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 N781 and N841 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 N14 and N92 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	217
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	6.00	63	378.00
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)					(778.08)
2. Tree crops and others					65
Total Gross Income					843.08
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					-25.92

/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 Gross Outgo					1,024
III. Net Reserve					92.07

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

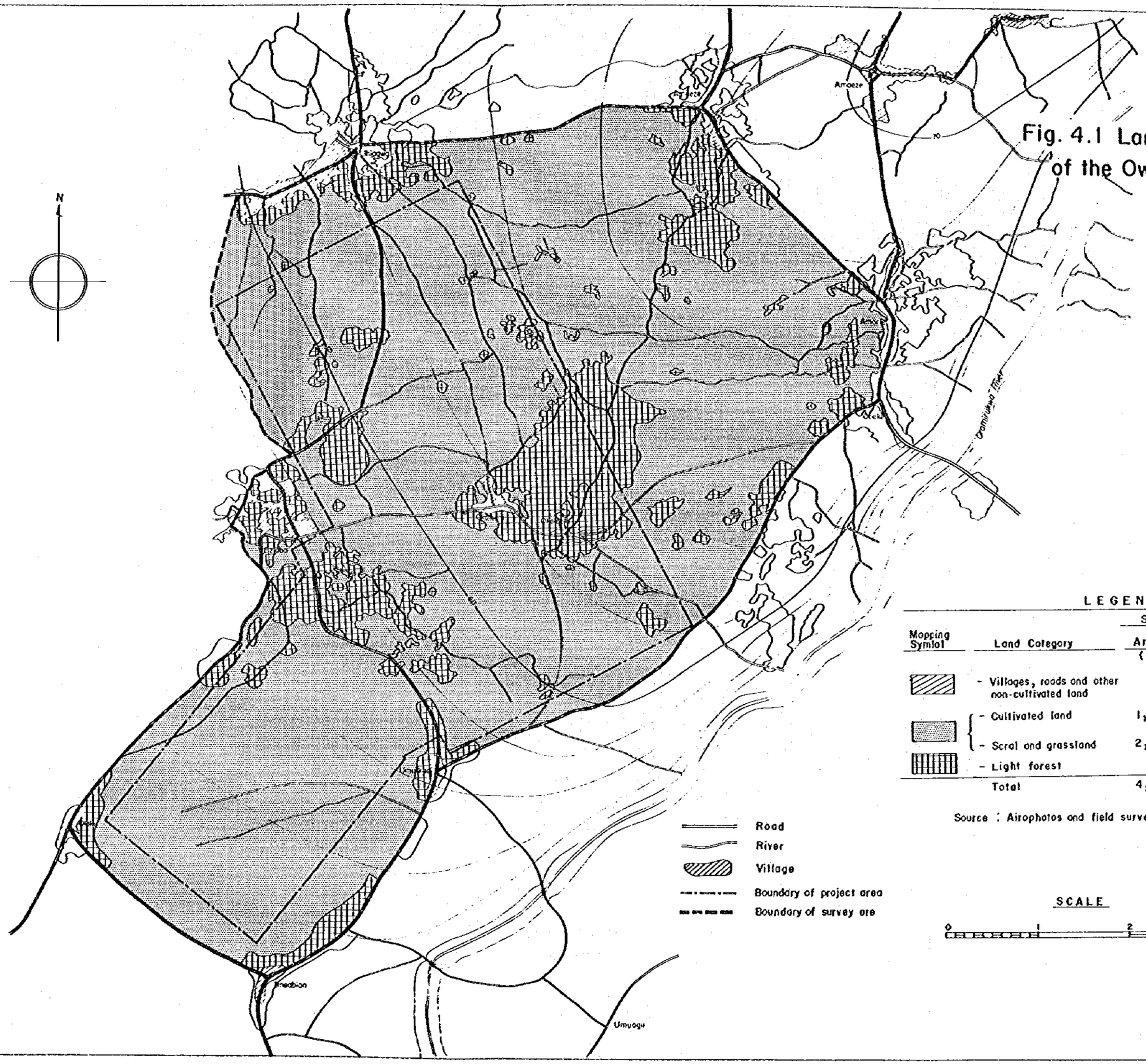


Fig. 4.1 Land Use Map of the Owerri Project Area

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

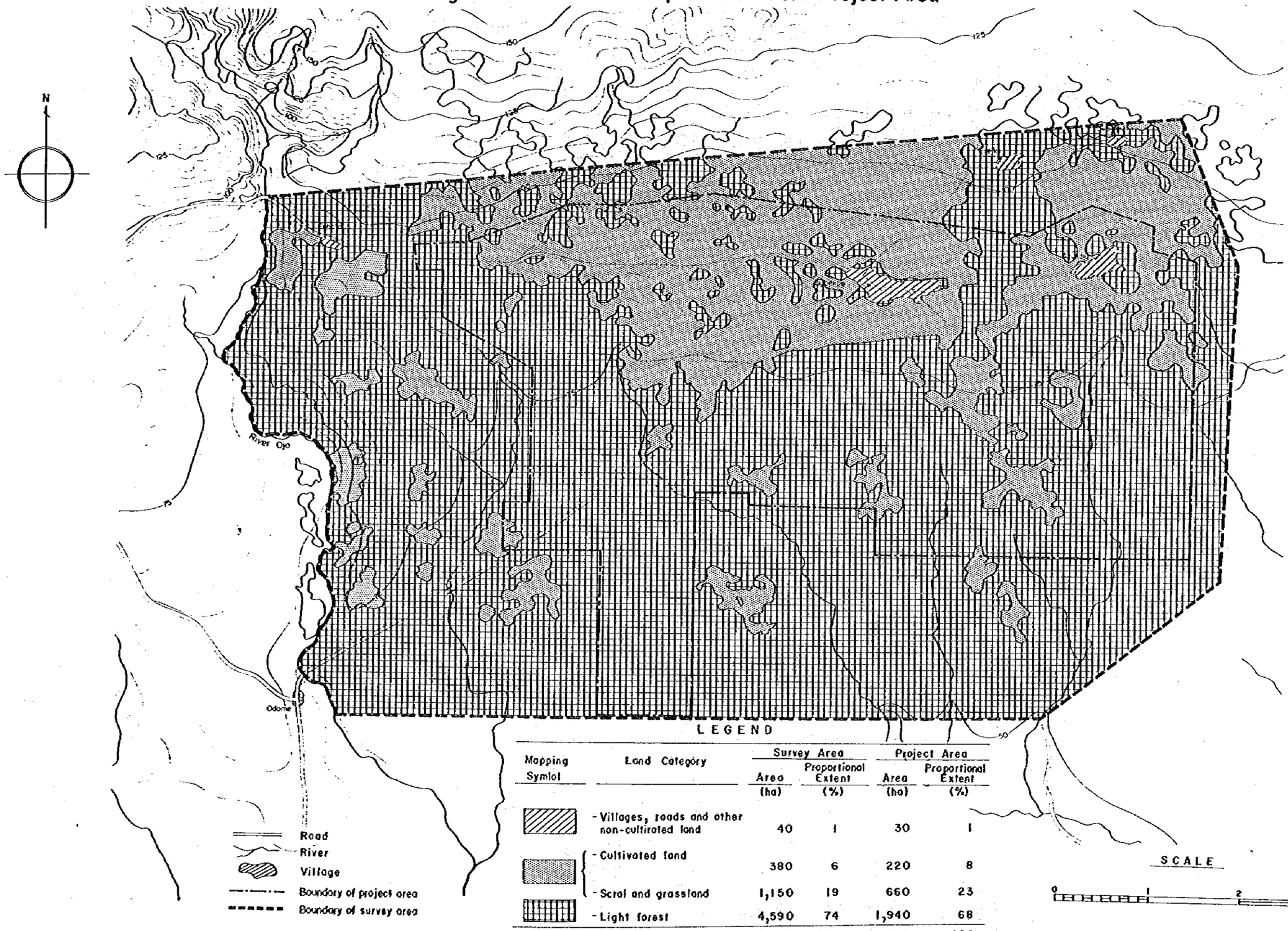
Source : Airophotos and field survey

Road
River
Village
Boundary of project area
Boundary of survey are

SCALE

0 1 2 3 km

Fig. 4.2 Land Use Map of the Auchi Project Area

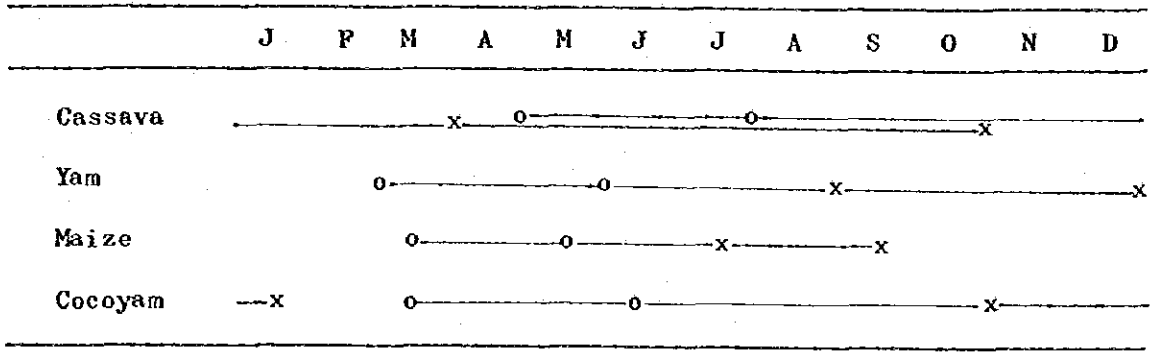


Mapping Symbol	Land Category	Survey Area Area (ha)	Survey Area Proportional Extent (%)	Project Area Area (ha)	Project Area Proportional Extent (%)
	- Villages, roads and other non-cultivated land	40	1	30	1
	- Cultivated land	380	6	220	8
	- Scrub and grassland	1,150	19	660	23
	- Light forest	4,590	74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

Source : Airaphotos and field survey

Fig. 4.3 Typical Cropping Calendar of the Major Crops

(Owerri Project Area)



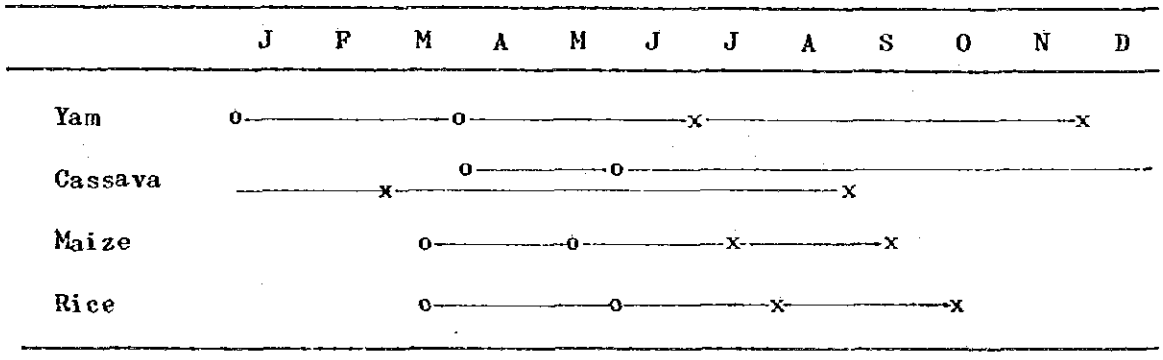
Remarks: o——o Seeding period

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. 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 practiced 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 59,200 mandays and 64,300 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
Dry season 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 kg	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 (ha)	Unit Yield (t/ha)	Paddy Production (t)	Harvested Area (ha)	Unit Yield (t/ha)	Paddy Production (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	Unit Yield	Paddy Production	Harvested Area	Unit Yield	Paddy Production			
	(ha)	(t/ha)	(t)	(ha)	(t/ha)	(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

Owerri Project Area (2,100ha)

