	30	33	484
2.1.3 Form for concrete	m^2	75	0.10	7.5	1.40	105	112.5
2.1.4 Concrete pipe ϕ1,000mm	m	10	-	0	75	750	750
2.1.5 Hoist-A	Pc	1	5,800	5,800	-	0	5,800
2.1.6 Sluice gate (2.0m x 1.5m)	Pc	1	-	0	160	160	160
2.1.2 Excavation-C	m^3	70	0.07	4.9	1.40	98	102.9
2.1.8 Embankment-B	m^3	15	0.04	0.6	1.50	22.5	23.1
2.2 Culvert							
2.2.1 Concrete-A	m^3	800	0.75	600	35.0	28,000	28,600
Concrete-B	m^3	190	0.75	142.5	30.0	5,700	5,842.5
Concrete-C	m^3	45	0.75	33.75	22.0	990	1,023.75
2.2.2 Reinforcement bar	Ton	55	410	22,550	30	1,650	24,200
2.2.3 Form for concrete	m^2	3,250	0.10	325	1.40	4,550	4,875
2.2.4 Embankment-B	m^3	1,800	0.04	72	1.50	2,700	2,772
2.3 Cross drain							
2.3.1 Concrete-A	m^3	330	0.75	247.5	35.0	11,550	11,797.5
Concrete-C	m^3	25	0.75	18.75	22.0	550	568.75
2.3.2 Reinforcement bar	Ton	25	410	10,250	30	750	11,000
2.3.3 Form for concrete	m^2	1,000	0.10	100	1.40	1,400	1,500
2.3.4 Excavation-C	m^3	700	0.07	49	1.40	980	1,029
2.3.5 Embankment-B	m^3	1,100	0.04	44	1.50	1,650	1,694
2.4 Turnout							
2.4.1 Concrete-A	m^3	23	0.75	17.25	35.0	805	822.25
Concrete-B	m^3	11	0.75	8.25	30.0	330	338.25
Concrete-C	m^3	4	0.75	3	22.0	88	91
2.4.2 Reinforcement bar	Ton	2	410	820	30	60	880
2.4.3 Form for concrete	m^2	120	0.10	12	1.40	168	180
2.4.4 Hoist-A	Pc	1	5,800	5,800	-	0	5,800
2.4.5 Sluice gate (2.0m x 1.5m)	Pc	1	-	0	100	160	160
2.4.6 Staff gage	m	3	15	45	6.5	19.5	64.5
2.4.7 Excavation-D	m^3	20	-	0	2.60	52	52
2.4.8 Embankment-B	m^3	30	0.04	1.2	1.50	45	46.2
2.5 Concrete Lining							
2.5.1 Concrete-B	m^3	30	0.75	22.5	30.0	900	922.5
Miscellaneous	L.S.			2,557.05		3,985	6,542.05
(Sub-total)				(50,000)		(69,000)	(119,000)
Total				125,000		372,000	497,000

IV. Secondary Canal for Owerri Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Canals							
1.1 Stripping	m^2	46,600	0.06	2,796	0.06	2,796	5,592
1.2 Excavation-C	m^3	14,000	0.07	980	1.40	19,600	20,580
" -B	"	3,500	0.07	245	1.65	5,775	6,020
1.3 Embankment-A	m^3	25,000	0.37	9,250	0.25	6,250	15,500
1.4 Sod facing	m^2	62,000	-	0	0.08	4,960	4,960
1.5 Miscellaneous	L.S.			729		2,619	3,348
(Sub-total)				(14,000)		(42,000)	(56,000)
2. Related Structures							
2.1 Turnout							
2.1.1. Concrete-A	m^3	200	0.75	150	35.0	7,000	7,150
" -B	"	105	0.75	78.75	30.0	3,150	3,228.75
" -C	"	40	0.75	30	22.0	880	910
2.1.2 Rainforcement bar	ton	15	410	6,150	30	450	6,600
2.1.3 Form for concrete	m^2	1,050	0.10	105	1.40	1,470	1,575
2.1.4 Sluice gate 1.5mx1.1m	Pc	10	-	0	65	650	650
2.1.5 Stoplog	m^3	2	-	0	26	52	52
2.1.6 Staf gage	m	15	15	225	6.5	97.5	322.5
2.1.7 Excavation-D	m^3	250	-	0	2.60	650	650
2.1.8 Embankment-B	"	450	0.04	18	1.50	675	693
2.2 Spillway							
2.2.1 Concrete-A	m^3	20	0.75	15	35.0	700	715
" -B	"	8	0.75	6	30.0	240	246
" -C	"	2	0.75	1.5	22.0	44	45.5
2.2.2 Rainforcement bar	ton	1.5	410	615	30	45	660
2.2.3 Form for concrete	m^2	100	0.10	10	1.40	140	150
2.2.4 Concrete pipe ϕ 800mm	m	20	-	0	58	1,160	1,160
2.2.5 Hoist-B	Pc	1	3,300	3,300	-	0	3,300
2.2.6 Sluice gate 1.1mx1.1m	Pc	2	-	0	37.5	75	75
2.2.7 Excavation-D	m^3	20	-	0	2.60	52	52
2.2.8 Embankment-B	"	15	0.04	0.6	1.50	22.5	23.1
2.3 Culvert							
2.3.1. Concrete-A	m^3	450	0.75	337.5	35.0	15,750	16,087.5
" -B	"	65	0.75	48.75	30.0	1,950	1,998.75
" -C	"	65	0.75	48.75	22.0	1,430	1,478.75
2.3.2. Rainforcement bar	ton	22	410	9,020	30	660	9,680
2.3.3. Form for concrete		1,300	0.10	130	1.40	1,820	1,950
2.3.4. Concrete pipe ϕ1,200	m	33	-	-	92	3,036	3,036
" ϕ1,000	m	58	-	-	75	4,350	4,350
" ϕ800	m	55	-	-	58	3,190	3,190
2.3.5. Embankment-B	m^3	1,800	0.04	72	1.50	2,700	2,772
2.4 Cross Drain							
2.4.1. Concrete-A	m^3	68	0.75	51	35	2,380	2,431
" -B	"	14	0.75	10.5	30	420	430.5
" -C	"	10	0.75	7.5	22	220	227.5
2.4.2. Rainforcement bar	ton	5	410	2,050	30	150	2,200
2.4.3. Form for concrete	m^2	280	0.10	28	1.40	392	420
2.4.4. Embankment-B	m^3	155	0.04	6.2	150	232.5	238.7
2.5 Miscellaneous				1,484.95		3,066.5	4,551.45
(Sub-total)				24,000		59,000	83,000
Total				38,000		101,000	139,000

V. Tertiary Canals and Supply Canals for Overri Project

(Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Canals							
1.1 Excavation-B	m^3	9,400	0.07	658	1.65	15,510	16,168
Excavation-D	m^3	10,700	-	0	2.60	27,820	27,820
1.2 Embankment-A	m^3	91,500	0.37	33,855	0.25	22,875	56,730
Embankment-B	m^3	446,000	0.04	17,840	1.50	669,000	686,840
1.3 Sod facing	m^2	92,000	-	0	0.08	7,360	7,360
1.4 Miscellaneous	L.S.			2,647		37,435	40,082
(Sub-total)				(55,000)		780,000)	(335,000)
2. Related Structures							
2.1 Turnout							
2.1.1 Concrete-A	m^3	800	0.75	600	35.0	28,000	28,600
Concrete-B	m^3	120	0.75	90	30.0	3,600	3,690
Concrete-C	m^3	100	0.75	75	22.0	2,200	2,275
2.1.2 Reinforcement bar	Ton	60	410	24,600	30	1,800	26,400
2.1.3 Form for concrete	m^2	4,000	0.10	400	1.40	5,600	6,000
2.1.4 Stoplog	m^3	15	-	0	26	390	390
2.1.5 Excavation-D	m^3	3,200	-	0	2.60	8,320	8,320
2.1.6 Embankment-B	m^3	5,300	0.04	212	1.50	7,950	8,162
2.2 Culvert							
2.2.1 Concrete-A	m^3	160	0.75	120	35.0	5,600	5,720
Concrete-B	m^3	160	0.75	120	30.0	4,800	4,920
Concrete-C	m^3	180	0.75	135	22.0	3,960	4,095
2.2.2 Reinforcement bar	Ton	11	410	4,510	30	330	4,840
2.2.3 Form for concrete	m^2	520	0.10	52	1.40	728	780
2.2.4 Concrete pipe ϕ400mm	m	1,298	-	0	28	36,344	36,344
ϕ300mm	m	709	-	0	21	14,889	14,889
2.2.5 Embankment-B	m^3	5,400	0.04	216	1.50	8,100	8,316
2.3 Cross drain							
2.3.1 Concrete-A	m^3	140	0.75	105	35	4,900	5,005
Concrete-B	m^3	140	0.75	105	30	4,200	4,305
Concrete-C	m^3	220	0.75	165	22	4,840	5,005
2.3.2 Reinforcement bar	Ton	10	410	4,100	30	300	4,400
2.3.3 Form for concrete	m^2	500	0.10	50	140	70,000	70,050
2.3.4 Concrete pipe ϕ500mm	m	1,065	-	0	34	36,210	36,210
ϕ300mm	m	1,200	-	0	21	25,200	25,200
2.3.5 Embankment-B	m^3	56,000	0.04	2,240	1.50	84,000	86,240
2.4 Miscellaneous	L.S.			2,105		17,739	19,844
(Sub-total)				(40,000)		380,000)	(420,000)
Total				95,000		1,160,000	1,255,000

VI. Collector Drains and Field Drains for Owerri Project (Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Drains							
1.1 Excavation-C for collector drains	m^3	242,600	0.07	16,982	1.40	339,640	356,622
1.2 Excavation-C for field drains	m^3	301,900	0.07	21,133	1.40	422,660	443,793
1.3 Miscellaneous	L.S.			1,885		38,700	40,585
(Sub-total)				(40,000)		801,000)	(841,000)
2. Related Structures							
2.1 Drop							
2.1.1 Concrete-A	m^3	110	0.75	82.5	35	3,850	3,932.5
Concrete-B	m^3	100	0.75	75	30	3,000	3,075
Concrete-C	m^3	10	0.75	7.5	22	220	227.5
2.1.2 Reinforcement bar	Ton	8	410	3,280	30	240	3,520
2.1.3 Form for concrete	m^2	580	0.10	58	1.40	812	870
2.1.4 Embankment-B	m^3	300	0.04	12	1.50	450	462
2.2 Drain culvert of collector drains							
2.2.1 Concrete-A	m^3	1,800	0.75	1,350	35	63,000	64,350
Concrete-B	m^3	500	0.75	375	30	15,000	15,375
Concrete-C	m^3	200	0.75	150	22	4,400	4,550
2.2.2 Reinforcement bar	Ton	130	410	53,300	30	3,900	57,200
2.2.3 Form for concrete	m^2	7,450	0.10	745	1.40	10,430	11,175
2.2.4 Concrete pipe ϕ1,000mm	m	256	-	0	75	19,200	19,200
2.2.5 Embankment-B	m^3	5,900	0.04	236	1.50	8,850	9,086
2.3 Drain culvert of field drains							
2.3.1 Concrete-A	m^3	5	0.75	3.75	35	175	178.75
Concrete-B	m^3	4	0.75	3	30	120	123
Concrete-C	m^3	7	0.75	5.25	22	154	159.25
2.3.2 Reinforcement bar	Ton	0.4	410	164	30	12	176
2.3.3 Form for concrete	m^2	20	0.10	2	1.40	28	30
2.3.4 Concrete pipe ϕ500mm	m	44	-	0	42	1,848	1,848
2.3.5 Embankment-B	m^3	160	0.04	6.4	1.50	240	246.4
2.4 Miscellaneous				3,144.6		7,071	
(Sub-total)				(63,000)		(143,000)	(206,000)
Total				103,000		944,000	1,047,000

VII. Main and Branch Road for Owerri Project (Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Main Road							
1.1 stripping	m^2	202,000	0.06	12,120	0.06	12,120	24,240
1.2 Excavation-C	m^3	1,000	0.07	700	1.40	1,400	2,100
1.3 Embankment-A	m^3	71,000	0.37	26,270	0.25	17,750	44,020
1.4 Laterite pavement	m^3	42,420	1.50	63,630	1.60	67,872	131,502
1.5 Miscellaneous	L.S.			5,280		5,858	11,138
(Sub-total)				(108,000)		(105,000)	(213,000)
2. Branch Road							
1.1 Stripping	m^2	1,040,000	0.06	62,400	0.06	62,400	124,800
1.2 Excavation-C	m^3	3,700	0.07	259	1.40	5,180	5,439
1.3 Embankment-A	m^3	364,000	0.37	134,680	0.25	91,000	225,680
1.4 Laterite pavement	m^3	164,680	1.50	247,020	1.60	263,488	510,508
1.5 Miscellaneous	L.S.			22,641		21,932	44,573
(Sub-total)				(467,000)		(444,000)	(911,000)
Total				575,000		549,000	1,124,000

VIII. Land Reclamation for Owerri Project (Unit: k)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Land Reclamation							
1.1 With forest clearing	ha	330	391	129,030	354	116,820	245,850
1.2 Without forest clearing	ha	1,770	250	442,500	228	403,560	846,060
1.3 Miscellaneous	L.S.			28,470		26,620	55,090
Total				600,000		547,000	1,147,000

Table 9.4 Detailed Breakdown of Construction Cost for Auchi Project

I. Preparatory Works

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Land Acquisition	ha	14	-	0	470	6,580	6,580
2. Access Road	m	12,000	-	0	1.95	23,400	23,400
3. Miscellaneous	L.S.					2,020	2,020
Total				0		32,000	32,000

II. Head Works for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Intake Structure							
1.1 Excavation-A	m^3	440	0.30	132	0.25	110	242
1.2 Embankment-A	m^3	270	0.37	99.9	0.25	67.5	167.4
1.3 Concrete-A	m^3	300	0.75	225	35	10,500	10,725
Concrete-B	m^3	150	0.75	112.5	30	4,500	4,612.5
Concrete-C	m^3	50	0.75	375	22	1,100	1,137.5
Mortar	m^3	1	-	0	34	34	34
1.4 Reinforcement bar	ton	16	410	6,560	30	480	7,040
1.5 Form for concrete	m^2	1,130	0.10	113	1.40	1,582	1,695
1.6 Sluice gate 2.0m x 1.5m	Pc	2	-	0	160	320	320
1.7 Stoplog	m^3	1	-	0	26	26	26
1.8 Hoist-A	Pc	2	5,800	11,600	-	0	11,600
1.9 Miscellaneous				1,520.1		1,680.5	3,200.6
(Sub-total)				20,400		20,400	40,800
2. Diversion Canal & Coffer dam							
2.1 Diversion Canal							
2.1.1 Excavation-E	m^3	850	0.34	289	0.30	255	544
2.1.2 Embankment-D	m^3	70	0.39	27.3	0.37	25.9	53.2
2.2 Coffer dam							
2.2.1 Embankment-D	m^3	600	0.39	234	0.37	222	456
2.3 Miscellaneous				49.7		97.1	146.8
(Sub-total)				600		600	1,200
3. Weir							
3.1 Excavation-E	m^3	1,010	0.34	343.4	0.30	303	646.4
3.2 Concrete-A	m^3	150	0.75	112.5	35	5,250	5,362.5
Concrete-B	m^3	920	0.75	690	30	27,600	28,290
3.3 Reinforcement bar	ton	1	410	410	30	30	440
3.4 Form for concrete	m^2	540	0.10	54	1.40	756	810
3.5 Miscellaneous				390.1		2,061	2,451.1
(Sub-total)				(2,000)		(36,000)	(38,000)
Total				23,000		57,000	80,000

III. Head Race for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Race							
1.1 Stripping	m^2	138,500	0.06	8,310	0.06	8,310	16,620
1.2 Excavation-C	m^3	95,000	0.07	6,650	1.40	133,000	139,650
1.3 Embankment-A	m^3	96,200	0.37	35,594	0.25	24,050	59,644
1.4 Sod facing	m^2	96,000	-	-	0.08	7,680	7,680
1.5 Miscellaneous				2,446		8,960	11,406
(Sub-total)				(53,000)		(182,000)	(235,000)
2. Related Structures							
2.1 Spillway							
2.1.1 Concrete-A	m^3	11.0	0.75	8.25	35	385	393.25
Concrete-B	m^3	4.0	0.75	3	30	120	123
Concrete-C	m^3	1.0	0.75	0.75	22	22	22.75
2.1.2 Reinforcement bar	ton	0.8	410	328	30	24	352
2.1.3 Form for concrete	m^2	55	0.10	5.5	1.40	77	82.5
2.1.4 Concrete pipe ϕ800mm	m	7.0	-	-	58	40.6	40.6
2.1.5 Hoist-A	Pc	1	5,800	5,800	-	-	5,800
2.1.6 Sluice gate 2.0m x 1.5m	Pc	1	-	-	160	160	160
2.1.7 Excavation-C	m^3	50	0.07	3.5	1.40	70	73.5
2.1.8 Embankment-B	m^3	15	0.04	0.6	1.50	22.5	23.1
2.2 Flume							
2.2.1 Concrete-A	m^3	550	0.75	412.5	35	19,250	19,662.5
Concrete-B	m^3	20	0.75	15	30	600	615
Concrete-C	m^3	150	0.75	112.5	22	3,300	3,412.5
2.2.2 Reinforcement bar	ton	39.0	410	15,990	30	1,170	17,160
2.2.3 Form for concrete	m^2	3,900	0.10	390	1.40	5,460	5,850
2.2.4 Embankment-B	m^3	2,000	0.04	80	1.50	3,000	3,080
2.3 Culvert							
2.3.1 Concrete-A	m^3	100	0.75	75	35	3,500	3,575
Concrete-B	m^3	20	0.75	15	30	600	615
Concrete-C	m^3	10	0.75	7.5	22	220	227.5
2.3.2 Reinforcement bar	ton	7.0	410	2,870	30	210	3,080
2.3.3 Form for concrete	m^2	380	0.10	38	1.40	532	570
2.3.4 Embankment-B	m^3	250	0.04	10	1.50	375	385
2.4 Cross Drain							
2.4.1 Concrete-A	m^3	740	0.75	555	35	25,900	26,455
Concrete-C	m^3	70	0.75	52.5	22	1,540	1,592.5
2.4.2 Reinforcement bar	ton	52	410	21,320	30	1,560	22,880
2.4.3 Form for concrete	m^2	3,400	0.10	340	1.40	4,760	5,100
2.4.4 Concrete pipe ϕ1,000mm	m	35	-	0	75	2,625	2,625
2.4.5 Excavation-C	m^3	2,000	0.07	140	1.40	2,800	2,940
2.4.6 Embankment-B	m^3	3,000	0.04	120	1.50	4,500	4,620
2.5 Concrete lining							
2.5.1 Concrete-B	m^3	90	0.75	67.5	30	2,700	2,767.5
2.6 Miscellaneous				3,239.9		4,476.9	7,716.8
(Sub-total)				(52,000)		(90,000)	(142,000)
Total				105,000		272,000	377,000

