THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF AGRICULTURE AND FOOD
AND NATURAL RESOURCES

# BASIC DESIGN REPORT
# ON
# THE EXPANSION OF
# THE AGRICULTURAL RESEARCH FARM

MARCH, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF AGRICULTURE, FOOD
AND NATURAL RESOURCES

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# THE EXPANSION OF
# THE ABU GASABA PILOT FARM



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# FOREWORD

Following the agreement reached between the Government of the Democratic Republic of the Sudan and the Government of Japan for cooperation on the expansion of the Abu Gasaba Pilot Farm, the Japan International Cooperation Agency (JICA) dispatched to the Sudan a basic design survey team consisting of five experts headed by Mr. R. Fujiya, Director of Development Division, Construction Department, Tohoku Regional Agricultural Bureau, Ministry of Agriculture, Forestry and Fisheries, for three weeks from October 29, 1977.

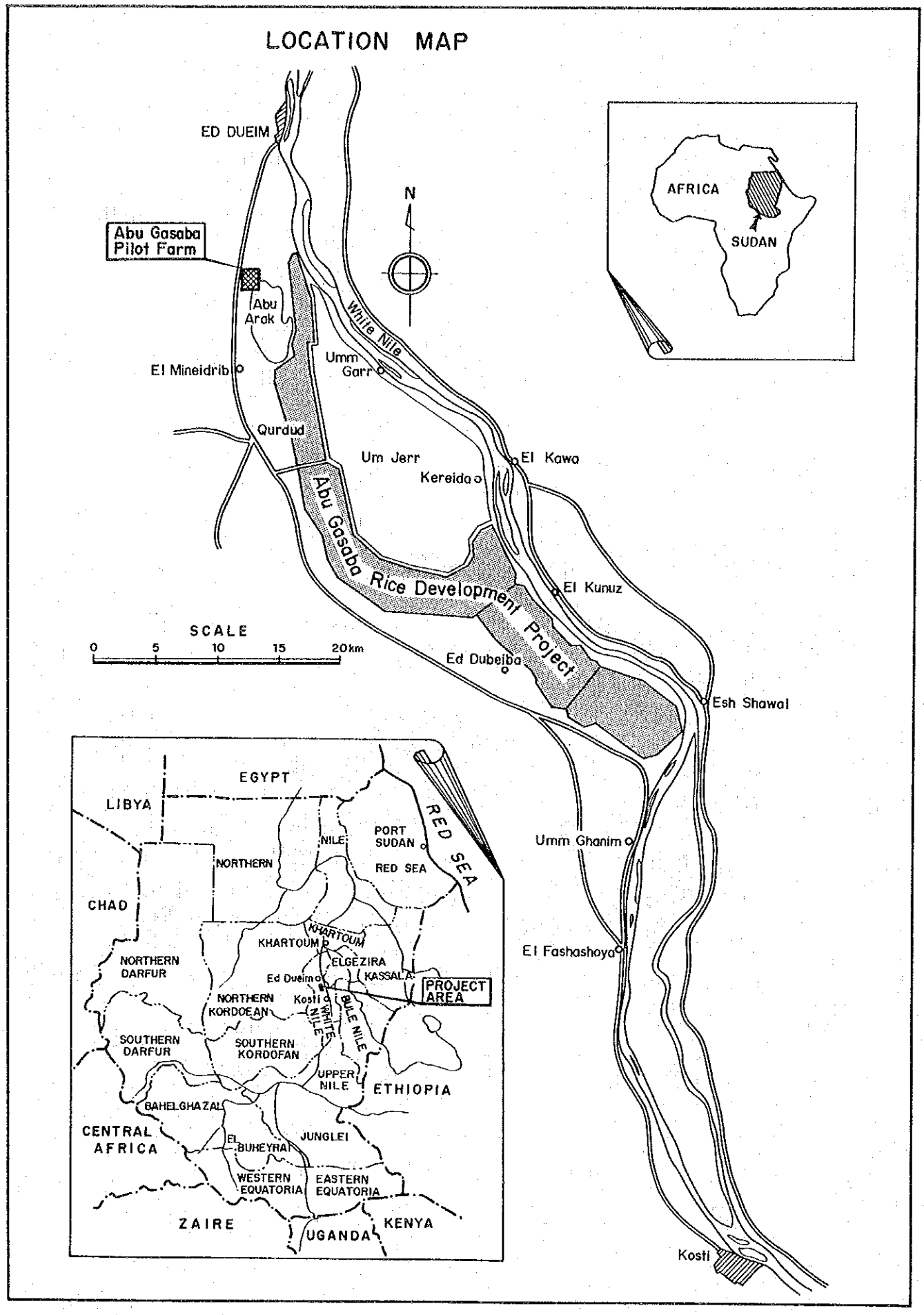
The report presented here has been compiled based on the results of the above survey as well as on the discussions which took place between the Sudanese Government officials concerned and the Japanese team for 10 days from February 22, 1979.

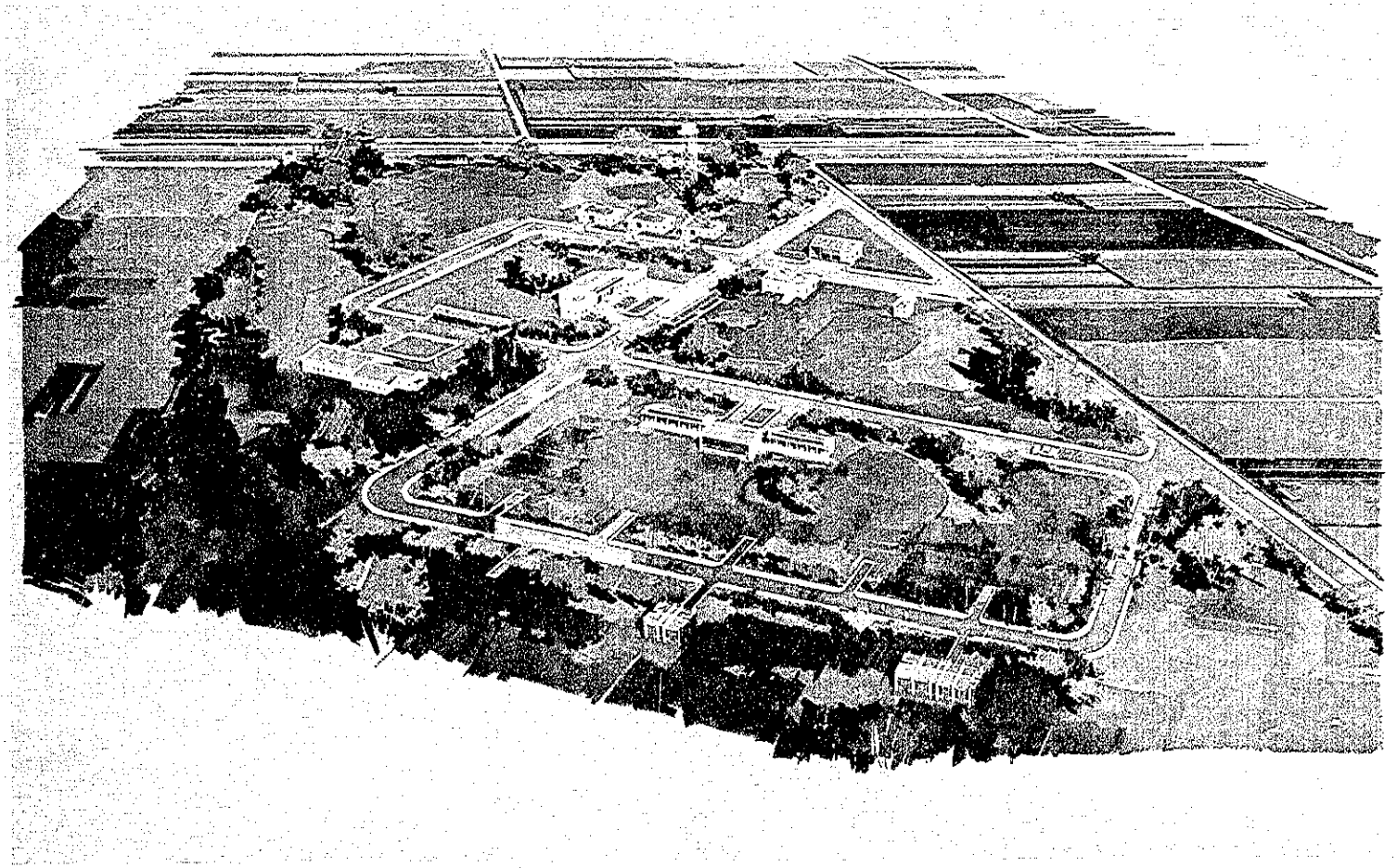
I hope that this report will be found to be useful for the social and economic development of the Sudan and will contribute to the promotion of friendship between the Democratic Republic of the Sudan and Japan.

I wish to express my heartfelt appreciation to the officials concerned of the Democratic Republic of the Sudan for their kind cooperation and assistance extended to our team.

March, 1979

Shinsaku HOGEN
President
Japan International Cooperation Agency


LOCATION MAP
ED DUEIM
Abu Gasaba Pilot Farm
Abu Arak
El Mineidrib
Umm Garr
White Nile
Qurdud
Um Jerr
Kereida
El Kawa
Abu Gasaba Rice Development Project
El Kunuz
Ed Dubeiba
Esh Shawal
Umm Ghanim
El Fashashoya
Kosti
N
AFRICA
SUDAN
SCALE
0 5 10 15 20km
EGYPT
LIBYA
CHAD
NORTHERN
NILE
PORT SUDAN
RED SEA
RED SEA
KHARTOUM
KHARTOUM
ELGEZIRA
KASSALA
NORTHERN DARFUR
Ed Dueim
PROJECT AREA
NORTHERN KORDOFAN
Kosti
WHITE NILE
BLUE NILE
SOUTHERN DARFUR
SOUTHERN KORDOFAN
UPPER NILE
ETHIOPIA
BAHELGHAZAL
CENTRAL AFRICA
EL BUHEYRA
JUNGLEI
WESTERN EQUATORIA
EASTERN EQUATORIA
ZAIRE
UGANDA
KENYA



PROSPECTIVE VIEW OF THE ABU GASABA PILOT FARM

BASIC DESIGN REPORT

ON

THE EXPANSION OF THE ABU GASABA PILOT FARM

CONTENTS

## ABBREVIATION

| | | | |
|---|---|---|---|
| km | kilometer | m | meter |
| cm | centimeter | mm | millimeter |
| t | ton | kg | kilogramme |
| g | gramme | $km^2$ | square kilometer |
| $m^2$ | square meter | ha | hectare |
| fedds | feddans | $m^3$ | cubic meter |
| ℓ | liter | $m^3$/sec | cubic meter per second |
| ℓ/sec/ha | liter per second per hectare | ℓ/sec | liter per second |
| $t/m^2$ | ton per square meter | $kg/cm^2$ | kilogramme per square centimeter |
| cm/sec | centimeter per second | m/sec | meter per second |
| hr(s) | hour(s) | mm/day | millimeter per day |
| kW | kilowatt | kVA | kilovolt ampere |
| oC | degree centigrade | % | percent |
| o | degree of angle | EL. | Elevation above mean sea level |
| PS | horse power | No(s) | Number(s) |
| L.S. | Lump Sum | S£ | Sudan pound |

# I. INTRODUCTION

## 1.1 Objective of Survey

At the request of the Government of Democratic Republic of the Sudan for the cooperation on the expansion of the 50-ha Pilot Farm which was implemented in the Abu Gasaba Basin under the 1977 Grant Aid of the Japanese Government, the mission conducted the field survey to confirm the details of the request, to collect data and information relevant to the expansion of the Pilot Farm and to prepare the basic designs of facilities to be involved in the expansion.

## 1.2 Survey Mission

The Survey Mission despatched to the Sudan consists of the following five members:

| | | |
|---|---|---|
| Leader | Ryoji FUJIYA | Director of Development Division, Construction Department, Tohoku Regional Agricultural Administration Bureau, Ministry of Agriculture, Forestry and Fisheries |
| Training Planning | Hiroyoshi TANABE | Chief of Training Section, International Cooperation Division, International Affairs Department, Ministry of Agriculture, Forestry and Fisheries |
| Institutional Facilities | Masashi SHONO | Director of Agricultural Department, Nippon Koei Co., Ltd. |
| Architecture | Hajime ENDO | Chief of Design Division Architectural Department, Nippon Koei Co., Ltd. |
| Cost Estimate | Yusaku TOHYA | Chief of 2nd Division Irrigation & Drainage Engineering Department, Nippon Koei Co., Ltd. |