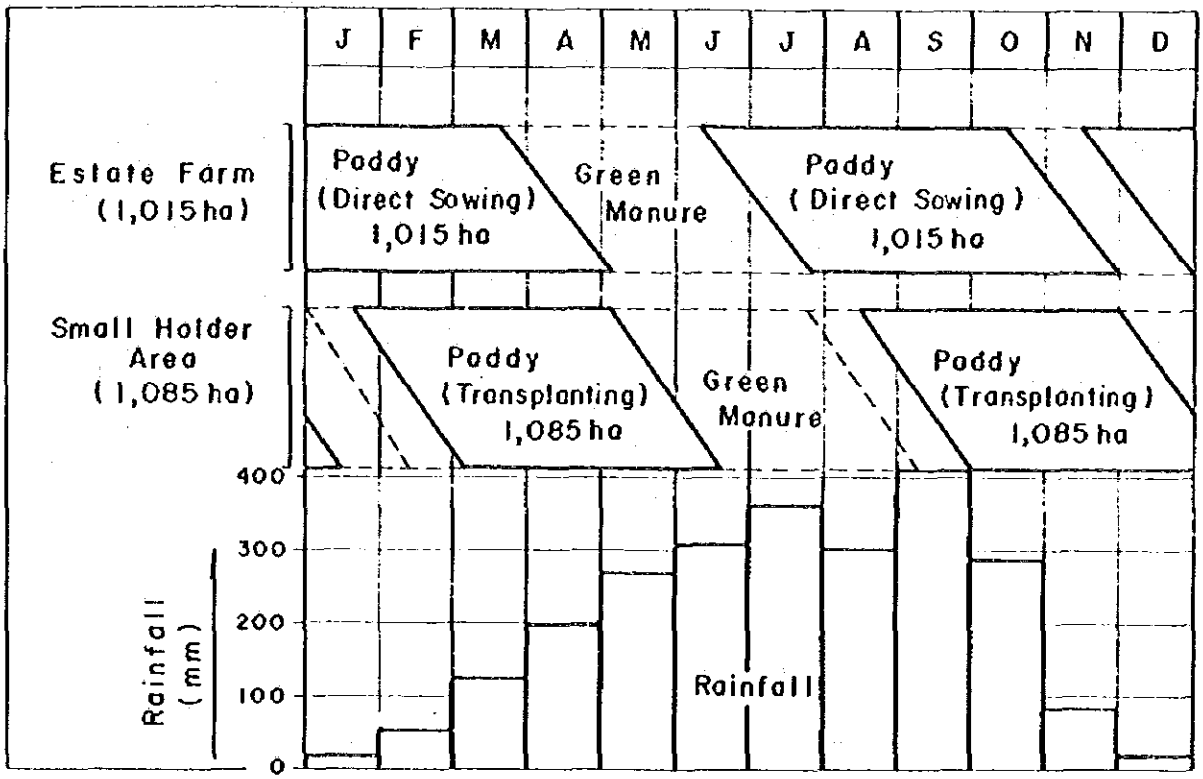


Fig. 5.2 Proposed Cropping Pattern

Auchi Project Area (2,100ha)

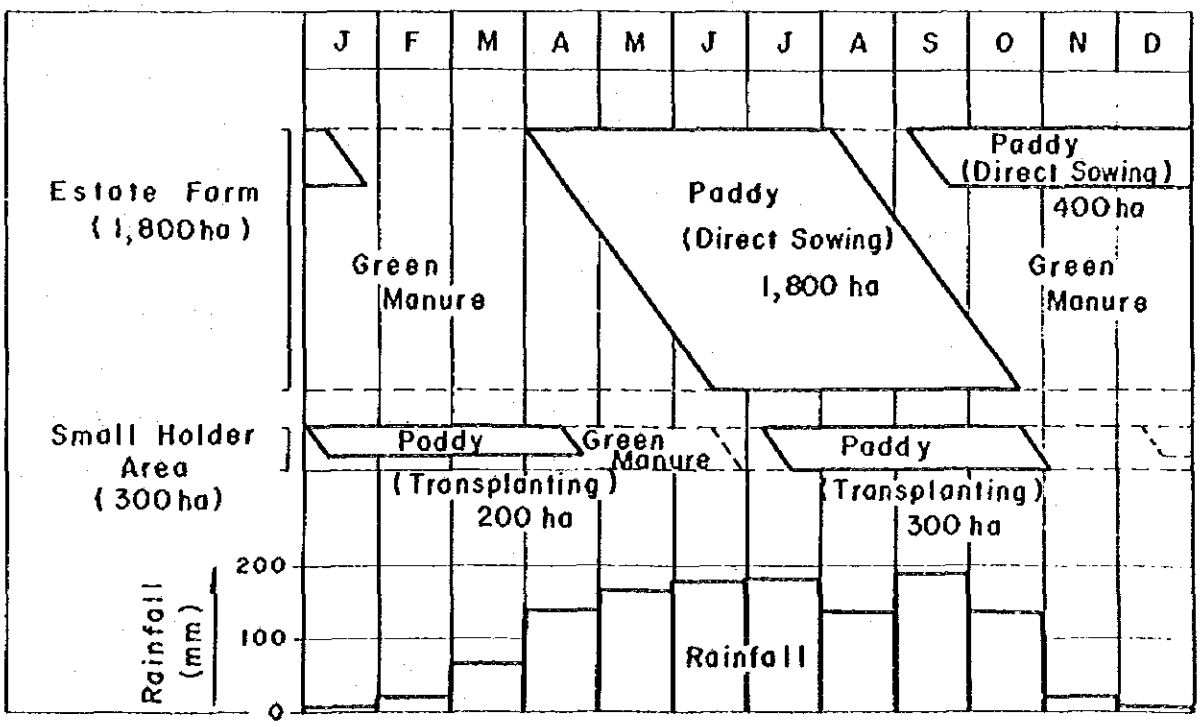
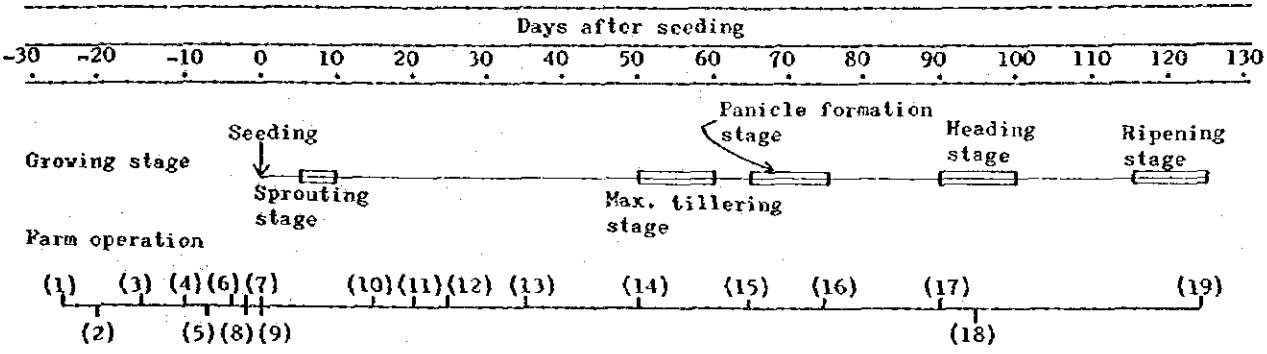
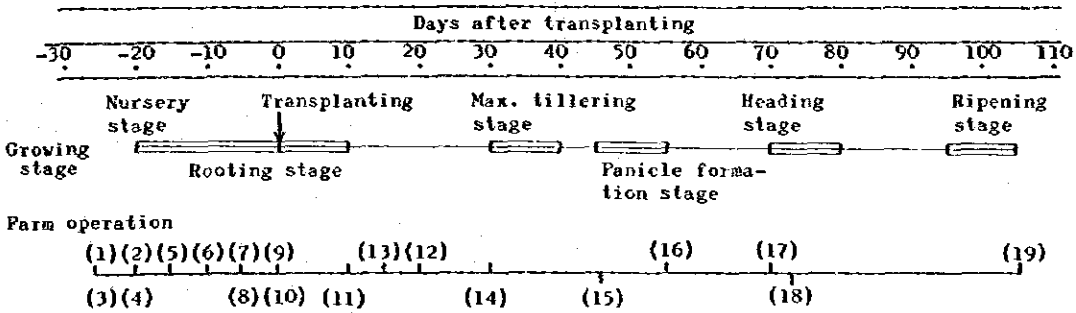


Fig.5.3 Proposed Farming Practices (Estate Farm)



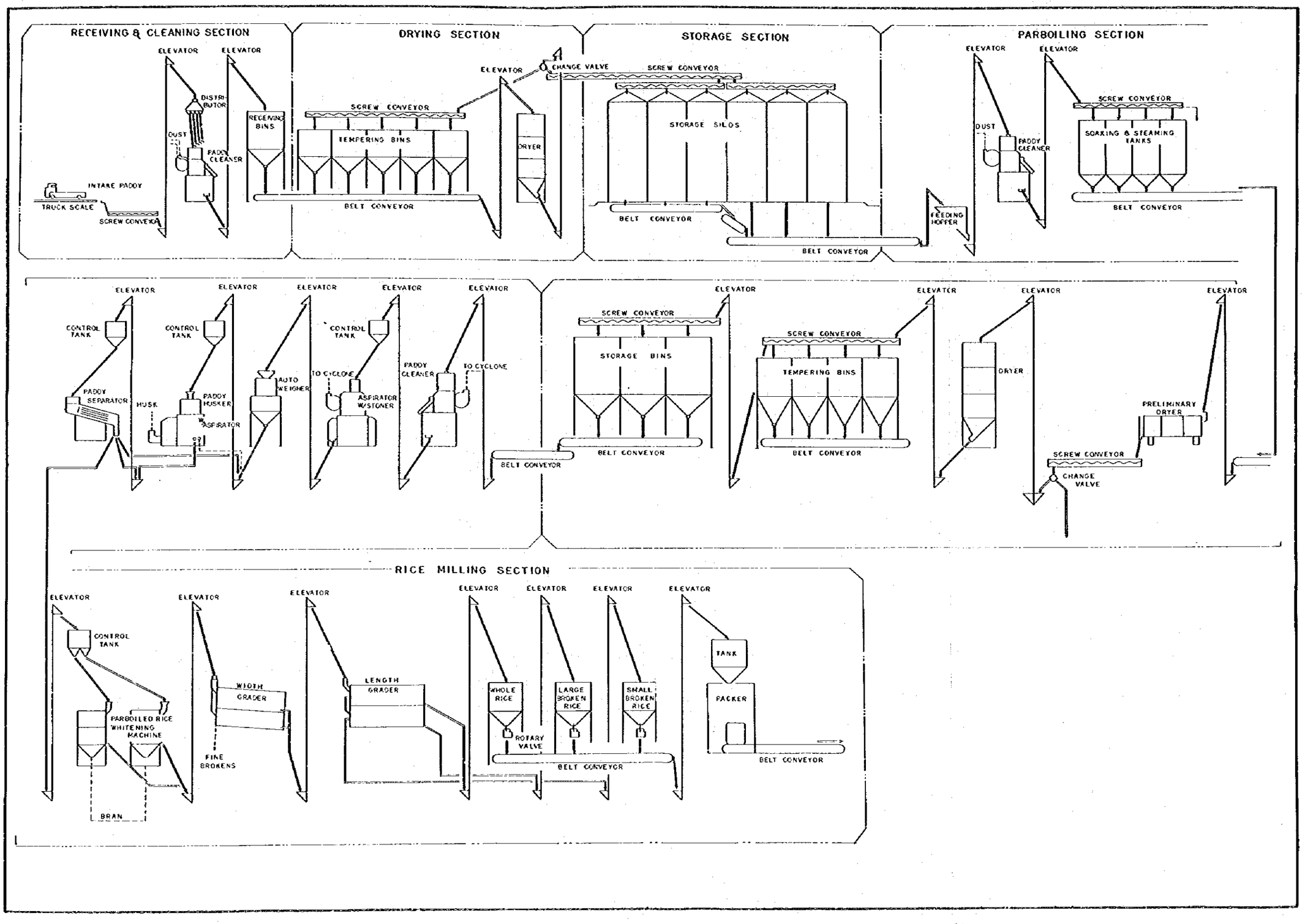
Operation Items	Operation Method	Attachment	Farm Inputs	Remarks
1) Cutting of used	40PS class tractor	Mower		
2) Burning	Man-power	-		
3) Plowing & harrowing	60PS class tractor	Disc Plow & disc harrow		First year 3 years interval
4) Rotavating		Rotavater		
5) Puddling	40PS class tractor	Puddling rake		
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	Potavater		
4) Seed treatment	Man-power	-	Seed: 35kg/ha Fungicide:6g/ha	
5) Ploving & 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. IRRIGATION PLAN