IV. Main Canal for Auchi Project

(Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Canal							
1.1 Stripping	m^2	58,000	0.06	3,480	0.06	3,480	6,960
1.2 Excavation-B	m^3	8,000	0.07	560	1.65	13,200	13,760
-C	"	18,500	0.07	1,295	1.40	25,900	27,195
1.3 Embankment-A	"	123,500	0.37	45,695	0.25	30,875	76,570
1.4 Sod facing	m^2	43,500	-	0	0.08	3,480	3,480
1.5 Miscellaneous				2,970		4,065	7,035
(Sub-total)				(54,000)		(81,000)	(135,000)
2. Related Structures							
2.1 Turnout							
2.1.1 Concrete-A	m^3	70	0.75	52.5	35	2,450	2,502.5
" -B	"	16	0.75	12	30	480	492
" -C	"	10	0.75	7.5	22	220	227.5
2.1.2 Reinforcement bar	ton	5	410	2,050	30	150	2,200
2.1.3 Form for concrete	m^2	350	0.10	35	1.40	490	525
2.1.4 Sluice gate 1.1m x 1.1m	pc	10	-	0	37.5	375	375
2.1.5 Hoist-B	"	1	3,300	3,300	-	0	3,300
2.1.6 Staff gage	m	10	15	150	6.5	65	215
2.1.7 Excavation-D	m^3	80	-	0	2.60	208	208
2.1.8 Embankment-B	m^3	130	0.04	5.2	1.50	195	200.2
2.2 Spillway							
2.2.1 Concrete-A	m^3	10.5	0.75	7.875	35	367.5	375.375
" -B	"	3.8	0.75	2.85	30	114	116.85
" -C	"	1.0	0.75	0.75	22	22	22.75
2.2.2 Reinforcement bar	ton	0.75	410	307.5	30	22.5	330
2.2.3 Form for concrete	m^2	55	0.10	5.5	1.40	77.0	82.5
2.2.4 Concrete pipe ϕ 700mm	m	10	-	0	50	500	500
2.2.5 Hoist-B	pc	1	3,300	3,300	-	0	3,300
2.2.6 Sluice gate 1.1m x 1.1m	"	1	-	0	37.5	37.5	37.5
2.2.7 Excavation-D	m^3	15	-	0	2.60	39	39
2.2.8 Embankment-B	"	10	0.04	0.4	1.50	15	15.4
2.3 Culvert							
2.3.1 Concrete-A	m^3	77.4	0.75	58.05	35	112.4	170.45
" -B	"	12.6	0.75	9.45	30	378	387.45
" -C	"	13.3	0.75	9.975	22	292.6	302.575
2.3.2 Reinforcement bar	ton	5.5	410	2,255	30	165	2,420
2.3.3 Form for concrete	m^2	383	0.10	38.3	1.40	536.2	574.5
2.3.4 Concrete pipe ϕ 1,000mm	m	14	-	0	75	1,050	1,050
ϕ 800mm	"	14	-	0	58	812	812
2.3.5 Embankment-B	m^3	400	0.04	16	1.50	600	616
2.4 Drop							
2.4.1 Concrete-A	m^3	6	0.75	4.5	35	210	214.5
" -B	"	4	0.75	3	30	120	123
" -C	"	1	0.75	0.75	22	22	22.75
2.4.2 Reinforcement bar	ton	0.4	410	164.0	30	12	176
2.4.3 Form for concrete	m^2	30	0.10	3	1.40	42	45
2.4.4 Embankment-B	m^3	14	0.04	0.56	1.50	21	21.56
2.5 Cross Drain							
2.5.1 Concrete-A	m^3	920	0.75	690	35	32,200	32,890
" -B	"	47	0.75	35.25	30	1,410	1,445.25
" -C	"	15	0.75	11.25	22	330	341.25
2.5.2 Reinforcement bar	ton	19	410	7,790	30	570	8,360
2.5.3 Form for concrete	m^2	1,290	0.10	129	1.40	1,806	1,935
2.5.4 Concrete pipe ϕ 1,000mm	m	14	-	0	75	1,050	1,050
ϕ 700mm	"	24	-	0	50	1,200	1,200
2.6 Miscellaneous				1,544.84		3,233.3	4,778.14
(Sub-total)				(22,000)		(52,000)	(74,000)
Total				76,000		133,000	209,000

V. Secondary Canals for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Canals							
1.1 Stripping	m^2	43,200	0.06	2,592	0.06	2,592	5,184
1.2 Excavation-B	m^3	67,000	0.07	4,690	1.65	110,550	115,240
-D		7,500	-	0	2.60	19,500	19,500
1.3 Embankment-A	m^3	48,000	0.37	17,760	0.25	12,000	29,760
-B		4,000	0.04	160	1.50	6,000	6,160
1.4 Sod facing	m^2	50,000	-	0	0.08	4,000	4,000
1.5 Miscellaneous	L.S.			1,798		8,358	10,156
(Sub-total)				(27,000)		(163,000)	(190,000)
2. Related Structures							
2.1 Turnout							
2.1.1 Concrete-A	m^3	230	0.75	172.5	35	8,050	8,222.5
Concrete-B	m^3	80	0.75	60	30	2,400	2,460
Concrete-C	m^3	50	0.75	37.5	22	1,100	1,137.5
2.1.2 Reinforcement bar	Ton	16	410	6,560	30	480	6,940
2.1.3 Form for concrete	m^2	1,150	0.10	115	1.40	1,610	1,725
2.1.4 Hoist-B	Pc	1	3,300	3,300	-	0	3,300
2.1.5 Sluice gate 1.1m x 1.1m	Pc	20	-	0	37.5	750	750
0.5m x 0.5m	Pc	15	-	0	10	150	150
2.1.6 Stoplog	m^3	3	-	0	26	78	78
2.1.7 Staff gage	m	30	15	450	6.5	195	645
2.1.8 Excavation-D	m^3	500	-	0	2.6	1,300	1,300
2.1.8 Embankment-B	m^3	750	0.04	30	1.50	1,125	1,155
2.2 Drop							
2.2.1 Concrete-A	m^3	130	0.75	97.5	35	4,550	4,647.5
Concrete-B	m^3	50	0.75	37.5	30	1,500	1,537.5
Concrete-C	m^3	21	0.75	15.75	22	462	477.75
2.2.2 Reinforcement bar	Ton	9	410	3,690	30	270	3,960
2.2.3 Form for concrete	m^2	630	0.10	63	1.40	882	945
2.2.4 Embankment-B	m^3	120	0.04	4.8	1.50	180	184.8
2.3 Spillway							
2.3.1 Concrete-A	m^3	48	0.75	36	35	1,680	1,716
Concrete-B	m^3	12	0.75	9	30	360	396
Concrete-C	m^3	3	0.75	2.25	22	66	68.25
2.3.2 Reinforcement bar	Ton	3.5	410	1,435	30	105	1,540
2.3.3 Form for concrete	m^2	250	0.10	25	1.40	350	375
2.3.4 Excavation-D	m^3	30	-	0	2.60	78	78
2.3.5 Embankment-B	m^3	18	0.04	0.72	1.50	27	27.72
2.4 Culvert							
2.4.1 Concrete-A	m^3	43	0.75	32.25	35	1,505	1,537.25
Concrete-B	m^3	30	0.75	22.5	30	900	922.5
Concrete-C	m^3	51	0.75	38.25	22	1,122	1,160.25
2.4.2 Reinforcement bar	Ton	3.0	410	1,230	30	90	1,320
2.4.3 Form for concrete	m^2	153	0.10	15.3	1.40	214.2	229.5
2.4.4 Concrete pipe ϕ700mm	m	61	-	0	50	3,050	3,050
ϕ600mm	m	69	-	0	42	2,890	2,890
ϕ500mm	m	138	-	0	34	4,692	4,692
ϕ400mm	m	66	-	0	28	1,848	1,848
ϕ300mm	m	44	-	0	21	924	924
2.4.5 Embankment-B	m^3	1,250	0.04	50	1.50	1,875	1,875
2.5 Cross Drain							
2.5.1 Concrete-A	m^3	240	0.75	180	35	8,400	8,580
Concrete-B	m^3	20	0.75	15	30	600	615
Concrete-C	m^3	3	0.75	2.25	22	66	68.25
2.5.2 Reinforcement bar	Ton	8	410	3,280	30	210	3,520
2.5.3 Form for concrete	m^2	600	0.10	60	140	840	900
2.5.4 Embankment-B	m^3	340	0.04	13.6	1.50	510	523.6
2.6 Miscellaneous	L.S.			1,919.33		3,515.8	5,435.13
(Sub-total)				(23,000)		(61,000)	(84,000)
Total				50,000		224,000	274,000

VI. Tertiary Canals and Supply Canals for Auchi Project

(Unit: N)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Canals							
1.1 Excavation-B	m^3	1,000	0.07	70	1.65	1,650	1,720
" -D	"	29,000	-	0	2.60	75,400	75,400
1.2 Embankment-A	"	9,100	0.37	3,367	0.25	2,275	5,642
" -B	"	403,000	0.04	16,120	1.50	604,500	620,620
1.3 Sod facing	m^2	12,000	-	0	0.08	960	960
1.4 Miscellaneous	L.S.			1,443		34,215	35,658
(Sub-total)				(21,000)		(719,000)	(740,000)
2. Related Structures							
2.1 Turnout							
2.1.1 Concrete-A	m^3	860	0.75	645	35	30,100	30,745
" -B	"	140	0.75	105	30	4,200	4,305
" -C	"	88	0.75	66	22	1,930	1,996
2.1.2 Reinforcement bar	ton	65	410	26,650	30	1,950	28,600
2.1.3 Form for concrete	m^2	4,400	0.10	440	1.40	6,160	6,600
2.1.4 Stoplog	m^3	17	-	0	26	442	442
2.1.5 Excavation-D	"	3,500	-	0	2.60	9,100	9,100
2.1.6 Embankment-B	"	5,700	0.04	228	1.50	8,550	8,778
2.2 Culvert							
2.2.1 Concrete-A	m^3	96	0.75	72	35	3,360	3,432
" -B	"	140	0.75	105	30	4,200	4,305
" -C	"	140	0.75	105	22	1,380	1,485
2.2.2 Reinforcement bar	ton	8	410	3,280	30	240	3,520
2.2.3 Form for concrete	m^2	350	0.10	35	1.40	490	525
2.2.4 Concrete Pipe ϕ 300mm	m	1,809	-	0	21	37,989	37,989
2.2.5 Embankment-B	m^3	4,300	0.04	172	1.50	6,450	6,622
2.3 Cross drain							
2.3.1 Concrete-A	m^3	80	0.75	60	35	2,800	2,860
" -B	"	90	0.75	67.5	30	2,700	2,767.5
" -C	"	120	0.75	90	22	2,640	2,730
2.3.2 Reinforcement bar	ton	6	410	2,460	30	180	2,640
2.3.4 Form for concrete	m^2	250	0.10	25	140	35,000	35,025
2.3.5 Concrete pipe ϕ 500mm	m	360	-	0	34	12,240	12,240
ϕ 300mm	"	1,065	-	0	21	22,365	22,365
2.3.6 Embankment-B	m^3	33,000	0.04	1,320	1.50	49,500	50,820
2.4 Miscellaneous	L.S.			2,074.5		13,034	15,108.5
(Sub-total)				(38,000)		(257,000)	(295,000)
Total				59,000		976,000	1,035,000

VII. Collector Drains and Field Drains for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		
			Unit Price	Amount	Unit Price	Amount	Total
1. Drains							
1.1 Excavation-C for collector drains	m^3	455,000	0.07	31,850	1.40	637,000	668,850
1.2 Excavation-C for field drains	m^3	289,500	0.07	20,265	1.40	405,300	425,565
1.3 Miscellaneous	L.S.			2,885		52,700	55,585
(Sub-total)				(55,000)		(1,095,000)	(1,150,000)
2. Related Structures							
2.1 Drop							
2.1.1 Concrete-A	m^3	580	0.75	435	35	20,300	20,735
" -B	"	660	0.75	495	30	19,800	20,295
" -C	"	60	0.75	45	22	1,320	1,365
2.1.2 Reinforcement bar	ton	44	410	18,040	30	1,320	19,360
2.1.3 Form for concrete	m^2	2,985	0.10	298.5	1.40	4,179	4,477.5
2.1.4 Embankment-B	m^3	1,475	0.04	59	1.50	2,212.5	2,271.5
2.2 Drain culvert of collector drains							
2.2.1 Concrete-A	m^3	540	0.75	405	35	18,900	19,305
" -B	"	290	0.75	2,175	30	8,700	10,875
" -C	"	274	0.75	205.5	22	6,028	6,233.5
2.2.2 Reinforcement bar	ton	39	410	15,990	30	1,170	17,160
2.2.3 Form for concrete	m^2	2,170	0.10	217	1.40	3,038	3,255
2.2.4 Concrete pipe ϕ 1,000 mm	m	347	-	0	75	26,025	26,025
ϕ 900 mm	"	77	-	0	66	5,082	5,082
ϕ 800 mm	"	300	-	0	58	17,400	17,400
ϕ 600 mm	"	66	-	0	42	2,772	2,772
ϕ 500 mm	"	55	-	0	34	1,870	1,870
2.2.5 Embankment-B	m^3	5,500	0.04	220	1.50	8,250	8,470
2.3 Drain culvert of field drains							
2.3.1 Concrete-A	m^3	14	0.75	10.5	35	490	500.5
" -B	"	15	0.75	11.25	30	450	461.25
" -C	"	17	0.75	12.75	22	374	386.75
2.3.2 Reinforcement bar	ton	1	410	410	30	30	440
2.3.3 Form for concrete	m^2	50	0.10	5	1.40	70	75
2.3.4 Concrete pipe ϕ 500 mm	m	66	-	0	42	2,772	2,772
ϕ 300 mm	"	99	-	0	21	2,079	2,079
2.3.5 Embankment-B	m^3	500	0.04	20	1.50	750	770
2.4 Miscellaneous	L.S.			1,945.5		8,618.5	10,564
(Sub-total)				(41,000)		(164,000)	(205,000)
Total				96,000		1,259,000	1,355,000

VIII. Main and Branch Road for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Main Road							
1.1 Stripping	m^2	234,000	0.06	14,040	0.06	14,040	28,080
1.2 Excavation-C	m^3	1,000	0.07	70	1.40	1,400	1,470
1.3 Embankment-A	"	81,900	0.37	30,303	0.25	20,475	50,778
1.4 Laterite pavement	"	49,140	1.50	73,710	1.60	78,624	152,334
1.5 Miscellaneous	L.S.			6,247		6,461	12,708
(Sub-total)				(125,000)		(121,000)	(246,000)
2. Branch Road							
2.1 Stripping	m^2	1,085,000	0.06	65,100	0.06	65,100	130,200
2.2 Excavation-C	m^3	4,000	0.07	280	1.40	5,600	5,880
2.3 Embankment-A	"	379,750	0.37	140,507.5	0.25	94,937.5	235,445
2.4 Laterite pavement	"	166,740	1.50	250,110	1.60	266,784	516,894
2.5 Miscellaneous	L.S.			23,482.5		21,578.5	45,061
(Sub-total)				(482,000)		(454,000)	(936,000)
Total				607,000		575,000	1,182,000

IX. Land Reclamation for Auchi Project

(Unit: ₦)

Works	Unit	Quantity	Financial Cost				
			Foreign Currency		Local Currency		Total
			Unit Price	Amount	Unit Price	Amount	
1. Land Reclamation							
1.1 With forest clearing	ha	1,300	460	598,000	470	611,000	1,209,000
1.2 Without forest clearing	"	800	319	255,200	295	236,000	491,200
1.3 Miscellaneous	L.S.			42,800		42,000	84,800
Total				896,000		889,000	1,785,000

Table 9.5 Procurement Cost of Construction Machinery and Equipment

Machinery and Equipment		Unit price* (₦)	Required Number		Procurement Cost	
			Owerri Project	Auchi Project	Owerri Project	Auchi Project
1. Bulldoser	13 ton - 15 ton	57,300	2	2	114,600	114,600
2. - " -	21 ton	72,300	8	7	578,400	506,100
3. - " -	21 ton w/rake	74,900	2	3	149,800	224,700
4. - " -	33 ton	84,300	2	2	168,600	168,600
5. Backhoe	0.3 m^3	36,800	3	3	110,400	110,400
6. - " -	0.6 m^3	50,300	2	2	100,600	100,600
7. Crawler loader	1.3 m^3	50,300	1	1	50,300	50,300
8. Motor grador	9 ton	35,800	2	2	71,600	71,600
9. Roadroller	8 - 10 ton	16,700	1	1	16,700	16,700
10. Dump truck	6 ton	17,700	12	10	212,400	177,000
11. Tractor shovel	0.6 m^3	5,600	2	2	11,200	11,200
12. Tractor crane	5 ton	37,400	1	1	37,400	37,400
13. Tamping roller	500 kg	12,200	2	1	24,400	12,200
14. Tamping rammer	80 kg	800	10	10	8,000	8,000
15. Concrete mixer	0.2 m^3	6,100	2	2	12,200	12,200
16. - " -	0.6 m^3	8,100	2	1	16,200	8,100
17. Ordinary truck	6 ton	11,600	10	10	116,000	116,000
18. Jeep		5,600	5	5	28,000	28,000
19. Water tanker	2 m^3	18,200	1	1	18,200	18,200
20. Fuel tanker	5 m^3	20,200	1	1	20,200	20,200
21. Grease car		37,400	1	1	37,400	37,400
22. Diesel generator	3.5 KVA	2,100	2	1	4,200	2,100
23. 100 mm sub. pump		1,700	1	1	1,700	1,700
Sub-total					1,908,500	1,853,300
24. Spare parts (20%)					381,500	376,700
Grand total					2,290,000	2,230,000

* Delivery price at site

Table 9.6 Construction Cost of Processing, Storage and Office Facilities, Owerri

Description	Unit	Quantity	Unit Cost (₦)	Amount (₦)
1. Project office	m^2	1,500	144	216,000
2. Garage	"	800	45	36,000
3. Training center	"	200	144	29,000
4. Weather station	"	25	45	1,000
5. Houses for senior staff	"	600	190	114,000
6. Dormitory	"	1,000	190	190,000
7. Warehouse	"	1,800	71	128,000
8. Generator house	"	450	339	153,000
9. Workshop	"	300	190	57,000
10. Motor pool	"	2,400	45	109,000
11. Rice mill buildings	"	6,000		1,174,000
i) Receiving, clearing & drying house	"	1,800	263	(473,000)
ii) Parboiling house	"	1,800	280	(504,000)
iii) Milling house	"	200	207	(41,000)
iv) Storage house	"	2,200	71	(156,000)
12. Rice mill/1	LS			2,102,000
13. Contingencies	"			1,911,000
Total				6,220,000

/1. Refer to Table 9.8

Table 9.7 Construction Cost of Processing, Storage and Office Facilities, Auchi

Description	Unit	Quantity	Unit Cost (₦)	Amount (₦)
1. Project office	m^2	1,500	144	216,000
2. Garage	"	800	45	36,000
3. Training center	"	200	144	29,000
4. Weather station	"	25	45	1,000
5. Houses for senior staff	"	600	190	114,000
6. Dormitory	"	1,000	190	190,000
7. Warehouse	"	1,800	71	128,000
8. Generator house	"	450	339	153,000
9. Workshop	"	300	191	57,000
10. Motor pool	"	2,200	45	100,000
11. Rice mill buildings	"	5,300		999,000
i) Receiving, clearing & drying house	"	1,800	263	(473,000)
ii) Parboiling house	"	1,200	280	(336,000)
iii) Milling house	"	200	207	(41,000)
iv) Storage house	"	2,100	71	(149,000)
12. Rice mill /1	LS			1,848,000
13. Contingencies	"			1,619,000
Total				5,490,000

/1. Refer to Table 9.9

Table 9.8 Cost of Rice Mill and Storage Facilities for Owerri Project

Item	Required Nos.	Amount (₦)
1) Receiving and drying equipment	3	588,000
- Receiving equipment: 3.5 t/hr		
- Drying equipment: 10 t/hr		
2) Parboiling equipment 1 t/hr	3	513,000
3) Milling equipment 1.5 t/hr	3	96,000
4) Storage equipment 1,000 t bin	5	600,000
5) Power supplying equipment 200 KVA	3	114,000
6) Spare parts (about 10% of the above)	L.S.	191,000
Total		2,102,000

Table 9.9 Cost of Rice Mill and Storage Facilities for Auchi Project

Item	Required Nos.	Amount (₦)
1) Receiving and drying equipment - Receiving equipment: 3 t/hr - Drying equipment: 10 t/hr	3	588,000
2) Parboiling equipment 0.6 t/hr	3	312,000
3) Milling equipment 1 t/hr	3	66,000
4) Storage equipment 1,000 t bin	5	600,000
5) Power supplying equipment 200 KVA	3	114,000
6) Spare parts (about 10% of the above)	L.S.	168,000
Total		1,848,000

Table 9.10 Initial Farm Investment

Item	Owerri Project (₦1000)	Auchi Project (₦1000)
1) Farm inputs		
Seed	43	59
Fertilizer		
- Compound	88	88
- Urea	62	62
Agro-chemicals		
- Fungicide	265	265
- Insecticide	35	35
- Herbicide	335	320
Sub-total	828	829
2) Farm machinery/1	1,733	1,371
3) Contingencies/2	1,209	1,070
Total	3,770	3,270

/1 The details of the farm machinery are given in Table 9.11 and 9.12.