The major activities of the Survey Mission during the stay in the Sudan are as summarized below:

| Date | Activities |
|---|---|
| 29/10/1978 | Left Tokyo for Khartoum via London |
| 30/10/1978 | Left London for Khartoum |
| 31/10/1978 | Arrived in Khartoum and made a courtesy call to Embassy of Japan |
| 1/11/1978 | 1) Visit to Ministry of Agriculture, Food and Natural Resources and courtesy call to State Ministers and First Under Secretary<br>2) Discussion with Director General of Agricultural Engineering Administration (A.E.A) and Director of Planning Administration about the expansion plan of the Gasaba Pilot Farm<br>3) Discussions with the staff of A.E.A. about the survey schedule |
| 2/11/1978 | Discussions with the staff of A.E.A. on details of the expansion plan of the Pilot Farm facilities and the training program |
| 3/11/1978 | 1) Inspection of various buildings in Khartoum.<br>2) Reporting the results of discussions to Embassy of Japan |
| 4/11/1978 | 1) Left Khartoum for Ed Dueim<br>2) Discussions with the staff of the White Nile Rice Project, Japanese rice specialist and the resident engineer of Nippon Koei. |

| Date | Activities |
|---|---|
| 5/11/1978 | 1) Courtesy call to Commissioner of the White Nile Province |
| | 2) Discussions with the Commissioner, Assistant Commissioner and Director of Agriculture Dept. of the White Nile Province about the progress of the 50-ha Pilot Farm construction and the expansion plan of the Farm |
| | 3) Inspection of the Rice Experiment Farm established by JICA |
| | 4) Inspection of the construction site of the 50-ha Pilot Farm and of the expansion area |
| 6/11/1978 | Team Leader, Mr. Tanabe & Mr. Shono |
| | 1) Discussion with the Health Dept. of White Nile Province about protection against malaria disease and bilharzia |
| | 2) Discussions with the staff of Public Works Office |
| | Mr. Endo & Mr. Tohya |
| | 1) Collection of data for construction cost estimation |
| | 2) Discussions with the staff of Public Works Office |
| 7/11/1978 | Team Leader, Mr. Tanabe & Mr. Shono |
| | 1) Discussions with the staff of A.E.A. |
| | 2) Inspection of the Khartoum University and discussions with the Dean of the Faculty of Agriculture |
| | Mr. Endo & Mr. Tohya |
| | 1) Collection of data on construction efficiencies, availability of labour, etc. |
| | 2) Left Ed Dueim for Khartoum |

| Date | Activities |
|---|---|
| 8/11/1978 | Team Leader, Mr. Tanabe & Mr. Shono |
| | 1) Left Khartoum for Wad Medani |
| | 2) Visited the Gezira Board and received information on the outline of the Gezira Scheme |
| | 3) Inspection of the Rice Experiment Station and discussion with the Chief of Rice Laboratory about rice culture |
| | Mr. Endo & Mr. Tohya |
| | 1) Visit to Ministry of Public Works and collection of data on standard building designs |
| | 2) Discussion with the staff of A.E.A. about details of facilities to be proviced under the expansion plan |
| | 3) Survey on availability of local contractors |
| 9/11/1978 | 1) Survey on availability of spare parts of construction equipment and repair shop facilities |
| | 2) Inspection of various facilities in Khartoum |
| 10/11/1978 | Meeting of the Mission members |
| 11/11/1978 | Meeting of the Mission members and preparation of the draft plan of training facilities |
| 12/11/1978 | Inspection of a private farm in the suburbs of Khartoum |
| 13/11/1978 | Inspection of a farm commanded by the Gezira Irrigation System |
| 14/11/1978 | 1) Discussions with the Director General of Planning Administration and Director General of A.E.A. about the Rice Development Project in Abu Gasaba Basin and the expansion plan of the Pilot Farm |
| | 2) Discussions with Director General of Agricultural Production Public Corporation |

| Date | Activities |
|---|---|
| 15/11/1978 | 1) Courtesy call to and discussion with Minister for Agriculture, Food and Natural Resources |
| | 2) Final discussion with the staff of A.E.A. |
| 16/11/1978 | Left Khartoum for Tokyo via London |
| 17/11/1978 | Left London for Tokyo |
| 18/11/1978 | Arrived in Tokyo |

1.3 List of Personnel Concerned

1) Ministry of Agriculture, Food & Natural Resources

| | |
|---|---|
| H.E. Dr. Abdalla | Minister |
| H.E. Dr. M. O. Elshazali | State Minister |
| H.E. Dr. Yasiem Hakim | State Minister |
| Mr. Gafar El Hassan | First Under Secretary |
| Mr. Towfik Hashim | Director General, Planning Administration |
| Dr. Mohamed Ibrahim | Director, Planning Administration |
| Dr. Abdien Hassan Abdoun | Director General, Engineering Administration |
| Mr. Gasim Ibrahim Hassan | Deputy Director General Engineering Administration |

2) White Nile Provincial Gov't

| | |
|---|---|
| Mr. Mohamed Elsayed Elshoar | Commissioner, White Nile Province |
| Mr. Mofied Berum | Director, Agricultural Service Office |

3) White Nile Rice Project

| | |
|---|---|
| Mr. Rayah A. El Zubeir | Manager |
| Mr. Isam Mustafa | Site Manager |
| Mr. Ali El Amin | Senior Agronomist |
| Mr. Ali Abdel Wahab | Agricultural Engineer |

| | |
|---|---|
| Mr. Ahmed El Sideg | Agricultural Engineer |
| Mr. Hassan Omer | Assist. Agronomist |

4) Agricultural Production Public Corporation

| | |
|---|---|
| Mr. Bayumi | Director General |

5) Khartoum University

| | |
|---|---|
| Dr. A. G. H. Khattab | Dean, Faculty of Agriculture |

6) Sudan Gezira Board & Research Corporation

| | |
|---|---|
| Dr. Mohd. Osman Mohd. Salih | Director, Research Corporation |
| Dr. George I. Ghabrial | Chief of Rice Laboratory |

7) Gezira University

| | |
|---|---|
| Dr. Hassan El Tak | Dean, Faculty of Agriculture |

8) Embassy of Japan in Khartoum

| | |
|---|---|
| H.E. Ambassador Hirano | |
| Mr. Hoshino | Counselor |
| Mr. Nishimura | Second secretary |
| Mr. Yoshida | Third secretary |

9) C/P Expert

| | |
|---|---|
| Mr. H. Niki | Rice specialist |

10) Others

| | |
|---|---|
| Mr. A. Sampei | Resident Engineer, Nippon Koei |
| Mr. A. M. Abdoun | Chairman of Amin Enterprises |

## 1.4 Summary of Discussions

The Survey Mission visited the Ministry of Agriculture, Food and Natural Resources of the Government of the Sudan and explained to the First Under Secretary, Director General of the Planning Administration and Director General of the Agricultural Engineering Administration the purposes of the survey, the survey schedule and the general rules of the Japanese Grant Aid. Further, the Mission had several discussions with the officials of the Sudan Government on the expansion plan of the Gasaba Pilot Farm. The summary of the discussions is as follows:

(1) Expansion of Experimental Fields and Farm Buildings

The Mission presented a rough plan for the exapnsion of experimental fields and farm buildings in the Pilot Farm, which are based on the detailed designs prepared in March 1978 under the 1977 Grant Aid. The rough plan presented by the Mission consists of i) the construction of experimental fields, irrigation and drainage canals and farm roads, ii) the construction of an irrigation pump station with an inlet channel, iii) the construction of a flood dike, a drainage pump station and a flood gate, and iv) the construction of farm buildings including a garage, warehouses, residential quarters, a work shed, guard houses and related utilities. The Mission further explained that the scale, size and extent of the above facilities would be adjusted through the formulation of the final expansion plan.

The Sudanese Authorities concerned agreed in general to the above rough plan, but expressed their wishes to have more building facilities and equipment rather than have more experimental fields. They, however, specified that the expansion of the fields be made for at least 50 ha in the lowland.

(2) Training Facilities

The Mission presented a tentative training plan consisting of three training courses involving 44 trainees per annum, and including provision of training facilities comprising a training center building, a dormitory for trainees, a repair shop and a garage.

The Sudanese Authorities expressed no special comments on the above plan but they desired that i) the dormitory for trainess should be provided separately for each of senior and junior groups, and ii) a standard curriculum for each training course together with the proposed qualifications of trainees should be added to the Basic Design Report to be prepared by the Mission.

(3) Agricultural Machineries and Training Equipment

The Mission explained that the expansion plan of the Pilot Farm might also include the supply of machineries and equipment required for the operation of the Pilot Farm, and that such supply would be made in strict accordance with the pertinent rules and regulations of the Japanese Government.

The Sudanese Authorities desired that the farm machineries to be supplied under the expansion plan should be selected in due consideration of the natural conditions in the Sudan, and that sufficient equipment be supplied for the efficient training operations, including audio-visual equipment, workshop equipment, etc.

(4) Items to be Excluded from the Expansion Plan

The Mission explained that provision of such items as furnitures, office equipment, curtains, etc. and gardening works in the compound is not included in the expansion plan. Then, the Sudanese Authorities agreed to supply such items by themselves.

## II. OUTLINE OF ABU GASABA PILOT FARM

### 2.1 Background

Agriculture dominates the economy of the Sudan. It accounts for about 80 % of the employment, 90 % of the export earnings and 40 % of the GDP. The major items of agricultural export are cotton, sesame, gum arabic and groundnuts, among which cotton's share in export earnings is around 60%. Most of the industrial and manufactured consumer goods and some agricultural commodities such as wheat, rice, etc. are the major imported items.

In recent years, the sharp fluctuation in the cotton price in the international market is the factor of unstability in agricultural production in the Sudan. For the harmonious agricultural development, the Sudan Government has encouraged diversification of the exportable crops. The local consumption of rice in the Sudan and demand for rice in the neighbouring Arabic countries have rapidly increased. Under these circumstances, the Sudan Government has included the expansion of rice production in its current Six-Year Plan, primarily to attain self-sufficiency and secondarily to export the surpluses to the neighbouring countries.

Under the above circumstances, the Sudan Government has envisaged for the rice production the development of the Abu Gasaba Basin, which is a vast swampy area extending along the left bank of the White Nile. In early 1977, the Sudan Government requested the Japanese Government for the technical assistance for the feasibility survey on the rice development in the Basin. Upon the request, the Government of Japan despatched a survey team to the Sudan and completed in June 1978 the feasibility study of the project including the formulation of the development plan, basic design, preliminary cost estimates, economic analysis, etc. At the same time, the Japanese Government has extended to the Sudan Government a Grant Aid to establish a 50-ha rice pilot farm in the Basin for experiments on rice cropping.

For the efficient experiments on the mechanized rice cultivation and for the training of technical staffs to be engaged in the farm operation in the Abu Gasaba Basin, the Sudan Government further

requested the Japanese Government for the technical and financial assistance for the expansion of the above 50-ha Pilot Farm including the establishment of a training center.

## 2.2 Effects of Pilot Farm Expansion

A large scale mechanized cultivation of paddy rice is a rather new task in the Sudan, and no previous experience is therefore available in this respect except a few trials in the Gezira area. Though the rice cultivation trials conducted in Ed Dueim as a supplemental survey to the feasibility study of the Abu Gasaba Basin have proved to some extent the possibility of double cropping of rice a year in the area, there remains a variety of problems still to be solved such as the establishment of the most optimum rice cultivation system, etc., prior to the implementation of the Abu Gasaba Rice Development Project. Another important item for the successful implementation of the project is to secure sufficient number of technical staffs for the farm operation in the project area.

The Pilot Farm, after the expansion, will serve for efficient execution of rice experiments especially on the establishment of an optimum mechanized farming system as well as for the training of engineers and technicians on their respective trades. Thus, it will contribute to not only the promotion of the Abu Gasaba Rice Development Project but also the rice development in the vast lands extending along the upper reach of the White Nile. Detailed effects of the expansion of the Pilot Farm are as follows:

i) The year-round irrigation of the field will become possible by installing additional pump station, making experimental works more flexible.

ii) The present 50-ha farm is located in the upland, while the fields to be provided under the expansion plan will be mostly in the lowland. Accordingly, the farming systems suitable for the respective lands can be tested.

iii) The 50-ha farm is considered large enough in scale for experiments for collection of the basic information on rice cultivation techniques but too small for the cultivation trials. As the farm area will be 130 ha after the expansion (and will be finally increased to 200 ha by the Sudan Government), it will be possible to conduct cultivation trials under mechanized farming on the viewpoint of farm management. Thus, it will serve the establishment of a realistic farming system adaptable to the Abu Gasaba Rice Development Project.

iv) The training facilities to be provided under the expansion plan will make the systematic training of technical staffs of the Abu Gasaba Project possible, which is one of the essential prerequisites for the successful implementation of the project.

## III. BASIC DESIGN OF FACILITIES

### 3.1 General

Detailed designs of all facilities for the 200-ha Pilot Farm were completed in March 1978 under the 1977 Grant Aid of the Japanese Government. Accordingly, under the basic design works for the expansion plan executed will be the review of the said existing designs, designs of additional facilities including training facilities, and selection of farm machineries and training equipment required for the expansion of the Pilot Farm.

### 3.2 Main Features of Pilot Farm

The Pilot Farm is located in the far northern part of the Abu Gasaba Basin where a large scale rice development is envisaged. The site is along Ed Dueim-Kosti road, about 20 km from Ed Dueim, the capital of the White Nile Province. The site has relatively regular and flat topography with an elevation ranging from El 377.0 m to El 380.0 m, and covers a gross area of about 250 ha. (600 feddans). About 50% of the area consists of lowland and is flooded every year during August to March, the high water period of the White Nile River.

The irrigation measures proposed for the Pilot Farm comprise two pump stations with inlet channels, a main canal and other distributaries with related canal structures. No.1 Pump Station will be located at the shore of the White Nile, whereas No.2 Pump Station will be provided nearby the Pilot Farm area. A 3-km long inlet channel will be constructed between the two stations. During the high water period of the White Nile, the river water will be directly introduced to No.2 Station through the inlet channel. During the low water prriod, however, the water will be first introduced to No.1 Station, pumped up at the Station and led to No.2 Station where the water is to be relifted.

The water lifted up at No.2 Station will be conveyed through a canal system to farmlands. The canal system will include a main canal, 2 secondary canals and 17 water courses. In relation to the canal system, a large number of structures of various types will be provided to control the flow and water level.

The flood control and drainage measures consist of a protection dike, a drainage pump station with a flood gate structure, and a drainage canal system. The flood protection dike is provided mainly along the southeastern skirt of the Pilot Farm area to protect the land against flooding from the river. The drainage pump station and flood gate structure will be installed at the mouth of a main drain, and they will be operated to allow the outflow of excess drainage water from the farmland and/or to prevent the inflow from the White Nile.

The proposed drainage canal system consists of 11 collector drains and two main drains. The former will collect excess irrigation water and surface runoff from rainfall, and the latter will drain the water collected by the collector drains outside the Pilot Farm area.

The construction of an adequate road system is considered essential for the smooth operation of the Pilot Farm. A main road will run from north to south through the middle of the Pilot Farm for traffic between the Headquarters and secondary roads. The secondary roads are for traffic between the main road and the individual farm plots, and will be constructed almost perpendicular to the main road along water courses with at least one secondary road to face one farm plot.

Various buildings are planned to be provided for the operation and management of the Pilot Farm and for the training of the Sudanese technical staffs. The buildings for the farm operation will consist of an office with laboratory, warehouses, a garage, a workshop, living quarters and some miscellaneous buildings. The buildings for the training will include a training center building (lecture rooms, office rooms, etc.), a repair shop (for training), a garage and a dormitory for trainees. These buildings will be constructed in a compound to be located in the northern corner of the Pilot Farm. A meteorological observatory will also be provided in the compound for the observation of climatic factors essential for examining the results of experiments.