6.1 General

For sustaining the year-round rice culture proposed in the preceding 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

Consumptive 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 elevation 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 Preliminary 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 1.5m x 2.0m 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 Preliminary 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 Preliminary 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 Roads

6.6.1 Layout of Roads

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 : $5^{0}29^{1}N$

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	Sunshine hour 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
Peb.	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	157	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 Intersity 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 mm	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	0.18 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 (Trans-planting) 300 ha							0.42 0.11	0.22 0.24	0.11 0.11	0.10		
Paddy (Trans-planting) 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	$Q \geqq 1.0$ (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)

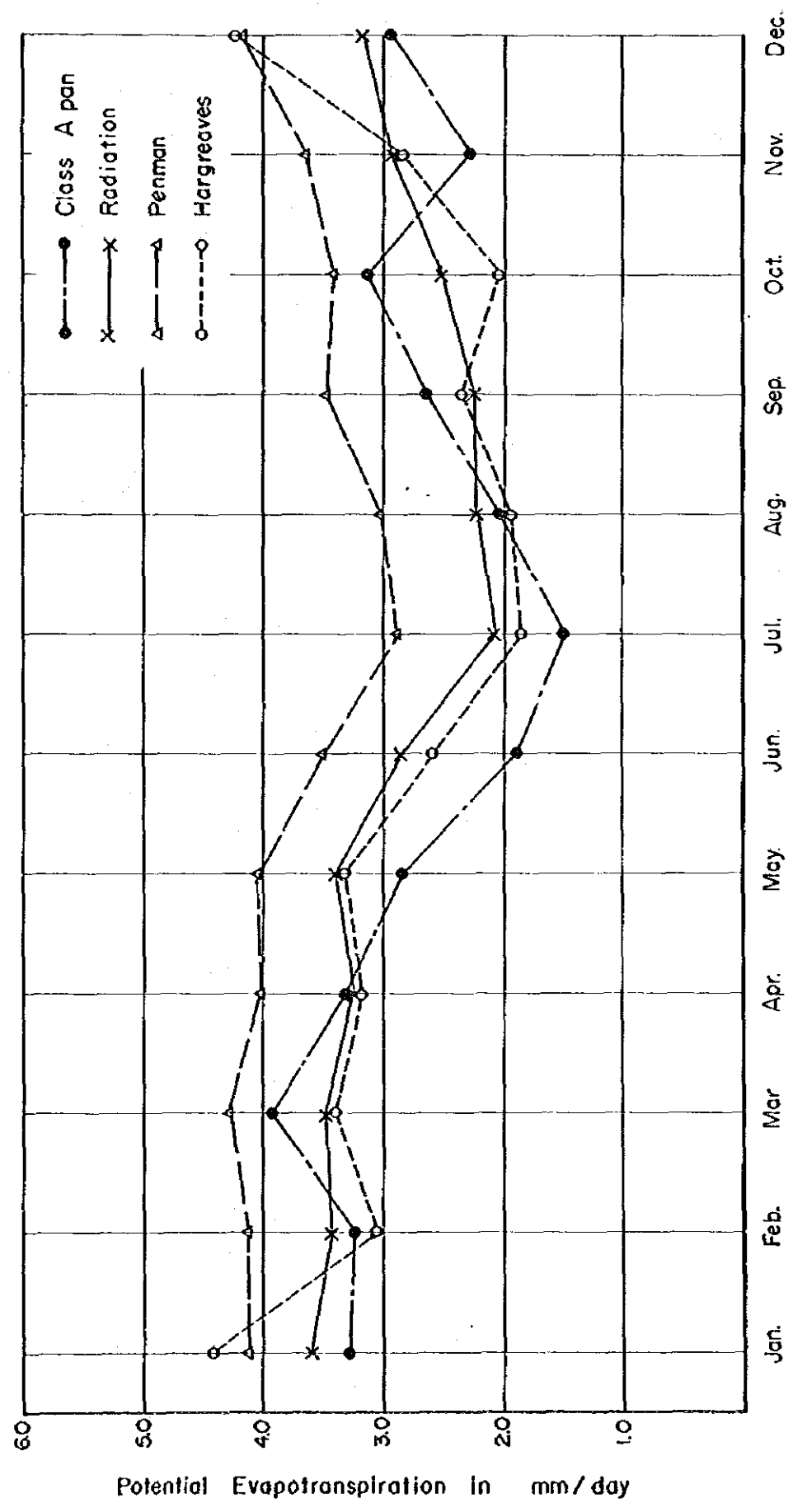


Fig. 6.1 Comparison of Potential Evapotranspiration at Umudike Station (1976)

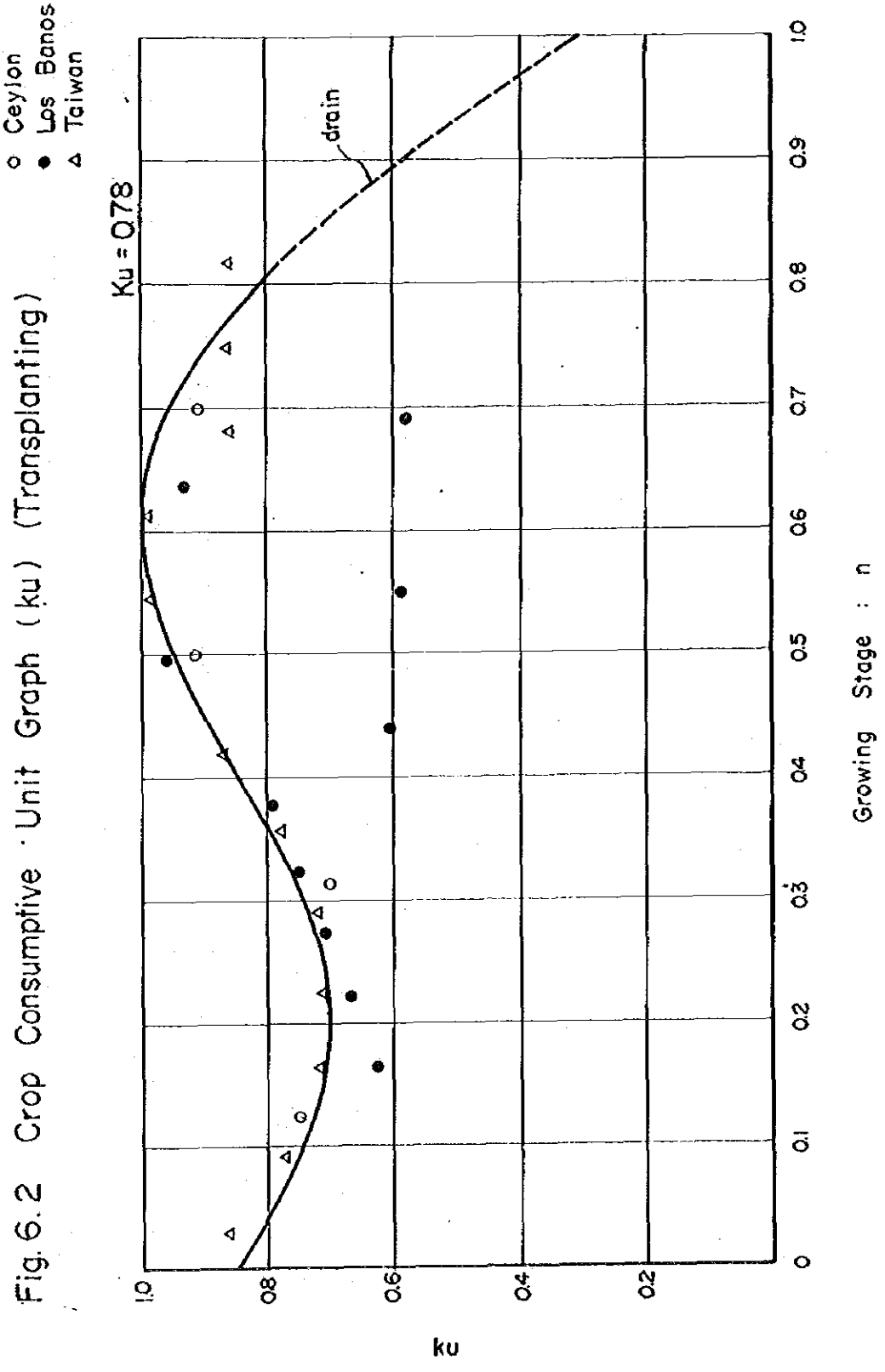


Fig. 6.2 Crop Consumptive Unit Graph (ku) (Transplanting)

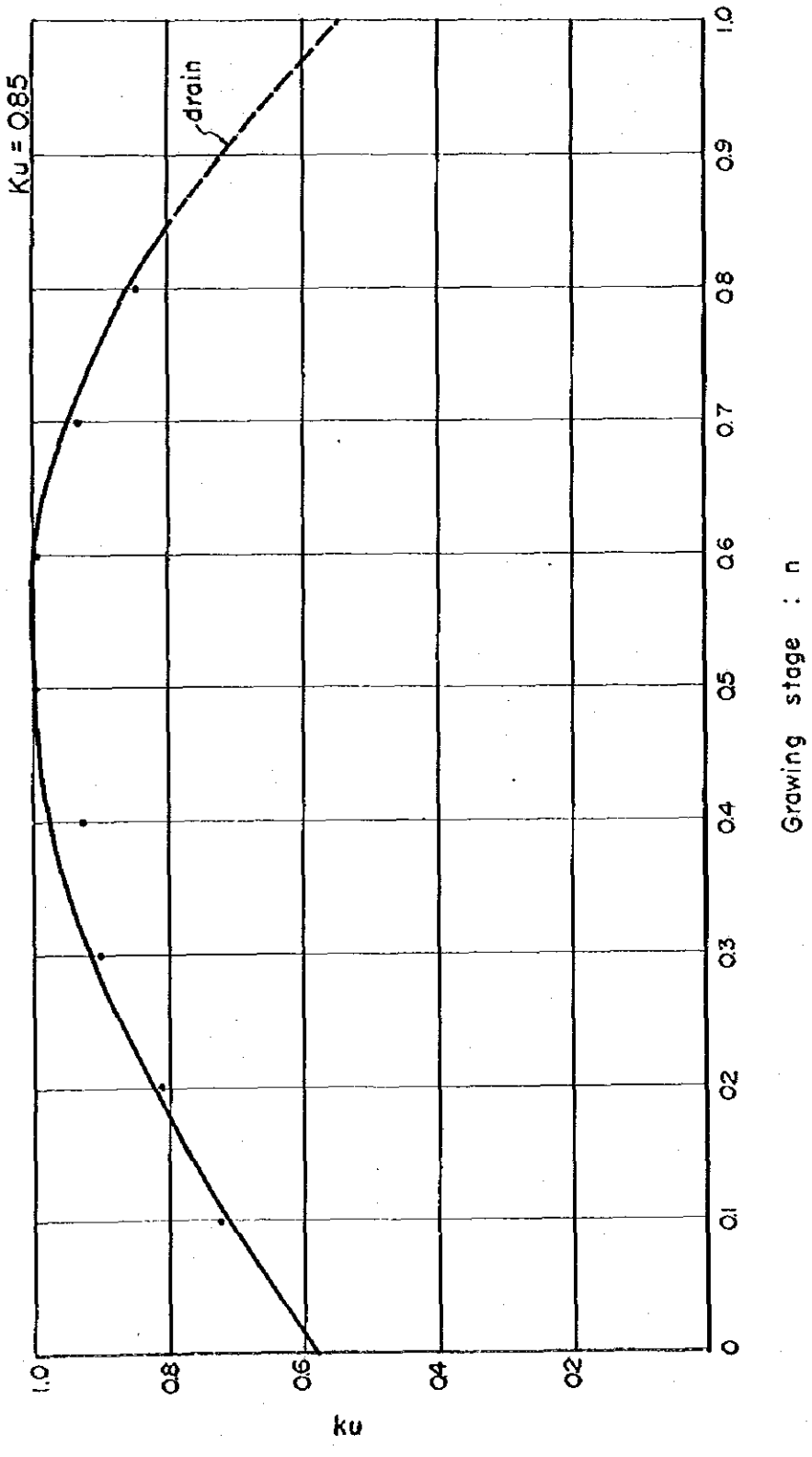


Fig. 6.3 Crop Consumptive Unit Graph (ku) (Direct Sowing)