/2 Contingencies include physical contingency and provisions for price escalation.

Table 9.11 Farm Machinery and Equipment of the Owerri Project Area

		Quantity (Nos.)	Unit Price (₦)	Amount (₦)
1) Tractor and combine				
- Wheel type tractors	60PS class	30	7,300	219,000
- Wheel type tractors	40PS class	40	5,900	236,000
- Crowler type tractors	60PS class	5	22,200	111,000
- Crowler type tractors	40PS class	5	13,900	69,500
- Self-propelled type combines	100PS class	20	27,200	544,000
2) Other equipment and attachment				
- Disc Plows	26" x 3	5	1,000	5,000
- Disc harrows	20" x 24	4	1,100	4,400
- Rotavaters	1.8 - 2.0 m	28	800	22,400
- Broad casters	350 kg	9	700	6,300
- Swath sprayer	400 ℓ	16	4,700	75,200
- Dusters	35 kg	6	900	5,400
- Puddling rakes	3.0 m	9	1,000	9,000
- Rear-mounted mowers	1.8 - 2.0 m	8	800	6,400
- Dump trailers	2-ton	25	1,700	42,500
- Trucks	6-ton	5	12,400	62,000
- Tool bar	3.0 m	10	40	400
- Float wheels		20 set	300	6,000
3) Spare parts		L.S.		283,500
4) Service tools and equipments		L.S.		25,000
Total				1,733,000

Table 9.12 Farm Machinery and Equipment of the Auchi Project Area

		Quantity (Nos.)	Unit Price (₦)	Amount (₦)
1) Tractor and combine				
- Wheel type tractors	60PS class	27	7,300	197,100
- Wheel type tractors	40PS class	27	5,900	159,300
- Crowler type tractors	60PS class	3	22,200	66,600
- Crowler type tractors	40PS class	3	13,900	41,700
- Self-propelled type combines	100PS class	16	27,200	435,200
2) Other equipment and attachment				
- Disc Plows	26" x 3	7	1,000	7,000
- Disk harrows	20" x 24	5	1,100	5,500
- Rotavaters	1.8 - 2.0 m	20	800	16,000
- Broad casters	350 kg	7	700	4,900
- Swath sprayer	400 ℓ	16	4,700	75,200
- Dusters	35 kg	5	900	4,500
- Puddling rakes	3.0 m	6	1,000	6,000
- Rear-mounted mowers	1.8 - 2.0 m	6	800	4,800
- Dump trailers	2-ton	20	1,700	34,000
- Truks	6-ton	5	12,400	62,000
- Tool bar	3.0 m	10	40	400
- Float wheels		15 set	300	4,500
3) Spare parts		L.S.		221,300
4) Service tools and equipments		L.S.		25,000
Total				1,371,000

Table 9.13 Project Cost for Owerri Project

(Unit: 1,000₦)

Item	Foreign currency	Local currency	Total
1. Civil works	5,680	6,970	12,650
2. Processing, storage, office facilities	2,980	3,240	6,220
3. Initial farm investment	2,390	1,380	3,770
Total	11,050	11,590	22,640

Table 9.14 Project Cost for Auchi Project

(Unit: 1,000₦)

Item	Foreign currency	Local currency	Total
1. Civil works	6,110	8,050	14,160
2. Processing and storage facilities	2,580	2,910	5,490
3. Initial farm investment	1,880	1,390	3,270
Total	10,570	12,350	22,920

Table 9.15 Annual Disbursement Schedule of Project Cost, Owerri Project

Item	Total Cost			1977			1978			1979			1980			1981			1982			1983		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
1. Civil works	5,680	6,970	12,650	231	27	258	2,828	382	3,210	812	1,828	2,640	855	2,148	3,003	465	1,237	1,702	489	1,348	1,837	-	-	-
2. Processing, storage office facilities	2,980	3,240	6,220	-	291	291	-	874	874	-	160	160	960	1,885	2,845	-	-	-	1,093	-	1,093	957	-	957
3. Initial farm investment	2,390	1,380	3,770	-	-	-	-	-	-	-	-	-	723	332	1,055	852	494	1,346	815	554	1,369	-	-	-
Total	11,050	11,590	22,640	231	318	549	2,828	1,256	4,084	812	1,988	2,800	2,538	4,365	6,903	1,317	1,731	3,048	2,397	1,902	4,299	957	-	957

Table 9.16 Annual Disbursement Schedule of Project Cost, Auchi Project

Item	Total Cost			1977			1978			1979			1980			1981			1982			1983		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
1. Civil works	6,110	8,050	14,160	270	39	309	2,868	570	3,438	1,074	2,516	3,590	755	1,857	2,612	557	1,483	2,040	586	1,585	2,171	-	-	-
2. Processing, storage office facilities	2,580	2,910	5,490	-	291	291	-	873	873	-	147	147	848	1,599	2,447	906	-	906	-	-	-	826	-	826
3. Initial farm investment	1,880	1,390	3,270	-	-	-	-	-	-	359	190	549	269	185	454	481	371	852	530	394	924	241	250	491
Total	10,570	12,350	22,920	270	330	600	2,868	1,443	4,311	1,433	2,853	4,286	1,872	3,641	5,513	1,944	1,854	3,798	1,116	1,979	3,095	1,067	250	1,317

Table 9.17 Annual Operation and Maintenance Cost

(Unit: ₦1,000)

Item	Owerri Project	Auchi Project
1. Irrigation & drainage facilities including road	100	100
2. Project office and related facilities	10	10
3. Personnel expenses and overhead		
i) Nigerian staff	48	48
ii) Foreign exports/1	200	150
Total	497	384

/1. Operation guidance by foreign exports will cover the first three years of operation.

10. MARKETING, PRICE PROSPECTS AND BENEFIT ESTIMATION

10.1 Market and Price Prospects

10.1.1 Market Prospects of Rice

In 1974, about 500,000 tons of rice including 6,000 tons of the imports was consumed in whole Nigeria, which means that per-capita consumption of rice is equivalent to only 7.0 kg. This low per-capita consumption seems not to represent the actual demand for rice in the country.
Current shifting of dietary preference from root crops to rice is significant in the country even in the low income group. Per-capita income has also increased significantly which accelerates further to raise the demand for rice. In this situation, present per-capita consumption would be too low compared with the potential demand. Existing potential demand for rice is reflected by the present high price which may be caused partly by the import restriction and partly by insufficient domestic production.

In this section, demand for rice in the future is forecasted for investigating the market prospect. The forecast is mado on the basis of the present demand though it does not represent potential demand. For the estimate it is assumed that the demand for rice will increase corresponding to per capita income increase and anticipated population growth as given below:

i) Population in the country is 75 million in 1976 and will increase by 2.5% per annum;

ii) Present per-capita consumption of rice is 7.0 kg and will increase by the rate of (income elasticity of demand) x (growth rate of per capita income);

iii) Income elasticity for rice is 0.6; and

iv) Growth rate of per capita income is 4.0%.

Result of the estimation are shown in Table 10.1
Total demand of rice is expected to attain 815,200 tons in 1985 and 1,320,000 tons in 1995. This estimate seems to be relatively low and conservative since the demand forecast is made on the basis of the present low per capita consumption of 7.0 kg instead of the higher potential demand in the country.

Table 10.1 Demand Forecast of Rice

Year	Per-Capita Consumption (kg)	Population (10^3)	Total-Demand (t)	Year	Per-Capita Consumption (kg)	Population (10^3)	Total-Demand (t)
1976	7.0	75,000	525,000	91	10.0	108,600	1,086,000
77	7.2	76,900	553,700	92	10.2	111,300	1,135,300
78	7.3	78,800	575,200	93	10.5	114,100	1,198,100
79	7.5	80,800	606,000	94	10.7	117,000	1,251,900
80	7.7	82,800	637,600	95	11.0	120,000	1,320,000
81	7.9	84,900	670,700	96	11.2	122,900	1,376,500
82	8.1	87,000	704,700	97	11.5	126,000	1,449,000
83	8.3	89,000	738,700	98	11.8	129,100	1,523,400
84	8.5	91,000	773,500	99	12.1	132,300	1,600,800
85	8.7	93,700	815,200	2000	12.4	135,700	1,682,700
86	8.9	96,000	854,400	01	12.7	139,000	1,765,300
87	9.1	98,400	895,400	02	13.0	142,500	1,852,500
88	9.3	100,900	938,400	03	13.3	146,100	1,943,100
89	9.5	103,400	982,300	04	13.6	149,700	2,035,900
90	9.8	106,000	1,038,800	05	13.9	153,500	2,133,700

Another demand forecast made by Federal Ministry of Agriculture and Natural Resources in 1974[1] indicates that the demand for rice is expected to reach 865,000 tons in 1985. Although the estimated figure is slightly higher than our estimate, it shows that our estimate is within a reasonable range.

In order to meet our estimated demand, anticipated increase in rice production would be around 5% per annum. Domestic production of rice is expected to grow at an annual rate of 14% in the third National Development Plan for satisfying the domestic demand, but, the expected growth rate seems to be too much ambitious in due consideration of the past trend and even 5% could not be attainable without intensive support of the Government for the implementation of rice development projects.

Incremental rice production generated by the Owerri Project and Auchi Project is expected to reach 23,000 tons at the full development stage in 1989. Taking into consideration of the existing potential demand for rice and its future increase the increased amount will be readily absorbed into the economy with no significant impact on domestic price.

10.1.2 Price Prospects

1) Price of Food Crops

Domestic retail prices or local market prices for food crops have been collected in the project area. On the basis of the average of the current local market prices, farm gate price is estimated for financial analysis by deducting market overhead cost, transportation cost and assembly cost.

Domestic price of rice has increased considerably since 1973. The price differs widely depending on the variety, location of the market and season. According to the collected information, present local market price of milled rice is around 700 - 1,000 ₦/t, which is considerably high compared with the current international market price of 170 - 200/t./2 However, in due consideration of the strong demand caused by the expected population increase and increase in per capita income, it is reasonably assumed that the present demand supply condition for rice will not change substantially in the domestic market and its relatively high price will continue in the future. Domestic inflationary trend for food crops is also expected to support the current high price. In this context, mill gate price of rice is estimated conservatively at 560 ₦/t for the financial analysis on the basis of the current market price. Farm gate price of paddy is also estimated at 308 ₦/t in view of the current market price and assumed milling efficiency.

Financial farm gate prices of other food crops are also estimated on the basis of the local market price, which are shown in Table 10.2.

Farm gate prices to be used for economic analysis are estimated principally on the basis of the international market price. The economic prices for tradable goods such as rice and maize are estimated by using IBRD forecast price around 1985 taking into account the transportation cost and marketing cost. For the conversion from US$ to ₦, shadow exchange rate of ₦ = US$1.27 is applied instead of the official rate. The economic prices for non-tradable goods such as yam, cassava and cocoyam are estimated based on the crop production cost plus assumed mark up rate. Results of the estimate are listed in Table 10.2 and the estimated figures are applied for economic analysis.

2) Price of Farm Inputs

As in the case of the estimate for the price of the food crops, financial prices of farm inputs are estimated on the basis of the current market price, while the economic prices are estimated by using international market prices taking into account the transportation cost, marketing cost, etc. Results of the estimate are shown in Table 10.3.

/1 "Agriculture Development in Nigeria 1973-1985" Federal Ministry of Agriculture and Natural Resources, Joint Planning Committee, Lagos 1974.

/2 Price of rice FOB Bangkok around 1976.

10.2 Estimate of Irrigation Benefit

Irrigation benefit to be expected from the project is estimated by calculating net incremental value. The net incremental value is defined as the difference of the total returns to be produced in the project area between under future without-project condition and future with-project condition. For estimating the benefit, estimated economic prices are applied both for inputs and outputs including shadow wage rate of farm labor which is valued at 60% of the current rate. Calculation for the estimate of the irrigation benefit is conducted in the following step.

10.2.1 Estimate of Net Income per Crop

On the basis of the estimated price and volume for inputs and outputs, net income of each crop is firstly calculated both on future without-project condition and future with-project condition. In the estimation, it is assumed that present condition of agricultural production will not change considerably and remain at the present level without introducing substantial investment in agricultural infrastructure and/or institutions. Results of the calculation are presented in Table 10.10 and Table 10.11 for the Owerri Project and the Auchi Project respectively. Retailed calculation for the estimate of the net income is shown in Table 10.12 to Table 10.14.

10.2.2 Estimate of Net Incremental Value

Multiplying the net income per crop estimated above by the cultivated area for each crop, total returns of agricultural production in the project area are calculated both for without-project condition and with-project condition. The irrigation benefit is estimated as the difference of two total returns. As shown in Table 10.15 to Table 10.16. The estimated annual irrigation benefits are ₦2.927 million and ₦1.925 million for the Owrri Project and the Auchi Project respectively.

Build-up period of the irrigation project is assumed at 5 years for the esta e farm and 7 years for the small holder both for the Owerri Project and Auchi Project after completion of the irrigation facilities during which the benefit will increase linearly. Based on this assumption, the expected annual irrigation benefits are calculated and presented in Table 10.17.

Table 10.2 Economic and Financial Farm Gate Price of Food Crops

(₦/t)

	Financial Price/1	Economic Price /2
Yam	232	175
Cassava	63	50
Maize	184	164
Cocoyam	136	102
Rice (Paddy)/3	560(308)	394(251)

/1 Financial farm gate price is estimated on the basis of the recent domestic retail price collected in the project areas taking into account the market overhead cost, transportation and assembly cost.

/2 Economic farm gate price for internationally traded crops is estimated on the basis of forecasted international price prepared by IBRD taking into account the transportation and marketing costs. The price for non-traded crops such as yam, cassava and cocoyam is estimated by assumed crop profit calculations.

/3 Price of rice is mill gate price while price of paddy is farm gate price.

Table 10.3 Economic and Financial Price of Farm Inputs

(₦/t)

	Economic/1	Financial/2
Seed		
Paddy	251	308
Yam	175	290
Cassava	-	-
Maize	164	230
Cocoyam	102	170
Fertilizer		
Urea	230	230
Compound	166	210
Chemicals		
Fungicide	3.5₦/kg	4.2₦/kg
Insecticide	4.5₦/kg	5.6₦/ℓ
Herbicide	1.9₦/kg(4.0₦/ℓ)	2.4₦/kg(5.0₦/ℓ)
Farm Labor	1.2₦/Manday	2.0₦/Manday

/1 Estimated basically on the basis of the international market price forecasted by IBRD.

/2 Estimated on the basis of the current market price.

Table 10.4 Local Market Price of Rice, Bendel State

(Kobo/kg)

1973		1974		1975		1976	
Jan.	29	Jan.	14	Jan.	32	Jan.	92
" Feb.	29	" Feb.	20	" Feb.	56	" Feb.	92
" Mar.	29	" Mar.	16	" Mar.	56	" Mar.	92
" Apr.	25	" Apr.	34	" Apr.	58	" Apr.	104
" May	25	" May	36	" May	58		
" June	19	" June	32	" June	70		
" July	19	" July	26	" July	70		
" Aug.	16	" Aug.	26	" Aug.	70		
" Sept.	13	" Sept.	26	" Sept.	72		
" Oct.	13	" Oct.	26	" Oct.	72		
" Nov.	12	" Nov.	26	" Nov.	72		
" Dec.	14	" Dec.	26	" Dec.	72		
Average of the year	20.3		25.7		63.2		(95)

Source : Regional Agricultural Office in Auchi, Bendel State

Table 10.5 Local Market Price of Rice, Imo State

(Kobo/kg)

1974		1975		1976	
Average	55	April	65	Jan.	76
		May	64	" Feb.	74
		June	65	" March	-
				" April	67
				" May	75
				" June	83
		Average of 1975	64	Average of 1976	75

Source : Abstract of Statistics, Imo State, June '76

Table 10.6 Recent Local Price of Rice (Mill Gate Price)

		SML	IR-5	TOS
1976	Jan.	75	65	65
	Feb.	80	66	66
	March	80	66	66
	April	80	66	66
	May	80	66	66
	June	80.5	66.5	66.5
	July	80.5	66.5	66.5
	Aug.	85	70	70
	Sept.	85	70	70
	Oct.	75	65	70
	Nov.	75	65	65
	Dec.	75	65	65
Average		79	66	70

(70)

Data Source : Adani Rice Mill

Table 10.7 Prices of Other Food Crops

(Kobo/kg)

	Imo State (Owerri)		Bendel State (Auchi)		
	1975	1976	1975	1976	Average
Yam	26	24/1	24	43/2	29
Cassava	-	-	8	11/2	9
Garri	17	18/1	-	-	17
Cocoyam	-	-	-	17/3	17
Maize	22	26/1	20	24/2	23
Beans	35	35/1	-	-	35

Note: /1 Average of Jan. to June

/2 Average of Jan. to April

/3 Average of Feb. to March

Data Source:

- Abstract of Statistics, Imo State, June '76
- Regional Agricultural Office in Auchi, Bendel State

Table 10.8 Economic Price of Paddy (Import Substitution)

International market price /1	US$359
Shipping cost incl. insurance	US$60
(CIF Port Harcourt)	US$419
Using shadow rate 1₦ = 1.27US$	₦329.9
Unloading, port charge and import margin	₦40
(CIF Price Warehouse Port Harcourt)	₦369.9
Storage and insurance costs	₦4
(Ex-Warehouse Price)	₦373.9
Transport cost from Port Harcourt to the Project area	₦20
Selling price of paddy (milling efficiency 0.70)	₦275.7
Milling charge	-₦24
Farm gate price	₦251.7
	(≒₦251)

/1 IBRD projected price for 1985 at 1976 constant price

Table 10.9 Economic Price of Maize (Import Substitution)

International market price /1	US$115
Shipping cost incl. insurance	US$45
(CIF Port Harcourt)	US$160
Using shadow rate 1₦ = 1.27US$	₦125.9
Unloading, port charge and import margin	₦14
(CIF Price Warehouse Port Harcourt)	₦139.9
Storage and insurance costs	₦4
(Ex-Warehouse Price)	₦143.9
Transport cost from Port Harcourt to the Project area	₦20
Farm gate price in the project area	₦163.9
	(≒₦164)

/1 IBRD projected price for 1985 at 1976 constant price

Table 10.10 Net Income per Ha for the Owerri Project

(₦/ha)

Kind of Crops	Future Without-Project			Future With-Project		
	Gross Returns /1	Production Costs /2	Net Income	Gross Returns /1	Production Costs /3	Net Income
Rice /4						
Direct Sowing	-	-	-	1,241.1	494.2	746.9
Transplanting	-	-	-	1,379		
Yam	1,225	673	552		575.0	804
Cassava	375	144	231	-	-	-
Maize	98	26	72	-	-	-
Cocoyam	316	142	174	-	-	-

/1 Economic price of the crop (₦/t) multiplied by crop production per ha (t/ha).

/2 Including the cost mainly for seed, and labor.

/3 Including the cost for farm inputs and operation and maintenance costs for farm machineries, rice mill and storage facilities.

/4 The net income for rice is calculated using mill gate price of rice.