Of the farmlands and facilities mentioned above, about 50 ha-farm with the irrigation and drainage facilities, and several buildings for farm operation were constructed under the 1977 Grant Aid of the

Japanese Government. Under this expansion plan, the farmlands will be expanded by 80 ha and the remaining buildings for farm operation and all the building for training will be provided.

The main features of the facilities completed under the 1977 Grant Aid and those to be constructed under this expansion plan are summarized as follows:

| Descriptions | Completed under 1977 Grant | Expansion Plan |
|---|---|---|
| (1) Net Irrigation Area | 50 ha | 80 ha |
| (2) Irrigation Pump Stations | | |
| - No.1 Pump Station | | |
| a. Inlet channel | - | 1,100 m |
| b. Pump house | - | 105 $m^2$ |
| c. Pumps | - | 12 $m^3$/min x 3 sets |
| d. Diesel engines | - | 33 p.s. x 3 sets |
| - No.2 Pump Station | | |
| a. Inlet channel | 2,900 m | - |
| b. Pump house | 105 $m^2$ | - |
| c. Pumps | 12 $m^3$/min x 1 set | 12 $m^3$/min x 2 sets |
| d. Diesel engines | 33 p.s. x 1 set | 33 p.s. x 2 sets |
| (3) Irrigation Canals | | |
| a. Main canal | 1,700 m | 700 m |
| b. Secondary canal | - | 1,300 m |
| c. Water courses | 2,500 m | 6,000 m |
| d. Canal structures | | |
| Turnouts | 6 nos. | 11 nos. |
| Checks | 1 no. | 5 nos. |
| Culvert | 2 nos. | 2 nos. |
| Division box | 71 nos. | 147 nos. |

| Descriptions | Completed under 1977 Grant | Expansion Plan |
|---|---|---|
| (4) Drainage Canals | | |
| a. Main drains | 1,200 m | 1,500 m |
| b. Collector drains | 1,400 m | 3,000 m |
| c. Drainage structures | | |
| Culvert | 5 nos. | 7 nos. |
| Cross drain | - | 1 no. |
| (5) Drainage Pump Station | | |
| a. Pump house | - | 40 $m^2$ |
| b. Pumps | - | 4.8 $m^3$/min x 2 sets |
| c. Diesel engines | - | 6 p.s. x 2 sets |
| d. Flood gate | - | ϕ900 m/m x 1 set |
| (6) Flood Dike | - | 3,900 m |
| (7) Farm Roads | | |
| a. Main road | 860 m | 650 m |
| b. Secondary road | 9,800 m | 5,000 m |
| (8) Buildings and Utilities | | |
| - Buildings for Farm Operation | | |
| a. Office w/laboratory | 320 $m^2$ x 1 no. | - |
| b. Family quarters | - | 136 $m^2$ x 1 no. |
| c. Bachelor quarters | - | 356 $m^2$ x 1 no. |
| d. Warehouse | 200 $m^2$ x 1 no. | 200 $m^2$ x 2 nos. |
| e. Workshop | 200 $m^2$ x 1 no. | - |
| f. Garage | - | 216 $m^2$ x 1 no. |
| g. Work shed | - | 98 m2 x 1 no. |
| h. Generator house | 23 $m^2$ x 1 no. | - |
| i. Guard house | - | 20 $m^2$ x 2 nos. |

| Description | Completed under 1977 Grant | Expansion Plan |
|---|---|---|
| - Building for Training | | |
| a. Training center building | - | 511 $m^2$ x 1 no. |
| b. Repair shop for training | - | 200 $m^2$ x 1 no. |
| c. Dormitory for trainees | - | 317 $m^2$ x 1 no. |
| d. Garage | - | 198 $m^2$ x 1 no. |
| - Utility Facilities | | |
| a. Water supply system | - | L.S. |
| b. Sewerage system | - | L.S. |
| c. Power supply system | L.S. | L.S. |
| (9) Machinery and Equipment | | |
| a. Farm machineries | For 50 ha | For 80 ha |
| b. Training equipment | - | L.S. |

## 3.3 Pilot Farm Area

### (1) Location

Ed Dueim, the capital of the White Nile Province, is situated on the left bank of the White Nile River in the central Sudan, about 200 km south of Khartoum. Population of the town including the neighboring area is about 250,000.

The Pilot Farm is located along the Dueim-Kosti Road, about 20 km from Ed Dueim, and covers an area of about 250 ha with flat topography. The surounding areas of the Pilot Farm are mostly irrigated agricultural lands, and existing pump stations and irrigation canals are located at the northern and southern edges of the Pilot Farm.

### (2) Climate

The area is under a tropical climate which is characterized by two distinct seasons, the wet season from June to September and the dry season for the reminaing months. Annual rainfall at Ed Dueim is about 280 mm, of which about 90% is concentrated in the wet season. Mean temperatures are fairly constant throughout the year, being $24^{\circ}C$ to $32^{\circ}C$. Humidity ranges from a low of 16% in April to a high of 48% in August.

The following table shows a summary of the meteorological feature recorded at Ed Dueim. Detailed meteorological data are shown in Annex IV.

| | | |
|---|---|---|
| Temperature | Annual mean:<br>Annual mean highest:<br>Annual mean lowest : | 28.7°C<br>36.3°C<br>21.1°C |
| Relative Humidity | Wet season (Jun.-Sept.):<br>Dry season (Oct.-May ):<br>Annual mean: | 27 - 48 %<br>16 - 32 %<br>28 % |
| Rainfall | Mean annual rainfall:<br>Rainy days:<br>Jun.-Sept.: 24-108 mm<br>Oct.-May : 0-10 mm | 280 mm<br>24 days<br>total 258 mm<br>total 22 mm |
| Snowfall | No snowfall | |
| Wind | Wet season (Jun.-Sept.):<br>Dry season (Oct.-May ):<br>Annual mean speed: | 2.2 m/s SW<br>1.3 - 2.7 m/s NE<br>2.2 m/s |
| Evaporation, Piche | Wet season (Jun.-Sept.):<br>Dry season (Oct.-May ):<br>Annual mean: | 7.7 - 16.0 mm/day<br>12.5 - 19.7 mm/day<br>14.3 mm/day |

(3) Topography and Soil

The Pilot Farm area has a gently undulating topography with an average slope of 0.5 - 0.2% in the eastern part and less than 0.1% in the western part. The soils in the area are mostly black clay soils with a thickness of 0.8 to 1.4 meters, which is underlain with fine sand layer. The penetration test results show that bearing capacities of foundations are 1 - 4 $t/m^2$ for the wet clay layer, 5 to 10 $t/m^2$ for the dry clay and more than 15 $t/m^2$ for the fine sand layer.

(4) Hydrology

The White Nile is the irrigation water source for the Pilot Farm. The water level of the river normally fluctuates between El. 372.90 m and El. 377.20 m by the operation of the Jebel Aulia Dam. The operation criteria of the dam are as summarized below:

a) The first filling of the reservoir begins in mid July. The water level reaches 376.50 m in mid August.

b) The second filling starts in mid September and the water level reaches the full water level of 377.20 m in mid October. The level of 377.20 m is continuously maintained until mid-February.

c) The water stored in the reservoir is gradually released from mid-February until the reservoir is completely emptied by the end of May.

The mean monthly water levels of the river at the Ed Dueim Station for the past 30 years are shown in Annex IV. The highest and lowest water levels recorded at the station are as follows:

| | | |
|---|---|---|
| Highest W.L. | El 377.80 m | Sept. 1975 |
| Lowest W.L. | El 371.80 m | May 1945 |

## 3.4 Irrigation and Drainage Facilities

### (1) General

The designs of all the irrigation and drainage facilities to be constructed under the expansion plan were completed in March 1978 under the 1977 Grant Aid of the Japanese Government. Herein mentioned are the outline of the said designs.

The basic conditions under which the designs were made are as follows:

i) The local conditions were duly considered for the easier operation and maintenance of the facilities.

ii) Maximum use of locally available construction materials was considered to minimize the import of materials from abroad.

iii) Unit discharge for design of irrigation facilities is 3.0 ℓ/sec./ha, which is computed based on the peak irrigation requirement of 2.0 ℓ/sec.ha and the maximum irrigation hours of 16 hrs/day.

iv) Unit design discharge for drainage facilities is 4.0 ℓ sec./ha, which is estimated based on a 10-year daily probable rainfall of 79 mm.

(2) Irrigation Pumping Stations and Inlet Channels

The White Nile is the water source for the irrigation of the Pilot Farm. The water level of the river largely fluctuates due to the operation of the Jubel Aulia Dam located about 150 km downstream of the Pilot Farm. During the high water period, half of the Pilot Farm area is flooded, whereas the river flow recedes about 4 km from the area during the low water period. Taking into account these natural conditions, the water intake system for the Farm was planned as follows:

Two pump stations, i.e. No.1 and No.2 Stations, will be provided. No.1 Station will be installed at the shore of the main stem of the White Nile, whereas No.2 Station will be located nearby the Pilot Farm area. An inlet channel will be provided between the two pump stations. During the high water period of the White Nile (August to March), the river water will be directly introduced to No.2 Station through the inlet channel, and pumped up to the main irrigation canal. In the low water period (April to July) during which the water level is below El. 376.5 m, the water will be first pumped up at No.1 Station, led through the inlet channel to No.2 Station and relifted there to the main canal.

Under the 1977 Grant Aid of the Japanese Government, the inlet channel and the pump house for No.2 Station were constructed, and a set of pumping equipment was installed. All the remaining facilities and equipment will be provided under the expansion plan. The relevant features of those facilities are as summarized below:

No.1 Pump Station

Inlet Channel

| | |
|---|---|
| Type: | Earth canal with trapezoidal section |
| Length: | 1,100 m approx. |

Pumps

| | |
|---|---|
| Type: | Double suction volute pump, ϕ350 x 300 m/m |
| Capacity & unit: | 12 $m^3$/min x 3 units |
| Rated head: | 7.3 m |

Engines

| | |
|---|---|
| Type: | 4-cycle water cooled diesel engine |
| Output & unit: | 33 p.s. x 3 units |

Pump House

| | |
|---|---|
| Type: | Brick construction with reinforced concrete foundation, wood truss and C.G.I. sheet roofing |
| Floor area: | 105 $m^2$ |

Discharge Pipes: 3 sets, ϕ300 m/m

No.2 Pump Station

Pumps

| | |
|---|---|
| Type: | Double suction volute pump, ϕ350 x 300 m/m |
| Capacity & unit: | 12 $m^3$/min x 2 units |
| Rated head: | 8.2 m |

Engines

| | |
|---|---|
| Type: | 4-cycle water cooled diesel engine |
| Output & unit: | 33 p.s. x 2 units |

Discharge Pipes: 2 sets, ϕ300 m/m

(3) Irrigation Canals and Related Structures

The irrigation canal system for the Pilot Farm consists of a main canal, secondary canals and water courses with related structures of various types.

The main canal begins from the outlet cistern of No.2 Pump Station and runs to the southwest through the center of the Pilot Farm over a distance of about 2.4 km. The design discharge of the canal varies from 600 ℓ/sec to 190 ℓ/sec according to the command area of each section.

Branching off from the main canal, two secondary canals will be constructed. No.1 secondary canal will serve the western part of the Pilot Farm covering an area of about 55 ha, while No.2 secondary canal will command the eastern part of 49 ha. The total length of the canals is about 1.3 km, and their design discharges vary from 180 ℓ/sec. to 60 ℓ/sec.

17 water courses will be provided to distribute the water to individual farm plots, taking off from the said main or secondary canals. One water course generally commands one farm block with an area of 8.5 to 17 ha. The total length of the water courses is about 11.2 km, and their discharges are 30 ℓ/sec. or 60 ℓ/sec.

All the above irrigation canals are of unlined type and have a trapezoidal cross section with the inside slope of 1 to 1.5. The longitudinal slopes range from 1/3,000 to 1/5,000 for the main canal and from 1/2,000 to 1/250 for the others, depending on the available heads. The canal velocity will not exceed 0.7 m/sec. in any of the canal sections.

In conjunction with the irrigation canals, a number of canal structures of various types will be provided to control the canal flow and water levels. These structures include turnouts, check structures, culvert and division boxes. They are generally of brick construction with pipes and concrete foundation.

Of the above canals and structures, the upper part of the main canal (about 1.7 km long), six water courses (2.5 km long in total), six turnouts, one check and 71 division boxes were already constructed under the 1977 Grant Aid. The following are the principal features of the canals and structures to be provided under the expansion plan.

| | | |
|---|---|---|
| Main Irrigation Canal | 1 no. | 0.7 km |
| Secondary Canals | 2 nos. | 1.3 km |
| Water Courses | 11 nos. | 6.0 km |
| Canal Structures | | |
| Trunouts | 11 nos. | |
| Check structures | 5 nos. | |
| Culverts | 2 nos. | |
| Division boxes | 147 nos. | |

(4) Drainage Canals

The proposed drainage canal system consists of main drains and collector drains. Two main drains with a total length of about 3.9 km will be provided to collect and carry excess water outside the Pilot Farm. 11 collector drains with a total length of 7.2 km will be constructed to receive excess irrigation water and surface runoff of rainfall. The collector drains are so arranged as to run almost perpendicularly to the main drains with an approximate interval of 300 m, facing the short side of farm plots.

The sections of the drains are of the type similar to the irrigation canal sections. The longitudinal slopes range from 1/1,000 to 1/10,000 for the main drains and from 1/200 to 1/4,000 for the collector drains. Both the minimum depth and bottom width of the drains are set at 0.5 m.

Culvert structures will be constructed where the drains cross farm roads or irrigation canals. The culverts are of single barrel type consisting of concrete pipe with a diameter of 400 to 1,000 mm.