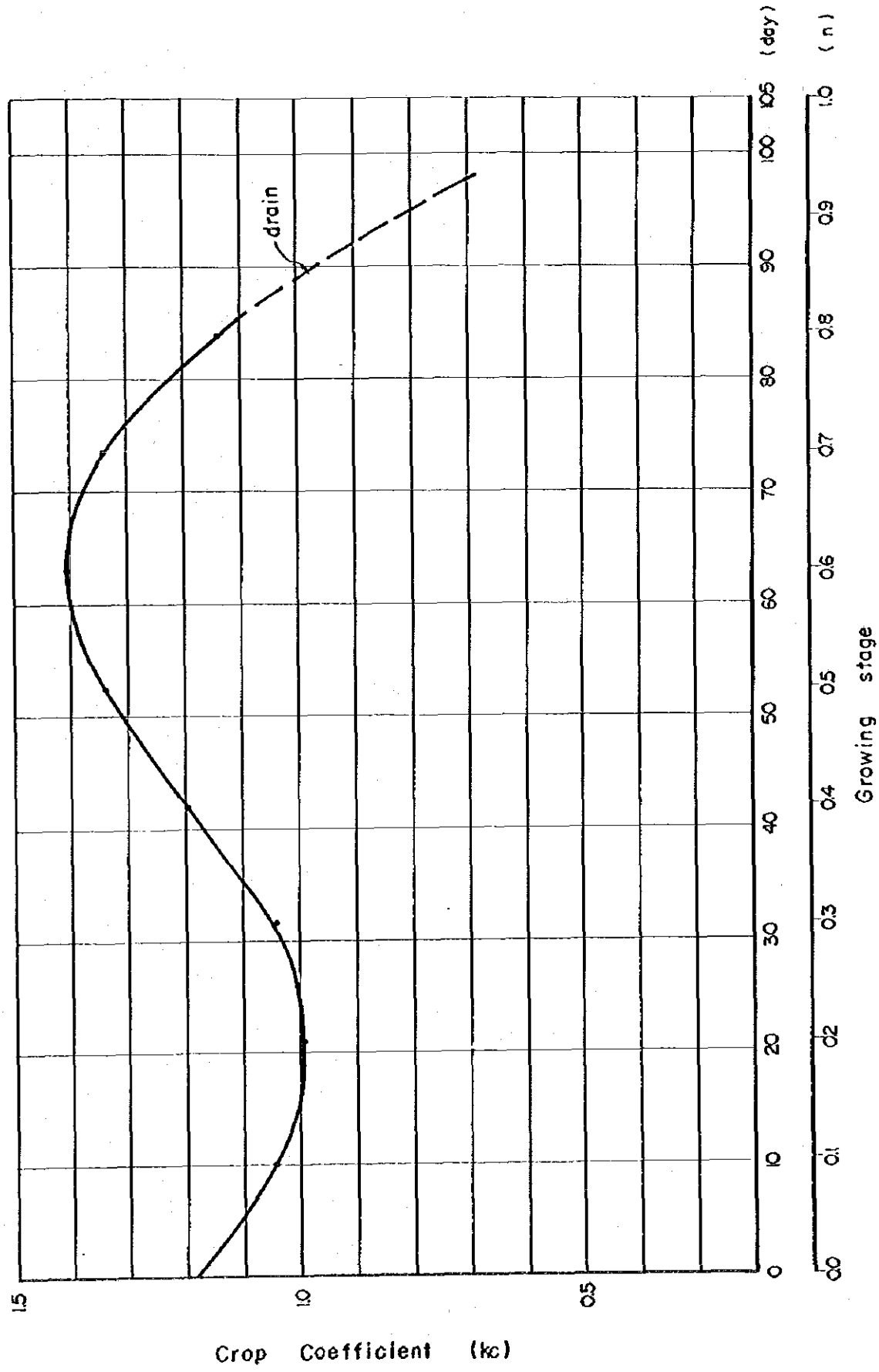


Fig. 6.4 Crop Coefficient for Paddy (Transplanting)

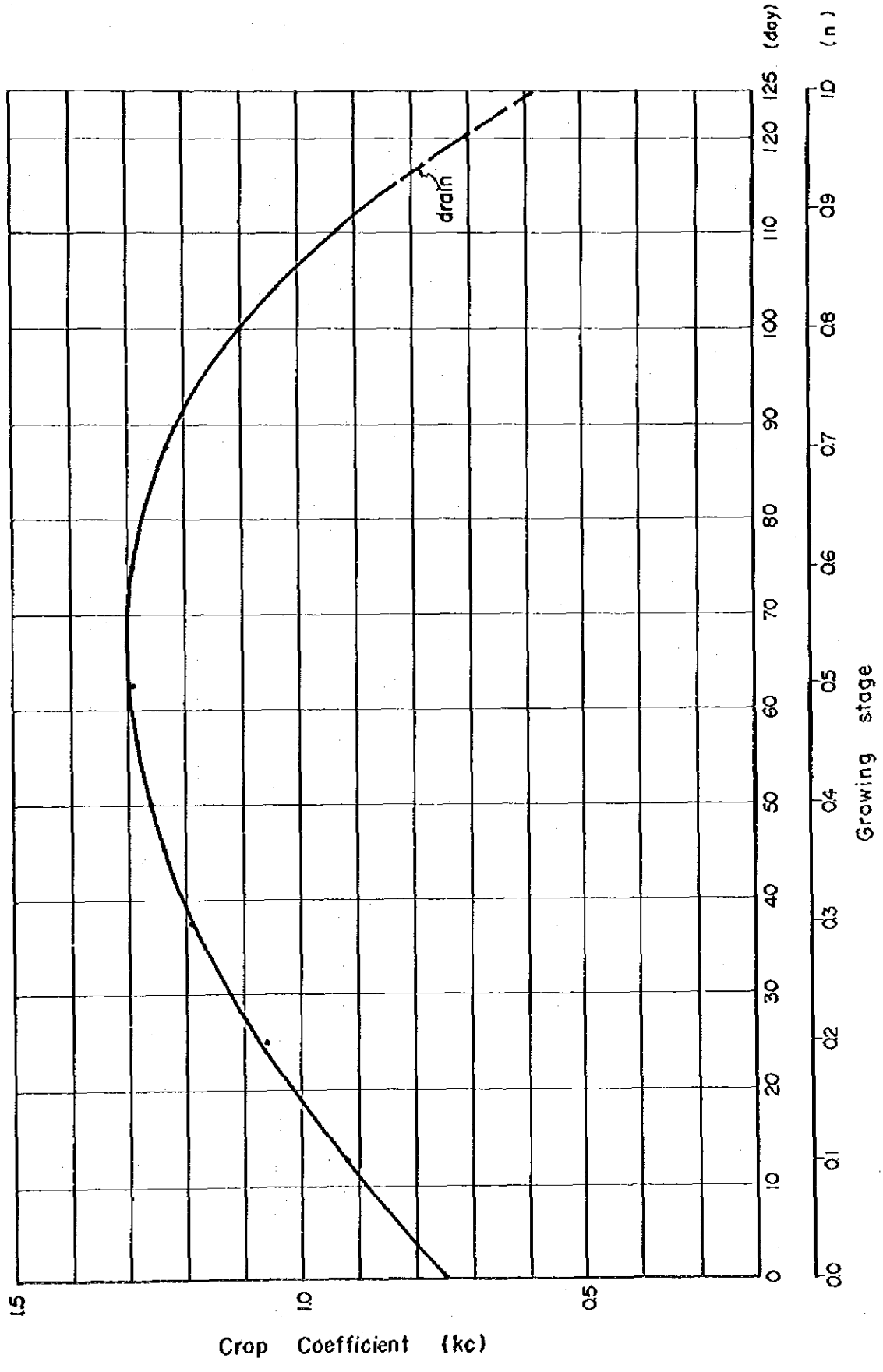
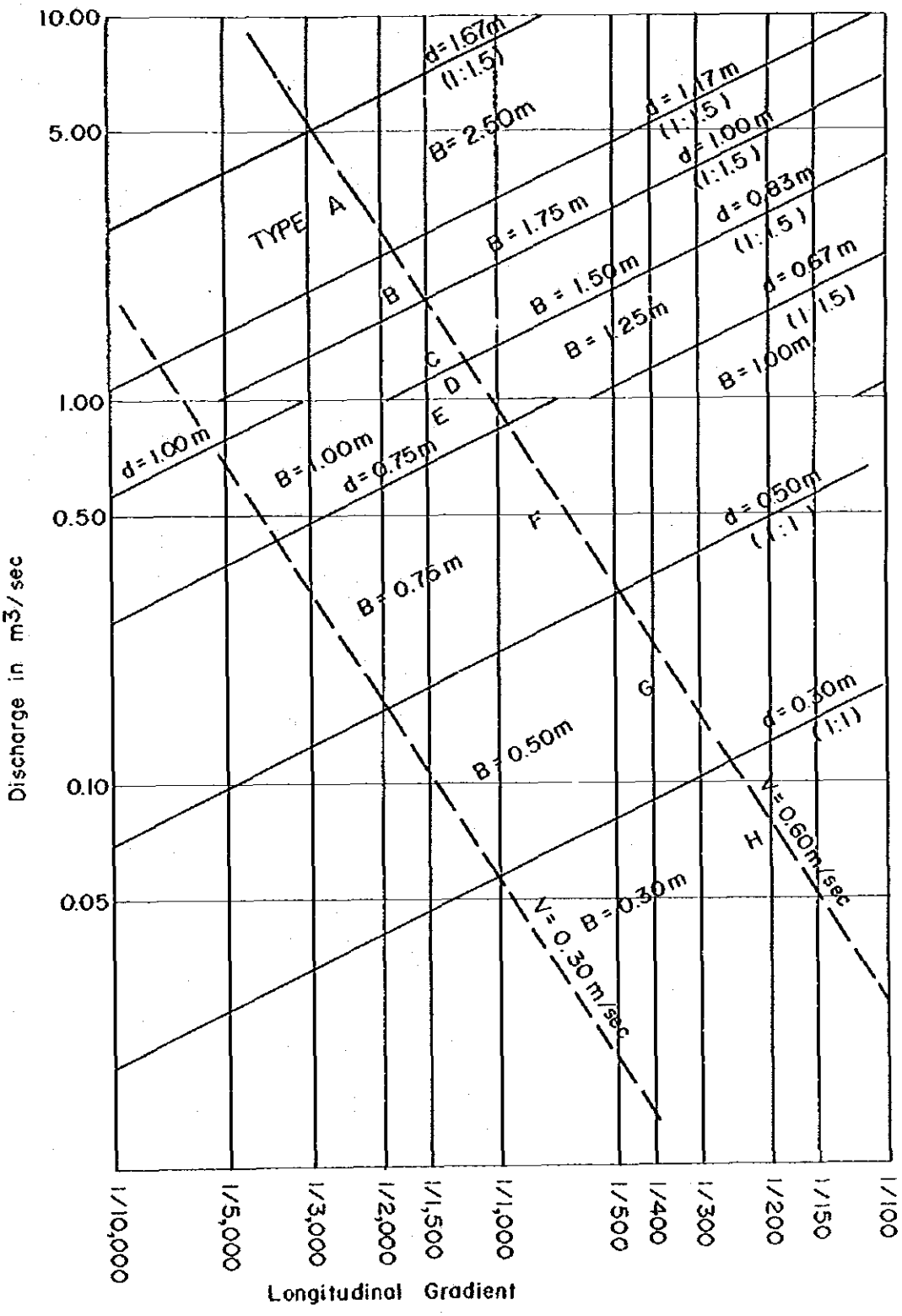


Fig. 6.5 Crop Coefficient for Paddy (Direct Sowing)

Fig.6.6 Classification of Canal Types

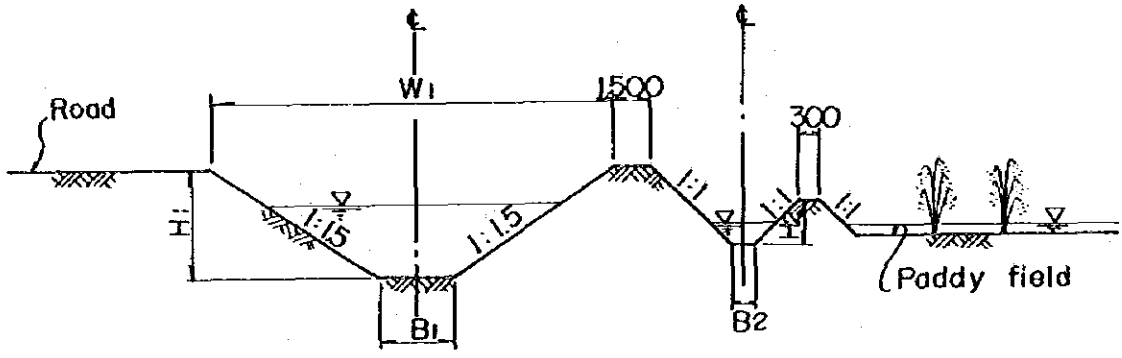


d : Water depth in m

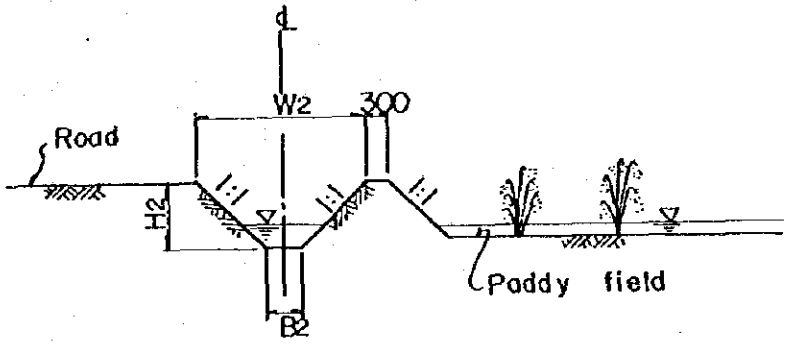
B : Canal bottom width in m

(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

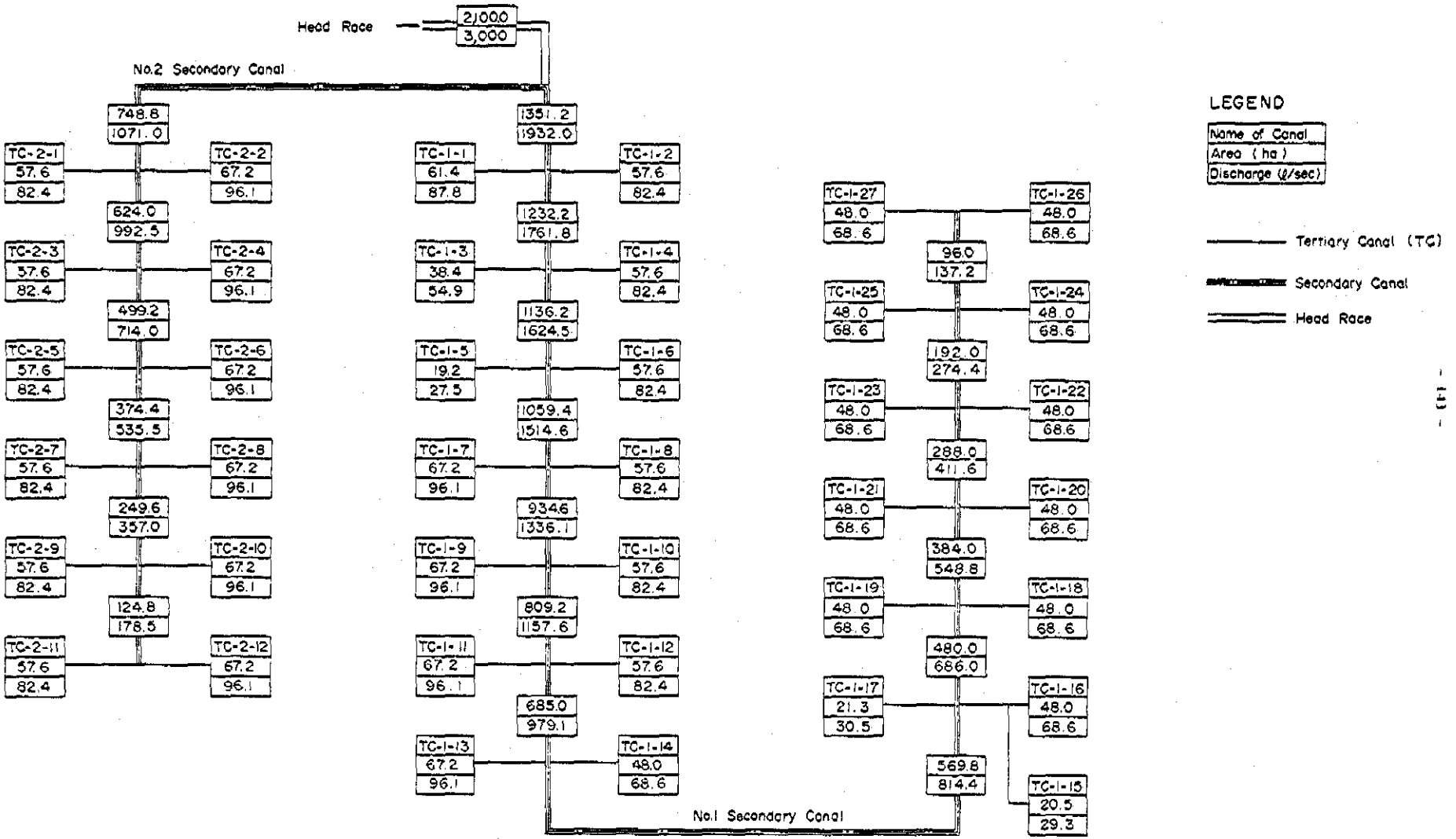


Fig. 6.9 Irrigation System Diagram for Auchi Project

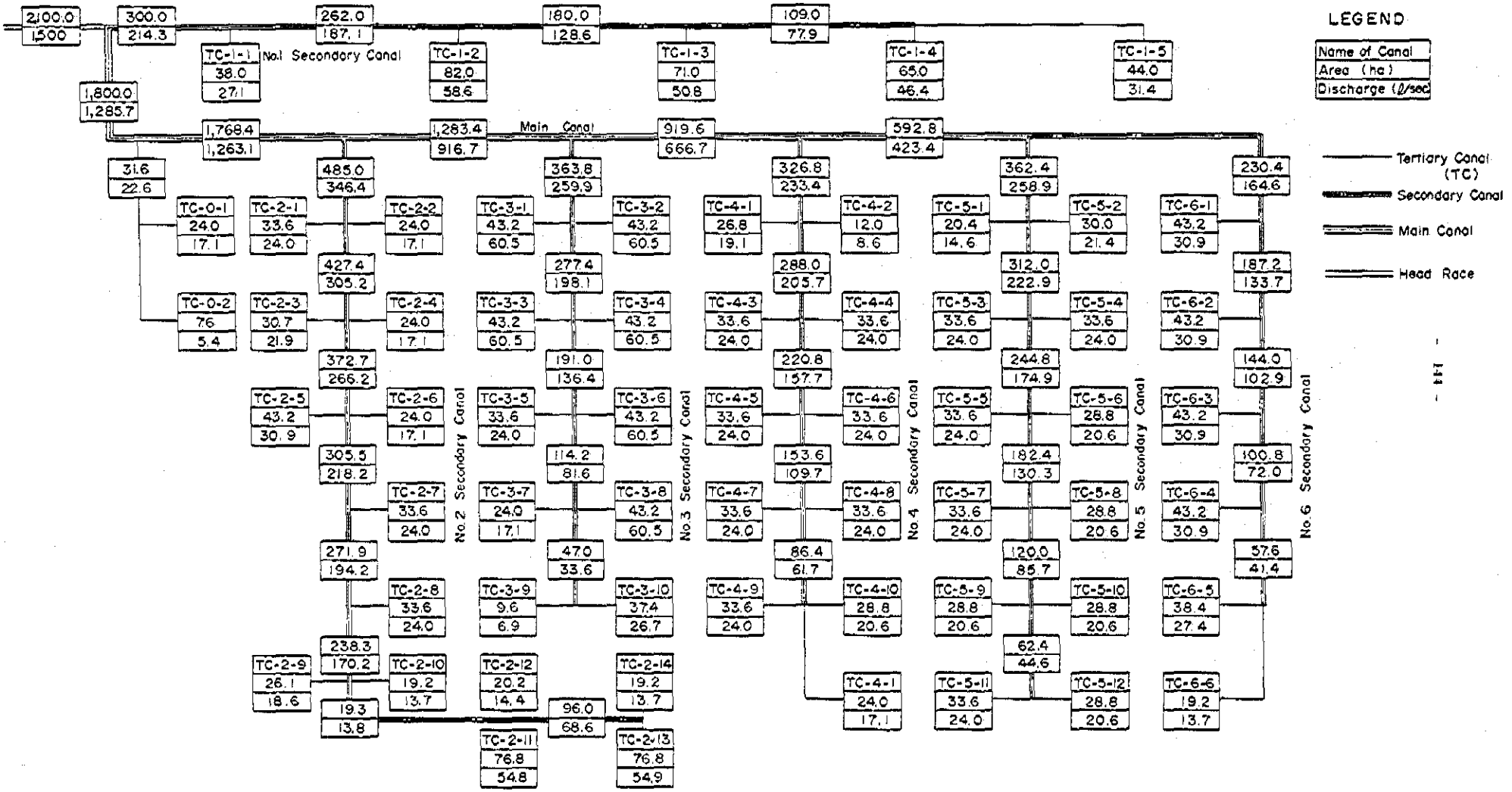


Fig. 6.10 Drainage System Diagram for Owerri Project

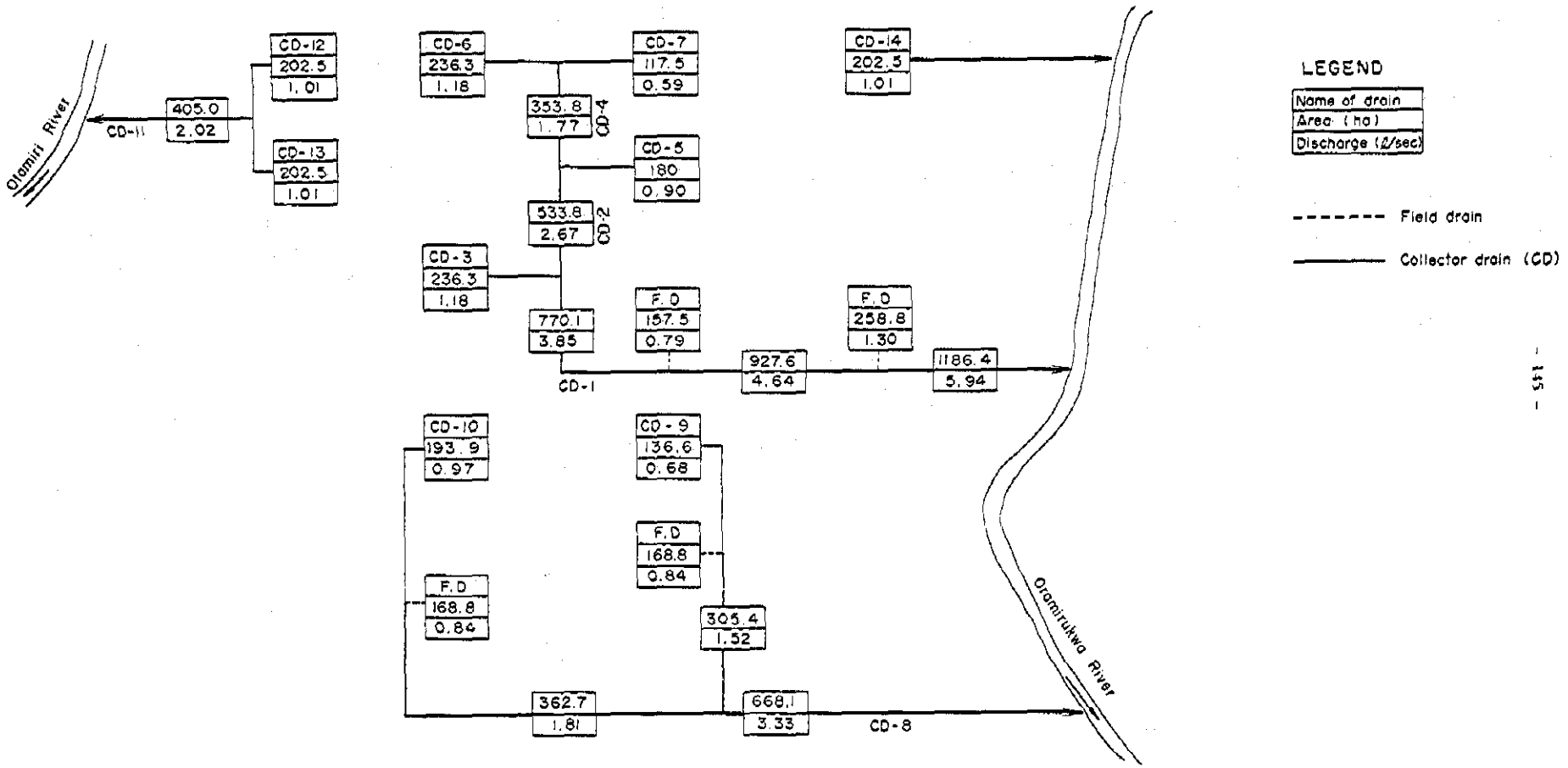


Fig.6.11 Drainage System Diagram for Auchi Project

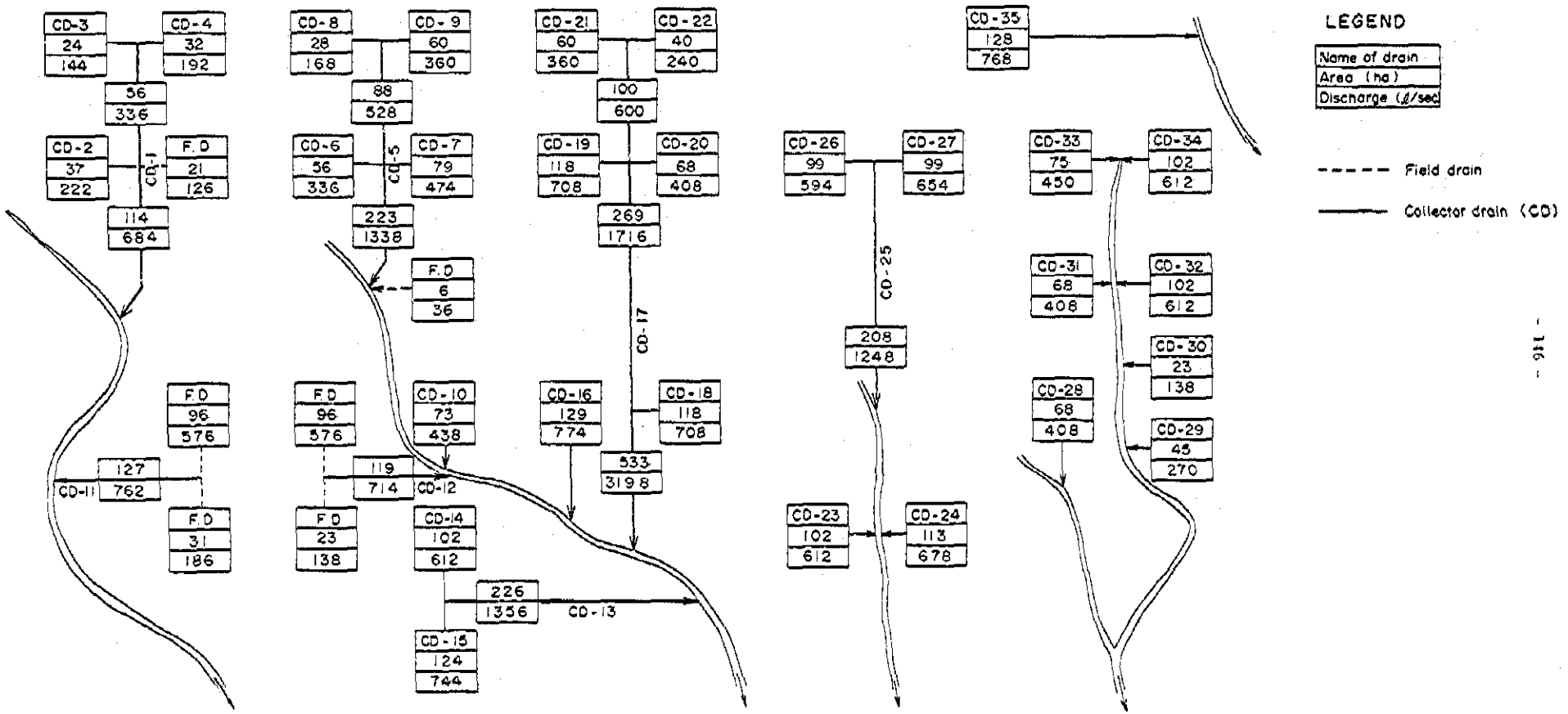
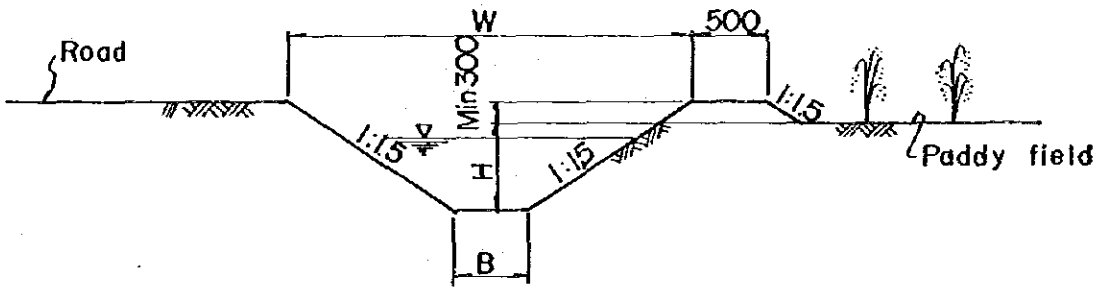
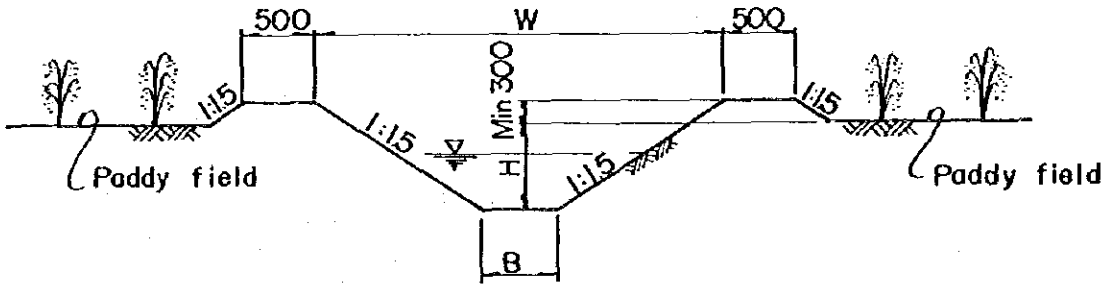


Fig. 6.12 Typical Sections of Drains.

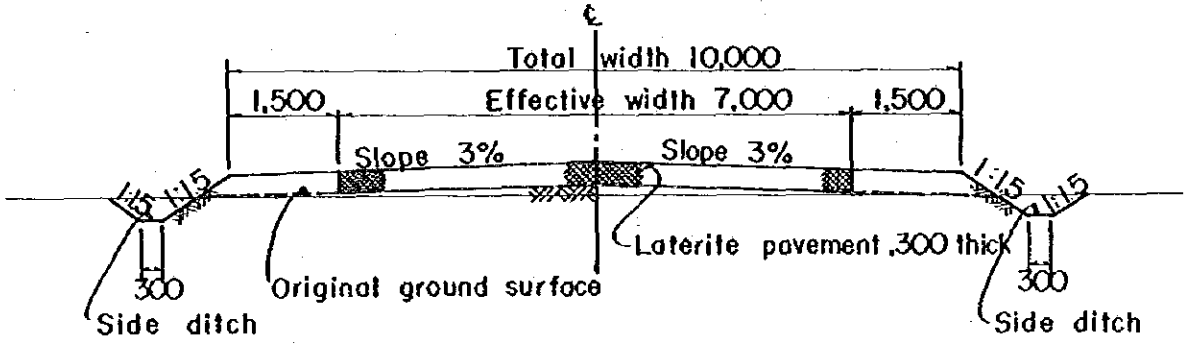


Collector Drain

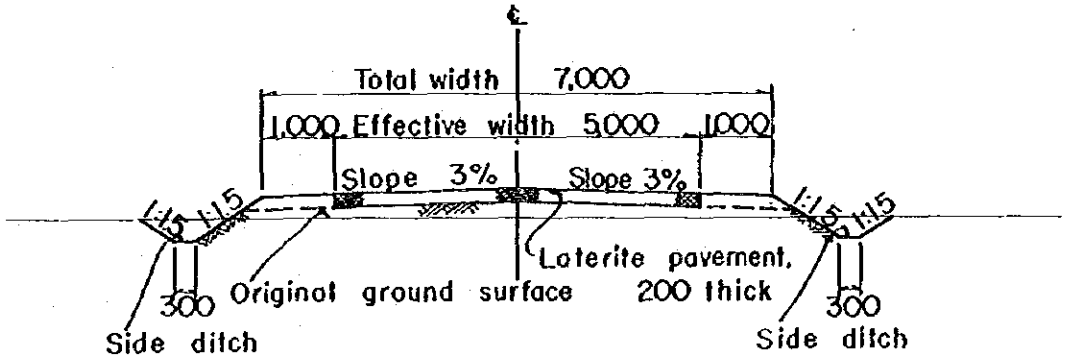


Field drain

Fig. 6.13 Typical Sections of Roads.

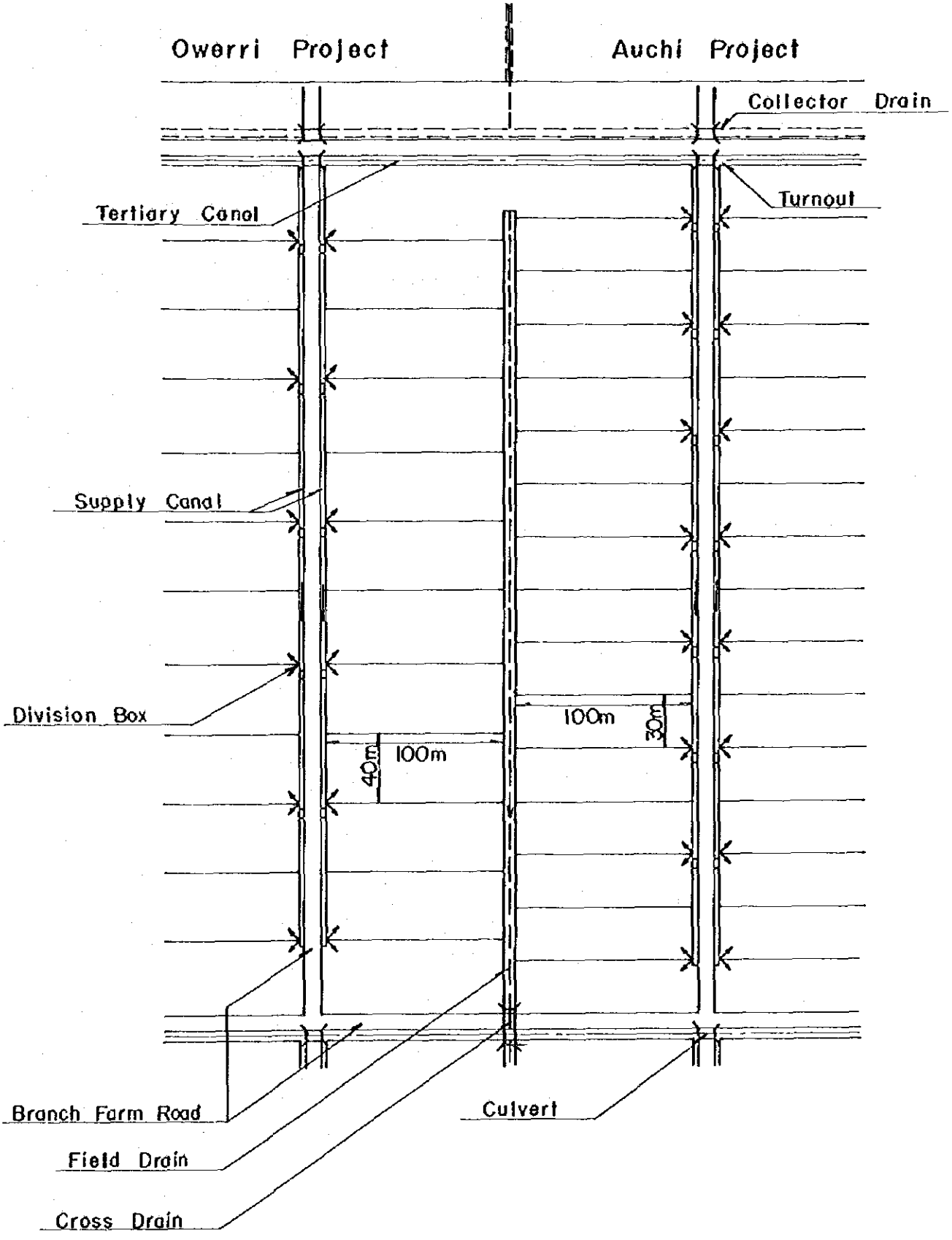


Main Road



Branch Road

Fig. 6.14 Typical Layout of Farm Unit



7. ORGANIZATION AND MANAGEMENT

7. 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 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 Engineer	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	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.

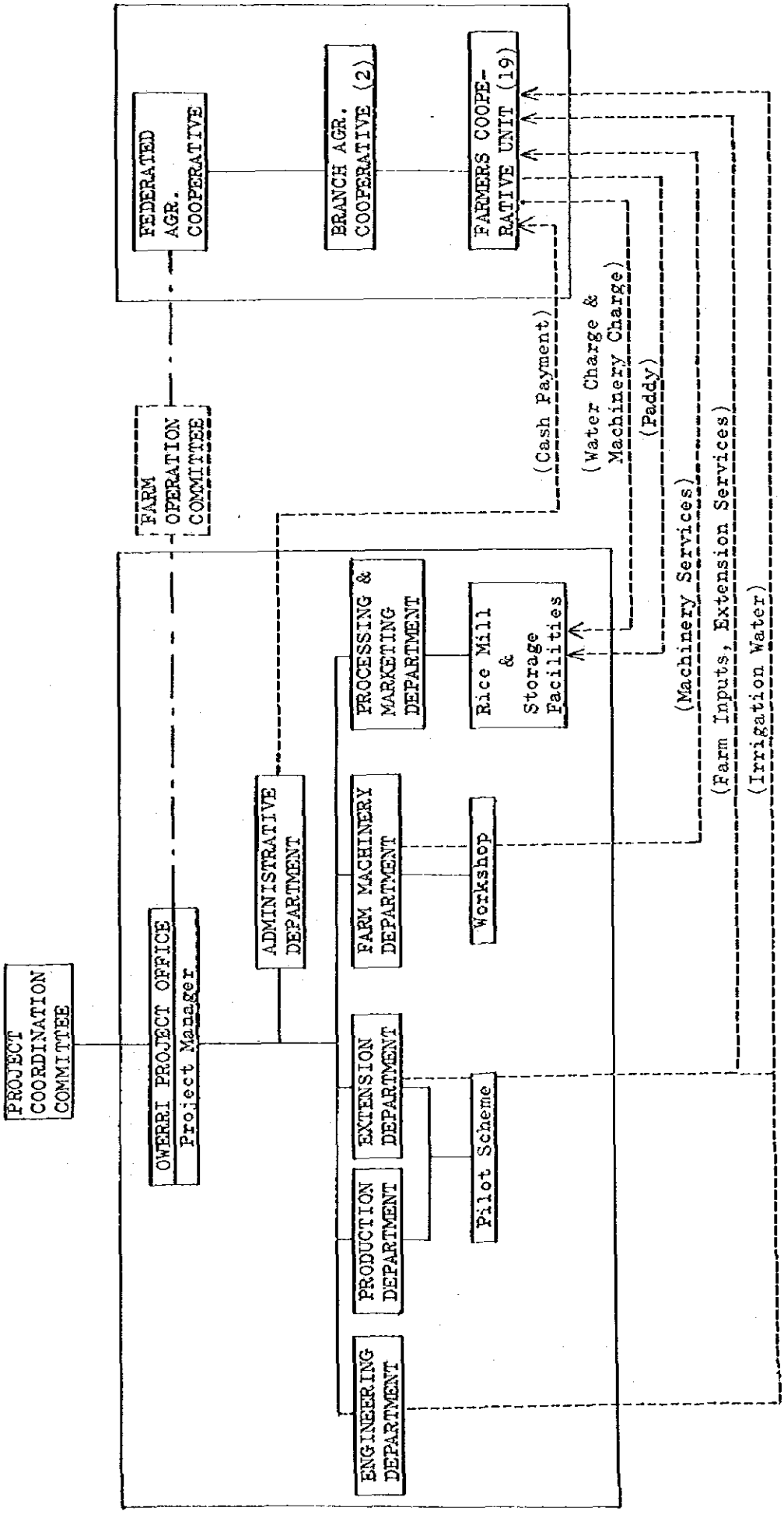


Fig. 7.1 Proposed Organization for Owerri Project

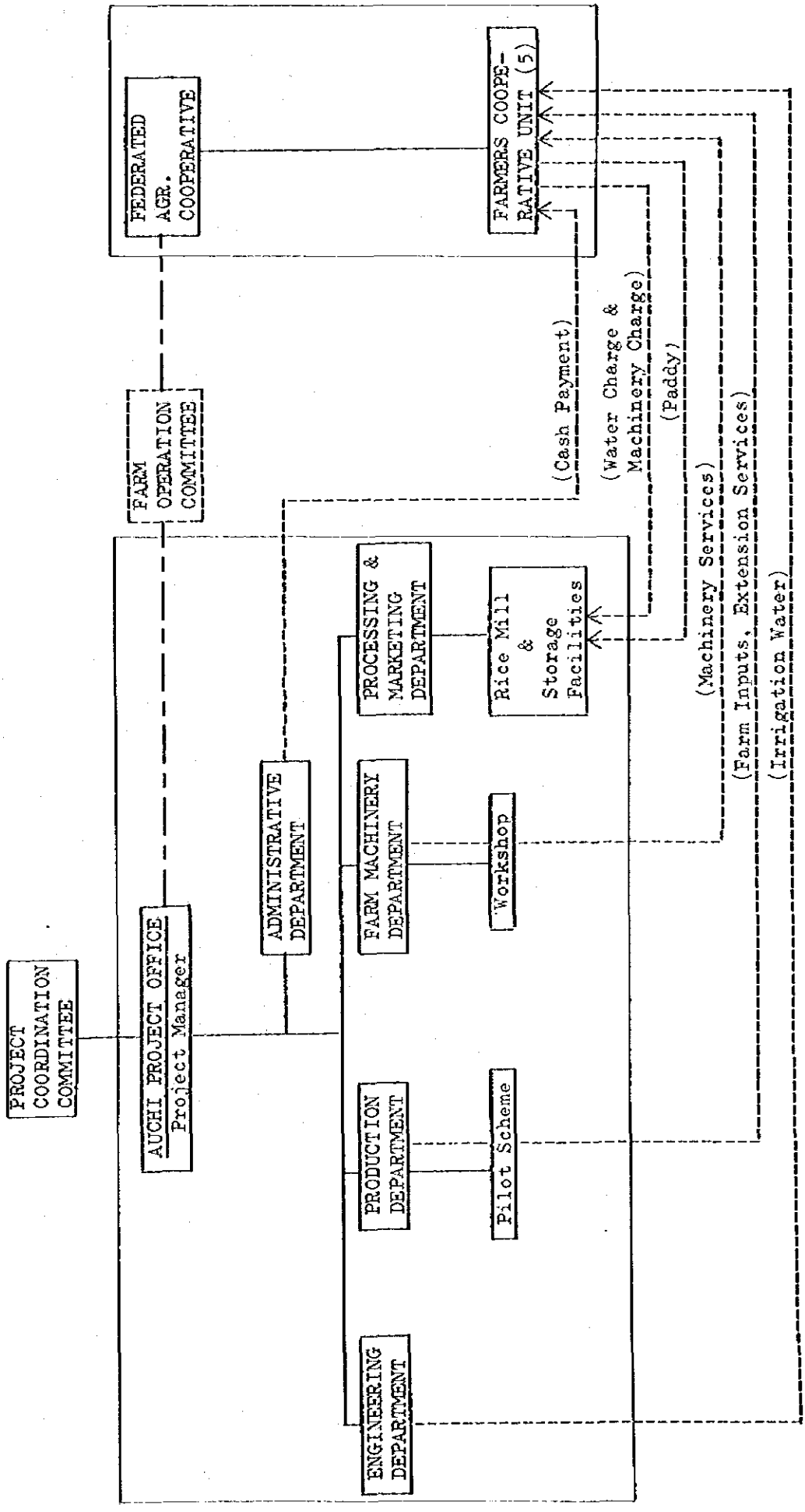
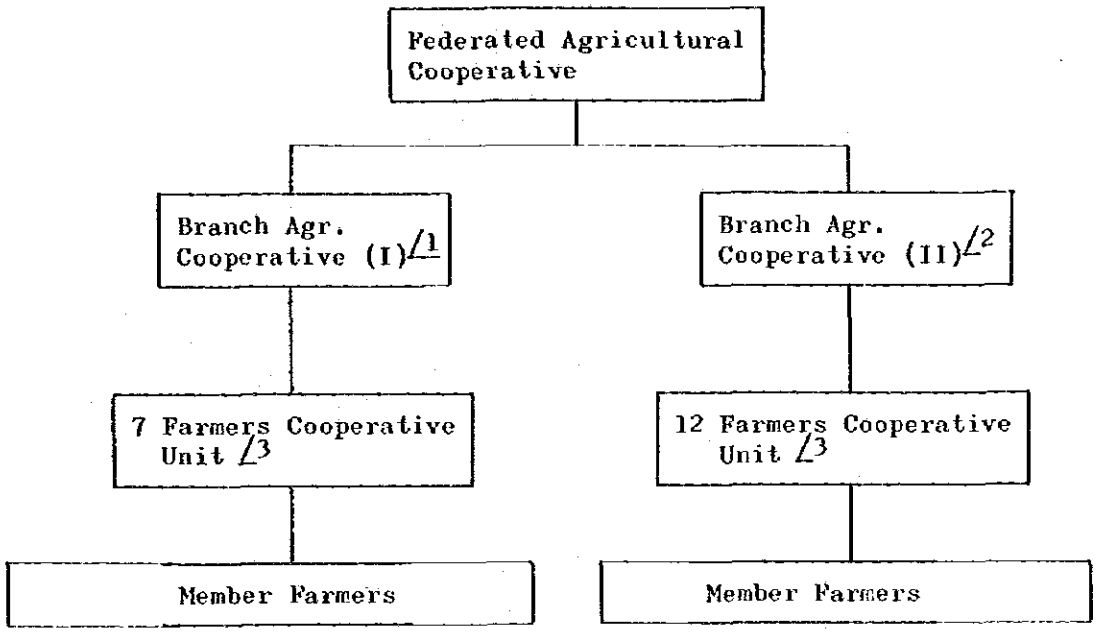


Fig. 7.2 Proposed Organization for Auchi Project

Fig. 7.3 Organization of Agricultural Cooperative for the Owerri Project

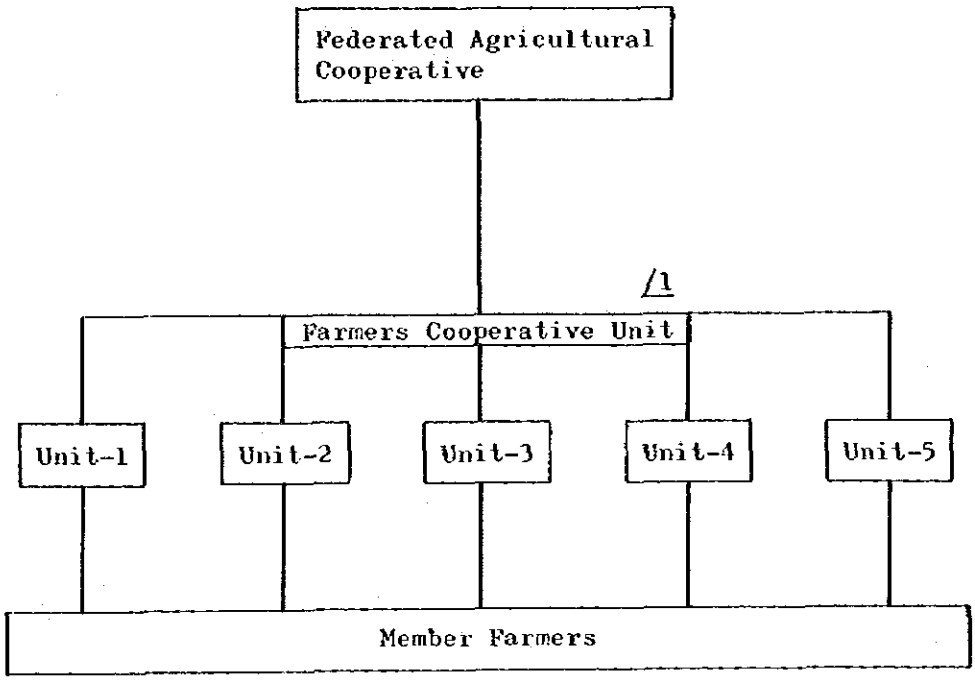


/1 The area covered by the Branch Agricultural Cooperative corresponds to the area to be commanded by No.1 Secondary Canal.

/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. 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 for 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 for 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	m^2	27,300
2.2 Excavation of Diversion Canal	m^3	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	m^3	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	m^2	278,000
3.2 Excavation	m^3	165,000
3.3 Embankment	"	116,000
3.4 Related Structures	LS	
4. Secondary Irrigation Canals	km	11.5
4.1 Stripping	m^2	47,000
4.2 Excavation	m^3	18,000
4.3 Embankment	"	25,000
4.4 Related Structures	LS	
5. Tertiary & Supply Canals	km	270
6. Drainage Canals	km	136.0
6.1 Collector Drains	"	26.0
6.2 Field Drains	"	110.0
7. Road	"	170
7.1 Main Road	"	20
7.2 Branch Road	"	150
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

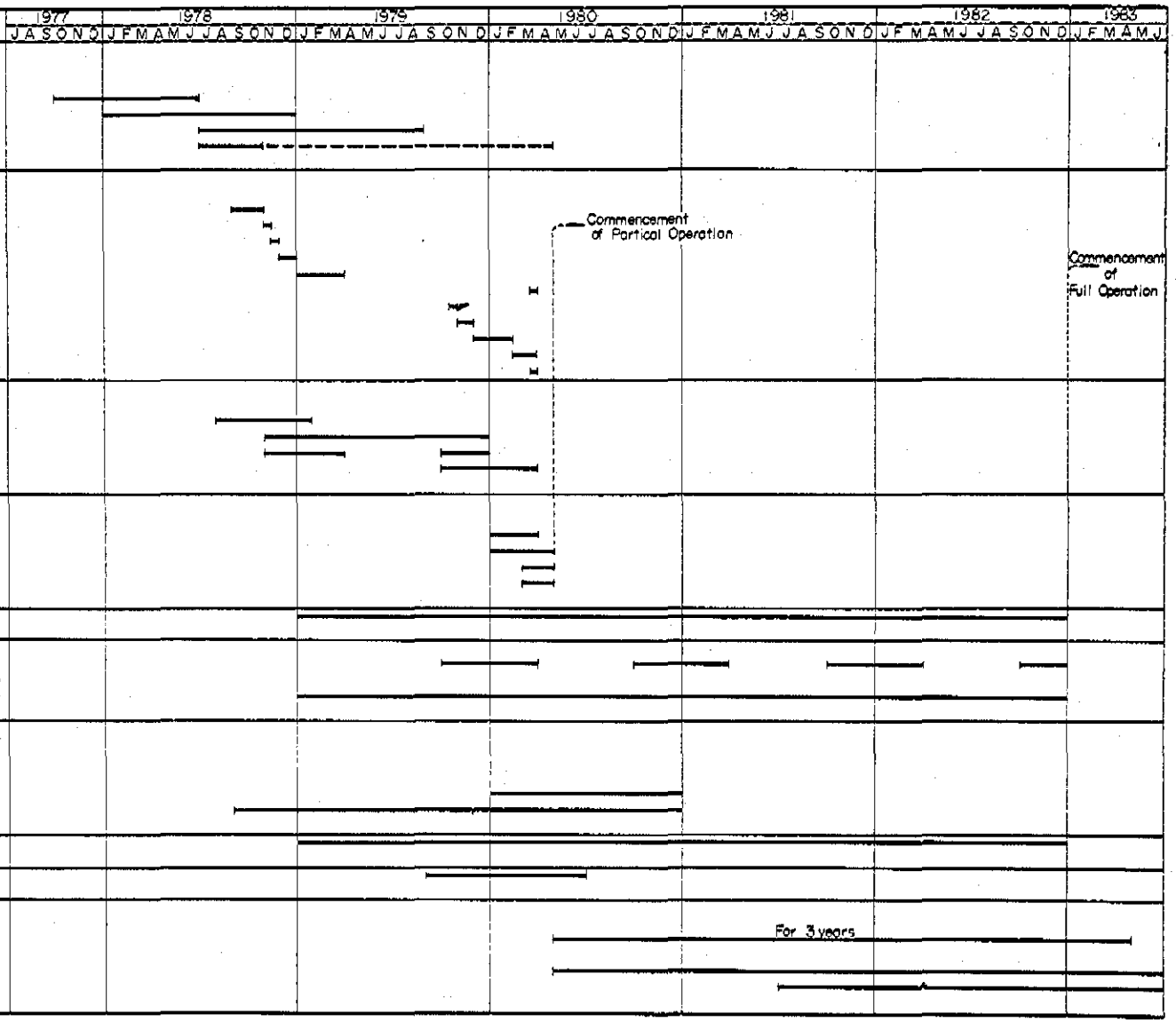
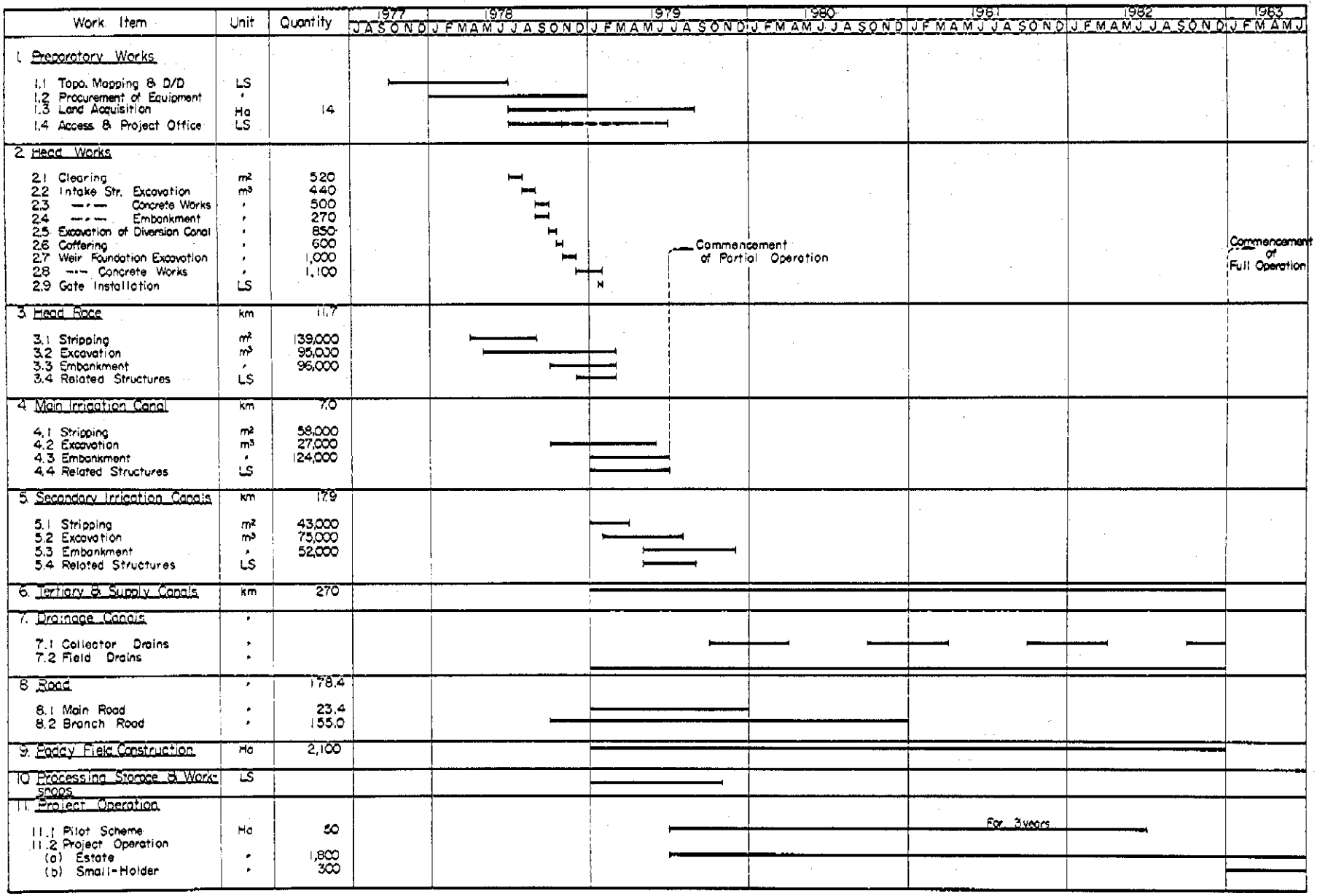


Fig. 8.2 Implementation Schedule for Auchi Project



9. COST ESTIMATE

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