Table 10.11 Net Income per Ha for the Auchi Project

(₦/ha)

Kind of Crops	Future Without-Project			Future With-Project		
	Gross Returns /1	Production Costs /2	Net Income	Gross Returns /1	Production Costs /3	Net Income
Rice /4						
Direct sowing	301	81	220	1,241.1	506.6	734.5
Transplanting	-	-	-	1,379	595.1	783.9
Yam	1,278	673	605	-	-	-
Cassava	375	144	231	-	-	-
Maize	180	50	130	-	-	-

/1 Economic price of the crop (₦/t) multiplied by crop production per ha (t/ha)

/2 Including the cost mainly for seed and labor.

/3 Including the cost for farm inputs and operation and maintenance costs for farm machineries, rice mill and storage facilities.

/4 The net income for rice on future without-project condition is calculated using farm gete price of paddy, while that of future with-project condition is calculated using mill gate price of rice.

Table 10.12 Net Income per Crop per Ha (Without-Project)

(1) Owerri Project Area

	Yam	Cassava	Maize	Cocoyam
Gross Income				
Production (t/ha)	7.0	7.5	0.6	3.1
Price (₦/t)	175	50	164	102
Gross Income (₦)	1,225	375	98.4	316.2
Production Cost				
Seed	473	-	2	102
Fertilizer & Chemicals	-	-	-	-
Farm Labor	200	144	24	40
Total Production Cost (₦)	673	144	26	142
Net Income (₦)	552	231	72.4 (±72)	174.2 (±174)

(2) Auchi Project Area

	Rice	Yam	Cassava	Maize
Gross Income				
Production (t/ha)	1.2	7.3	7.5	1.1
Price (₦/t)	251	175	50	164
Gross Income (₦)	301.2	1,277.5	375	180.4
Production Cost				
Seed	15	473	-	2
Fertilizer & Chemicals	-	-	-	-
Farm Labor	66	200	144	48
Total Production Cost (₦)	81	673	144	50
Net Income (₦)	220.2 (±220)	604.5 (±605)	231	130.4 (±130)

Table 10.13 Net Income of Paddy Production per Ha (with-Project)

Direct Sowing

(Unit: ₦)

Item		Owerri Project	Auchi Project
Gross Income			
Production (paddy)		4.5 t	4.5 t
Production (milled rice)/1		3.15 t	3.15 t
Price of Rice (at mill gate)		394/t	394/t
Gross Income		1,241.1	1,241.1
Production Cost			
Seed	100 kg x ₦0.251/kg	25.1	25.1
Fertilizer			
Compound	200 kg x ₦0.166/kg	33.2	33.2
Urea	129 kg x ₦0.23/kg	29.7	29.7
Agro-chemicals			
Fungicide	30 kg x ₦3.5/kg	105	105
Insecticide	3 ℓ x ₦4.5/ℓ	13.5	13.5
Herbicide	30 ℓ x ₦4.0/ℓ	120	120
O & M Cost of Farm Machineries		86.9	94.6
Personnel Cost		37.1	36.1
O & M Cost of Rice Mill		43.7	49.4
Total Cost		494.2	506.6
Net Income		746.9	734.5

/1 Milling efficiency is assumed to be 70%

Table 10.14 Net Income of Paddy Production per Ha (with -Project)

Transplanting

(Unit: ₦)

Item		Owerri Project	Auchi Project
Gross Income			
Production (paddy)		5.0 t	5.0 t
Production (milled rice)/1		3.5 t	3.5 t
Price of Rice (at mill gate)		394/t	394/t
Gross Income		1,379	1,379
Production Cost			
Seed	100 kg x ₦0.251/kg	8.7	8.7
Fertilizer			
Compound	200 kg x ₦0.166/kg	33.2	33.2
Urea	129 kg x ₦0.23/kg	29.7	29.7
Agro-chemicals			
Fungicide	30 kg x ₦3.5/kg	105	105
Insecticide	3 ℓ x ₦4.5/ℓ	13.5	13.5
Herbicide	70 kg x ₦1.9/ℓ	133	133
O & M Cost of Farm Machineries		74.6	88.2
Per sonnel Cost/2		128.8	129
O & M Cost of Rice Mill		48.5	54.8
Total Cost		575.0	595.1
Net Income		804.0	783.9

/1 Milling efficiency is assumed to be 70%

/2 Includes the cost for family laborers

Table 10.15 Estimate of Irrigation Benefit (Owerri Project)

Kind of Crops	With-Project			Without-Project			(3)-(6)
	(1) Cult. Area (ha)	(2) Net Income (₦/ha)	(3) Total Return (₦)	(4) Cult. Area (ha)	(5) Net Income (₦/ha)	(6) Total Returns (₦)	Net Incremental Income (₦)
Paddy							
Direct sowing	2,030	746.9	1,516,210	-	-	-	1,516,210
Transplanting	2,170	804	1,744,680	-	-	-	1,744,680
Yam	-	-	-	240	552	132,480	-132,480
Cassava	-	-	-	720	231	166,320	-166,320
Maize	-	-	-	320	72	23,040	- 23,040
Cocoyam	-	-	-	70	174	12,180	- 12,180
Total	4,200		3,260,890	1,350		334,020	2,926,870 (≒2,927,000)

Table 10.16 Estimate of Irrigation Benefit (Auchi Project)

Kind of Crops	With-Project			Without-Project			(3)-(6)
	(1) Cult. Area (ha)	(2) Net Income (₦/ha)	(3) Total Return (₦)	(4) Cult. Area (ha)	(5) Net Income (₦/ha)	(6) Total Returns (₦)	Net Incremental Income (₦)
Paddy							
Direct sowing	2,200	734.5	1,615,900	100	220	22,000	1,615,900
Transplanting	500	783.9	391,950	-	-	-	391,950
Yam	-	-	-	40	605	24,200	-24,200
Cassava	-	-	-	120	231	27,720	-27,720
Maize	-	-	-	70	130	9,100	- 9,100
Total	2,700		2,007,850	330		83,020	1,924,830 (≒1,925,000)

11. PROJECT EVALUATION

11.1 Economic Evaluation

11.1.1 General

Economic feasibility of the two projects is analized by calculating internal rate of return on the basis of the estimated economic costs for the implementation of the project and economic benefits. Sensitivity analysis is also made with respect to change in the construction cost, productivity of rice and price of rice for checking the sensitivity of the project feasibility.

For the economic analysis the project life is assumed at 30 years after completion of the project facilities from 1983 - 2012.

11.1.2 Economic Project Costs and Benefits

1) Economic project costs

In order to estimate the economic construction cost, adjustments are made to the project costs (or financial project cost) estimated in Chapter 9 in the following manner:

a) Cost for the construction machineries is valued by their depreciation cost instead of the procurement cost;

b) Compensation costs for land acquisition are excluded;

c) Price contingency for the construction cost is excluded;

d) Shadow exchange rate of ₦ = US$1.27 is applied instead of the official rate for conversions from US$ to ₦;

e) Wage of the unskilled labor is shadowed at 60% of the current wage rate; and

f) Import taxes on the construction machineries are excluded.

Through these adjustments, the economic construction costs for the Owerri Project and the Auchi Project are estimated as shown below.

Economic cost of the Owerri Project

Economic construction cost of the Owerri Project is estimated at ₦14.37 million consisting of ₦8.556 million of foreign currency portion and ₦5.814 million of local currency portion. Details of the cost estimate are presented in Table 11.1 and its annual disbursement schedule is shown in Table 11.2.

Annual operation, maintenance and replacement costs for the Owerri Project are estimated at ₦497,000 at its full development stage in 1983.

Economic cost of the Auchi Project

Economic construction cost of the Auchi Project is estimated at ₦14.56 million comprising of ₦8.164 million of foreign currency portion and ₦6.396 million of local currency portion. Details of the cost estimate are shown in Table 11.3 and its annual disbursement schedule is given in Table 11.4.

Annual operation, maintenance and replacement costs are estimated at ₦465,000 at the full development stage of the project in 1983.

2) Project benefits

As explained in the preceding chapter (Chapter 10), irrigation benefits are estimated at ₦2,927,000 and ₦1,925,000 for the Owerri Project and the Auchi Project respectively at the full development stage of the projects.

11.1.3 IRR of the Projects

On the basis of the economic construction costs and benefits estimated above, economic internal rate of return of the two projects are calculated for the project life of 30 years after completion of the project construction works.

The estimated IRRs are 12.0% for the Owerri Project and 7.1% for the Auchi Project, which indicate that the Owerri Project is economically feasible while the Auchi Project possesses relatively low economic viability.

Sensitivity test

For the analysis of the project sensitivity, sensitivity test is made with respect to the project cost, productivity of rice and price of rice. The results of the sensitivity analysis show that the economy of the project is quite sensitive to the change in productivity of rice and price of rice but not so sensitive to increase in the project cost. Details of the analysis are shown in Table 11.5 and Table 11.6 for the Owerri Project and the Auchi Project respectively.

11.2 Financial Evaluation

11.2.1 General

Financial evaluation of the two projects is made both from the view point of farmers to be involved in the projects and of project implementing organizations.

Typical farm budget is firstly analized to assess whether the project will have sufficient incentive to the farmers in the project area with enough income increase and to assess the plausible amount of the charges for irrigation water and machinery services to be provided by the estate farm.

Profitability of the estate farm is assessed on the basis of the expected revenue and the operation cost. Repayment capacity of the project is also evaluated under the assumed financial conditions.

11.2.2 Farm Budget Analysis

For evaluating the feasibility of the project from farmer's economy, farm budget both in the Owerri Project area and the Auchi Project area is investigated.

As explained in Chapter 4, Present Agricultural Condition, gross farm incomes for typical farmer holding 1.0 ha in the Owerri Project area and 1.5 ha in the Auchi Project area are ₦883 and ₦1,021 respectively. The net incomes after deducting crops production cost and living expenses from the gross income are only ₦14 and ₦92 for the typical farmer in the Owerri Project area and the Auchi Project area.

Upon completion of the project, 1.2 ha of the irrigated land will be allocated to the farmers. Through the introduction of the intensive agricultural production, farm income from selling food crops is expected to increase considerably. Instead, income gaining from tree crops will decrease since most of the available family labor will be used for paddy cultivation and the land for tree crops will be reduced.

In the Owerri Project area, the gross income will reach ₦3,742 at the full development stage of the project, which means about 4 times increase from that of the present. The gross income will be about ₦3,166 in the Auchi Project area, which is slightly lower than that of the Owerri Project area due to the less intensive agricultural production.

As for expenses, farming expenses will increase considerably in proportion to the increase in farm input dosage. Living expenses will also increase for the improvement of their Living standard. Total expenses will be ₦2,085 and ₦2,016 for the typical farmer in the Owerri Project and the Auchi Project areas.

Annual net reserve or capacity to pay which is defined as the difference between the gross income and the total expenses will grow to ₦1,657 in the Owerri Project and ₦1,150 in the Auchi Project. The increased net reserves indicate sufficient capacity to pay for charges on the irrigation water and machinery services. (Details of the farm budgets on future with-project condition are presented in Table 11.7 to Table 11.8).

11.2.3 Profitability of the Estate Farm and Repayment Capacity

Profitability of the estate farm is assessed on the basis of the expected revenue and the operation cost. Repayment capacity of the project finance is also evaluated on the assumed financial conditions.

1) Project revenue

The revenue for the estate farm consists of income from selling rice and charges on irrigation water and machinery services to be collected from farmers in the small holder area.

With respect to income from selling rice, it is assumed that all the products both in the estate farm and small holder area will be sold through the Processing and Marketting Department of the estate farm except home consumption of farmers. Selling price of milled rice is set at ₦560/t for the calculation of the revenue.

The irrigation water charge and machinery services charge to be imposed on the farmers are set in such a manner that the charges shall cover the operation and maintenance cost of the irrigation facilities, farm machineries and rice mills. The estimated charges are ₦210/ha (or about ₦500/farm family) and ₦270/ha (or ₦540/farm family) for the Owerri Project area and the Auchi Project area respectively. The proposed charges amount to 30% and 47% of the net reserve for the typical farmer in the Owerri Project area and the Auchi Project area.

The estimated annual revenue is ₦8.11 million and ₦4.95 million at the full development stage for the Owerri Project and the Auchi Project respectively.

2) Operation cost

Operation cost for the estate farm comprises such rice production costs as farm input costs, operation and maintenance costs of farm machinery and rice mill and depreciation cost for all equipment and building facilities. Purchasing cost of paddy at the rate of ₦308/t from farmers in the small holder area is also included in the operation cost.

The estimated operation costs of the estate farm are ₦5.40 million for the Owerri Project and ₦2.80 million for the Auchi Project.

3) Profit ratio

Net profit is calculated by deducting the project operation cost from the revenue. The estimated net profit is N2.71 million and N2.15 million for the Owerri Project and the Auchi Project respectively.

The estimated profit ratio is 11.9% to the project cost or total investment amount for the Owerri Project, while the profit ratio is 9.4% for the Auchi Project. Taking into account the low profitability during the build-up period and long gestation period of the projects, both projects are financially less viable.

4) Repayment capacity

As explained in the preceding chapter, build-up period of the irrigation project is relatively long and it takes long time to get the target profit after the completion of the project. It is, therefore, recommended to acquire soft loan as much as possible for making the project finance repayable.

In due consideration of the characteristics of the projects cash flow tables are prepared for the estate farm of the Owerri Project and the Auchi Project assuming that the following soft loan is available for the implementation:

a) The investment costs for the infrastructure including irrigation facilities and roads are financed by Federal Government or governmental institutions with free of interest and its repayment period of about 30 years including 10 years of grace period; and

b) The farm investment costs including farm machineries and equipment, rice mills, storage facilities and initial farm investment are financed by relatively soft loan such as NAB loan or other institutional credit with 4% interest rate and its repayment period of 15 years including 7 years of grace period.

The results are presented in Table 11.11 and Table 11.12. The calculated cash flow tables indicate that the project finance for both projects will be repayable if relatively soft loan is available for the implementation.

11.3 Socio-Economic Impact of the Project

In addition to the irrigation benefits which are evaluated in the preceding chapter of Economic Evaluation, favourable socio-economic impacts are expected to be derived from the implementation of the project.

Creation of employment opportunity will be one of the valuable contribution to the regional economy from the stage of the construction to the operation. During the construction of the irrigation facilities, considerable number of laborers will be employed at the project site. In the operation stage, about 321 permanent staffs and labores and 24,600 mandays of seasonal laborers will be employed for the Owerri Project, while about 248 permanent staffs and laborers and 35,000 mandays of seasonal laborers will be employed for the Auchi Project. Increase in employment opportunity is also expected on farm by the introduction of intensive crop cultivation. Since there exist considerable unemployment and under-employment on farm, increased job opportunity will no doubt provide benefit for solving the unemployment problem in the region. Additional income to be gained from the increased labor opportunity will further contribute to the national economy by increasing the aggregate consumption.

Transfer of knowledge and demonstration effect are another impacts on the economy. The implementation of the project will provide good opportunity to the local staff for gaining the experience in various work fields and will improve their skills and technics. The project staffs, extension workers and farmers in the project area will be trained intensively for acquiring the know-how and technics of the irrigation farming together with the operation and maintenance of the farm machineries and equipment. Transfer of the knowledge for operation and management of the project are also expected through the project implementation. Since the project is the first intensive irrigated paddy cultivation project with mechanized farming in each state, considerable demonstration effects will be provided to the region, which will facilitate the agricultural development in the region.

Increased agricultural production with the irrigation project will give effects to solve the food shortage in the country and will also increase farm income in the project areas, since the project aims to develops not only the estate farm but also the small holder in the area. As the farm income is relatively lower compared with the income of urban people, the increased farm income of the small holder will not only contribute to enhance the economic activity in the region through its multiple effects on other sectors of the economy but also contribute to even income distribution considerably.

Living conditions including health and sanitary conditions will be improved. Irrigation water will be used for convenient water source for home consumption of the farmers in the region, who are now getting their drinking water from the distant stream. Although it is feared that the application of the agricultural

chemicals will damage the environment in the region, the effect is considered to be negligible in view of the scale of the project and present environmental situation in the region. Instead, faborable effect for improvement health is expected to be derived from the chemical dosage by diminishing flies and mosquitoes.

All these effects mentioned above will contribute to promote the national policy of the third development plan which includes even distribution of income, reduction of unemployment and increase in the food supply. Socio-economic stability is also expected to be facilitated in the region through these effects.

Table 11.1 Economic Construction Cost of the Owerri Project

(10^3 ₦)

Cost Item	Foreign Currency	Local Currency	Total
Civil Works	3,560	3,790	7,350
Rice Mill, Storage Facilities and Office Facilities	2,746	2,024	4,770
Initial Farm Investment	2,250	-	2,250
Total	8,556	5,814	14,370

Table 11.3 Economic Construction Cost of the Auchi Project

(10^3 ₦)

Cost Item	Foreign Currency	Local Currency	Total
Civil Works	3,970	4,530	8,500
Rice Mill, Storage Facilities and Office Facilities	2,414	1,866	4,280
Initial Farm Investment	1,780	-	1,780
Total	8,164	6,396	14,560

Table 11.2 Annual Disbursement Cost of Economic Construction Cost (Owerri Project)

Item	Total Cost	1977	1978	1979	1980	1981	1982	1983
Civil works								
1) Construction works	5,169	7	259	1,568	1,756	789	790	-
2) Engineering services, & administration	1,525	299	306	317	250	180	173	-
3) Physical contingency	656	-	34	200	224	99	99	-
Sub-Total	7,350	306	599	2,085	2,230	1,068	1,062	-
Processing, storage, officee facilities								
1) Processing facilities	3,554	-	-	-	1,866	-	927	761
2) Workshop & storage facilities	147	-	147	-	-	-	-	-
3) Office and related facilities	678	203	386	89	-	-	-	-
4) Physical contingency	391	30	80	13	184	-	46	38
Sub-Total	4,770	233	613	102	2,050	-	973	799
Initial farm investment								
1) Agricultural machinery	2,142	-	-	-	691	764	687	-
2) Farm inputs	-	-	-	-	-	-	-	-
3) Physical contingency	107	-	-	-	36	38	34	-
Sub-Total	2,250	-	-	-	727	802	721	-
Grand Total	14,370	539	1,212	2,187	5,007	1,870	2,756	799

Table 11.4 Annual Disbursement of Economic Construction Cost (Auchi Project)

Item	Total Cost	1977	1978	1979	1980	1981	1982	1983
Civil works								
1) Construction works	6,032	16	368	2,202	1,468	989	989	-
2) Engineering services, & administration	1,680	346	388	319	269	247	111	-
3) Physical contingency	788	5	50	286	191	128	128	-
Sub-Total	8,500	367	806	2,807	1,928	1,364	1,228	-
Processing, storage, office facilities								
1) Processing facilities	3,099	-	0	-	1,621	821	-	657
2) Workshop & storage facilities	147	-	147	-	-	-	-	-
3) Office and related facilities	670	202	388	80	-	-	-	-
4) Physical contingency	364	33	80	12	165	41	-	33
Sub-Total	4,280	235	615	92	1,786	862	-	690
Initial farm investment								
1) Agricultural machinery	1,694	-	-	369	258	431	447	189
2) Farm inputs	-	-	-	-	-	-	-	-
3) Physical contingency	86	-	-	18	13	22	23	10
Sub-Total	1,780	-	-	387	271	453	470	199
Grand Total	14,560	602	1,421	3,286	3,985	2,679	1,698	889

Table 11.5 Sensitivity Analysis of the Owerri Project

	Project Cost	Productivity of Rice	Price of Rice	IRR (%)
1)	0	0	0	12.0
2)	+5%	0	0	11.3
3)	+10%	0	0	10.7
4)	0	-10%	0	9.4
5)	0	-20%	0	6.0
6)	0	0	-10%	9.4
7)	0	0	-20%	6.0
8)	+5%	-10%	-10%	7.2

Table 11.6 Sensitivity Analysis of the Auchi Project

	Project Cost	Productivity of Rice	Price of Rice	IRR (%)
1)	0	0	0	7.1
2)	+5%	0	0	6.6
3)	+10%	0	0	6.1
4)	0	-10%	0	4.7
5)	0	0	-10%	4.7

Table 11.7 Typical Farm Budget in the Owerri Project Area (Future With-Project)

	Cult. Area (ha)	Unit Yield (t/ha)	Total Yield (t)	Unit Price (₦/t)	Total Value (₦)
Average Farm Size		(1.2 ha)			
I. Gross Income					
1. Food crops					
Wet season paddy	1.2	5.0	6.0	308	1,848
Dry season paddy	1.2	5.0	6.0	308	1,848
(Sub-total)					(3,696)
2. Tree crops and others					46
Total Gross Income					3,742

	Area (ha)	Unit Amount (kg/ha)	Total Amount (kg)	Unit Price (₦/kg)	Total Cost (₦)
II. Gross Outgo					
1. Farming expenses					
Seed	2.4	35	84	0.31	26.0
Fertilizer					
Urea	2.4	129	309.6	0.23	71.2
Compound	2.4	200	480	0.21	100.8
Chemicals					
Insecticide	2.4	3 ℓ/ha	7.2 ℓ	5.6 ₦/ℓ	40.3
Fungicide	2.4	30	72	4.2	302.4
Herbicide	2.4	70	168	2.4	403.2
(Sub-total)					(943.9)
2. Living expenses					
Food consumption/1					781
Other living expenses					360
(Sub-total)					(1,141)
Total Outgo					2,084.9
III. Net Reserve					1,657.1

/1 Includes the value of food crops which are produced by farmers themselves.