Under the 1977 Grand Aid constructed were a 1.2 km-long main drain and five collector drains with a total length of 1.4 km. The following are the principal features of the drains and structures to be provided under the expansion plan.

| | | |
|---|---|---|
| Main Drains | 2 nos. | 1.5 km |
| Collector Drains | 7 nos. | 3.0 km |
| Related Structures | | |
| Culverts | 7 nos. | |

(5) Flood Dike

A flood dike will be provided for preventing flood inflow into the farmlands from the White Nile. The dike will be erected mainly along the southeastern edge of the Pilot Farm and tied in to the high ground on the northeast and the southeast of the Farm.

The crest elevation of the dike is set at El 378.5 m, so providing protection against the maximum flood recorded at Ed Dueim and also allowing free board against wave, consolidation of the embankment, etc. The crest width is 7 meters to permit movement of trucks, farm machineries as well as maintenance equipment. Bank slope adopted is 1:1.5 both for the inside and outside slopes. The length is about 3.9 km, and the maximum height is 1.5 m from the ground surface.

The entire length of the flood dike will be constructed under the expansion plan.

(6) Drainage Pump Station and Flood Gate

The flood inflow into the Pilot Farm will be prevented by means of the flood dike as mentioned above. However, there still remains the hazard of inundation due to the rain water that falls within the farm area and the excess of irrigation water. In order to be able to remove such excess water, provision of a drainage pump station together with a flood gate structure is planned.

The required pumping capacity was determined at 9.6 $m^3$/min based on the runoff from a 10-year daily probable rainfall of 56 mm in the period of August to October and 4-day retardation in the farmlands. To meet this, two units of pumping equipment will be installed, each having a rated capacity of 4.8 $m^3$/min. The pumps will be operated when the water level in the suction pit exceeds El. 376.28 m and the river water level is higher than the water level of the suction pit.

Together with the drainage pump station, a flood gate structure will be provided to allow the outflow of drain water by gravity during the low water period of the White Nile and to prevent the back-flowing from the river during the high water period.

All the facilities related to the drainage pump station and flood gate will be constructed under the expansion plan. The principal features of those facilities are as shown below:

Drainage Pump Station

| | |
|---|---|
| Pumps | Type: Horizontal shaft volute type mixed flow pump, ϕ250 mm |
| | Capacity and unit: 4.8 $m^3$/mm x 2 units |
| | Rated head : 2.5 m |
| Engines | Type: Air cooled diesel engine |
| | Output and unit : 6 p.s. x 2 units |
| Discharge Pipe | 1 set, ϕ400 mm steel pipe |
| Pump House | Type: Brick construction with CGI sheet roofing, wood roof truss and reinforced concrete foundation |
| | Floor area: 40 $m^2$ |
| Flood Gate | 23 m-long precast concrete pipeline, ϕ900 mm, equipped with a circular slide gate at the outlet |

(7) Farm Road

The proposed farm road network consists of a main road and secondary roads. The main road will run from northeast to southwest through the middle of the Pilot Farm for traffic between the headquarters to be located in the northern corner of the area and the secondary roads. It will also be connected to the existing Dueim-Kosti road for communication with the outside. The width of the main road is 12 m including 2.5 m of shoulder width on both sides.

The secondary roads will be provided for traffic between the main raod and the individual farm plots. Most of the roads are arranged almost perpendicular to the main road along water courses with at least one secondary road to face one farm plot. The secondary roads have a total width of 7 m including 1.0 m of shoulder width on both sides.

Under the 1977 Grant Aid, a part of the main road and several secondary roads were already constructed. The following are the principal features of the roads to be provided under the expansion plan.

| | | | |
|---|---|---|---|
| Main Road | Type | : | Dirt road with 40-cm high embankment |
| | Length | : | 0.65 km |
| Secondary Road | Type | : | Dirt road with 30-cm high embankment |
| | Length | : | 5.0 km |

(8) Typical Farm Unit

A farm plot will in general have an acreage of 0.45 ha, and dimensions of 150 m x 30 m. Each farm plot faces a farm road, water course and collector drain at its short sides. The long sides of the farm plots are generally arranged along contour lines so that the earth moving volume for levelling will be minimized.

The irrigation water through the water courses is diverted to the field by means of division boxes. Access structures are also provided for the passage of farm machineries across the water courses.

Under the expansion plan, 178 farm plots with a total area of about 80 ha will be constructed together with the related facilities.

### 3.5 Buildings and Utility Facilities

#### (1) General

The buildings to be constructed under the expansion plan are largely divided into two parts, i.e. the buildings for farm operation and those for training. The former was already designed in detail under the 1977 Grant Aid, and its designs were basically approved by the Sudanese Authorities concerned. The latter is to be newly designed under the expansion plan.

The basic design of the training buildings are made in due consideration of the tentative training program (see Annex-I) and based on the following conditions:

1) The opinion of the local authorities have been duly considered.

2) The local conditions have been duly considered for conveniency of future maintenance.

3) The local building technical standard has been duly considered.

4) The maximum use of locally produced construction materials was considered in order to minimize import of materials from abroad.

(2) Building

Building Plan

The main features of the buildings to be provided under the expansion plan are as outlined below:

A. Buildings for Farm Operation

a. Residential quarters

The residential quarters will be provided for the accommodation of the staffs engaged in the operation of the Pilot Farm in view of the shortage of housings in the town of Ed Dueim. The quarters will be separated from the administrative area and located at the northeast of the compound. The surrounding will be provided with a large open area in order to allow the quarters independency.

i) Family quarters

The family quarters are designed as one story building with a floor area of 136 $m^2$. Two bedrooms, a kitchen, a living room and western style bathroom and toilet are provided to accommodate a family of three to four including one or two children. Each room is completely separated.

ii) Bachelor's quarters

The bachelor's quarters are designed to accommodate six persons with six individual bedrooms separately provided with bathroom and toilet. Kitchen and dining room are separately provided for common use; the dining room is designed to be used also as a common recreation and communication area.

b. Warehouse

The warehouses are required for storing farm products, fertilizers, agricultural chemicals, etc. In the expansion plan, two units of warehouse will be constructed in addition to a warehouse constructed under the 1977 Grant Aid.

c. Work shed

The work shed is required for threashing and drying of paddy rice. It is provided with concrete floor with an area of 98 $m^2$, on which the threshing and drying works will be made.

d. Garage

The garage is required for vehicles and agricultural machineries to be used for the operation of the Pilot Farm. It will be located in front of the administration office building constructed under the 1977 Grant Aid for convenience of the use.

e. Guard houses

The guard houses will be provided at the entrance gates to check and control visitors. The entrance gates were constructed under the 1977 Grant Aid together with the barbed wire fencing along the boundary of the compound.

B. Buildings for Training

a. Training center building

The training center building will be provided for training and lecturing of engineers and technicians to be engaged in the rice cultivation in the Abu Gasaba basin as well as for the administration of the training works.

The basic plan of the training center building was prepared in consideration of the training program explained in Annex-I. The building, having I-shape plan, consists of the administration and the training sections. They are connected by a common lobby which will also be used for bulletins and other exhibition purpose. The training section is provided with three lecture rooms, a laboratory and a multi-purpose hall to be used for a wide variety of training activities including lectures, audio-visual education, etc. The administration section consists of a manager room, an administration room and two instructor rooms.

b. Dormitory for trainees

The dormitory is required for the accommodation of trainees during the training period. The numbers of trainee to be accommodated at a time are 24 according to the training program explained in Annex-I.

The dormitory is separated into 3 sections; i.e., the dormitory for senior class trainees on one wing and the dormitory for junior class trainees on another wing and the kitchen, dining room and the recreation/meeting room in the mid section, which are connected with a corridor.

The dormitory for senior class trainees will be provided with four rooms with a total area of 80 $m^2$ for the accommodation of 8 persons (2 persons per each room). The dormitory for junior class trainees will consist of four rooms with a total area of 90 $m^2$ for the accommodation of 16 persons (4 persons per each room). Both buildings will be provided with a common use shower and toilet room at the end of the buildings.

The kitchen and dining rooms will be provided in the mid-section; one for each of the senior and junior trainee groups. A recreation and meeting room will be provided for common use.

c. Repair shop

The repair shop is required to afford trainees opportunities for the practices in the maintenance and repairing of farm machineries.

d. Garage

The garage is required for vehicles and tractors to be used for the training purposes. It will be located in front of the training center building for convenience.

Structural Design

a. Basic conditions

1) The horizontal forces to the buildings are considered minor in the structural designs and special consideration will not be required, since the maximum wind velocity is only 32 m/sec and no occurrence of earthquake would be considered in this area.

2) The buildings will generally be constructed of reinforced concrete foundation, brick masonry wall and corrugated galvanized iron sheet roof cover over wooden truss.

3) The building foundations shall be made of reinforced concrete footing since the buildings are of one story and the soil bearing capacity is expected to be about 10 ton/$m^2$.

4) The structural materials shall generally be of materials available in the local market.

b. Structural design conditions

There are no specific codes and/or regulations on building structural design in the Sudan and therefore the design is commonly left to the option of the designer. We have therefore adopted the following standard in processing the structural design.

1) External force and loads

The external forces and loads for buildings were determined considering the meteorological conditions, geological conditions and the purpose for which the buildings are used.

2) The allowable stress of structural materials will be determined in conformance with the actual quality of the local materials.

c. Determination of external force and loads

The external force and loads for the buildings will be determined as follows:

1) Live load ($kg/m^2$)

| Rooms | Floor Sub. Beams | Columns Beams |
|---|---|---|
| Office, classrooms, hall, and laboratory | 300 | 180 |
| General living space | 180 | 130 |
| Warehouse | 400 | 300 |
| Garage | 550 | 400 |

2) Seismic coefficient — K = 0

3) Wind ($kg/m^2$) — $q = 17\sqrt{h}$

4) Soil bearing force — Fe = 10 $ton/m^2$

5) Concrete strength (design strength) — F = 180 $kg/cm^2$

Finishing Schedule

a. Main exterior finishes

1) Roof - Corrugated galvanized iron sheet cover over wooden or steel trusses

2) Exterior wall - Ornamental brick and common brick w/paint over cement mortar plastering

3) Joinery - Double wooden (or steel) sash, paint finish

b. Main interior finishes

1) Living rooms, bed rooms and corridors

Floor - Cement tile
Skirting - Cement tile
Wall - Cement mortar plastering, paint finish
Ceiling - Chip board

2) Toilet and bathroom

Floor - Cement tile
Wall - Cement mortar plastering, paint finish
Ceiling - Chip board

3) Work shed, warehouse and garage

Floor - Concrete, non-finish
Skirting - Cement mortar plastering
Wall - non-finish
Ceiling - non-finish

(3) Utility facilities

The utility facilities proposed consist of the electrical facilities, water supply facilities, sewerage and drainage facilities and the air conditioning and ventilation facilities, the extent of which is as briefly explained hereinafter.

a. Electrical facilities

i) General

The electrical facilities will include the outdoor and indoor electrical facilities, the source of which will be taken from the panel board provided in the generator house (which was constructed under the 1977 Grant Aid). The electric source is rated for 3 phase, 4 lines, 380V/220V, 50 Hz.

The outdoor distribution line will be of overhead line strung on concrete poles and delivered to each of the required points of delivery from the generator house. The electric power load is estimated at approximately 105 kVA in total and 59 kVA for the facilities to be provided under the expansion plan as broken-down below:

| | Total | Completed under 1977 Grand | Expansion Plan |
|---|---|---|---|
| i) Lighting and convenience outlet | 45 kVA | 15 kVA | 30 kVA |
| ii) Water supply and drainage | 8 " | - | 8 " |
| iii) Work shop equipments | 50 " | 30 " | 20 " |
| iv) Street lighting | 2 " | 1 " | 1 " |
| Total | 105 kVA | 46 kVA | 59 kVA |

ii) Lighting and convenience outlet

Lighting will be made of fluorescent lighting and partially with incandescent lighting. Convenience outlets will be adequately provided for rooms and also for ventilation fans and ceiling fans.

iii) Street lighting

Street lighting will be proviced on the outdoor electric distribution poles and shall be of weather proof type with electro-photo switch device. Manual knife switch will also be provided for emergency cases, should the electro-photo switch fail to operate.

b. Air conditioning and ventilation facilities

Air conditioning facilities shall be provided for main rooms for cooling during the summer season and ventilation facilities throughout the year; no heating will be provided.

i) Air conditioning facilities

The manager room, managing staff room and lecturer's room shall be provided with local-made air coolers of water evaporation type and ceiling fans.

ii) Ventilation facilities

Ventilation fans will be provided in kitchens.

c. Water supply facilities

The water supply facilities will include the supply of water taken from the canal running at the south-east of the compound, which will be pumped up to the high tank and distributed to each of the required points by gravity. The required quantity of water will be about 12 $m^3$/day. The high water tank capacity will be 4 $m^3$ and the height 10 meters.

d. Sewerage and drainage facilities

The sewerage and drainage facilities will include the drainage and disposal of the building sewer and waste water drainage. The building sewer and waste drain will be collected into each of the drain pits provided near the buildings, drained into the septic tank and then lead into the seepage pit and drained into the ground.

## 3.6 Required Machineries and Equipment

For the smooth and efficient operation of the Pilot Farm, it is required to supply various machineries and equipment for use in both the experiemental works and the training. The farm machineries were selected assuming that double cropping of rice a year will be practiced over the whole area of the Pilot Farm. Detail explanations on the selection of the farm machineries are given in Annex-II.

Training equipment will include audio-visual equipment, equipment and apparatus for crop experiements, work shop equipment, farm tractors, etc. which were selected in due consideration of the proposed training program explained in Annex-I.

The following table shows the machineries and equipment thus selected and to be supplied under the expansion plan.

Table III-1 List of Farm Machineries and Training Equipment

| Equipment | Make, Model, Type | No. or Set |
|---|---|---|
| A. Farm Machineries | | |
| 1. Crawler tractor | Swamp type, w/3-point shaft | 1 |
| 2. Wheel tractor | 40 PS, 4 wheel drive | 3 |
| 3. Power duster | 7 kg/min | 1 |
| 4. Power mist duster | 3.5 ℓ/min. | 2 |
| 5. Combine harvester | 25 PS, w=1,300 m/m | 3 |
| 6. Paddy dryer | 3.2-ton, 0.7-1.0%/hr | 1 |
| 7. Rice mill set | 0.5 ton/hr | 3 |
| 8. Disc plow | 3 x 26" | 2 |
| 9. Disc harrow | 20 x 18" | 1 |
| 10. Rotary tiller | 1,800 m/m | 3 |
| 11. Drill seeder | 7-line | 2 |
| 12. Drum rotor | 3,100 m/m | 1 |
| 13. Dump trailer | 2 ton | 1 |
| 14. Rotary cutter | 1,500 m/m | 2 |
| 15. Cage wheel | | 3 |
| 16. Front weight | | 3 |
| 17. Swamp dozer | 11-ton | 1 |
| 18. Motor grader | 9-ton | 1 |
| 19. Dump truck | 8-ton | 1 |
| 20. Ordinary truck | 6-ton | 2 |
| 21. Jeep | 4 x 4, long chassis | 2 |
| 22. Concrete mixer | 0.12 $m^3$, w/engine | 2 |
| 23. Concrete vibrator | ϕ35 m/m | 2 |
| 24. Submersible pump | ϕ80 m/m, w/generator | 1 |
| 25. Spare parts | | L.S. |

| Equipment | Make, Model, Type | No. or Set |
|---|---|---|
| B. Training Equipment | | |
| Audio-visual aids | | |
| 1. TV-video set | 20", recorder, camera, etc. | 1 |
| 2. Projector | Slide picture w/screen | 1 |
| 3. - do - | 16 m/m & 8 m/m | 1 |
| 4. Copy machine | Dry type | 1 |
| Agronomy course | | |
| 1. Hand huller | For one panicle | 5 |
| 2. Huller | For one hill | 2 |
| 3. Thresher | By foot | 2 |
| 4. Winnower | By hand | 2 |
| 5. Polisher | For experimental works | 1 |
| 6. Yield diagnosis apparatus | | 5 |
| 7. Grain counter board | 500 grains | 5 |
| 8. Electric oven | For germination | 1 |
| 9. Moisture meter | Infrared ray | 3 |
| 10. Hardness tester | | 2 |
| 11. Hand sprayer | | 2 |
| 12. Hand sprayer | | 2 |
| 13. Table balance | 100 g | 2 |
| 14. - do - | 500 g | 2 |
| 15. Auto balance | 100 - 01 g | 2 |
| 16. Table balance | Blam scale, 200 g | 2 |
| 17. - do - | Blam scale, 10 kg - 5 g | 1 |
| 18. - do - | 2 kg - 1 g | 2 |
| 19. Platform table balance | 100 kg | 1 |
| 20. Micro scale for grain | 0 - 10 m/m | 3 |
| 21. Nonius | 150 m/m | 1 |
| 22. Measuring rope | 100 m | 3 |
| 23. Convex rule | 5 m | 10 |
| 24. Stop watch | | 3 |
| 25. Counter | | 5 |

| | Equipment | Make, Model, Type | No or Set |
|---|---|---|---|
| 26. | Plate for grains | ϕ18 cm x 3 | 50 |
| 27. | Plate for germination | 25 x 20 x 3 cm | 10 |
| 28. | Desicater | ϕ21 cm, ϕ30 cm & ϕ36 cm | 3 each |
| 29. | Shallay | 60, 90, 150 m/m | 30 each |
| 30. | Beaker | 50, 100, 100 m/ | 10 each |
| 31. | Cylinders measure | 50, 100, 1000, 2000 m/ | 5 each |
| 32. | Ripets measure | 5, 10 m/ | 5 each |
| 33. | Microscope | Zoom type stereoscope | 2 |
| 34. | Microscope | | 2 |
| 35. | Microphotographic attachment | | 1 |
| 36. | Slide glass & cover glass | | 3 |
| 37. | Hydrometer | Baume's, 25 cm | 2 |
| 38. | Hook gauge | | 2 |
| 39. | Parshall flume | 2" | 2 |
| 40. | P.H. meter | | 2 |
| 41. | E.H. meter | | 1 |
| 42. | Hardness meter | | 3 |
| 43. | Soil sampler | | 5 |
| 44. | E.C. meter | | 1 |
| 45. | Soil colour book | | 3 |
| 46. | Hoe, furrow, knife | | 5 |
| 47. | Lupe | X5 - X10 | 10 |
| 48. | Dissection set | For research works | 5 |
| 49. | Soil pressure gauge | | 1 |
| | Farm Machinery Course | | |
| 1. | Diesel engine | 40 PS | 1 |
| 2. | - do - | 7 PS | 3 |
| 3. | Kerosene engine | 4 PS | 2 |
| 4. | Tool cabinet set | | 1 |
| 5. | Hand tachometer | | 5 |
| 6. | Mechanic set | | 5 |
| 7. | Circuit tester | | 5 |
| 8. | Parts washing stand | | 1 |
| 9. | Work bench | | 2 |

| | Equipment | Make, Model, Type | No. or Set |
|---|---|---|---|
| 10. | Diesel nozzle tester | | 2 |
| 11. | Outside micrometer caliper set | | 2 |
| 12. | Inside micrometer caliper set | | 2 |
| 13. | Dial couple nonius | | 2 |
| 14. | Standard feeder gauge | | 2 |
| 15. | Dial indicator | | 2 |
| 16. | OTC hydraulic tester | | 1 |
| 17. | Electric grinder | | 1 |
| 18. | Compression gauge | Diesel | 2 |
| 19. | Electric drill | | 1 |
| 20. | Battery hydrometer | | 1 |
| 21. | Vice | UV-100 | 1 |
| 22. | - do - | UV-200 | 1 |
| 23. | Stud remover | | 1 |
| 24. | Screw extractor | | 2 |
| 25. | Universal puller set | | 1 |
| 26. | Torque wrench | 720F | 2 |
| 27. | - do - | 5600F | 2 |
| 28. | Socket wrench set | | 2 |
| 29. | Straight shank twist drill set | | 1 |
| 30. | Piston ring compressor | RC-25 | 2 |
| 31. | - do - | RC-30 | 2 |
| 32. | Piston ring tool | | 2 |
| 33. | Cylinder gauge | BC-45 | 1 |
| 34. | Cylinder gauge | BC-58 | 1 |
| 35. | - do - | BC-160 | 1 |
| 36. | Oil filter wrench | | 2 |
| | Machinery Operation Course | | |
| 1. | Wheel tractor | 70 P.S. | 1 |
| 2. | Disc plow | 16" x 4 | 1 |
| 3. | Rotary tiller | 2,276 m/m | 1 |
| 4. | Front loader | | 1 |

| Equipment | Make, Model, Type | No. or Set |
|---|---|---|
| 5. Hand tractor | | 1 |
| 6. Rotary tiller | | 1 |
| 7. Trailer | | 1 |
| 8. Iron wheel | | 1 |
| 9. Cage wheel | 500 m/m | 1 |
| 10. Plow | | 1 |
| 11. Power mist duster | | 2 |
| 12. Soil pressure gauge | | 1 |

## IV. IMPLEMENTATION PLAN AND COST ESTIMATE

### 4.1 Implementation Time Schedule

All the works involved in the expansion plan of the Pilot Farm would be completed within 12 months after the Diplomatic Notes have been exchanged between the Government of the Democratic Republic of the Sudan and the Government of Japan in this respect. For the first three months, the detailed design works will be carried out, and it will be immediately followed by tendering and contracting works. Actual construction works including the supply of equipment and materials will be started from the 5th month and continued until the 12th month after the exchange of the said Diplomatic Notes.

A tentative implementation time schedule is shown in the following figure.

Fig. IV-1 Tentative Implementation Schedule

| Item | Month after E/N | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. | Basic Design | ——— | | | | | | | | | | | | | | | |
| II. | Exchange of Diplomatic Notes (E/N) | | | | —— | | | | | | | | | | | | |
| III. | Detailed Design | | | | | | | | | | | | | | | | |
| | 1) Detailed design | | | | | ——— | | | | | | | | | | | |
| | 2) Tendering & contracting | | | | | | | ——— | | | | | | | | | |
| IV. | Construction | | | | | | | | | ——— | | | | | | | |

## 4.2 Cost Estimate

The total cost required for the expansion of the Pilot Farm was estimated at Japanese Yen 1.0 billion as summarized in Table IV-1. The estimated costs for civil works and buildings are primarily based on the actual costs incurred at the 50-ha Pilot Farm implemented under the 1977 Grant Aid of the Japanese Government. Further, it is assumed that import tax and duties on the imported items are to be exempted. Physical contingencies of about 10% have been allowed for in the estimate.

Table IV-1 Summary of Cost Estimate

| | Works | Amount (1,000 JPN.Yen) |
|---|---|---|
| I. | Civil construction works, including the construction of an irrigation pump station, an inlet channel, irrigation and drainage canals, a flood dike, farm roads, a drainage pump station and land levelling | 178,580 |
| II. | Building works, including the construction of buildings for farm operation, training facilities and utilities | 313,680 |
| III. | Equipment and materials, including farm machineries, training equipment, pumping equipment and construction materials | 267,960 |
| IV. | Engineering and administration, including detailed designs and construction supervision | 239,780 |
| | Total | 1,000,000 |

# ANNEXES

## ANNEX I PROPOSED TRAINING PLAN

1. OBJECTIVE

2. TRAINING PLAN

   (1) Number of Trainees

   (2) Training Courses

3. Qualification of Trainees

4. Standard Curriculums of Training

## 1. OBJECTIVE

The objective of the training in the Abu Gasaba Pilot Farm is to secure sufficient numbers of qualified agronomists, engineers and technicians to be engaged in the rice cultivation in the Abu-Gasaba Basin.

## 2. TRAINING PLAN

### (1) Number of Trainees

According to the Feasibility Report for the Rice Development in the Abu Gasaba Basin (JICA, 1978), the required number of the technical staffs of the project are estimated at around 500 in total, consisting of 65 agronomists, 20 agricultural engineers, 390 machinery operators, and 25 workshop mechanics. For the successful implementation of the project, it is considered essential to train all the technical staff, except half of the machinery operators, on their respective trades prior to the engagement in the farm operation. Thus, the total number of prospective trainees would be 322, and the annual training requirements are estimated as indicated in Table I-1 based on the tentative construction schedule of the project.

Table I-1 Number of Trainees by Year

| | Total required personnel | Number of trainees | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | Total |
| Senior Agronomist | 25 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 28 |
| Junior Agronomist | 40 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 42 |
| Sub-total | 65 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 70 |
| Agricultural Engineer | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |
| Assistant Agricultural Engineer | 10 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 14 |
| Mechanical Engineer | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |
| Sub-total | 20 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 28 |
| Farm Machinery Operator | 390 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 196 |
| Workshop Mechanic | 25 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 28 |
| Sub-total | 415 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 224 |
| Total | 500 | 46 | 46 | 46 | 46 | 46 | 46 | 46 | 322 |

(2) Training Course

In view of the major specialities of the prospective trainees mentioned above, the proposed training program would consist of three courses, i.e. a) rice cultivation, b) farm machinery, and c) farm machinery operation.

The rice cultivation course is to train agronomists for rice cultivation techniques including selection of suitable rice varieties, raising and planting seedlings, water control, weeding, soil improvement and fertilization, diseases and insects control, etc. with the aim of giving them up-to-date knowledges required for making farming plans and supervising daily farm operations.

The farm machinery course would be divided into three sub-courses, i.e. a) primary course, and b) advance course, and c) mechanic course. The primary course is to provide both the agricultural and mechanical engineers with the basic knowledges on farm machineries. The advance course would be further divided into two courses, i.e. agricultural engineering and mechanical engineering. The agricultural engineering course is to train the agricultural engineers, who completed the primary course, mainly on the supervision of farm machinery operations and the management of farm machineries. The mechanical engineering course is for the training of the mechanical engineers who completed the same primary course for the agricultural engineers and aims to provide them with an intensive training on structures of farm machineries, maintenance and repairing techniques and the management of workshops.

The mechanic course is to give workshop mechanics a specialist training in the maintenance and repairing techniques of farm machineries. The farm machinery operation course is to train operators for the operation practices of various farm machineries for rice cultivations.

The training period for each course is decided to be six months so that the trainees will be able to get practical experience on rice cropping from soil preparation to harvesting and milling.

## 3. REQUIRED QUALIFICATIONS OF TRAINEES

The qualifications of trainees for the respective training courses are tentatively proposed as follows:

### (1) Rice cultivation course

Senior agronomist

- University graduate
- At least 5 years' experience in practical agriculture
- Basic knowledge of administration and farm management

Junior agronomist

- College or high school graduate
- At least 3 years' experience in agriculture

### (2) Farm machinery course

Agricultural engineer

- University graduate
- At least 3 years' experience in practical mechanized agriculture
- Basic knowledge of administration and farm management

Mechanical engineer

- University or college graduate
- Basic knowledge of farm machineries
- Experience of maintenance and repairing works of machineries

Workmanship mechanic

- Middle school or primary school
- Experience of maintenance and repairing works of machineries
- Can read and write

### (3) Machinery operation course

Farm machinery operator

- Primary school or higher
- Experience of machinery operation
- Can read and write

## 4. STANDARD CURRICULUM OF TRAINING

The standard curriculums of training for the respective courses are tentatively proposed as shown in Tables I-2 to I-5. These tentative curriculums would be checked and revised by instructors concerned in due consideration of abilities of actual candidates. It is also important that, after the first training period has passed, the training program should be evaluated and the curriculums of the next training be prepared accordingly.

Table 1-2 Standard Curriculum of Training for Rice Cultivation Course

| Goal of Training | Training Items | Aims | Contents | Training Method | Unit[1] |
|---|---|---|---|---|---|
| To make rice farming plans with rational technilogical background and to supervise seasonal and daily farm operations | 1. Rice varieties | (1) To understand special feature of varieties of rice<br>(2) To make the plan of cultivation area of each suitable variety | 1. Introduction program of suitable varieties<br>2. Characteristics of vareities | Lecture, observation, discussion<br>" " " | 10 |
| | 2. Yield-diagnosis | (1) To review and improve the cultivation practice | 1. Estimation of yield<br>2. Analaysis of yield by yield components<br>3. Defect finding in the cultivation practices<br>4. Proposal for improving cultivation practices | Lecture, discussion, exercise<br>" " "<br>" " "<br>" " " | 30 |
| | 3. Soil and fertilization | (1) To sum up the characteristics of the soil<br>(2) To make a plan of soil improvement and fertilization | 1. Preparation of soil map<br>2. The nutrients movement<br>3. Soil improvement method<br>4. Design of application standard of fertilizer including estimation of fertilizer requirement | Lecture, exercise<br>Lecture,<br>Lecture, discussion<br>Lecture, discussion, experiment | 20 |
| | 4. Sowing and planting practices | (1) To understand the plant physiological charactristics of rice seeds and to select the most applicable sowing and palnting method<br>(2) To prepare the best suitable cropping pattern | 1. Growth response of rice by weather condition<br>2. Sowing practices including chemical treatment of seeds, pre-germination etc., and technique of seedling preparation<br>3. Preparation of cropping pattern | Lecture, discussion<br>" "<br>" " | 20 |
| | 5. Weeding practice | (1) To make plan of weed control system | 1. Whole cycle of weeds<br>2. Nature and effect of herbicides<br>3. Tests of herbicides | Lecture, observation, discussion<br>Lecture, examination<br>Lecture, exercise | 15 |
| | 6. Plant protection practice | (1) To understand the kind and characteristics of diseases and insects<br>(2) To make the standard design of disease and insects control | 1. Physiological mechanism of the outbreak of diseases and insects<br>2. Pre-inspection and protection method<br>3. Safty treatment of agro-chemicals and agro-chemical pollution<br>4. Standard design of diseases and insects control including estimation of agro-chemical requirement | Lecture, discussion<br>Lecture, discussion<br>Lecture, discussion<br>" " | 15 |
| | 7. Harvesting practice | (1) To understand the correlation of harvesting method with weather and other farm management factors<br>(2) To make a plan of harvesting | 1. Judgement of optimum time of reaping<br>2. Assessment of yield<br>3. Efficiency of machines and cultivation method<br>4. Drying method<br>5. Planning of reaping and drying system | Lecture, discussion<br>Lecture, exercise, discussion<br>Lecture, discussion<br>" "<br>" " | 10 |
| | 8. Water control | (1) To control irrigation water in consideration of growth stage of rice, soil condition, etc. | 1. Water control method in different<br>2. Water control method under different soil condition<br>3. Quality of rice under different water control | Lecture, observation, discussion<br>" " "<br>" " " " | 10 |
| | 9. Rice cultivation technical system | (1) To make a plan of rice cultivation technique suitable for the local condition | 1. Rice cultivation technical system<br>2. Technical system by farming system | Discussion, exercise<br>" " | 20 |
| | | | | Total | 150 |

Note: [1] 1 unit = 6 hours

| Goal of Training | Training Items | Aims | Contents | Training Methods | Unit |
|---|---|---|---|---|---|
| II. Advance Cource | | | | | |
| A (For Agricultural Engineer)<br>To supervise the field operation of farm machinery and to make a management plan of farm machinery | 1. Adjustment of farm machinery | (1) To adjust the farm machinery to fit the farming condition | 1. Tillage machinery<br>2. Seed-bed preparation machinery<br>3. Cultivation machinery<br>4. Sowing machinery<br>5. Chemical application machinery<br>6. Grain harvesting machinery<br>7. Grain processing machinery<br>8. Material handling machinery | Lecture, exercise<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  " | 25 |
| | 2. Field operation of farm machinery | (1) To operate each farm machinery | 1. Tillage<br>2. Seed-bed preparation<br>3. Cultivating<br>4. Sowing<br>5. Chemical application<br>6. Grain harvesting<br>7. Grain processing<br>8. Material handling | Lecture, exercise<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  " | 50 |
| | 3. Estimation of number and size of farm machinery | (1) To estimate required number and size of farm machinery for farming in given farming conditions | 1. Field efficiency<br>2. Cover area each macine<br>3. Operation period of each practice<br>4. Required number of machinery | Lecture, exercise<br>"  "<br>"  " | 10 |
| | 4. Operation plan of farm machinery and cost estimate | (1) To make detailed plan of farm machinery operation | 1. Review of cropping pattern<br>2. Organization for field operation | Lecture, exercise<br>"  " | 15 |
| | | (2) To estimate the operation cost of machinery | 1. Depreciation method<br>2. Replacement<br>3. Repair and maintenance cost<br>4. Operation cost | "  "<br>"  "<br>"  " | |
| | | | | | Total 100 |
| B (For Mechanical Engineer)<br>To supervise and manage the maintenance and repair of farm machinery | 1. Overhaul of engine | (1) To overhaul and repair the engine of farm tractor | 1. Gasoline engine<br>2. Diesel engine | Exercise, discussion<br>"  " | 75 |
| | 2. Overhaul of farm tractor | (1) To overhaul and repair the farm tractor | 1. Wheel tractor<br>2. Crawler tractor | Exercise, discussion<br>"  " | |
| | 3. Overhaul of farm machinery | (1) To overhaul and repair the farm machinery | 1. Tillage machinery<br>2. Seed-bed preparation machinery<br>3. Cultivating machinery<br>4. Sowing machinery<br>5. Chemical application machinery<br>6. Grain harvesting machinery<br>7. Grain processing machinery<br>8. Materials handling machinery | Exercise, discussion<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  "<br>"  " | |
| | 4. Management of mechanical element, space parts, Fuel and oil | (1) To make plan of management and storing for mechanical element, spare parts, fuel and oil | 1. Mechanical elements<br>2. Spare parts<br>3. Fuel and oil<br>4. Others | Lecture, exercise<br>"  "<br>"  "<br>"  " | 10 |
| | 5. Planning and cost estimation of maintenance and repair for farm machinery | (1) To make detailed plan for maintenance and repair work | 1. Depreciation method<br>2. Replacement<br>3. Repair and maintenance cost | Lecture, exercise.<br>"  "<br>"  " | 15 |
| | | | | | Total 100 |

Table I-3 Standard Curriculum of Training for Farm Machinery Course

| Goal of Training | Training Item | Aims | Contents | Training Methods | Unit |
|---|---|---|---|---|---|
| I. Primary Cource | | | | | |
| To operate farm tractors with understanding of the related technical terms and basic knowledge on farm machinaries for rice cultivation; | 1. General situation of farm machinary and present use | (1) To understand, modernized agricultural condition porticularly of mechnized rice cultivation | 1. History and progress of farm machinery | Lecture, observation | 1 |
| | | | 2. Kind and classification of farm machinery | " " | |
| | 2. Structure of farm tractor | (1) To understand structure of farm tractor | 1. Wheel type tractor<br>2. Crawler type tractor | Lecture, observation | 1 |
| | 3. Devices of farm tractor | (1) To understand structure and function of each devices of farm tractor | 1. Gasoline engine | Lecture, observation | 10 |
| | | | 2. Diesel engine | " " | |
| | | | 3. Transmission device | " " | |
| | | | 4. Running device | " " | |
| | | | 5. Steering device | " " | |
| | | | 6. Brake device | " " | |
| | | | 7. Frame and body | " " | |
| | | | 8. Electric device | " " | |
| | | | 9. Hydraulic device | " " | |
| | | | 10. Power-take-off device | " " | |
| | 4. Mechanical elements | (1) To understand function and principle of mechanical element | Screw, spring, bearing, gear, belt drive, chain drive, link mortion, cam mortion, etc. | Lecture, observation | 1 |
| | 5. Fuel and oil | (1) To understand function and charactor of fuel and oil | Fuel, oil, grease | Lecture, observation | 1 |
| | 6. Structure of farm machinery | (1) To understand mechanical structure of farm machinery | 1. Tillage machinery | Lecture, observation | 8 |
| | | | 2. Seed bed preparation machinery | " " | |
| | | | 3. Cultivating machinery | " " | |
| | | | 4. Sowing machinery | " " | |
| | | | 5. Chemical application machinery | " " | |
| | | | 6. Grain processing machinery | " " | |
| | | | 8. Material handling machinery | " " | |
| | 7. Driving and maintenance of farm tractor | (1) To operate the driving of farm tractor | 1. Driving of wheel tractor<br>2. Driving of crawler tractor | Lecture, expercise<br>" " | 28 |
| | | (2) To make periodical maintenance of farm tractor | 1. Periodical maintenance of wheel tractor | Lecture, exercise | |
| | | | 2. Periodical maintenance of crowler tractor | " " | |
| | | (3) To understand the rules for safty operation of farm tractor | 1. General rules for safty operation operation | Lecture, exercise | |
| | | | 2. Regulation for road transportation | Lecture, exercise | |
| | | | | Total | 50 |

Table I-4 Standard Curriculum of Training for Mechanic Course

| Goal of Training | Training Items | Aims | Contents | Training Methods | Unit |
|---|---|---|---|---|---|
| To operate the overhaul and repair of farm machinery | 1. General situation of farm machinery and present use | (1) To understand modernized agricultural condition particularly of mechanized rice cultivation | 1. History and progress of farm machinery | Lecture, observation | 1 |
| | | | 2. Kind and classification of farm machinery | " " | |
| | 2. Structure of farm tractor | (1) To understand structure of farm tractor | 1. Wheel type tractor | Lecture, observation | 2 |
| | | | 2. Crawler type tractor | " " | |
| | 3. Structure of farm machinery | (1) To understand mechanical structure of farm machinery | 1. Tillage machinery | Lecture, observation | 10 |
| | | | 2. Cultivating machinery | " " | |
| | | | 3. Sowing machinery | " " | |
| | | | 4. Chemical application machinery | " " | |
| | | | 5. Grain harvesting machinery | " " | |
| | | | 6. Material handling machinery | " " | |
| | 4. Mechanical elements and spare parts | (1) To understand function and principle of mechanical element and spare parts | 1. Mechanical elemtns | Lecture, observation | 1 |
| | | | 2. Spare parts | " " | |
| | 5. Oil and fuel | (1) To understand function and charactor of fuel and oil | 1. Fuel, oil, grease | Lecture, observation | 1 |
| | 6. Overhaul of engine | (1) To overhaul and repair the engine of farm tractor | 1. Gasoline engine | Exercise, discussion | 30 |
| | | | 2. Diesel engine | " " | |
| | 7. Overhaul of farm tractor | (1) To overhaul and repair farm tractor | 1. Wheel tractor | Exercise, discusion | 50 |
| | | | 2. Crawler tractor | " " | |
| | 8. Overhaul of farm machinery | (1) To overhaul and repair farm machinery | 1. Tillage machinery | Exercise, discussion | 55 |
| | | | 2. Cultivating machinery | " " | |
| | | | 3. Sowing machinery | " " | |
| | | | 4. Chemical application machinery | " " | |
| | | | 5. Grain harvesting machinery | " " | |
| | | | 6. Material handling machinery | | |
| | | | | | Total 150 |

Table I-5 Standard Curriculum of Training for Farm Machinery Operation Course

| Goal of Training | Training Items | Aims | Contents | Training Methods | Unit |
|---|---|---|---|---|---|
| To operate the farm machinery for rice cultivation | 1. General situation of farm machinery and present use | (1) To understand modernized agricultural condition particularly of mechanized rice cultivation | 1. History and progress of farm machinery | Lecture, observation | 1 |
| | | | 2. Kind and classification of farm machinery | " " | |
| | 2. Structure of farm tractor | (1) To understand structure of farm tractor | 1. Wheel type tractor | Lecture, observation | 1 |
| | | | 2. Crawler type tractor | " " | |
| | 3. Structure of farm machinery | (1) To understand mechanical structure of farm machinery | 1. Tillage machinery | Lecture, observation | 6 |
| | | | 2. Cultivation machinery | " " | |
| | | | 3. Sowing machinery | " " | |
| | | | 4. Chemical application machinery | " " | |
| | | | 5. Grain harvesting machinery | " " | |
| | | | 6. Material handling machinery | " " | |
| | 4. Driving and maintenance of farm tractor | (1) To operate farm tractor | 1. Driving of wheel tractor | Lecture, exercise | 30 |
| | | | 2. Driving of crawler tractor | " " | |
| | | (2) To make periodical maintenance of farm tractor | 1. Periodical maintenance of wheel tractor | Lecture, exercise | |
| | | | 2. Periodical maintenance of crawler tractor | " " | |
| | | (3) To understand the rules for safty operation of farm tractor | 1. General rules for safty operation | Lecture, exercise | |
| | | | 2. Regulation for road transportation | " " | |
| | 5. Adjustment and/or calbiration of farm machinery | (1) To adjust the farm machinery to fit the farming condition | 1. Tillage machinery | Lecture, exercise | 22 |
| | | | 2. Cultivating machinery | " " | |
| | | | 3. Sowing machinery | " " | |
| | | | 4. Chemical application machinery | " " | |
| | | | 5. Grain harvesting machinery | " " | |
| | | | 6. Material handling machinery | " " | |
| | 6. Field operation of farm machinery | (1) To operate each farm machinery | 1. Tillage | Lecture, exercise, practice | 90 |
| | | | 2. Cultivating | " " " | |
| | | | 3. Sowing | " " " | |
| | | | 4. Chemical application | " " " | |
| | | | 5. Grain harvesting | " " " | |
| | | | 6. Material handling | " " " | |
| | | | | Total | 150 |

# ANNEX II PROPOSED FARM OPERATION PLAN

1. OBJECTIVE

2. FARM OPERATION PROGRAM

   2.1 Experimental Work

   2.2 Farm Operation Trials

   2.3 Seed Multiplication

3. ALLOTMENT OF FIELD

4. FARM MACHINERY FOR FARM OPERATION

   4.1 Mechanization Plan of Farm Operation

   4.2 Farm Machinery to be Used

   4.3 Number of Farm Machinery Required

## 1. OBJECTIVES

The objective of the Gasaba Rice Pilot Farm is to examine and establish an optimum farming system adaptable to the rice development of the Abu Gasaba Basin (15,600-ha) where a double cropping of rice a year will be made by full mechanized farming under a year-round irrigation.

In order to satisfactorily achieve the above objective, a systematic operation of the Pilot Farm is programmed as follows:

## 2. FARM OPERATION PROGRAM

Operation program of the Pilot Farm will include:

(1) Experimental work on crop-soil-irrigation water response.

(2) Farm operation trial by the use of farm machinery, and

(3) Producing pure seeds and their multiplication

The experimental study in the Pilot Farm will be the continuation of the experimental works conducted in Ed Dueim. The study aims to obtain the basic information and data on crop-soil-water response and rice cultivation techniques. The seeds to be used in the project area must be purified by using the technique of pure line selection, and then the purified seeds must be multiplied for the foundation seeds and further certified seeds.

Mechanized cultivation trials will be carried out for comparative studies on farming systems, particularly on seeding practices, i.e. (1) broadcast transplanting under puddling soil preparation, and (2) direct seeding under both puddling and dry field conditions.

### 2.1 Experimental Work

The experimental work comprises various studies on the rice cultivation technique and irrigation technique. The essential items to be studied are as follows:

A) Experiment on rice cultivation technique

(1) Experiment on varieties

More than 30 varieties of rice have been preliminarily selected as the suitable varieties for the project through the previous variety test made in Ed Dueim during the period of 1976 to early 1979. In addition to those varieties, it is necessary to make through studies applying more varieties to select the recommendable varieties suitable for mechanized farming.

(2) Experiment on seasonal sowing dates and transplanting dates.

Using the varieties of short-term, medium-term and long-term, every month sowing and every month transplanting will be carried out throughout the year in order to determine the most optimum cropping pattern.

(3) Experiment on optimum plant spacing

In order to find out the most suitable plant spacing, sowing as well as transplanting density will be tested by the use of several varieties. Test plots will be set up with the randomized method with three replications.

(4) Experiment on fertilizer response

To determine the most economical dosage of fertilizers, relationship between the essential chemical elements and the crop growth and yield will be clarified.

For this purpose, the fertilizer treatment test will be made at different level of dosage under the randomized method with three replications.

(5) Experiment on herbicide response

To select the suitable kinds of harbicides and also to determine their optimum dosage, effects of herbicide on weeding will be examined by the use of chemicals available. The test will be made for both cases of the broadcast transplanting and direct sowing.

(6) Purification of foundation seeds

Purification of seeds of the recommendable varieties selected by the variety test will be made prior to the operation of seed multiprication programme, which is one of the essential works for future extension of the rice cultivation in the Gasaba area. For purifying the seeds, a pure line selection method will be used.

B) Experiments on Irrigation

(1) Experiments on irrigation water requirements

Tank experiments by the use of lysimeters will be designed to determine i) total irrigation requirements, ii) the month of peak consumptive use, and iii) the normal consumptive use at the peak month. Besides, measurement of consumption of water in large fields will be made to make comparison with the results of the tank experiments.

(2) Experiments on irrigation methods

Optimum irrigation method will be studied on the following conditins;

- Optimum depth of irrigation water at the different growing stages of paddy
- Optimum interval of irrigation in case of intermittent application
- Trials on water saving cultivation practices
- Trials of mid-season drying practices

(3) Experiments on irrigation efficiency

- Measurement of vertical and horizonal percolation losses in paddy field
- Measurement of water losses in conveyance canals.

2.2 Farm Operation Trials

In view of the shortage of available labour force in the project area, the establishment of a mechanized farming system is one of the most important items to be studied in the Pilot Farm. The trial cultivations with the full use of farm machinery will be carried out in large scale farm plots to determine the optimum farming system and the extent of mechanization.

## 2.3 Seed Multiplication

Parallel with the purification of seeds as mentioned in 2.1(6), seed multiplication will be carried out to increase qualified seeds for the future extension of rice cultivation.

## 3. ALLOTMENT OF FIELD

For execution of the farm operation program briefly stated in the preceding Sections 2.1 to 2.4, field allotments for the major work programs are tentatively designed as follows:

| | | |
|---|---|---|
| 1. | Experiments on crops, irrigation, etc. | 10 ha |
| 2. | Purification of seeds, seed multiplication, training etc. | 20 ha |
| 3. | Farm operation trials | 100 ha |
| | Total | 130 ha |

## 4. FARM MACHINERY FOR FARM OPERATION

Operation of the Pilot Farm will be generally carried out by the full use of farm machineries. Number of machineries and equipment required for the farm operation are estimated under the following conditions:

(1) Cropping pattern; double cropping a year,

(2) Farming practices; soil preparation with and without puddling, broadcast transplanting and direct sowing, etc.

(3) Area of the farm to be subjected to the machinery operation; 130 ha

(4) General field conditions; climate, soils reflecting to the working efficiency of each machinery and workable days, etc.

## 4.1 Mechanization plan of Farm Operation

The farm operation will consist of the following working items:

(1) Soil preparation,

(2) Sowing,

(3) Plant protection and fertilization, and

(4) Harvesting

There are some different methods in the farming practices particularily in planting works as shown below;

a) Direct sowing on dry field

- Ploughing ___ 1st and 2nd Harrowing ___ Basic Fertilization ___ (Disc harrow)
  3rd Harrowing ___ Ridging and Final levelling ___ sowing ___ (Rotarvator)
  Irrigation

b) Transplanting and Direct sowing on submerged field

- Ploughing ___ 1st and 2nd Harrowing ___ Basic Fertilization ___
  3rd Harrowing ___ Ridging and Final levelling ___ Initial Irrigation ___ Tranplanting or Direct sowing

- Ploughing ___ 1st Harrowing ___ Basic Fertilization ___
  2nd Harrowing ___ Ridging and Final levelling ___ Initial Irrigation ___ Puddling ___ Transplanting or Direct sowing

(1) Soil preparation

The soil preparation will be made immediately after harvesting of the former crop, and then, followed by sowing.

Ploughing will be made by use of four-wheel type tractors mounted with disc ploughs. Harrowing will be practiced twice after ploughing and it will be made by the use of disc harrows attached to tractors. Application of the basic fertilization will be made by broadcasters.

Third harrowing is essential for mixing of the fertilizer with soil and for preparation of good seed bed for promoting the uniform germination of seeds as well as good seedling establishment. Rotarvators mounted to tractors will be used for this purpose.

Ridgers will be used to form temporary ridges in order to divide one field plot into 2 or 3 small sub-plots, if required. Final levelling of fields will be made by the use of levellers.

Puddling will be made by dram rotors and drive harrows attached to tractors.

(2) Sowing and transplanting

After the soil preparation works, sowing on dry field will be practiced using drill seeders. About 80 kg/ha of seeds will be used.

In case of sowing in the submerged field condition, seeds will be sown by hand. Transplanting will be made by means of the broadcast transplanting method.

(3) Plant protection and additional Fertilization

Application of herbicides, insecticides, fungicides and fertilizer will be conducted by the use of swath sprayers, power sprayers or power mist dusters.

Transportation of fertilizers and chemicals will be made by the use of trucks or dump trailar towed with tractors.

(4) Harvesting

Harvesting of rice will be conducted by rice combine harvesters. Rice straw will be cut down by straw choppers attached to the combine harvesters and the remaining stubble will be thereafter slashed by rotary cutters attached to tractors.

Trucks will be used for the transportation of rice grain from fields to stores.

4.2 Farm machinery to be used

Farm machineries to be used for the above farm operation are as follows.

(1) Tractor

Tractors will be of four-wheel drive type of 40 ps class. Crawler tractors of 45 ps class will be used supplementally.

(2) Attachments to tractors

The elementary attachments to tractors selected are as follows:

| | | |
|---|---|---|
| Ploughing | ; | Disc plough, 26" x 3 |
| Harrowing | ; | Offset disc harrow, tandem type, 18" x 20, width 1.9 m |
| | | Rotarvator, width 1.8 m |
| Ridging | ; | One row ridger |
| Levelling | ; | Rear grader, width 2.1 m |
| Puddling | ; | Dram rotor, width 3.1 m |
| | | Drive harrow, width 2.4 m |
| Sowing | ; | Drill seeder, 7 lines |
| Slashing | ; | Rear-mounted rotary cutter, width 1.5 m |

(3) Combine Harvester

Rice combine harvesters are of self propelled crowler type of 25 ps class with a cutting width of 1.3 m

(4) Equipment for other works

Application of fertilizers and chemicals will be made by power dusters and/or power sprayers.

The power dusters will be able to spray powdery or granular type fertilizers and agro-chemicals. Liquid spraying will be conducted by the use of power sprayers and knapsack type power mist dusters.

| | | |
|---|---|---|
| Power sprayer | ; | Swath type with tank capacity of 550 ℓ, with 60 m hose |
| Power duster | ; | Self propelled type, with 60 m hose |
| Power mist duster | ; | Knapsack type with tank capacity of 13 ℓ. |

4.3 Number of Farm Machinery Required

Field operation is scheduled to be made on two crop seasons in a year, and the net working days in each crop season is about 120 days. The working days for sowing and harvesting is 30 days in net and, therefore, those operations will be made at a rate of 4.3 ha per day.

Normal daily operation hour is scheduled to be 7 hours, but 2 or 3 hours of overtime working are expected for soil preparation, seeding and harvesting.

Actual field working capacity and working efficiency of each farm machinery is estimated as shown in Table II-1, 2.

Tractor is the basic power for 1) transportation of farm input, 2) ploughing, 3) harrowing, 4) levelling or puddling 5) sowing, and 6) rice strow cleaning etc. For these works, about 20 attachments are selected.

Number of the above farm machineries required in the farm operation are estimated as shown in Table II-3.

Table II-1 Cropping Pattern and Form Machinery Operation

| OPERATION | EQUIPMENT | HA/DAY |
|---|---|---|
| CROPPING PATTERN | | (130 HA) |
| **SOIL PREPORATION** | | |
| 1. Ploughing | Disc plough | 1.8 |
| 2. 1st Harrowing | Disc harrow | 6.0 |
| 3. 2nd Harrowing | Disc harrow | 6.0 |
| 4. Basic Fertilizing | Broad caster | 6.4 |
| 5. 3rd Harrowing | Rotavator | 2.5 |
| 6. Ridging | Ridger | 4.0 |
| 7. Levelling | Backgrader | 8.4 |
| 8. Puddling | Drum rotor | 5.8 |
| **SOWING** | | |
| 9. Sowing | Drill seeder | 1.8 |
| **PLANT PROTECTION AND FERTILIZATION** | | |
| 10. Weeding | Power duster | 20.3 |
| 11. 2nd Fertilizing | Power duster | |
| 12. 1st Chemical application | Power sprayer | 21.0 |
| 13. 3rd Fertilizing | Poser duster | |
| 14. 2nd Chemical application | Power sprayer | |
| 15. 4th Fertilizing | Power duster | |
| **HARVESTING** | | |
| 16. Harvesting | Combine harvester | 1.0 |
| 17. Straw slashing | Rotary cutter | 5.7 |
| 18. Paddy Transportation | Truck | |
| **OTHER WORK** | | |
| 19. Transportation of farm inputs | Dump trailar & Truck | |

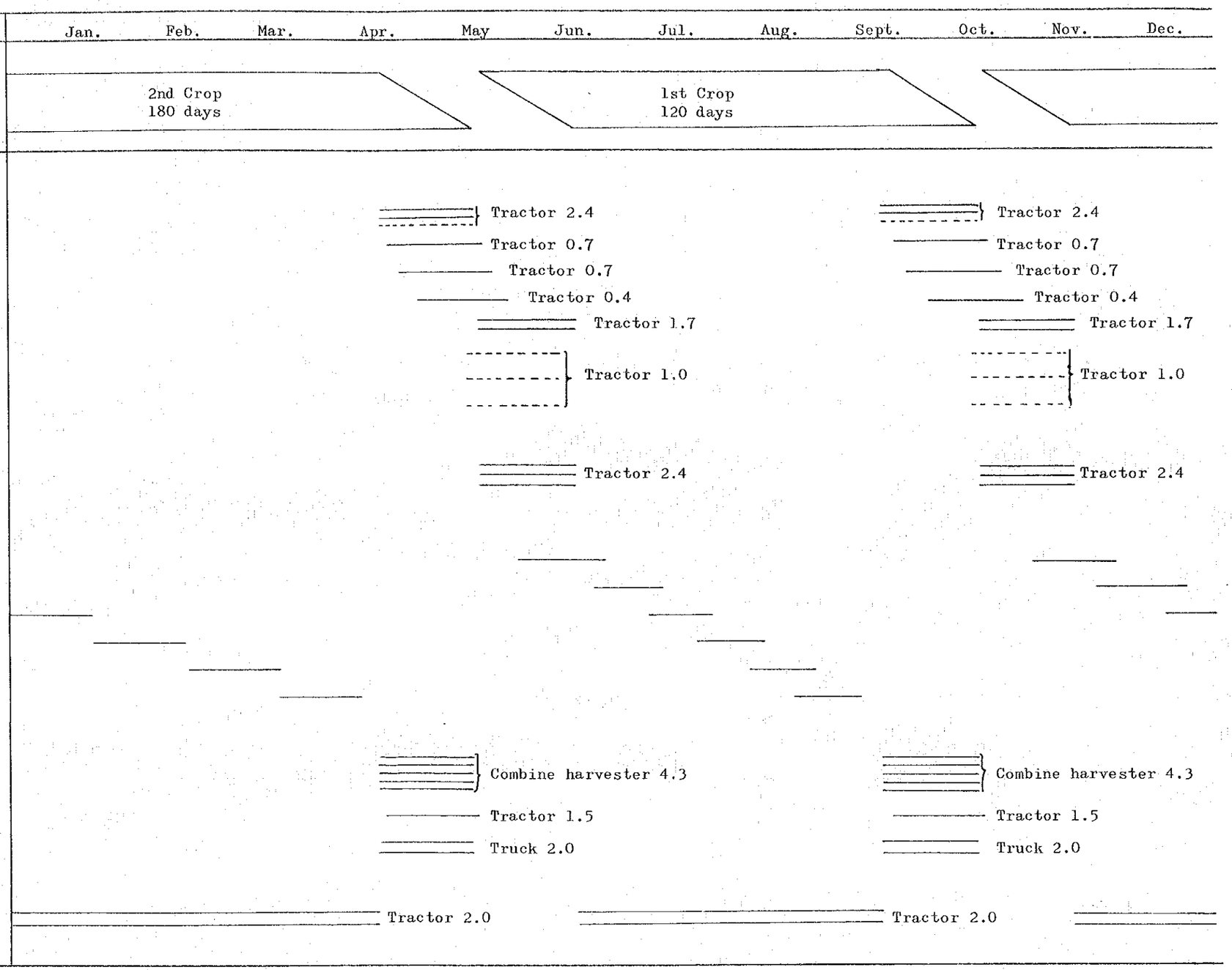


Table II-2 Farm Machinery Requirement for 130 Ha Operation

| Operation | Equipment | Type | Working Capacity ha/hr | Working Capacity ha/day | Working days | Covering Area (ha) | Required Number of Equipment | Number of Equipment | |
|---|---|---|---|---|---|---|---|---|---|
| 1. Ploughing | Disc plough | 26" x 3 | 0.26/1 | 1.8 | 30 | 54.0 | 2.4 | 3 | Wheel Tractor 40 ps Class/1 (0.38 x 70% = 0.2 ha/hr) |
| 2. 1st Harrowing | Disc harrow | 18" x 20 | 0.87 | 6.0 | 30 | 180 | 0.7 | 2 | " |
| 3. 2nd Harrowing | Disc harrow | 18" x 20 | 0.87 | 6.0 | 30 | 180 | 0.7 | 2 | " |
| 4. Basic Fertilizing | Broad caster | 280 ℓ 3 m | 2.0 | 14.0 | 20 | 280.0 | 0.4 | 1 | " |
| 5. 3rd Harrowing | Rotavator | 1,800 mm | 0.36 | 2.5 | 30 | 75.0 | 1.7 | 5 | " |
| 6. Ridging | Ridger | 1 row | 5.8 | 4.0 | 30 | 120.0 | 1.1 | 1 | " |
| 7. Levelling | Rear grader | 2,100 mm | 1.2 | 8.4 | 20 | 168.0 | 0.8 | 1 | " |
| 8. Puddling | Drum rotor | 3,100 mm | 0.84 | 5.8 | 15 | 87.0 | 1.5 | 2 | Crowlar Tractor 45 ps Class/2 |
| 9. Sowing | Drill seeder | 3 m 7 line | 0.26/1 | 1.8 | 30 | 54.0 | 2.4 | 3 | Wheel Tractor 40 ps Class (0.35 x 75% = 0.26 ha/hr) |
| 10. Weeding | Power duster | 25kg 7kg/min | 2.90 | 20.3 | 10 | 200.3 | 0.6 | 1 | Self propelled |
| 11. 2nd Fertilizing | Power duster | " | 2.90 | 20.3 | 10 | 200.3 | - | - | " |
| 12. 1st pest control | Power sprayer | 500 ℓ 95 ℓ/min | 3.0 | 21.0 | 10 | 210.0 | 0.6 | 1 | " |
| 13. 3rd Fertilizing | Power duster | 25kg 7kg/min | 2.90 | 20.3 | 10 | 200.2 | - | - | " |
| 14. 2nd pest control | Power sprayer | 550 ℓ 95 ℓ/min | 3.0 | 21.0 | 10 | 210.0 | 0.6 | 1 | " |
| 15. 4th Fertilizing | Power duster | " | 2.90 | 20.3 | 10 | 200.3 | - | - | " |
| | Power mist duster | 13 ℓ 3.5 ℓ/min | 0.54 | 3.7 | 10 | 37.0 | 3.5 | 4 | " |
| 16. Harvesting | Combine harvester | 1,300 mm | 0.15 | 1.0 | 30 | 30.6 | 4.3 | 5 | " |
| 17. Slashing | Rotary cutter | 1,500 mm | 0.82 | 5.7 | 15 | 85.5 | 1.5 | 2 | Wheel Tractor 40 ps Class |
| 18. Puddy Transportation | Truck | 4.0 ton | - | - | - | - | 2 | 2 | Self, propelled |
| 19. Transportation | Dump trailer | 2.0 ton | - | - | - | - | 2 | 2 | Wheel Tractor 40 ps Class |
| 20. Rice milling | Rice mill | 0.5 t/hr | (780 t) | 5 tons/day | 60 | 300 t | 2.6 | 4 | |

Table II-3 Farm Machinery Selected and Their Number Required

| Machinery | Type | Total Numbers Required | Supplied under 1977 Grant | To be supplied under Expansion Plan |
|---|---|---|---|---|
| 1) Tractor | | | | |
| Wheel tractor | 40 ps class, 4 wheel drive | 5 | 2 | 3 |
| Crawler tractor | 45 ps class swamp type | 1 | 0 | 1 |
| 2) Combine harvester | 25 ps class cutting width 1.3 m | 5 | 2 | 3 |
| 3) Attachments | | | | |
| Disc plough | 26" x 3 | 3 | 1 | 2 |
| Disc harrow | 18" x 20 | 2 | 1 | 1 |
| Rotarvator | 1.8 m | 5 | 3 | 2 |
| Broad caster | 280 ℓ | 1 | 1 | 0 |
| Drill seeder | 7 line | 3 | 1 | 2 |
| Drum rotor | 3.1 m | 2 | 1 | 1 |
| Drive harrow | 2.4 m | 1 | 1 | 0 |
| Riger | 1 row | 1 | 1 | 0 |
| Rear grader | 2.1 m | 1 | 1 | 0 |
| Rotary cutter | 1.5 m | 2 | 0 | 2 |
| Dump trailer | 2 ton | 2 | 1 | 1 |
| Cage wheel | | 5 units | 2 units | 2 units |
| Front weight | 28 kg | 5 sets | 2 sets | 3 sets |
| 4) Equipment | | | | |
| Power sprayer | Trailed type 550 ℓ | 1 | 0 | 1 |
| Power duster | Self propelled type 60 m in length | 1 | 0 | 1 |
| Power mist & duster | Knapsack type 13 ℓ | 4 | 2 | 2 |
| Paddy dryer | 0.7-1.0%/hr 320 kg | 1 | 0 | 1 |
| Rice mill | 0.5 ton/hr | 4 | 1 | 3 |
| 5) Spare parts | | LS | LS | LS |

# ANNEX III METEOROLOGY AND HYDROLOGY

1. Meteorological Data

2. Water Level and Discharge of the White Nile River

3. Water Quality of the White Nile River

## 1. METEROLOGICAL DATA (1) AT ED DUEIM (1941 - 1970)

| Element | Relative Humidity (%) (29 years) | | | Cloud Amount (0-8) | | | Total | Rainfall (MM) (30 years) | | | | | Evaporation Piche | Wind | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | No. of days | | | Max. off one | In day | (MM) | Prevailing direction | Mean Scalar Speed (M.P.H.) |
| Month | 0600 | 1200 | 1800 | 0600 | 1200 | 1800 | | 0.1 | 1.0 | 10.0 | Total | Date | | (10 years) | |
| Jan. | 38 | 25 | | 1.7 | 1.8 | | 0 | 0 | 0 | 0 | 0 | - | 14.0 | NE | 4 |
| Feb. | 34 | 20 | | 1.6 | 1.6 | | TR | 0 | 0 | 0 | 0.7 | 11-1966 | 15.7 | NE | 6 |
| Mar. | 29 | 17 | | 2.0 | 2.0 | | TR | 0 | 0 | 0 | TR | 21-1965 | 18.2 | NE | 6 |
| Apr. | 26 | 16 | | 2.1 | 2.1 | | 4 | 0.2 | 0.2 | 0.1 | 57.0 | 27-1959 | 19.7 | NE | 6 |
| May | 32 | 20 | | 2.6 | 2.8 | | 8 | 1.1 | 1.0 | 0.2 | 47.6 | 1-1942 | 18.8 | NE | 6 |
| Jun. | 49 | 27 | | 3.6 | 3.5 | | 24 | 2.8 | 2.8 | 0.8 | 54.0 | 2-1964 | 16.0 | SW | 5 |
| Jul. | 65 | 38 | | 4.8 | 5.1 | | 79 | 6.4 | 6.1 | 2.6 | 64.4 | 25-1943 | 10.9 | SW | 5 |
| Aug. | 73 | 48 | | 5.1 | 5.1 | | 108 | 8.1 | 7.9 | 3.4 | 88.6 | 11-1942 | 7.7 | SW | 5 |
| Sept. | 67 | 41 | | 3.8 | 3.9 | | 47 | 4.3 | 4.2 | 1.6 | 78.0 | 10-1959 | 9.1 | SW | 3 |
| Oct. | 52 | 32 | | 2.5 | 3.1 | | 10 | 1.3 | 1.2 | 0.2 | 43.6 | 14-1946 | 12.5 | NE | 3 |
| Nov. | 39 | 24 | | 1.6 | 1.6 | | TR | 0 | 0 | 0 | 5.3 | 3-1946 | 14.9 | NW | 4 |
| Dec. | 40 | 25 | | 1.3 | 1.3 | | 0 | 0 | 0 | 0 | 0 | - | 13.9 | NE | 4 |
| Year | 45 | 28 | | 2.7 | 2.8 | | 280 | 24.2 | 23.4 | 8.9 | 88.6 | 11-8-1942 | 14.3 | | |

Notes: (1) All times are G.M.T.

(2) To Obtain; aproximate evaporation from an open water surface Piche figures by 0.5

## METEOROLOGICAL DATA (2) AT ED DUEIM (1941 - 1970)

| Element | Atmospheric Pressure (MB) Station Level (30 years) | | | Air Temperature °C. Dry Bulb (30 years) | | | Daily Maximum (29 years) | | | Daily Minimum (29 years) | | | Vapour Pressure (MB) (29 years) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | 0600 | 1200 | 1800 | 0600 | 1200 | 1800 | Mean Highest | | Date | Mean Lowest | | Date | 0600 | 1200 | 1800 |
| Jan. | 969.0 | 965.8 | | 20.3 | 31.2 | | 32.1 | 40.0 | 12-1945 | 6.4 | 8.8 | 6-1949 | 9.3 | 11.3 | |
| Feb. | 968.7 | 965.1 | | 20.9 | 32.5 | | 33.3 | 44.8 | 23-1956 | 17.1 | 6.0 | 10-1949 | 8.3 | 9.6 | |
| Mar. | 966.8 | 963.3 | | 24.6 | 36.5 | | 37.3 | 45.2 | 29-1953 | 19.8 | 11.2 | 7-1959 | 9.1 | 10.3 | |
| Apr. | 965.6 | 962.3 | | 28.1 | 39.1 | | 40.0 | 46.0 | 23-1944 | 21.7 | 18.1 | 8-1949 | 9.8 | 11.4 | |
| May | 965.3 | 962.2 | | 30.3 | 40.1 | | 41.1 | 45.7 | 23-1952 | 24.2 | 16.2 | 21-1949 | 13.7 | 14.8 | |
| Jun. | 966.3 | 963.4 | | 29.7 | 38.4 | | 39.6 | 45.4 | 3-1963 | 24.4 | 14.3 | 23-1956 | 20.1 | 18.1 | |
| Jul. | 967.2 | 964.5 | | 27.1 | 34.9 | | 36.0 | 44.3 | 2-1962 | 23.4 | 14.2 | 7-1956 | 23.2 | 20.9 | |
| Aug. | 367.4 | 064.9 | | 26.1 | 32.8 | | 34.0 | 43.6 | 11-1956 | 22.7 | 14.6 | 11-1952 | 24.6 | 23.2 | |
| Sept. | 967.0 | 964.0 | | 27.3 | 34.7 | | 35.9 | 41.4 | 21, 29, 1956 | 22.7 | 13.0 | 3-1956 | 24.0 | 22.6 | |
| Oct. | 966.3 | 963.2 | | 26.5 | 36.7 | | 37.9 | 41.6 | 27-1951 | 23.2 | 16.5 | 25-1948 | 20.3 | 19.4 | |
| Nov. | 967.6 | 964.5 | | 25.8 | 35.0 | | 35.9 | 41.2 | 4-1957 | 20.7 | 10.7 | 29-1949 | 12.9 | 18.5 | |
| Dec. | 969.1 | 965.7 | | 21.7 | 31.9 | | 32.7 | 39.6 | 24-1943 | 17.2 | 5.4 | 24-1949 | 10.7 | 11.6 | |
| Year | 967.2 | 964.1 | | 25.0 | 35.3 | | 36.3 | 46.0 | 28-4-1944 | 21.1 | 5.4 | 24-1949 | 15.5 | 15.5 | |

## 2. WATER LEVEL AND DISCHARGE OF THE WHITE NILE

| | Mean Water Level Ed Dueim 1944 - 1976 | Mean Discharge Malakal 1967 - 1977 |
|---|---|---|
| Jan. | El 377.46 m | 1,088 $m^3/s$ |
| Feb. | 377.35 | 851 |
| Mar. | 376.92 | 765 |
| Apr. | 375.63 | 707 |
| May | 373.82 | 728 |
| Jun. | 372.90 | 904 |
| Jul. | 373.66 | 1,056 |
| Aug. | 376.26 | 1,190 |
| Sep. | 377.06 | 1,279 |
| Oct. | 377.40 | 1,422 |
| Nov. | 377.41 | 1,433 |
| Dec. | 377.43 | 1,354 |

## 3. WATER QUALITY OF THE WHITE NILE (DE DUEIM)

| | | | |
|---|---|---|---|
| PH | 8.0 | Alkalinity | 1,70 me/ℓ |
| EC | 2.2 x 10 mha/cm | Total anion | 2.61 me/ℓ |
| $Na^+$ | 0.97 me/ℓ | Mn | 0.03 mg/ℓ |
| | 22.4 me/ℓ | $SiO_2$ | 25.31 me/ℓ |
| $K^+$ | 0.12 me/ℓ | $PO_4^{3-}$ | 0.02 ppm |
| | 4.64 mg// | | |
| $Ca^{2+}$ | 0.52 me/ℓ | COD | 6.38 mg/ℓ $O_2$ |
| | 10.42 mg/ℓ | $NO_3$ | 0.49 mg/ℓ |
| $Mg^{2+}$ | 0.62 mg/ℓ | | |
| | 7.50 mg/ℓ | | |
| Total Cation | 2.23 me/ℓ | | |
| $Cl^-$ | 0.63 me/ℓ | | |
| | 22.27 mg/ℓ | | |
| $SO_4^{2-}$ | 0.28 me/ℓ | | |
| | 13.33 mg/ℓ | | |