Table 11.8 Typical Farm Budget in the Auchi Project Area (Future With-Project)

	Cult. Area (ha)	Unit Yield (t/ha)	Total Yield (t)	Unit Price (₦/t)	Total Value (₦)
Average Farm Size		(1.2 ha)			
I. Gross Income					
1. Food crops					
Wet season paddy	1.2	5.0	6.0	308	1,848
Dry season paddy	0.8	5.0	4.0	308	1,232
(Sub-total)					(3,080)
2. Tree crops and others					86
Total Gross Income					3,166

	Area (ha)	Unit Amount (kg/ha)	Total Amount (kg)	Unit Price (₦/kg)	Total Cost (₦)
II. Gross Outgo					
1. Farming expenses					
Seed	2.0	35	70	0.31	21.7
Fertilizer					
Urea	2.0	129	258	0.23	59.3
Compound	2.0	200	400	0.21	84
Chemicals					
Insecticide	2.0	3 ℓ/ha	6 ℓ	5.6 ₦/ℓ	33.6
Fungicide	2.0	30	60	4.2	252
Herbicide	2.0	70	140	2.4	336
(Sub-total)					(786.6)
2. Living expenses					
Food consumption/1					841
Other living expenses					388
(Sub-total)					(1,229)
Total Outgo					2,015.6
III. Net Reserve					1,150.4

/1 Includes the value of food crops which are produced by farmers themselves.

Table 11.9 Project Revenue and Cost (Owerri Project)

Item		Amount (₦1,000)
I)	Project Revenue	
	1) Sales of rice 13,670 t/1 x ₦560/t	7,655
	2) Machinery & water charge 2,170 ha x ₦210/ha/2	456
	Total	8,111
II)	Operation Cost	
	1) Production cost	
	- Farm inputs 2,030 ha x ₦395.3/ha	802
	- Farm machinery cost	523
	- Rice mill & storage	205
	- Depreciation cost /3	375
	Sub-total	1,905
	2) O & M cost /4 4,200 ha x ₦70.8	297
	3) Purchasing cost of paddy from farmer (10,850 - 460)t x ₦308/t	3,200
	Total	5,402
III)	Net Profit	2,709

/1 Rice production (13,990 t) - Self consumption of farmers (320 t) = 13,670 t

/2

O & M cost for irrigation	:	₦70.8/ha
O & M cost for farm machinery	:	₦83.4/ha
O & M cost for rice mill & storage facilities	:	₦51.3/ha
Total		₦205.5/ha ≒ ₦210/ha

/3 Includes the depreciation cost for the farm machineries, rice mill and building facilities.

/4 Inclues OM cost for irrigation facilities and project offices.

Table 11.10 Project Revenue and Cost (Auchi Project)

Item		Amount (₦1,000)
I) Project Revenue		
1) Sales of rice	8,590 t/1 x ₦560/t	4,810
2) Machinery & water charge	500 ha x ₦270/ha/2	135
Total		4,945
II) Operation Cost		
1) Production cost		
- Farm inputs	2,200 ha x ₦395.3/ha	870
- Farm machinery cost		417
- Rice mill & storage		147
- Depreciation cost /3		318
Sub-total		1,752
2) O & M cost /4	2,700 ha x ₦116.7	315
3) Purchasing cost of paddy from farmer	(2,500 - 130)t x ₦308/t	730
Total		2,797
III) Net Profit		2,148

/1 Rice production (8,680 t) - Self consumption of farmers (90 t) = 8,590 t

/2 O & M cost for irrigation : ₦116.7/ha
O & M cost for farm machinery : ₦ 97.4/ha
O & M cost for rice mill & storage facilities : ₦59.3/ha
Total ₦273.4/ha ≒ ₦270/ha

/3 Includes the depreciation cost for the farm machineries, rice mill and building facilities.

/4 Includes OM cost for irrigation facilities and project offices.

Table 11.11 Cash Flow Statement of the Owerri Project

(Unit: ₦1,000)

Year	Year in Order	Cash Inflow: Sales of Rice /1	Machinery Charge & Water Charge	Loan: Soft Loan /2	Loan: State or NAB /3	Total Inflow	Cash Outflow: Project Cost: Irrigation Facilities	Farm Machineries Rice Mill & Storage Facilities	Production Cost	O&M Cost	Loan Repayment: Repayment: Soft Loan /2	Repayment: State or NAB Loan /3	Total Outflow	Cash Surplus	Accumulated Surplus
1977	1	-	-	258	291	549	258	291	-	-	-	12	561	-12	-12
1978	2	-	-	3,210	874	4,084	3,210	874	-	-	-	47	4,131	-47	-59
1979	3	-	-	2,640	160	2,800	2,640	160	-	-	-	53	2,853	-53	-112
1980	4	441	-	3,003	3,900	7,344	3,003	3,900	266	53	-	209	7,431	-87	-199
1981	5	1,776	-	1,702	1,346	4,824	1,702	1,346	897	179	-	263	4,387	437	238
1982	6	3,999	137	1,837	2,462	8,435	1,837	2,462	2,327	372	-	361	7,359	1,076	1,314
1983	7	5,896	303	-	957	7,156	-	957	3,654	497	-	400	5,514	1,642	2,956
1984	8	6,634	339	-	-	6,973	-	-	3,935	497	-	1,484	5,916	1,057	4,013
1985	9	6,889	356	-	-	7,245	-	-	4,134	497	-	1,484	6,115	1,130	5,143
1986	10	7,144	392	-	-	7,536	-	-	4,333	297	-	1,484	6,114	1,422	6,565
1987	11	7,400	419	-	-	7,819	-	-	4,531	297	633	1,484	6,945	874	7,439
1988	12	7,655	456	-	-	8,111	-	241	4,730	297	633	1,484	7,385	726	8,165
1989	13	7,655	456	-	-	8,111	-	301	4,730	297	633	1,484	7,445	666	8,831
1990	14	7,655	456	-	-	8,111	-	607	4,730	297	633	1,484	7,751	360	9,191
1991	15	7,655	456	-	-	8,111	-	355	4,730	297	633	1,484	7,499	612	9,803
1992	16	7,655	456	-	-	8,111	-	310	4,730	297	633	-	5,970	1,141	10,944
1993	17	7,655	456	-	-	8,111	-	-	4,730	297	633	-	5,660	2,451	13,395
1994	18	7,655	456	-	-	8,111	-	-	4,730	297	633	-	5,660	2,451	15,846
1995	19	7,655	456	-	-	8,111	-	-	4,730	297	633	-	5,660	2,451	18,297
1996	20	7,655	456	-	-	8,111	-	241	4,730	297	633	-	5,901	2,210	20,507
1997	21	7,655	456	-	-	8,111	-	301	4,730	297	633	-	5,961	2,150	22,657
1998	22	7,655	456	-	-	8,111	-	314	4,730	297	633	-	5,974	2,137	24,794
1999	23	7,655	456	-	-	8,111	-	-	4,730	297	633	-	5,660	2,451	27,245
2000	24	7,655	456	-	-	8,111	-	1,253	4,730	297	633	-	6,913	1,198	28,443
2001	25	7,655	456	-	-	8,111	-	355	4,730	297	633	-	6,015	2,096	30,539
2002	26	7,655	456	-	-	8,111	-	1,403	4,730	297	633	-	7,063	1,048	31,587
2003	27	7,655	456	-	-	8,111	-	927	4,730	297	633	-	6,587	1,524	33,111
2004	28	7,655	456	-	-	8,111	-	241	4,730	297	633	-	5,901	2,210	35,321
2005	29	7,655	456	-	-	8,111	-	301	4,730	297	633	-	5,961	2,150	37,471
2006	30	7,655	456	-	-	8,111	-	314	4,730	297	633	-	5,974	2,137	39,608
2007	31	7,655	456	-	-	8,111	-	-	4,730	297	-	-	5,027	3,084	42,692
2008	32	7,655	456	-	-	8,111	-	-	4,730	297	-	-	5,027	3,084	45,776
2009	33	7,655	456	-	-	8,111	-	-	4,730	297	-	-	5,027	3,084	48,860
2010	34	7,655	456	-	-	8,111	-	2,178	4,730	297	-	-	7,205	906	49,766
2011	35	7,655	456	-	-	8,111	-	355	4,730	297	-	-	5,380	2,729	52,495
2012	36	7,655	456	-	-	8,111	-	551	4,730	297	-	-	5,578	2,533	55,028

/1 Price of milled rice: 560 ₦/t

/2 Repayment period : 30 years, Grace period : 10 years, Interest : free

/3 Repayment period : 15 years, Grace period : 7 years, Interest rate : 4%

Table 11.32 Cash Flow Statement of the Auchi Project

(Unit : ₦1,000)

Year	Year in Order	Cash Inflow: Sales of Rice /1	Machinery Charge & Water Charge	Loan: Soft Loan /2	Loan: State or NAB /3	Total Inflow	Cash Outflow: Project Cost: Irrigation Facilities	Project Cost: Farm Machineries Rice Mill & Storage Facilities	Project Cost: Production Cost	O&M Cost	Loan Repayment: Repayment: Soft Loan /2	Repayment: State or NAB Loan /3	Total Outflow	Cash Surplus	Accumulated Surplus
1977	1	-	-	309	291	600	309	291	-	-	-	12	612	-12	-12
1978	2	-	-	3,438	873	4,311	3,438	873	-	-	-	47	4,358	-47	-59
1979	3	-	-	3,590	696	4,286	3,590	696	-	-	-	74	4,360	-74	-133
1980	4	940	-	2,612	2,901	6,453	2,612	2,901	598	174	-	190	6,475	-22	-155
1981	5	1,766	-	2,040	1,758	5,564	2,040	1,758	975	281	-	261	5,315	249	94
1982	6	2,941	-	2,171	924	6,036	2,171	924	1,317	375	-	298	5,085	951	1,045
1983	7	3,928	73	-	1,317	5,318	-	1,317	1,782	456	-	350	3,905	1,413	2,458
1984	8	4,497	92	-	-	4,589	-	-	1,909	465	-	1,301	3,675	914	3,372
1985	9	4,575	103	-	-	4,678	-	-	1,972	465	-	1,301	3,738	940	4,312
1986	10	4,634	111	-	-	4,745	-	-	2,020	315	-	1,301	3,738	1,007	5,319
1987	11	4,693	119	-	-	4,812	-	116	2,068	315	708	1,301	4,508	304	5,623
1988	12	4,752	127	-	-	4,879	-	123	2,116	315	708	1,301	4,563	316	5,939
1989	13	4,810	135	-	-	4,945	-	314	2,164	315	708	1,301	4,802	143	6,082
1990	14	4,810	135	-	-	4,945	-	271	2,164	315	708	1,301	4,759	186	6,268
1991	15	4,810	135	-	-	4,945	-	294	2,164	315	708	1,301	4,782	163	6,431
1992	16	4,810	135	-	-	4,945	-	225	2,164	315	708	-	3,412	1,533	7,964
1993	17	4,810	135	-	-	4,945	-	83	2,164	315	708	-	3,270	1,675	9,639
1994	18	4,810	135	-	-	4,945	-	-	2,164	315	708	-	3,187	1,758	11,397
1995	19	4,810	135	-	-	4,945	-	116	2,164	315	708	-	3,303	1,642	13,039
1996	20	4,810	135	-	-	4,945	-	123	2,164	315	708	-	3,310	1,635	14,674
1997	21	4,810	135	-	-	4,945	-	176	2,164	315	708	-	3,363	1,582	16,256
1998	22	4,810	135	-	-	4,945	-	187	2,164	315	708	-	3,374	1,571	17,827
1999	23	4,810	135	-	-	4,945	-	238	2,164	315	708	-	3,425	1,520	19,347
2000	24	4,810	135	-	-	4,945	-	932	2,164	315	708	-	4,119	826	20,173
2001	25	4,810	135	-	-	4,945	-	1,100	2,164	315	708	-	4,287	658	20,831
2002	26	4,810	135	-	-	4,945	-	225	2,164	315	708	-	3,412	1,533	22,364
2003	27	4,810	135	-	-	4,945	-	1,025	2,164	315	708	-	4,212	733	23,097
2004	28	4,810	135	-	-	4,945	-	123	2,164	315	708	-	3,310	1,635	24,732
2005	29	4,810	135	-	-	4,945	-	176	2,164	315	708	-	3,363	1,582	26,314
2006	30	4,810	135	-	-	4,945	-	187	2,164	315	708	-	3,374	1,571	27,885
2007	31	4,810	135	-	-	4,945	-	100	2,164	315	-	-	2,579	2,366	30,251
2008	32	4,810	135	-	-	4,945	-	-	2,164	315	-	-	2,479	2,466	32,717
2009	33	4,810	135	-	-	4,945	-	138	2,164	315	-	-	2,617	2,328	35,045
2010	34	4,810	135	-	-	4,945	-	1,638	2,164	315	-	-	4,162	783	35,828
2011	35	4,810	135	-	-	4,945	-	310	2,164	315	-	-	2,789	2,156	37,984
2012	36	4,810	135	-	-	4,945	-	348	2,164	315	-	-	2,827	2,118	40,102

/1 Price of rice : 560N/t
/2 Repayment period : 30 years, Grace period : 10 years, Interest : free
/3 Repayment period : 15 years, Grace period : 7 years, Interest rate : 4%

Fig. 11.1 Estimate of IRR, Owerri Project

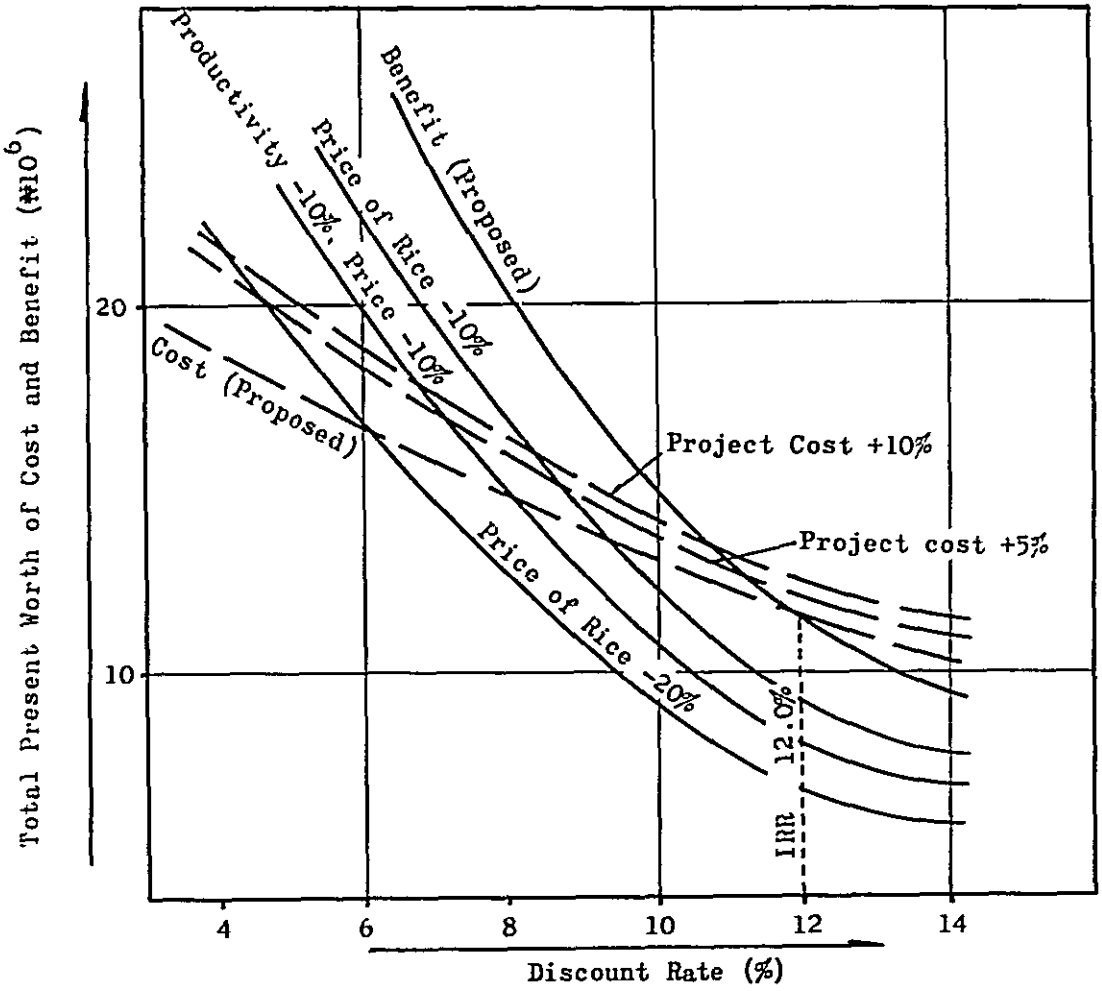
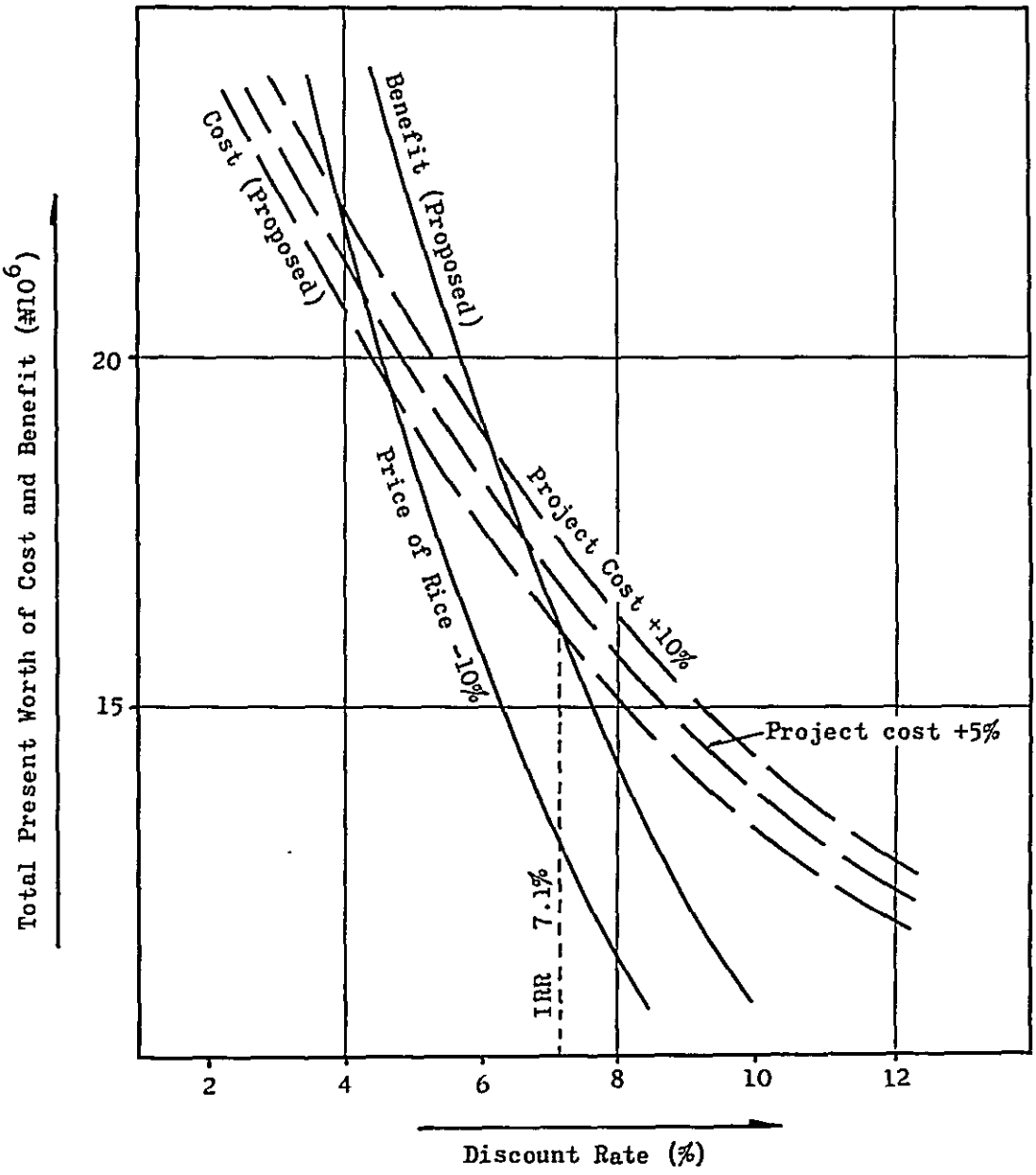
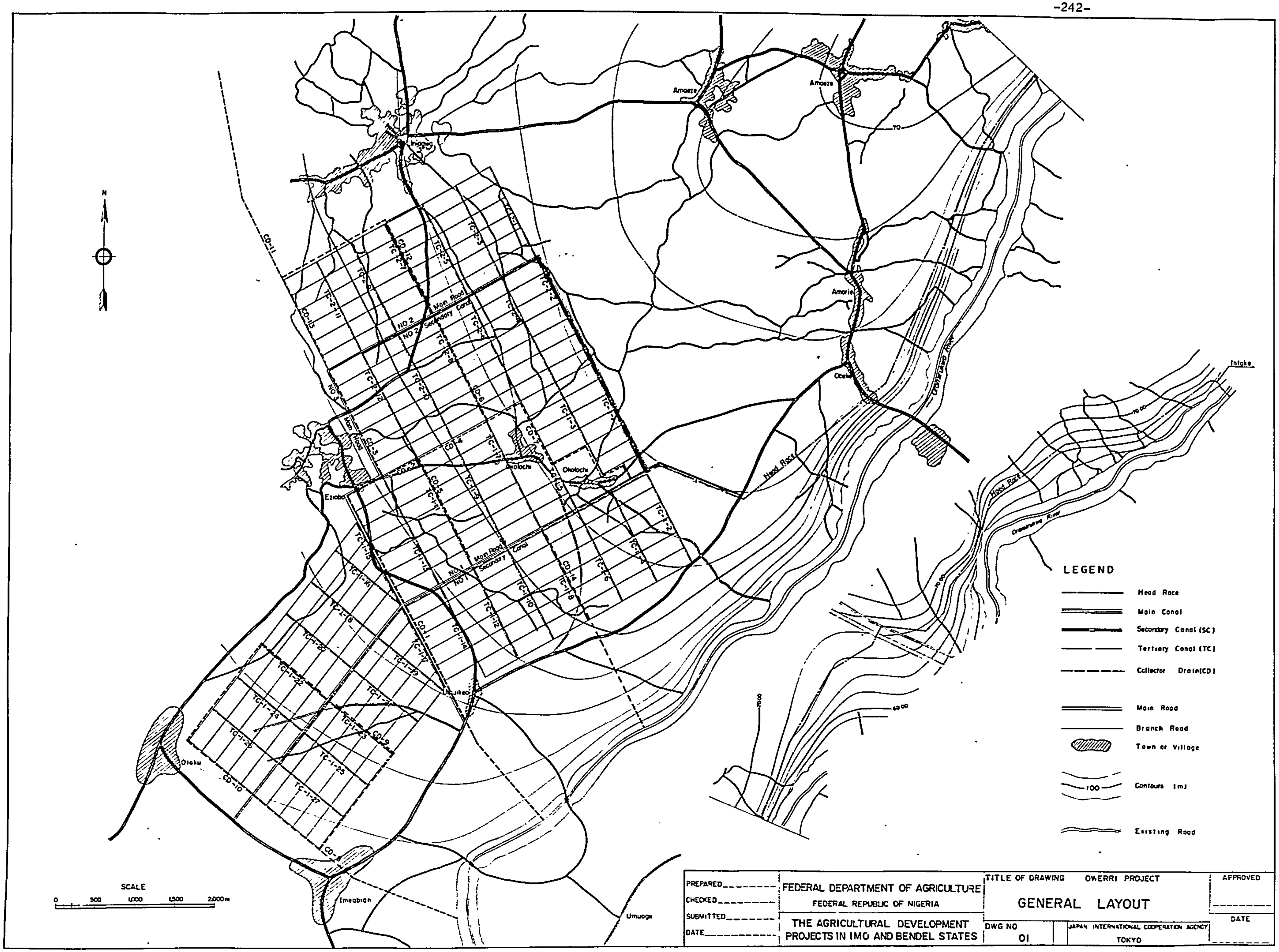


Fig. 11.2 Estimate of IRR, Auchi Project



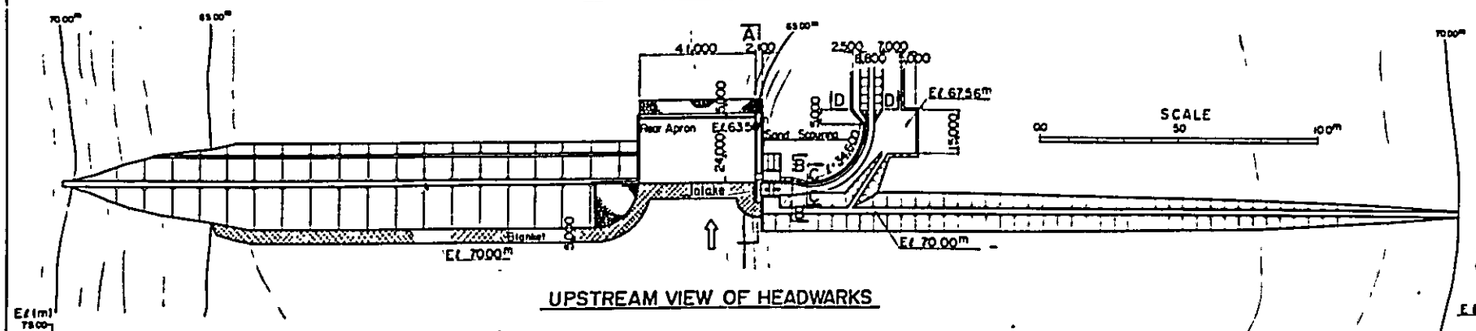


Amaeze
Amaeze
Inyogwu
Amorie
Obeke
Eziobo
Okolochi
Okolochi
Otoku
Imeabian
Umuoga
Intake
Head Race
Head Race
Oramirukwa River
Oramirukwa River
Main Road
NO 2 Secondary Canal
NO 1 Secondary Canal
CD-11
CD-12
CD-13
CD-14
CD-10
CD-9
CD-8
CD-1
TC-2-1
TC-2-3
TC-2-11
TC-1-16
TC-1-18
TC-1-20
TC-1-22
TC-1-24
TC-1-26
TC-1-27
TC-1-25
TC-1-23
LEGEND
Head Race
Main Canal
Secondary Canal (SC)
Tertiary Canal (TC)
Collector Drain (CD)
Main Road
Branch Road
Town or Village
Contours (m)
Existing Road
SCALE
0 500 1,000 1,500 2,000m
N
PREPARED
CHECKED
SUBMITTED
DATE
FEDERAL DEPARTMENT OF AGRICULTURE
FEDERAL REPUBLIC OF NIGERIA
THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES
TITLE OF DRAWING OWERRI PROJECT
GENERAL LAYOUT
DWG NO 01
JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO
APPROVED
DATE

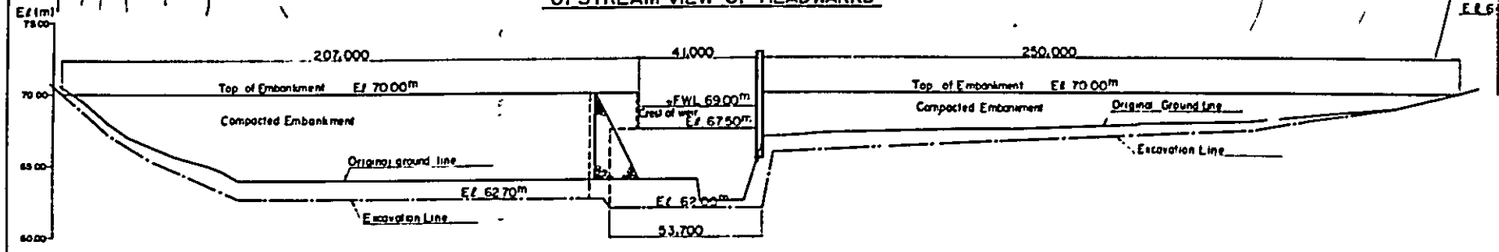
PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING AUCHI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	GENERAL LAYOUT	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES	DWG.NO. 02	DATE
DATE		JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO	

PLATE NO

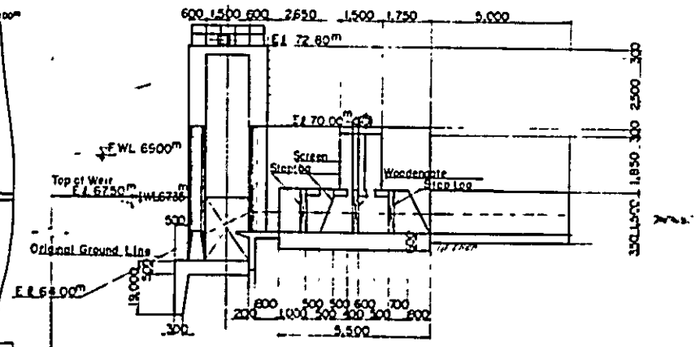
PLAN OF HEADWORKS



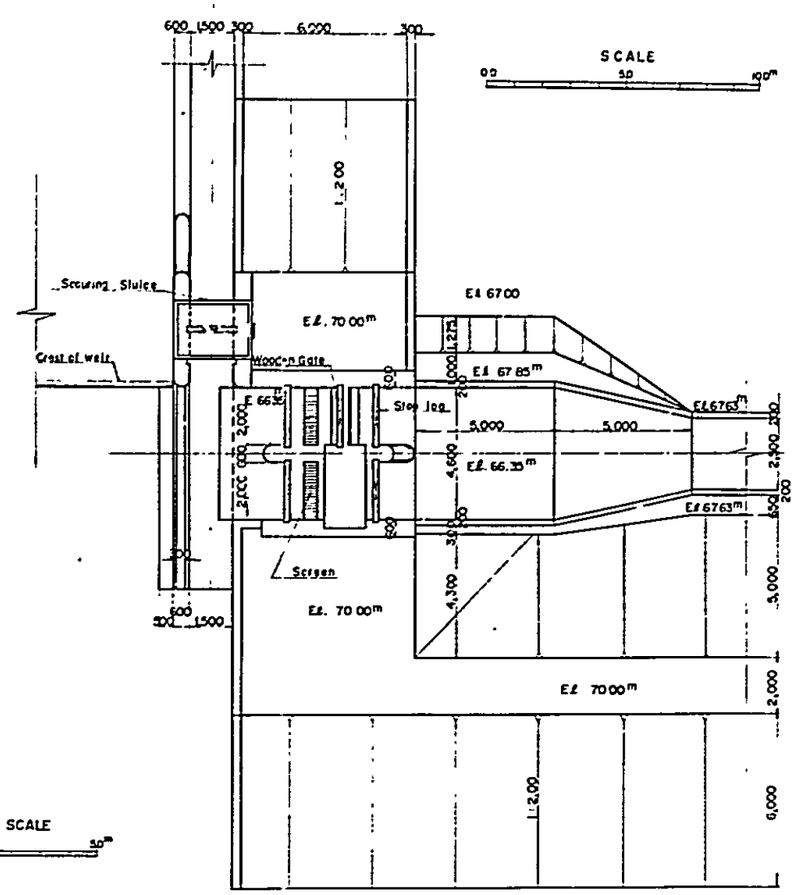
UPSTREAM VIEW OF HEADWARKS



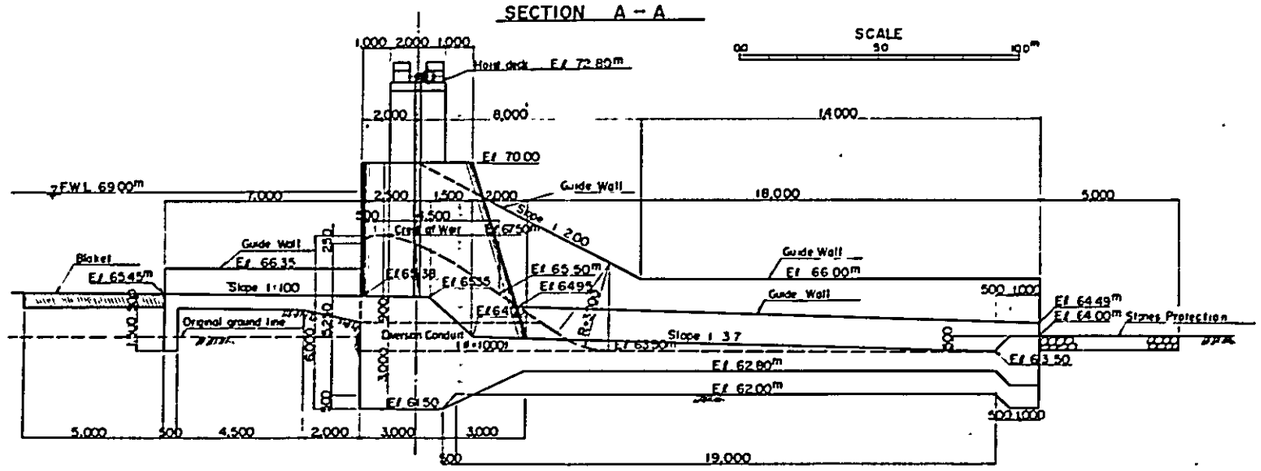
PROFILE OF INTAKE



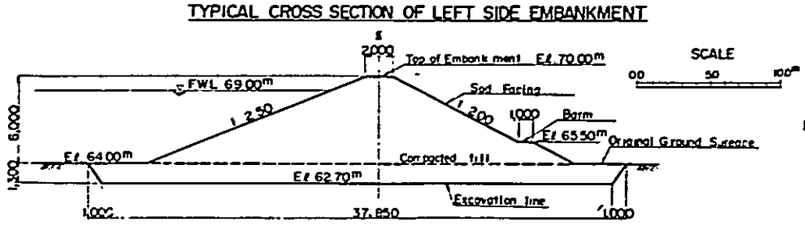
PLAN OF INTAKE



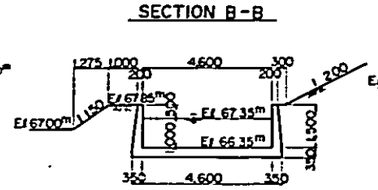
SECTION A – A



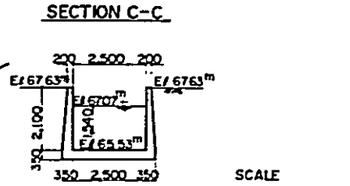
TYPICAL CROSS SECTION OF LEFT SIDE EMBANKMENT



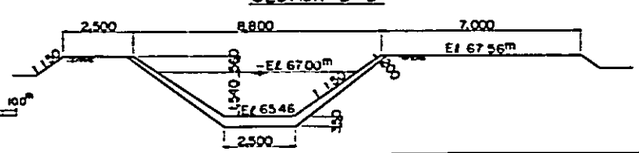
SECTION B-B



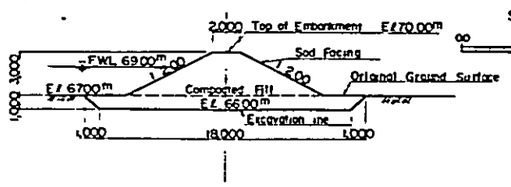
SECTION C-C



SECTION D-D



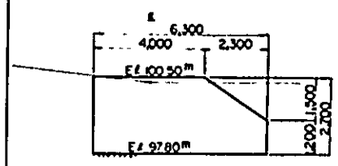
TYPICAL CROSS SECTION OF RIGHT SIDE EMBANKMENT



PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING OWERRI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	HEAD WORKS	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES	DWG NO 03	DATE
DATE		JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO	

PLATE NO

SECTION A - A'



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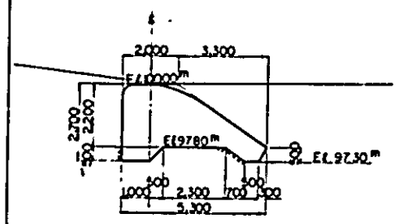

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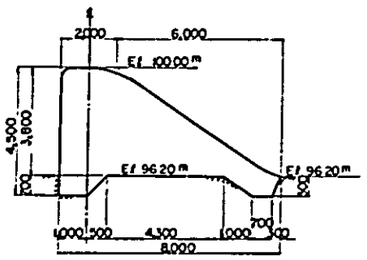
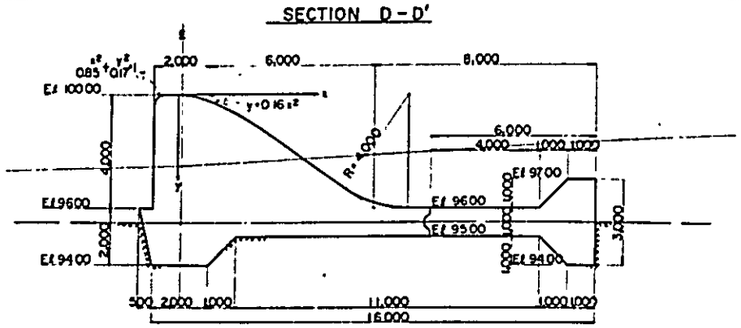


SECTION D - D'



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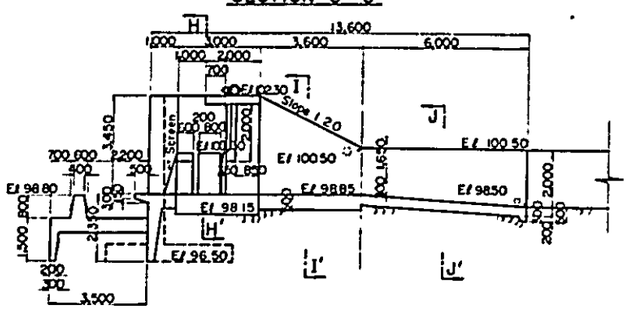
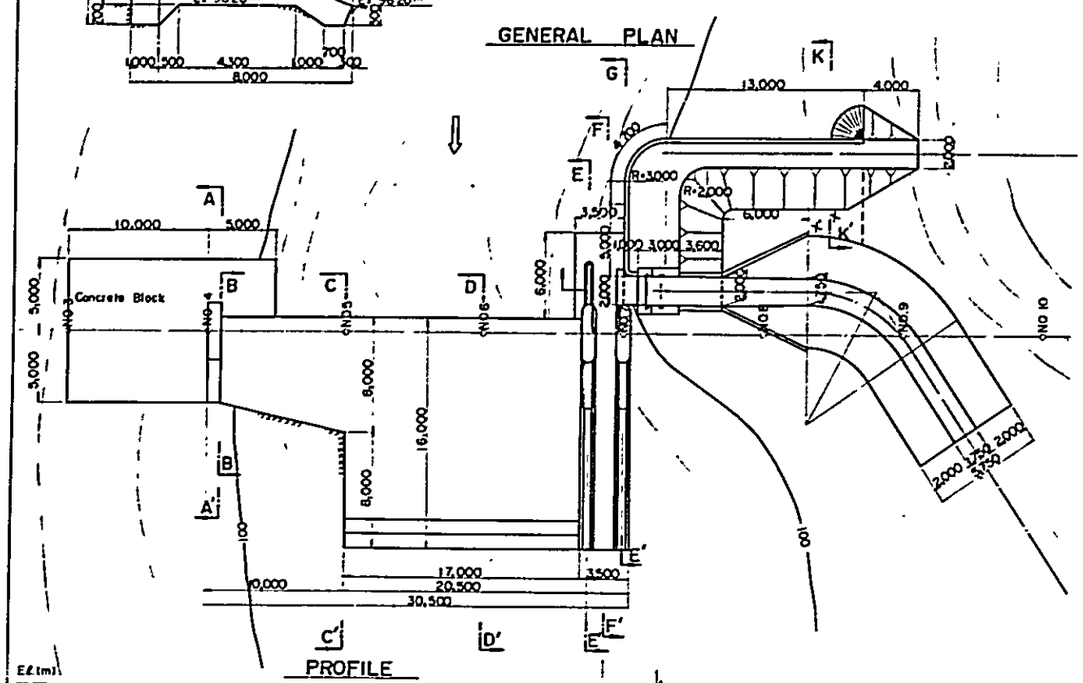
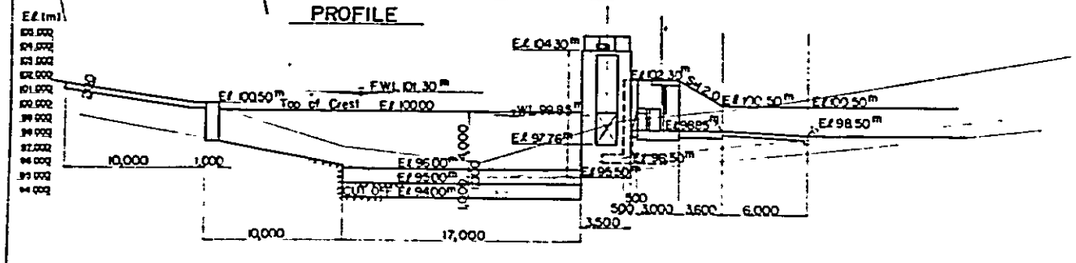


GENERAL PLAN



PROFILE



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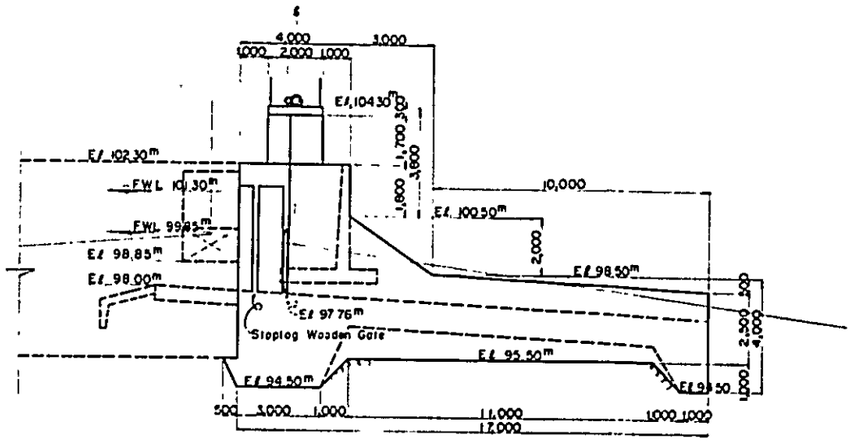
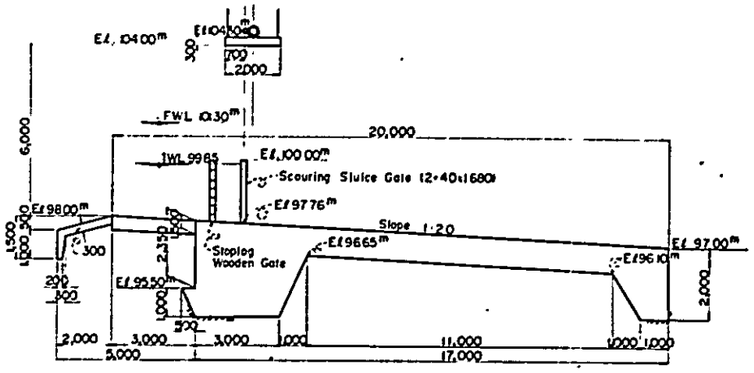
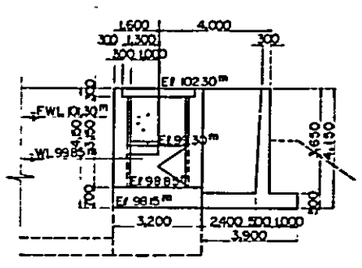


SECTION F - F'



SECTION H-H'



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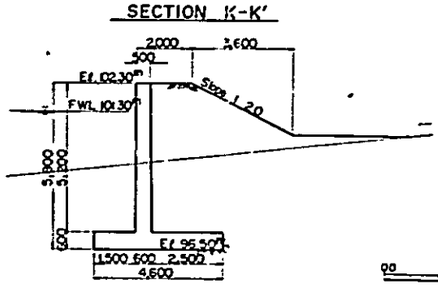
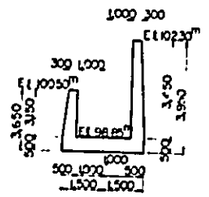


SECTION I-I



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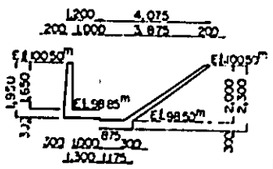
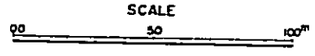
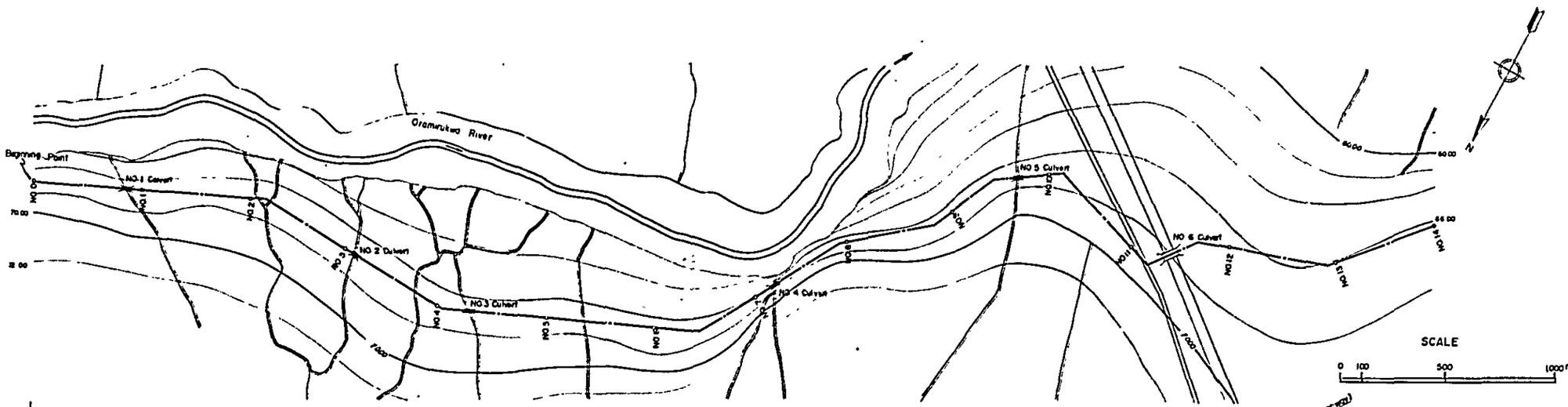


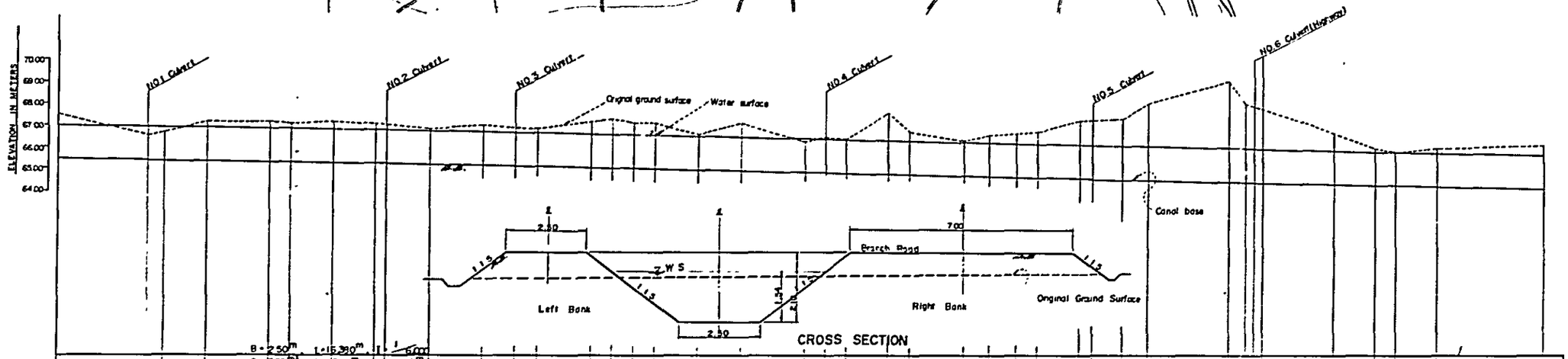
SCALE



PREPARED	FEDERAL DEPARTMENT OF AGRICULTUPE	TITLE OF DRAWING AUCHI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	HEAD WORKS	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES	DWG NO 04	DATE
DATE		JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO	

PLATE NO





	STATION	NO 0	NO 1	NO 2	NO 3	NO 4	NO 5	NO 6	NO 7	NO 8	NO 9	NO 10	NO 11	NO 12	NO 13	NO 14
IRRIGATION CANAL	DISTANCE	0	+ 420	80	+ 200	300	+ 100	+ 200	200	+ 90	+ 200	250	+ 150	+ 100	250	+ 100	+ 100	+ 100	200	+ 200	+ 100	+ 200	300	+ 100	+ 100	+ 200	+ 250	+ 120	130	+ 100	+ 200	140	+ 120	360	40	40	340	+ 200	+ 100	200	800
	REDUCED DISTANCE	0	420	500	700	1,000	1,100	1,300	1,500	1,590	1,790	2,000	2,150	2,250	2,500	2,600	2,700	2,800	3,000	3,200	3,500	3,600	3,700	3,900	4,000	4,250	4,270	4,400	4,600	4,800	4,860	5,000	5,120	5,500	5,540	5,580	6,000	6,200	6,300	6,500	7,000
	GROUND SURFACE ELEVATION	67.50	66.30	66.70	67.10	67.10	67.00	67.10	67.00	66.95	66.75	66.90	66.80	66.75	67.05	67.20	67.00	67.00	66.60	67.00	66.15	66.35	66.30	67.50	66.60	66.25	66.50	66.60	66.70	67.20	67.25	67.30	68.00	68.00	67.95	67.85	68.00	68.00	68.00	68.00	66.15
	WATER SURFACE ELEVATION	67.00	65.93	66.90	66.89	66.86	66.81	66.79	66.78	66.73	66.71	66.68	66.63	66.61	66.61	66.58	66.55	66.53	66.49	66.47	66.45	66.43	66.40	66.37	66.21	66.23	66.17	66.15	66.13	66.11	66.08	66.07	66.02	66.00	65.94	65.93	65.92	65.86	65.83	65.80	65.78	65.76	63.67
	CANAL BASE ELEVATION	65.46	65.39	65.36	65.35	65.32	65.27	65.25	65.22	65.19	65.17	65.14	65.11	65.07	65.04	65.01	64.99	64.95	64.93	64.91	64.89	64.86	64.83	64.78	64.77	64.74	64.72	64.68	64.67	64.63	64.61	64.59	64.57	64.54	64.46	64.40	64.39	64.38	64.35	64.29	64.26	64.24	64.21	64.13

NOTE

SCALE
VERTICAL 1 : 100
HORIZONTAL 1 : 10000

: Culvert
B : Canal Base Width
L : Canal Length
I : Longitudinal Gradient
Q : Discharge
V : Velocity
H : Water Depth

PREPARED
CHECKED
SUBMITTED
DATE

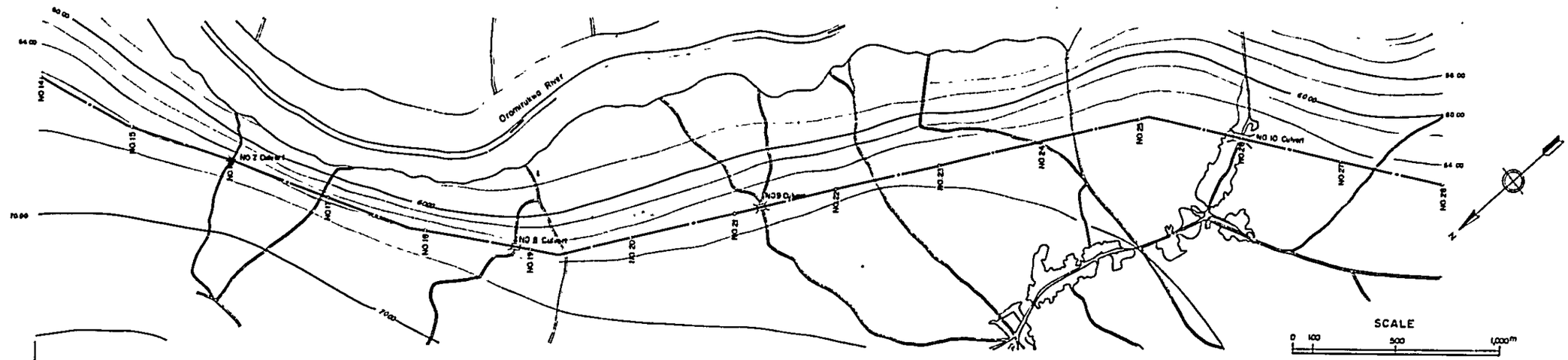
FEDERAL DEPARTMENT OF AGRICULTURE
FEDERAL REPUBLIC OF NIGERIA
THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES

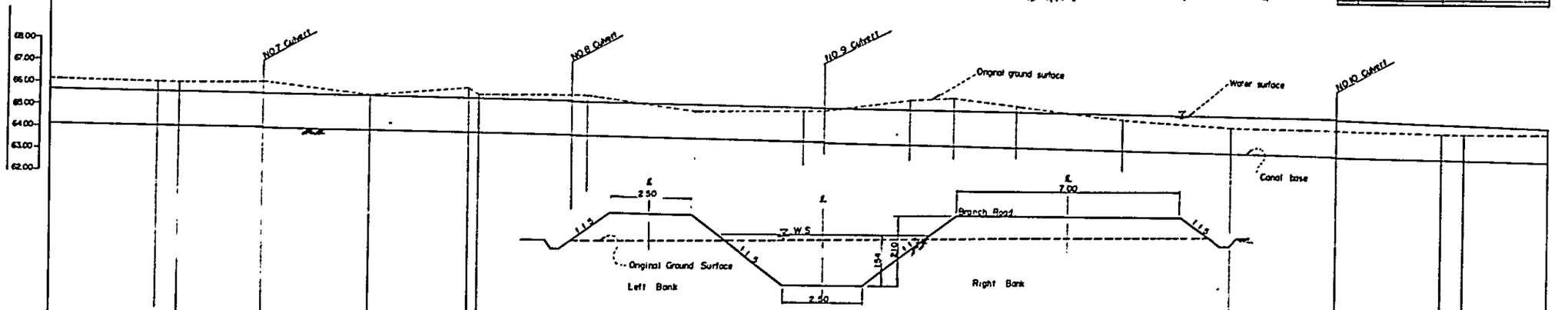
TITLE OF DRAWING OWERRI PROJECT
HEAD RACE (I)
DWG NO 05

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

APPROVED
DATE

PLATE NO





IRRIGATION CANAL

	STATION	NO14	NO15		NO16	NO17	NO18		NO19	NO20	NO21		NO22	NO23	NO24	NO25	NO26	NO27		NO28
	DISTANCE	0	500	+ 100	400	500	+ 480	40	+ 430	500	500	+ 100	400	+ 200	300	500	500	500	500	+ 100	400
	REDUCED DISTANCE	7,000	7,500	7,600	8,000	8,500	8,980	9,000	9,430	9,500	10,000	10,300	10,600	11,000	11,200	11,500	12,000	12,500	13,000	13,500	13,600	14,000
	GROUND SURFACE ELEVATION	66.16	66.00	66.00	66.00	65.50	65.80	65.50	65.47	65.50	64.75	64.85	64.90	65.40	65.50	65.15	64.80	64.30	64.22	64.12	64.10	64.10
	WATER SURFACE ELEVATION	65.67	65.59	65.57	65.50	65.47	65.31	65.30	65.23	65.20	65.11	65.03	65.00	64.90	64.87	64.82	64.74	64.65	64.58	64.45	64.43	64.37
	CANAL BASE ELEVATION	64.13	64.08	64.03	63.96	63.88	63.77	63.76	63.69	63.66	63.57	63.49	63.46	63.36	63.33	63.28	63.20	63.11	63.08	62.91	62.89	62.83

PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE
CHECKED	FEDERAL REPUBLIC OF NIGERIA
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES
DATE	

TITLE OF DRAWING OWERRI PROJECT

HEAD RACE (2)

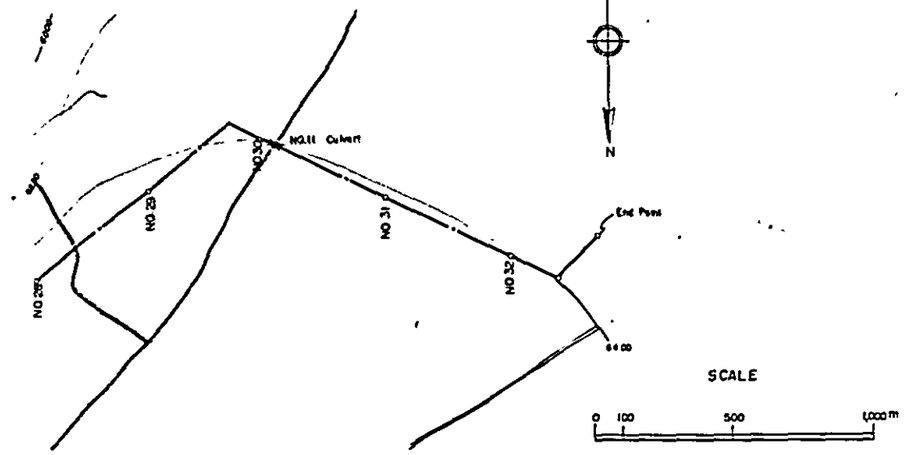
DWG NO 06

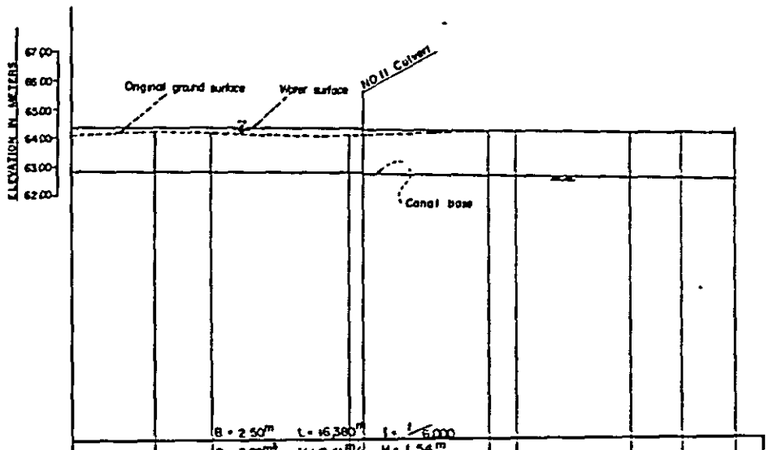
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

APPROVED

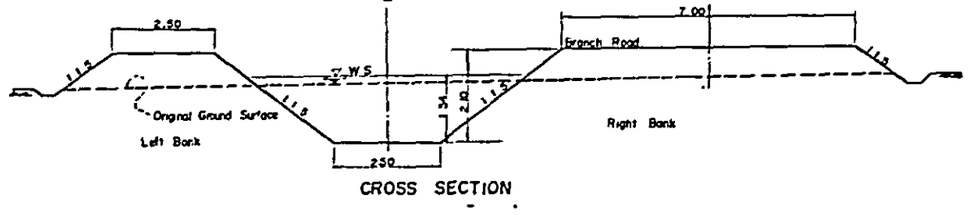
DATE

PLATE NO





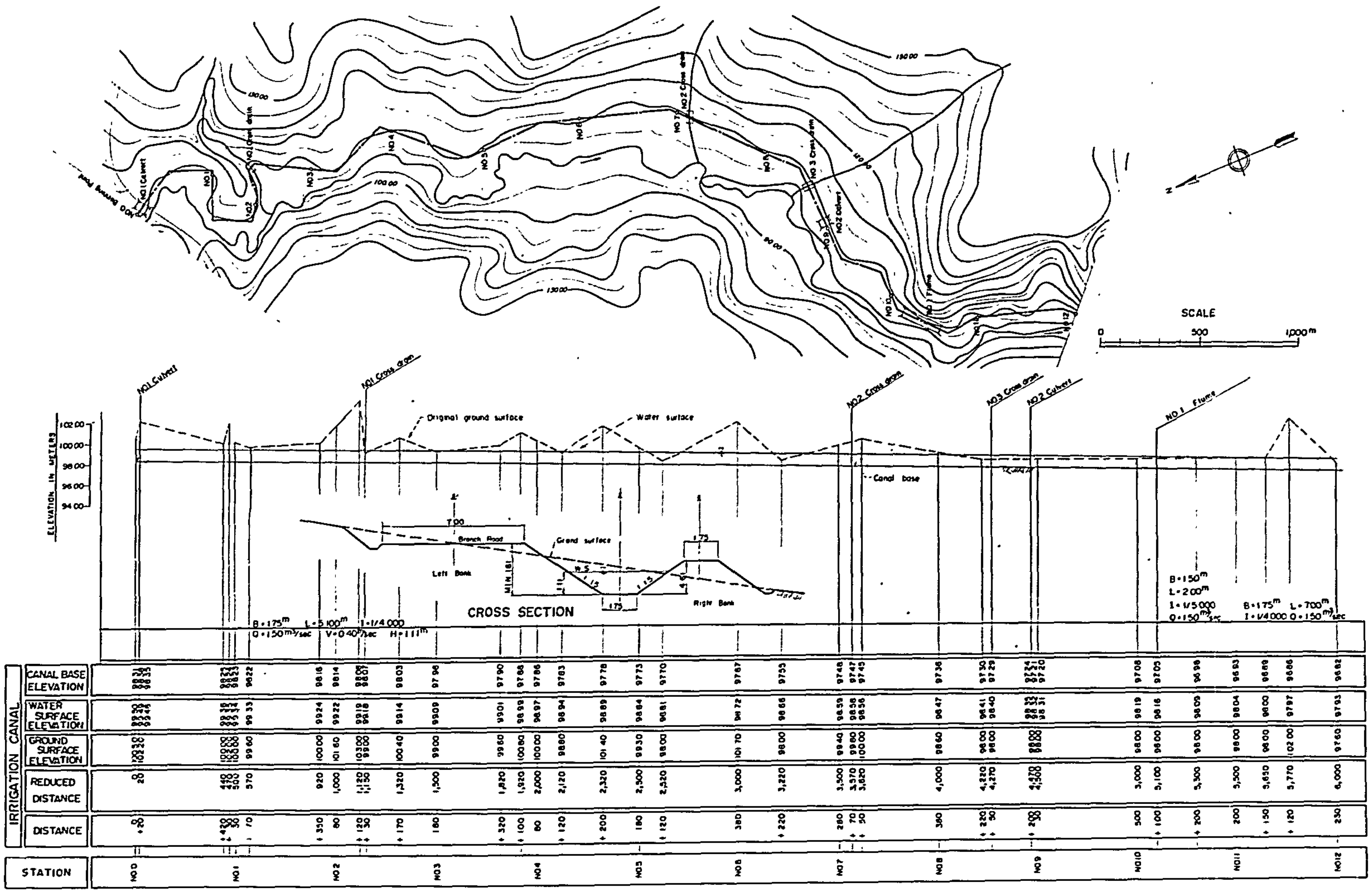
IRRIGATION CANAL	CANAL BASE ELEVATION	62.83	62.78	62.78	62.58 62.58 62.58	62.57	62.55	62.49	62.48	62.43
	WATER SURFACE ELEVATION	64.37	64.32	64.29	64.22 64.22 64.19	64.11	64.09	64.03	64.00	63.97
	GROUND SURFACE ELEVATION	64.10	64.20	64.14	63.98 64.00	64.10	64.10	64.02	64.00	63.97
	REDUCED DISTANCE	14,000	14,300	14,500	15,000 15,030	15,500	15,600	16,000	16,180	16,380
	DISTANCE	0	+ 300	200	500 + 30	450	+ 100	400	+ 180	+ 200
STATION		NO.29		NO.29	NO.30	NO.31		NO.32		



CROSS SECTION

PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING OWERRI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	HEAD RACE (3)	DATE
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES	DWG NO 07	JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO
DATE			

PLATE NO



SCALE

VERTICAL 1 : 200

HORIZONTAL 1 : 10,000

NOTE

Culvert

Cross Drain

Flume

B : Canal Base Width

L : Canal Length

I : Longitudinal Gradient

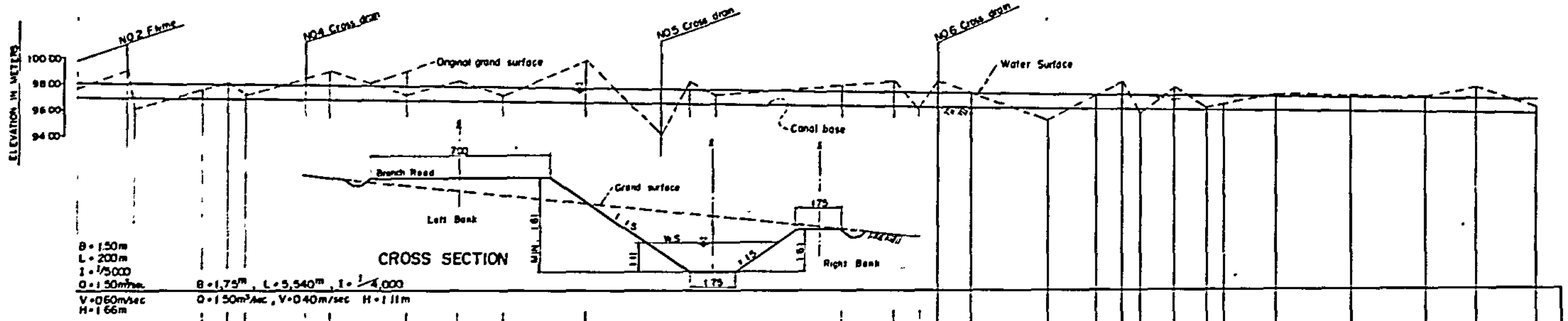
Q : Discharge

V : Velocity

H : Water Depth

PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING AUCHI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	HEAD RACE (1)	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT PROJECTS IN IMO AND BENDEL STATES	DWG NO 08	DATE
DATE		JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO	

PLATE NO



IRRIGATION CANAL

STATION	DISTANCE	REDUCED DISTANCE	GROUND SURFACE ELEVATION	WATER SURFACE ELEVATION	CANAL BASE ELEVATION
NO12	230	6,000	9760	9793	9682
	+200	6,200	98.80	9786	96.73
	+30	6,230	98.80	9785	96.74
NO13	270	6,500	9740	9778	9667
	+100	6,600	9800	9775	9664
	+70	6,670	9700	97.74	9663
	+240	6,910	9830	9768	9657
NO14	90	7,000	9880	9765	9654
	+300	7,300	9700	9757	9646
NO15	200	7,500	9800	9732	9641
	+180	7,680	9700	9748	9637
NO16	320	8,000	9980	9740	9629
	+290	8,290	9400	9733	9622
	+110	8,400	9800	9730	9619
NO17	100	8,500	9700	9727	9616
NO18	500	9,000	9770	9715	9604
	+200	9,200	9800	9710	95.99
	+100	9,300	9800	9707	9596
	+70	9,370	9800	9706	9595
NO19	130	9,500	9720	9703	9592
	+300	9,800	9500	9695	9584
NO20	200	10,000	9700	9690	9579
	+100	10,100	9800	9687	9576
	+70	10,170	9580	9686	9575
	+130	10,300	9760	9683	9572
	+130	10,430	98.00	9680	9569
NO21	70	10,500	98.30	9679	9568
	+200	10,700	9700	9674	9563
NO22	300	11,000	9890	9666	9555
	+300	11,300	9880	9658	9542
NO23	200	11,500	9740	9653	9542
	+240	11,740	9800	9647	9536

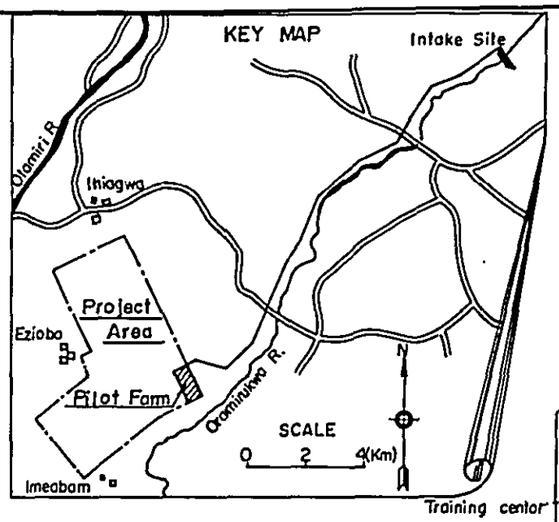
SCALE

VERTICAL 1 200

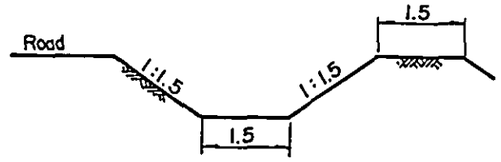
HORIZONTAL 1-10000

PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING AUCHI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	HEAD RACE (2).	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT	DWG NO	DATE
DATE	PROJECTS IN IMO AND BENDEL STATES	09	JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO

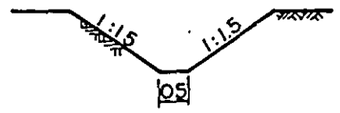
KEY MAP



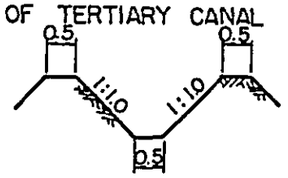
TYPICAL SECTION OF SECONDARY CANAL



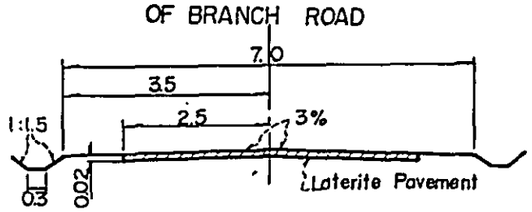
TYPICAL SECTION OF FIELD DRAIN



TYPICAL SECTION OF TERTIARY CANAL



TYPICAL SECTION OF BRANCH ROAD



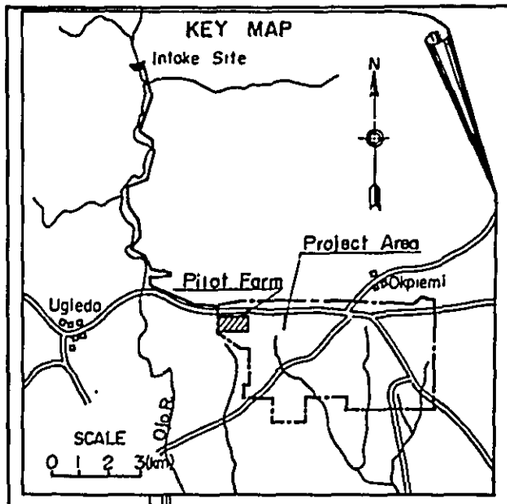
LEGEND

- Head Race
- Secondary Canal
- Tertiary Canal
- Field Drain
- Main Road
- Branch Road
- Boundary of Pilot Scheme

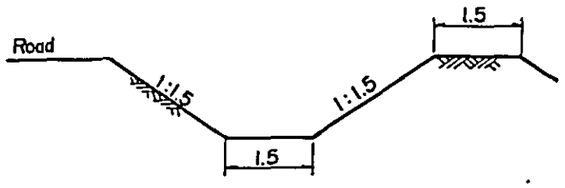
SCALE
0 100 200m

PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING OWERRI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	GENERAL LAYOUT OF PILOT SCHEME	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT	DWG. NO. 10	DATE
DATE	PROJECTS IN IMO AND BENDEL STATES	JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO	

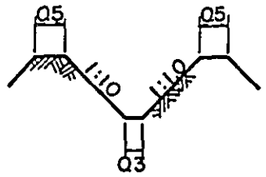
KEY MAP



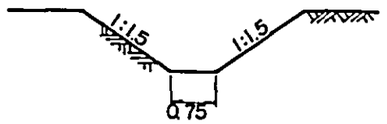
TYPICAL SECTION OF MAIN CANAL



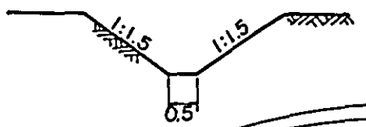
TYPICAL SECTION OF TERTIARY CANAL

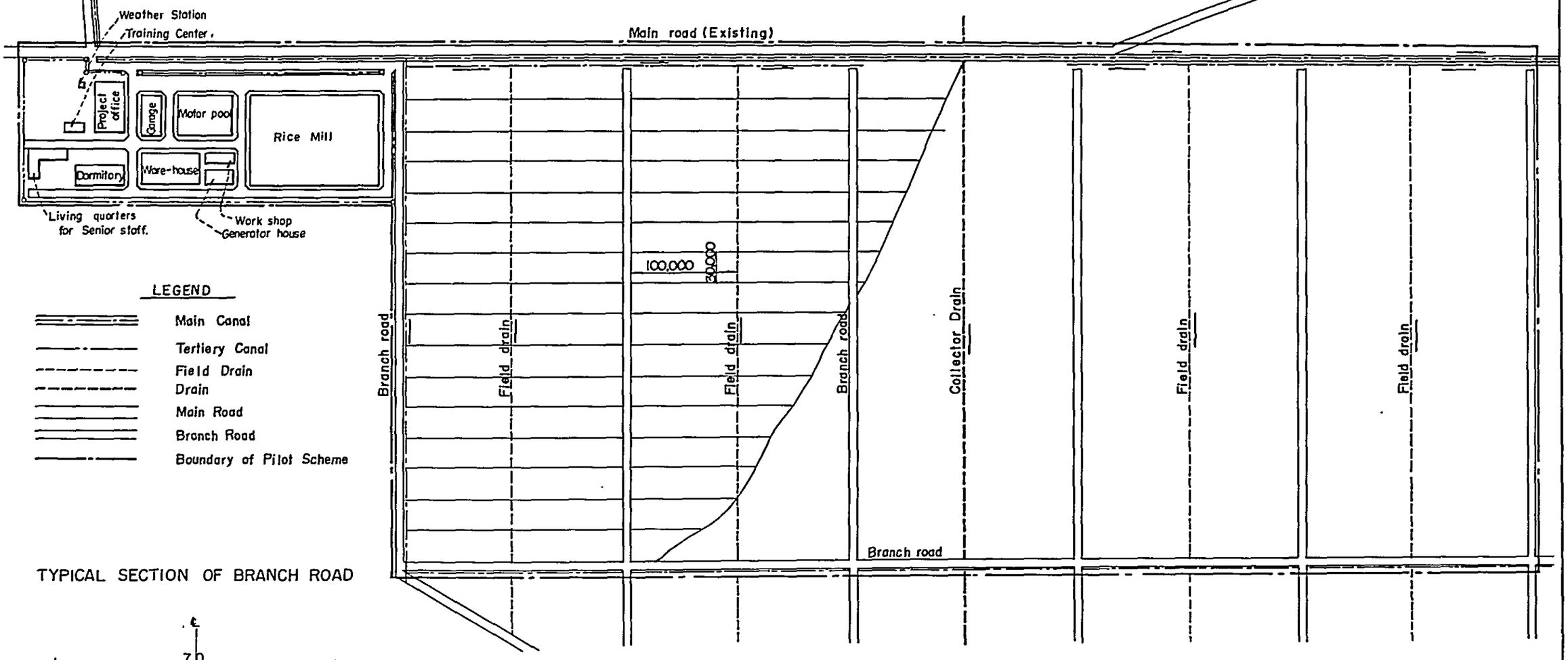


TYPICAL SECTION OF COLLECTOR DRAIN



TYPICAL SECTION OF FIELD DRAIN

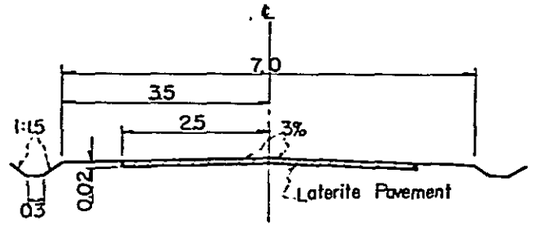




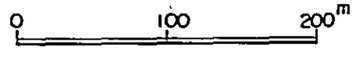
LEGEND

- Main Canal
- Tertiery Canal
- Field Drain
- Drain
- Main Road
- Branch Road
- Boundary of Pilot Scheme

TYPICAL SECTION OF BRANCH ROAD



SCALE



PREPARED	FEDERAL DEPARTMENT OF AGRICULTURE	TITLE OF DRAWING: AUCHI PROJECT	APPROVED
CHECKED	FEDERAL REPUBLIC OF NIGERIA	GENERAL LAYOUT OF PILOT SCHEME	
SUBMITTED	THE AGRICULTURAL DEVELOPMENT	DRG NO. 11	DATE
DATE	PROJECTS IN IMO AND BENDEL STATES	JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO