THE DEMOCRATIC REPUBLIC OF THE SUDAN

MINISTRY OF AGRICULTURE, FOOD
AND NATURAL RESOURCES

# FEASIBILITY REPORT
# ON
# RICE DEVELOPMENT PROJECT
# IN ABU GASABA BASIN

## MAIN REPORT

JUNE, 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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

# FEASIBILITY REPORT
# ON
# RICE DEVELOPMENT PROJECT
# IN ABU GASABA BASIN



## MAIN REPORT



JUNE, 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

FOREWORD

Based on the request made by the Government of the Democratic Republic of the Sudan to the Government of Japan for technical cooperation on the rice cultivation development along the White Nile River, the Japan International Cooperation Agency, the Government agency responsible for implementing Government's technical cooperation programmes, dispatched to Sudan a preliminary survey team consisting of six experts headed by Mr. J. Kitamura, Head of Development Planning Division for Agriculture & Forestry, Japan International Cooperation Agency, for about three weeks from November 5, 1976.

Subsequent to the preliminary survey team, the Agency dispatched to the Sudan in May 1977 a feasibility study team comprising eleven experts headed by Mr. H. Yamamoto of Nippon Koei Co., Ltd. The team conducted technical and economic feasibility studies of the project.

The report presented here has been compiled based on the above studies as well as on the discussions which took place between the Sudanese Government officials concerned and the Japanese team for 10 days from January 24, 1978.

I am confident that this report will made a valuable contribution to the social and economic development of the Sudan as well as to the promotion of friendship between the Democratic Republic of the Sudan and Japan.

I wish to express my heartfelt gratitude to the officials concerned of the Democratic Republic of the Sudan for their kind cooperation and assistance extended to the team, without which the survey would not have been completed so successfully.

June. 1978

Shinsaku HOGEN
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo

Dear Sir,

We have the pleasure of submitting herewith the feasibility report on the Abu Gasaba Rice Development Project in compliance with the Terms of Reference agreed between the Government of Japan and the Government of the Democratic Republic of the Sudan (to be referred to as the Sudan).

In the course of the field investigation, we held meetings with the officials of the authorities concerned of the Sudan. All the findings and comments raised during the meetings are studied and fully incorporated in the report.

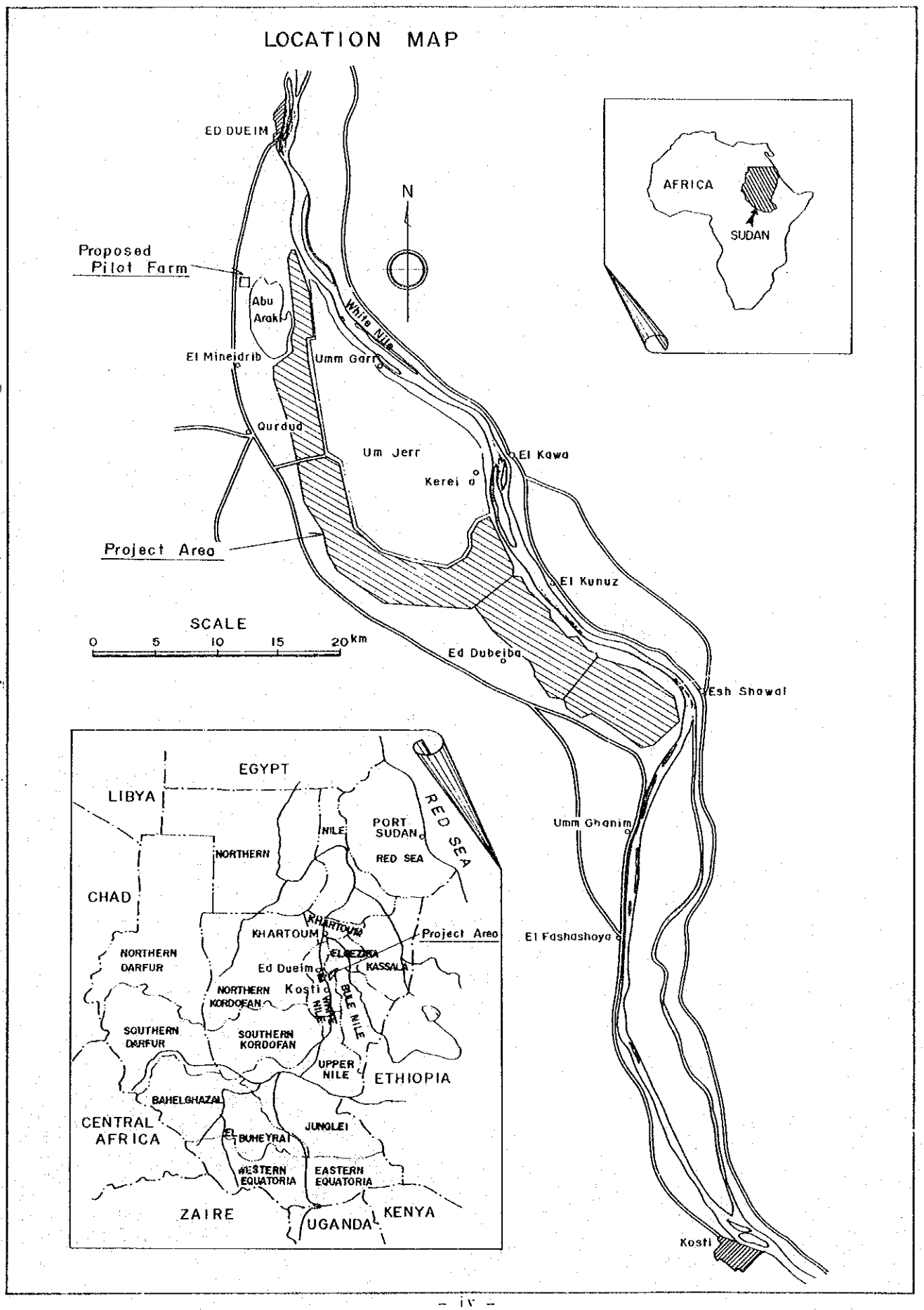
The purpose of the project is to realize rice cultivation in the Abu Gasaba area. The net area of 15,600 ha has been developed on around 40 km southward from the Ed Dueim, the capital of the White Nile Province. The scope of the project is limited to the land reclamation for rice cultivation and the establishment of rice processing plants. It is possible to expect an annual yield of 100,000 tons or more of milled rice for the domestic consumption in the Sudan as well as for the exportation to the neighbouring Arabic countries.

It is our sincere hope that the project will be implemented soon along the conclusion presented in this report. In submitting this report, we wish to express our sincere appreciation and gratitude to all personnel of your Agency, the Embassy of Japan in the Sudan and the authorities concerned of the Government of the Sudan for the courtesies and cooperation extended us during our field survey and home office work.

Very truly yours,

H. Yamamoto

Hiroshi Yamamoto
Leader for Feasibility Study Team
on Rice Development Projects in
Abu Gasaba Basin in the SUDAN


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

FEASIBILITY REPORT
ON THE RICE DEVELOPMENT PROJECT
IN ABU GASABA BASIN

SUMMARY OF CONTENTS

MAIN REPORT



ANNEXES

# SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY, CONCLUSION AND RECOMMENDATION

## Summary and Conclusion

### Economic and Agricultural Background

1. The Democratic Republic of the Sudan is the largest country in the African Continent, the total area of which is about 2.5 million $km^2$. The population and the density of population are about 16.5 million, 6.6 per $km^2$, respectively.

2. Gross Domestic Product (GDP) of the Sudan in 1974/75 fiscal year was £s.1,510 million. The GDP increased at an average growth rate of 12.8 % per annum during the 1968-74 period. The GDP per capita in 1974/75 year was £s.98.5 (US$250 equivalent).

3. The Sudan possesses a vast fertile land for agricultural development. Total cultivable land is estimated at 84 million ha of which only about 7.1 million ha are cultivated at present.

4. Agricultural sector is predominant in the national economy of the Sudan. More than 40 % of the GDP is produced in the sector and more than 70 % of employment opportunities is provided by the sector. About 95 % of the total export value is also derived from the sector.

5. Main crops produced in the Sudan are cotton, sorghum, wheat, millet, rice, maize, sesame, ground nuts and sugar cane. The total production of these crops amounted to 5.56 million tons in 1975/76 fiscal year. Among the commodities for export, cotton is prevailing; the share of cotton in the total export value has been in the range of 35 % to 60 % in recent years.

6. The types of farming in the Sudan can be classified into rainfed, irrigation and flood farming according to the way of water supply. According to the statistical data on 1973/74 fiscal year, about 90 % of the cultivated land was under rainfed condition; the remaining 10 % was under irrigation and less than 1 % was under flood condition.

7. The agricultural sector can be classified into two subsectors according to the productivity and the average income earned. They are the modernized sub-sector with the higher production and the traditional sub-sector with the lower production. The modernized sub-sector is mainly located in the Northern Region, while the traditional sub-sector occupies the Southern and Western regions. This dualism in the agriculture causes inequality in living and wealth not only among the farmers but also among the regions.

8. Under the Six-year Development Plan (1977/78 - 82/83), the largest portion or about 32 % of the budget will be invested in the agricultural sector to expand the agricultural production. The expected annual growth rate during the said Plan period is about 6.5 %.

9. One of the key policies of the Six-year Plan for the agricultural sector is to promote the exportation of suitable commodities such as sugar, wheat and rice.

10. The domestic demand for rice in the Sudan has exceeded the domestic production. The balance has been covered by importing rice from abroad. According to the Six-year Plan, rice production in the Sudan will be expanded from 12,000 tons in 1976/77 fiscal year to 57,000 tons in 1982/83 fiscal year. Self-sufficiency in rice will be attained in 1981/82 fiscal year if the Plan is implemented. Thereafter, the surplus will be exported.

11. The Agricultural Bank was established in 1959 to develop agriculture and to promote commercial activities in the Sudan. The main activities of the Bank are to provide loans to farmers and to import agricultural inputs including fertilizers and agricultural machinery.

12. The Public Corporation for Agricultural Production was established for the purpose of promoting agricultural development in the Sudan. The total area cultivated by the corporation is about one million ha.

The Project Area

13. The project area is located at about 40 km south of Ed Dueim, the capital of the White Nile Province which is situated at about 200 km south of Khartoum. The area is a narrow and flat strip along the left bank of the White Nile.

14. Many provincial roads are stretching from the area via Ed Dueim and Kosti and linking the area with local markets. The infrastructures in and around the project area are still not sufficiently developed. A new super highway 800 km long to run between Khartoum and Port Sudan is under construction. The railway lines between Kosti and Port Sudan are heavily burdened at present. The navigation network extends from the project area as far as Khartoum on the north and Juba on the south.

15. The total population in and around the project area is about 110,000. Out of the total population, the potentital labour force comprising 45,000 is conservatively assessed for the project area. While, as of July, 1977, the total number of registered labourers is about 21,000 at Dueim and Kosti labour offices; about 8,000 unskilled, about 6,000 semi-skilled and about 7,000 skilled. The supply of labour around the project area seems to be adequate to meet the labour requirement for the projects.

16. During the high water season of the White Nile, the area is submerged except the levees and terraces. The area is mostly covered with grasses, and during the low water season, a number of nomads stay there for grazing. No agrarian community is found in the area.

17. The average altitude of the area is about 376.20 m above MSL. The area is geologically composed of fluvial alluvium, the subsurface layer of which has a comparatively high bearing capacity.

18. Most soils in the project area are characterized by the Vertisols. They are very fine in texture, mild to moderate in alkalinity,

relatively poor in humus, rich in mineral elements, free from salinity and chemical toxin, high in cation exchange capacity, high in water holding capacity, and very low in permeability.

19. From the agronomic point of view, the lands in the project area are graded into four land suitability classes, namely

i. Moderately Suitable Land ($S_2$)
ii. Marginally Suitable Land ($S_3$)
iii. Conditionally Suitable Land ($S_c$) and
iv. Currently Unsuitable Land ($N_1$)

The land graded as $S_2$ with an area of about 13,200 ha and the land graded as $S_3$ with an area of about 4,000 ha are demarcated as the arable land, of which 15,600 ha are proposed for the net cultivable land in the project area.

20. The climate in the area is tropical and continental, and is notable for its high temperature and low humidity. The area is characterized by two distinct seasons, long term dry season and short term wet season. The mean monthly temperature seasonally varies between 25°C and 33°C. The relative humidity is 22 % in March and April, and 71 % in August, respectively. The annual evaporation is quite high, amounting to about 2,200 mm. The average annual rainfall at Ed Dueim is about 296 mm and varies widely from year to year, and 80 % of which is concentrated from July to September.

21. The water flow of the White Nile is rather stable throughout the year, which ranges from 1400 $m^3$/sec in Oct. to 700 $m^3$/sec in April. The water level of the river seasonally fluctuates between 372.90 m and 377.46 m above MSL. by the operation of the Jebel Aulia Dam; the high water season is from August through February of the following year, and the low water season is from March through July.

22. The intensity of agricultural land use is quite low in the project area. No irrigation and drainage facility exists in the area. Around the Abu Gasaba area, about 250 government and private pumping

schemes have been developed since the full operation of the Jebel Aulia reservoir was commenced.

23. Research activities are carried out administratively by the Agricultural Research Corporation under MAFN. However, no regional station nor sub-station of the said Department exist in the White Nile Province. In the project area, the research activities are undertaken by the Agricultural Extension Department and its liaison offices in Ed Dueim in cooperation with the Gezira Regional Research Station.

24. Near the project area there exist 17 cooperatives of various kinds handling agricultural production, flour milling, dairy farming, bakery and transports, etc. Eight cooperatives are multipurposed. Furthermore, two agricultural production cooperatives have recently been instituted.

The Project

25. The project is proposed with placing particular emphasis on rice production. The net area of about 15,600 ha is developed for the project. Together with the land reclamation for rice field development, the project also includes the establishment of rice processing plants.

26. The irrigation water required for the project can be obtained from the White Nile. The water level of the river is not sufficiently high even during the period of high water season to divert irrigation water into the project area by gravity.

27. The cropping pattern based on twice rice culture is introduced in the project area. The production of about 10 tons per ha of paddy per annum is anticipated at the full development stage with proper irrigation farming. Total production at the full stage will amount to about 156,000 tons of paddy or about 110,000 tons of milled rice. Approximately 230,000 tons of rice straw would be produced as by-product through twice rice cultivation, of which

about 80 % will be used as fodder substituting for the natural grasses grown in the project area. The implementation of the project will never exert unfavourable influence on the grazing prevailing in the Abu Gasaba area.

28. The farming practices are intensively mechanized to meet the systematic work flow from land preparation to harvest-to-mill processes. The appropriate number of tractors and combines for the whole project is 235 of 60 to 75 p.s. class and 25 of 60 p.s. class.

29. A year-round pumping irrigation system is proposed as the result of detailed study. The max. diversion requirement for the whole project is estimated at about 29 $m^3$/sec (1.85 ℓ/sec/ha). In due consideration of circulating use of the drained water for irrigation, total amount of annual net water requirement would be estimated at about 330 million $m^3$ on an average for the whole project area. Furthermore, about 250 million $m^3$ of water resources would be curtailed by land reclamation work of the project. The net water resources to be additionally consumed in the whole project area would be only 80 million $m^3$.

30. A well-drained condition in paddy field substantially increases yield of rice. Where the daily maximum rainfall with 10 years probability (79 mm/day) occurs, total amount of 11 million $m^3$ must be drained by pumping; unit requirement per ha is equivalent to about 2 ℓ/sec/ha. While, the total amount of drainage requirement through the dry season is assessed at about 90 million $m^3$; the unit requirement per ha is equivalent to about 0.2 ℓ/sec/ha.

31. Lengthy polder dikes are proposed for the prevention of submergence of the area. Feeder channels are provided to divert irrigation water for the existing pumping Schemes around the project area. The irrigation ditches and drains of onfarm facilities are alternately aligned. Onfarm road is proposed along the ditch. The size and shape of the terminal plot are designed with 0.8 ha, 40m x 200m, respectively.

32. The main features of the proposed facilities are tabulated below:

| | |
|---|---|
| - Irrigation canal | |
| Total length of main (km) | 52 |
| Total length of lateral (km) | 121 |
| - Drainage canal | |
| Total length of main (km) | 73 |
| Total length of lateral (km) | 103 |
| - Road | |
| Total length of main (km) | 206 |
| Total length of farm road (km) | 260 |
| - Polder dike | |
| Height of dike (m) | 2.5 to 4.5 |
| Total length of dike (km) | 155 |
| - Pumping station | |
| Total delivery discharge ($m^3$/min) | 2,100 |
| Pumping bore (mm) | 1,000 and 1,100 |
| Unit (Nos.) | 14 |
| Total gross power (p.s.) | 5,100 |
| - Canal structures | |
| Turnout (Nos.) | 936 |
| Check structure ( " ) | 84 |
| Irrigation culvert ( " ) | 189 |
| Drainage culvert ( " ) | 241 |
| Junction ( " ) | 435 |
| (Total) | 1,885 |
| - On-farm facilities | |
| On-farm ditch (m/ha) | 50 |
| On-farm drain ( " ) | 25 |
| On-farm road ( " ) | 21 |
| - Feeder channel | |
| Average bottom width (m) | 40 |
| Total length (km) | 100 |

- Processing plant (in each station)

| | |
|---|---|
| Milling capacity (t/hr x Unit) | 2 x 3 |
| Power (kVA x Unit) | 250 x 5 |

- Building

| | |
|---|---|
| Project office ($m^2$) | 2,700 |
| Processing center (") | 31,400 (6,200 x 5) |
| Workshop (") | 5,900 |
| Office and quarters for engineering service (") | 800 |

33. In the full operation stage, some 1,600 staffs and labours are required; 1,200 for the operation of irrigation & drainage facilities and farm machinery, 70 for workshops, 230 for the operation of rice mill & storage facilities, and 90 for the administration of the project. In addition, some 800 seasonal labourers are required during harvest season.

Cost and Benefit

34. The financial project cost estimated according to the current prices as of Oct., 1977 is about £s.82.65 million or US$210.8 million equivalent, including contingencies; the proportion of the foreign and local currency components is 65 % and 35 %, respectively. The cost breakdown is as shown below.

(Unit: £s.$10^3$)

| | Description | Foreign C. | Local C. | Total |
|---|---|---|---|---|
| i. | Civil works | 20,170 | 12,414 | 32,584 |
| ii. | Processing & storage facilities | 9,240 | 4,951 | 14,191 |
| iii. | Initial farm investment | 4,633 | 39 | 4,672 |
| | Sub-total | (34,043) | (17,404) | (51,447) |
| iv. | Contingencies | | | |
| | - Physical | 4,416 | 2,364 | 6,780 |
| | - Price | 15,461 | 8,962 | 24,423 |
| | (Total) | 53,920 | 28,730 | 82,650 |

35. The economic project cost is estimated at £s.61.17 million which consists of £s.41.40 million of the foreign currency component and £s.19.77 million of the local currency component as shown below.

(Unit: £s.$10^3$)

| | Description | Foreign C. | Local C. | Total |
|---|---|---|---|---|
| i. | Civil works | 20,581 | 12,414 | 32,995 |
| ii. | Processing & storage facilities | 11,035 | 4,951 | 15,986 |
| iii. | Initial farm investment | 5,076 | 39 | 5,115 |
| | (sub-total) | (36,692) | (17,404) | (54,096) |
| iv. | Physical contingency | 4,708 | 2,366 | 7,074 |
| | (Total) | 41,400 | 19,770 | 61,170 |

36. The annual production cost for the whole project at the full operation stage is financially estimated at about £s.11.9 million, US$30.3 million equivalent and is economically at about £s.5.6, US$11.2 million equivalent.

37. The economic net production value attributable to the project is assessed on the basis of the yield of 10 t/ha of paddy per annum, milled ratio of 70 % and £s.176/t of the world market price forcasted by IBRD.

(Unit: £s.$10^3$)

| | | With project | Without project | Incremental |
|---|---|---|---|---|
| i. | Production value | 19,219 | 61 | 19,158 |
| ii. | Production cost | 5,612 | 48 | 5,564 |
| iii. | Net production value | 13,607 | 13 | 13,594 |

While, the financial net production value is also estimated at full operation stage as follows.

(Unit: £s.$10^3$)

| | | |
|---|---|---|
| i. | Production value | 25,455 |
| ii. | Production cost | 11,902 |
| iii. | Net production value | 13,553 |

Project Evaluation

38. The internal rate of return of the project is estimated at 17.6 %. The figure is considered sufficient to justify the economic feasibility of the project. The benefit/cost ratio of the project is also calculated as follows, with three different annual discount rates.

| | Discount rate (%) | B/C |
|---|---|---|
| i. | 4.0 | 2.1 |
| ii. | 6.0 | 1.9 |
| iii. | 8.0 | 1.6 |

39. The financial feasibility of the project is assessed by the repayability of loans. The project is capable of fully repaying the loan under the following conditions.

| | Interest rate (% per annum) | Grace period (year) | Repayment period (year) |
|---|---|---|---|
| Case A | 10 | 8 | 30 |
| Case B | 11 | 8 | 40 |

Recommendation

1. The topographic map provided for the purpose of this study is not sufficiently accurate. An accurate aerial photo map covering the project area should be urgently prepared on an appropriate scale for the next stage.

2. The land ownership of the Abu Gasaba swamps is still being legally held by the inhabitants living around the swamps, despite being compensated for the inundation. The ownership of the project area should be legally clarified, prior to the project implementation.

3. Financing for the implementation of the project should be urgently promoted to avoid the excess cost caused by the delay of the project implementation.

4. The project authority should carry out the transfer of nomadic graziers through negotiation prior to the commencement of the construction work.

5. In order to assure the efficient implementation of the project, a qualified consulting firm should be employed to perform the engineering works of the project.

6. A competent contractor should be selected for carrying out the construction work of the project.

7. From the technical and economical viewpoints, stagewise development is recommended. In this connection, the construction of tract-1 can be given the top priority.

8. The infrastructures, particularly road and railway networks around the project area, should be urgently improved for transportation of inputs and outputs of the project in the future.

9. The terraces about 3,000 ha in total are scattered in the project area enclosed by polders. These terraces are excluded from paddy field development in this report, but are available for the cultivation of upland crops in the future.

10. The existing agricultural institutions around the project area should be improved for carrying out efficiently the support services of the project, such as research, training, input supply, credits, marketing, etc.

11. The annual yield of 10 tons of paddy is assumed in this study to evaluate the project, based on the results of the tests conducted at the experimental farm during the period of the study. To obtain further reliable data on paddy cultivation in the project area, the test now being conducted should be extended as long as possible.

12. The paddy cultivation practices proposed in this study should be confirmed through the cultivation trial and test in the pilot farm, which is under construction by the grant of the Japanese Government.

13. Operators of farm machinery in the Sudan have no experience in paddy cultivation at all. The operators to be employed in the project should be urgently and intensively trained before the operation of the project.

14. Bi-lateral agreements for rice export with foreign countries should be concluded in the future to secure the stable market for the Sudanese rice.

MAIN REPORT

TABLE OF CONTENTS

CONTENTS OF TABLE

CONTENTS OF FIGURE



CONTENTS OF DRAWINGS

## 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 |
| kℓ | kiloliter | gal. | gallon |
| ℓ | liter | $m^3$/sec | cubic meter per second |
| $m^3$/day | cubic meter per day | ℓ/sec | liter per second |
| ℓ/sec/ha | liter per second per hectare | t/ha | ton per hectare |
| $t/m^2$ | ton per suqare meter | ℓ/ha | liter per hectare |
| kg/ha | kilogramme per hectare | $kg/cm^2$ | kilogramme per square meter |
| t/hr | ton per hour | m/sec | meter per second |
| cm/sec | centimeter per second | $t/m^3$ | ton per cubic meter |
| hr(s) | hour(s) | mm/day | millimeter per day |
| kW | kilowatt | kVA | kilovolt ampere |
| pH | potential of Hydrogen | ppm | part per million |
| $^oC$ | *degree centigrade* | % | *percent* |
| $^o$ | degree of angle | EL. | Elevation above mean sea level |
| ft | feet | MSL | Mean Sea Level |
| PS | horse power | No(s) | Number(s) |
| L.S. | Lump Sum | US$ | U.S. dollar |
| £s | Sudan pound | Fig. | Figure |
| IRR | Internal Rate of Return | O & M | Operation and Maintenance |
| GDP | Gross Domestic Product | GNP | Gross National Product |
| JICA | Japan International Cooperation Agency | | |
| FAO | Food and Agriculture Organization of the United Nations | | |
| IBRD | International Bank for Reconstruction and Development | | |
| C.I.F. | Cost, Insurance and Freight | | |
| F.O.B. | Free on Board | | |
| MAFN | Ministry of Agriculture, Food and Natural Resources | | |
| H.E.E. | Hydroelectricity and Energy | | |

## CONVERSION TABLE OF MEASURES

| | |
|---|---|
| 1 mile = 1.609 km | 1 yard = 0.914 m |
| 1 foot = 0.305 m | 1 gallon = 4.546 ℓ |
| 1 feddan = 0.42 ha | |

## CURRENCY EQUIVALENT

| | |
|---|---|
| £s 1 = US$ 2.55/1 | US$ 1 = £s 0.39/1 |
| £s 1 = ¥ 689 | US$ 1 = ¥ 270 |

/1 Effective exchange rate which includes exchange incentives

# I. INTRODUCTION

# I. INTRODUCTION

## General

The Sudan is blessed with the favourable natural conditions for agriculture, which is a predominant sector in its share of the GDP and is making great contribution to its exportation.

In recent years, the sharp fluctuation in the cotton price in the foreign market has become the cause of unstable agricultural production in the Sudan. To carry out the agricultural development harmoniously, the Sudan Government has encouraged the diversification of the exportable crops. The local consumption of rice in the Sudan and the 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 the Six-Year Plan, primarily to attain self-sufficiency and secondarily to export the surpluses to the neighbouring countries.

## Historical background

The Sudan Government has made clear the possibility of promoting rice production in the vast swampy areas adjoining the riverside of the White Nile, which had been well developed before the construction of the Jebel Aulia Dam. Eversince the full operation of the dam was commenced in 1942, the areas have been subjected to seasonal inundation and have consequently been abandoned.

The authorities of the Sudan Government concerned have grasped the basic concept of re-development of the abandoned areas and carried out the preliminary study. As the result of the study, three areas around Ed Dueim, inclusive of Abu Gasaba Basin were recommended out of the seven investigated areas, with first priority given by the authorities concerned.

In July, 1975, the Sudan Government invited Nippon Koei Co., Ltd. to execute a reconnaissance survey for the said three areas, in response to the technical proposal prepared by the said consulting firm. The team headed by Mr. Yano, Chief of Irrigation and Drainage Dept.,

dispatched by the Nippon Koei carried out the field reconnaissance for the proposed Ed Dueim development scheme, as well as for the existing pilot paddy field area under the Gezira scheme, and submitted the Reconnaissance Report to the Sudan Government in January, 1976. The report concluded that the schemes are suitable for rice development and both technically and economically sound.

On the basis of the conclusion of the report, the Sudan Government requested the Japanese Government to dispatch a contact mission for the promotion of the said project. At the beginning of November, 1976, the contact mission headed by Mr. Kitamura, Head of Development Division, Agriculture and Forestry Dept. of JICA/1 was dispatched by the Japanese Government. The mission specified the Abu Gasaba Basin, out of three schemes, for the feasibility survey to be undertaken on the coming stage, in due consideration of the easiness of access, the overall soundness of the project and the availability of topographic map. The mission, furthermore, recommended the construction of a small scaled pilot farm to obtain the field data on rice cultivation.

In early 1977, the Sudan Government requested the Japanese Government for the technical assistance of the feasibility survey on the Abu Gasaba Rice Development Project in compliance with the decision and recommendation of the said contact mission. In March, 1977, the Japanese Government decided to execute the said survey and entrusted it to JICA. The Agency singed a contract for the survey with Nippon Koei Co., Ltd., Tokyo, and dispatched a survey team to the Sudan during May to August. The objective of the survey was to formulate the physical plan for rice development in the Abu Gasaba Basin and evaluate the feasibility of the project. The survey included the preparation of the development plan, basic design, preliminary estimates of costs and benefits and economic analysis.

Scope of project and its importance

The proposed project aims at producing rice production in the abandoned Abu Gasaba swamp extending along the left bank of the White Nile.

---

/1 JICA: Japan International Cooperation Agency

The scope of the project includes the implementation of infrastructural facilities necessary for rice cultivation together with the installation of rice processing centers.

The net project area to be developed is 15,600 ha. It will play an important role in the agricultural development in the Sudan. The project is expected to produce annually about 110,000 tons of milled rice at the full operation stage. The amount of products is far greater than that of the self-sufficiency in rice in the Sudan. The surpluses will be exported to the neighbouring Arabic countries. They will substantially reduce the outflow of the foreign exchange for import of rice and will earn a large amount of foreign exchange from the export of rice. The project will largely contribute to the improvement of the balance of payment.

# II. GENERAL ECONOMIC AND AGRICULTURAL BACKGROUND

## II. ECONOMIC AND AGRICULTURAL BACKGROUND

### 2.1 National Economy and Agriculture

#### 2.1.1 General Economy

Gross Domestic Product of the Sudan in 1974/75 fiscal year was £s.1,510 million. The average annual growth rate of GDP from 1966/67 to 1974/75 fiscal year was 12.8%. Population of the Sudan in 1977 is estimated at about 16,536,000. Population growth rate of the nation is 2.5%, and is 2.7% in the Northern Region and 1.7% in the Southern Region. Per capta GDP is £s.98.5. Economically active population is 88.9% among males and 21.2% among females.

Agricultural sector is dominating among all. Its share in GDP is about 40% and more than 70% of the total population are engaged in agriculture. Its share in export is over 95% and about 50% of government revenues are derived from this sector directly and indirectly. Next comes the sector of commerce, finance and real estate.

The main items of imports are transport equipment, machinery with spare parts, textile, chemical and pharmaceutical products, sugar, crude materials, other food stuffs, tea, coffee and others. The import-share of the transport equipment is about 18%, the maximum share among them. Main items of export are cotton, groundnut, sesame, gum Arabic, meat and others. The export share of cotton is approximately half share of the total export amounts, the maximum share among them.

The current account has been in deficit in recent years. On the other hand, capital account has been in surplus. The deficit of the current account, however, exceeds the surplus of the capital account, resulting in the deficit of the balance of payments. The value of the balance of payments in 1974/75 and 1975/76 were £s. -2.6 million and £s. -134.4 million, respectively.

The Sudan has been recently confronted by some problems in economic development. Main economic activities including modernized agriculture are seen in the northern part of the Sudan, while very premitive farming

prevails in the southern and western regions, resulting in the economic inequality among the regions.

Transportation in the Sudan is not sufficiently developed so far Road network is poor and most of the roads remain unpaved. Railway transport can not cope with the amount of freight and passengers. There is only one international port i.e., Port Sudan. The capacity of this port is not large enough to handle exports and imports promptly.

### 2.1.2 Main Characteristics of Agriculture

Domestic market for agricultural products is relatively small. However, Arab countries can be a big market for Sudanese agricultural commodities. They are located very close to the Sudan and the agricultural potentials of these countries are very limited. The social and cultural tie between the Sudan and these countries is very strong.

Main crops are cotton, sorghum, wheat, ground nut, gum arabic, millet, sesame and maize. Estimated cropping area and output of these crops in 1974/75 are given below.

| | Sorghum | Millet | Ground nut | Sesame | Maize | Wheat | Cotton | Gum arabic |
|---|---|---|---|---|---|---|---|---|
| Area ($10^3$ fedds) | 5,577 | 2,576 | 1,792 | 2,173 | 197 | 591 | 1,219 | NA |
| Production ($10^3$ t) | 1,702 | 402 | 930 | 233 | 46 | 269 | 647 | NA |

The Sudan possesses vast fertile flat land. However, large extent of the northern Sudan are covered with desert, while the southern Sudan is blessed with sufficient rainfall for farming. The area between the north and the south is largely constrained with less rainfall except for the short rainy season. Mechanized irrigation farming is practiced in the northern and central parts of the country, whereas rainfed primitive farming is mainly prevailing in the southern and western area. About one fourth of agricultural labor force is migrating as nomadic graziers. Their productivity in animal production is very low and their living standard is also very poor.

### 2.1.3 Current Situation of Rice Production

Rice is a relatively new crop introduced into the Sudan. It is being cultivated in Gezira, Bahr El Ghazal and Equatoria. Average area and production of rice during the past six years in the Sudan are estimated at about 10,000 ha and 12,000 tons, respectively. The average yield of rice in 1975/76 in Gezira, Bahr El Ghazal and Equatoria is 1.19 ton/ha, 0.32 ton/ha and 0.57 ton/ha, respectively.

Only single cropping has been adopted in the Sudan. Average yield of rice production in the Sudan is low with the maximum figure of 1.55 ton per ha in Gezira compared with other rice producing countries.

The demand for rice has been exceeding the supply in the Sudan. The balance has been compensated by imported rice. The amount of imported rice in the recent years has increased from 5,000 tons level to 10,000 tons level per annum.

Under these conditions, the Sudan Government is planning to expand rice production so that the Sudan attain self-sufficiency in rice at an earlier stage and to export rice at a latter stage. According to the Six-Year Plan, per capita consumption and total rice demand in the Sudan will be 1.50 kg/year and 29,000 ton/annum[/1] at the end of the plan.

Rice production will be expanded both vertically and horizontally. Rice production will be increased from 12,000 tons in 1976/77 to 57,000 tons in 1982/83, i.e., nearly 400% increase. Self-sufficiency in rice will be attained in 1981/82. Thereafter, the production will exceed the demand and surplus will be exported mainly to Arab countries.

---

/1 The per capita consumption is expressed in terms of milled rice and the total demand is in terms of paddy.

### 2.1.4 Present Status of Irrigation and Its Development

The types of agriculture in the Sudan can be classified into the irrigated agriculture, rainfed agriculture and flood farming agriculture, according to the water supply practice. According to the Statistical Year Book, 1973 in Sudan, the area of the respective type of agriculture in 1973/74 is tabulated below.

| | Irrigated | Rainfed | Flood | Total cropping area |
|---|---|---|---|---|
| Area ($10^3$ ha) | 490 | 4,464 | 28 | 4,982 |
| Ratio ( % ) | 9.8 | 89.6 | 0.6 | 100 |

The importance of irrigated agriculture is, however, far greater than the figures of 9.8% indicate above since the bulk of foreign exchange earnings is derived from the irrigated cotton crop.

The 1959 agreement between the Sudan and Egypt allocates 18.5 milliard $m^3$ of the Nile water to the Sudan without any restriction on the irrigation period. The agreement gave a big boost to the expansion of irrigation in the Sudan. The harvest area increased from 1 million fedds in 1959 to 1.7 million fedds in 1968/69 and the amount of irrigation water increased during the same period from about 4 milliard $m^3$ to about 7 milliard $m^3$. The present water balance in the Nile system represent an available surplus of about 2 milliard $m^3$. But, in the future, the balance will have a deficit of about 7 milliard $m^3$ with the implementation of many short and medium term plans for irrigation development, if any water resource development plan will not be implemented.

In the dry north zone, the accent on the irrigation development has been indicated to use the Nile water; in the central Savannah, rainfed agriculture and livestock raising are being mainly featured, and in the south zone with much rainfall, the development have been suited for the local condition which vary from area to another.

Nearly 50% of the irrigated harvest area are cultivated under the pumping schemes. By location and the type of irrigation, the pump schemes may be grouped into three categories;

- the pumping schemes in the northern province which are mainly governed to provide subsistence living for most of the people in the area,
- the private and government cotton schemes of the White Nile and the Blue Nile, and
- the vegetable, fruit and fodder areas around the large towns along the rivers and especially the three towns of Khartoum, Ondurman and Khartoum North. The cropping intensity in the pumping scheme is about 100 percent.

The storage irrigation project, such as Gezira and Managil Extension, of which the water resource depends on reservoirs, accounts for slightly more than 50% of the irrigated harvest area. In the case of the storage irrigation projects, one third of the equipped area is left fallow and this lowers the cropping intensity. The low cropping intensity is due to the fallow steming from the characteristics of the soil, the shortage of labour in the irrigated area and the restricted water supply.

In the Sudan, the Ministry of Irrigation and Hydro-Electric Energy is responsible for excavating canals, reservoir and distributaries and for ensuring their proper maintenance. The small canals and distributaries into farmers fields are also built by the Ministry. The Ministry is responsible for the development of Nile water, namely, the water distribution to the canals for the Gezira scheme, Managil extension, Khasm El Girba and the maintenance of dams.

### 2.1.5 Agricultural Support Services

#### 1) Agricultural Research

Agricultural Research Corporation under the Ministry of Agriculture, Food and Natural Resources (MAFN) conducts research works on production of field and horticultural crops. Under the Research Corporation there are four regional stations and six research substations as shown below. The Agricultural Research Corporation, the Technical Committee and the Agricultural Research Council formulate research programmes and prepare annual research report. Research activities of these stations consist of crop husbandry, phytopathology, plant selection and breeding, entomology, soil science, botany, and others.

| Name of Station | Service Area | Number of Staff |
|---|---|---|
| Gezira R. St. | Gezira Scheme & neighbouring area. | 1 - Director<br>31 - Scientists |
| Hudeiba R. St. | Northern Province | 1 - Head<br>9 - Research workers |
| Kenana R. St. | Kenana area | 1 - Head<br>8 - Research workers |
| Yambio R. St. | Southern provinces | not functioning |
| Shambat R. Sub. | Gezira R. Station | 1 - Head<br>1 - Research worker |
| Kadugli R. Sub. | Nuba, Kordofan Prov. | 1 - Head<br>1 - Research worker |
| Sennar R. Sub. | Sennar area | 1 - Head<br>2 - Research workers |
| Maatry R. Sub. | Managil Extension | 1 - Scientist |
| Guineid R. Sub. | Sugarcane research | 1 - Head<br>2 - Research workers |
| Khashm El Girba R. Sub. | Khashm el Girba Scheme | 1 - Head<br>3 - Research workers |

2) Extension Services

Extension services are provided by the Department of Extension of the Ministry of Agriculture, Food and Natural Resources. Under the technical supervision of the Director there are 13 extension centers under the administration of the Provincial Government. In some provinces and districts there is an Extension Advisory Committee comprising representative of each interested Government department, cooperatives and farmers' leaders to advise the guide the extension work in their area. A typical unit has an Inspector of Extension and 2 or 3 Shambat diplomates each with three local extension workers.

3) Credit and Inputs

The Agricultural Bank was established in 1959 to develop agriculture and promote commercial activities in the Democratic Republic of the Sudan. The paid-in capital in 1976 was £s. 15 million which was shared by the Bank of Sudan and the Ministry of Finance and National

Planning. The Bank has 20 branches in the country including those in Kosti and Ed Dueim.

The Bank provides three kinds of loans, 1) short-term or seasonal loan, 2) medium-term loan and 3) long-term loan. Main objectives, loan conditions and activities are described in Annex VIII. The activities of the Bank are to provide loan to farmers and businessmen and also to supervise storage, transportation and marketing of products on behalf of the lessees under certain circumstances. The Bank also imports agricultural inputs including fertilizers and agricultural machinery./1

4) Plant Protection

Plant Protection Department of MAFN is responsible for the extermination of pests which are harmful to crops. It is responsible for eradication of national pests such as rats, desert locust, and grain eating birds. It is also responsible for the control of water hyacinth which is prevalent in the White Nile River and is considered dangerous. Hyacinth is carried to the fields either by flood or by irrigation water and becomes the noxious weed. The expenses for the extermination of pests and water hyacienth are borne by the Government.

Some of the staffs of the Plant Protection Department have been transferred to the Public Corporation for Agricultural Production. They have formed a plant protection section in the Corporation and are engaged in plant protection activities.

5) Public Corporation for Agricultural Production

The Public Corporation for Agricultural Production is an autonomous public corporation established for the purpose of agricultural development in the Sudan. It is under the control of MAFN. The Corporation supervises 10 subcorporations. Total cropping acreage of these subcorporations amounts to about one million ha. Cotton, sorghum, wheat and vegetables are the main crops.

Each subcorporation manages and supervises the own public scheme. It determines tenancy and rotation pattern in the schemes and instructs tenants so that they follow proper farming practices. It also supplies agricultural inputs for the tenants.

In case of cotton, subcorporations cooperate with the tenants in such farming operations as fertilizer and insecticide application, picking and ridging. These expenses are entered into the joint account. After picking, subcorporations classify cotton into 8 grades and transport it to ginning factories. Headquarters of the Public Corporation ginns seed cotton in the ginning factories and transport ginned cotton to Port Sudan where the ginned cotton is graded and delivered to the Cotton Marketing Corporation. These expenses are entered into the general account.

Subcorporations give loans which are financed by the Headquarters to tenants when they need cash to cover cotton production expenses without interest and specified repayment. These loans are entered into the farmer's individual account.

6) Cooperative Movement

To achieve higher efficiency in the agricultural sector, cooperative unions and cooperatives have been established. The Central Cooperative Union in Khartoum controls the regional cooperative union in each province. Each regional cooperative union supervises the local individual cooperative in each province. The organization chart of the structure in the White Nile Province is shown in Fig. 2.1. Local government assigns one assistant commissioner who supervises the local offices of the Cooperative Department of the Central Government. The staff of local offices usually consist of cooperation inspectors, cooperation officers and cooperation controllers.

7) Agricultural Education and Training

Agricultural education and training are of vital importance for the development of agriculture in the Sudan.

They are conducted at five levels:

i) Agricultural secondary schools (under the Ministry of Education).
ii) Agricultural training colleges and schools (under the Ministry of Agriculture).
iii) Faculty of Agriculture (University of Khartoum).
iv) Post graduate training (mainly abroad).
v) Vocational Training Centers

The secondary schools select pupils who have passed the 9th grade and give them either art or science-oriented training in agriculture or engineering for four years.

Shambat Agricultural College is the only agricultural training college for training people for intermediate diploma level, below university standards. The college provides a three-year course in general agriculture, oriented towards applied and practical training and leading to a Diploma in Agriculture. Its entrants are selected from the students with Higher Secondary Certificate of Education, i.e., after 12 years of education.

Candidates for the BS of Agriculture are selected from the students of good school records holding the Higher Secondary Certificate of Education after 12 years of schooling. The Faculty of Agriculture covers not only crop husbandry but animal husbandry, range management and forestry. Practical training is limited but arrangements are made for study and work tours during vacations to projects in the rural areas.

It is planned to increase post graduate training within the Sudan rather than abroad in more general fields than is normally given abroad aiming at usefulness and relevance to the Sudan.

The vocational training centers are established for the purpose of training skilled laborers under the management of the Department of Labour, Ministry of Public Service and Administrative Reform. They provide the training courses of three years mainly for those who have completed junior high school level education. The courses mainly consist of mechanical, electrical, automobile and farm machinery engineering.

## 2.2 Agricultural Achievements

Wheat area was increased as programmed, reaching 753,000 fedds, but the yield did not come up to the level required for achieving self-sufficiency. In case of rice, domestic production is now meeting about 52% of the demand. A promising start has been made in coffee production, and local production is now supplying about 10% of the demand. Tea is a slow growing plant and major plantations have not yet been established. Production of fruits and vegetables increased sufficiently to meet the growing demand, and except for seasonal peaks, the prices remained at a reasonable level. The main achievements in crop production during the last Five-Year Plan are summarized as follows.

Planned and Actual Crop Production during Five Year Plan

| | Crop | Base Year 1969/70 ($10^3$ MT) | Target 1974/75 ($10^3$ MT) | Actual 1974/75 ($10^3$ MT) | Actual as Percentage of Target (%) |
|---|---|---|---|---|---|
| 1. | Sorghum (Dura) | 1,453 | 2,356 | 1,702 | 72 |
| 2. | Millet (Dukhn) | 385 | 442 | 402 | 91 |
| 3. | Wheat | 115 | 304 | 269 | 88 |
| 4. | Rice | 3 | 16 | 7 | 44 |
| 5. | Maize | 36 | 55 | 46 | 84 |
| 6. | Groundnuts | 385 | 603 | 930 | 154 |
| 7. | Sesame | 175 | 266 | 233 | 88 |
| 8. | Castor | 23 | 32 | 14.5 | 45 |
| 9. | Cotton: Long Staple | 561 | 873 | 529 | 61 |
| | Medium Staple | 114 | 326 | 102 | 31 |
| 10. | Sugar cane | 826 | 2,030 | 1,290 | 64 |
| | Total Ten Crops | 4,076 | 7,303 | 5,524 | 76 |

## 2.3 Development Plan for Agriculture

The six year development plan starts in 1977/78 fiscal year and ends in 1982/83 fiscal year. Thirty-two percent (32%) of the budget will be spent in the agricultural sector which is supposed to play the leading role as before for the development of the Sudan. The planned growth rate in agriculture is 6.5% per annum; the overall growth rate expected is 7.5%.

### 2.3.1 Targets of the Six Year Plan

The production targets mentioned in the Six-Year Plan are summarized in the following table. It is evident from the table that the rates of increase envisaged for various products vary widely reflecting the overall effect of the strategies adopted for the Six-Year Plan.

Production Targets

| | | Base Year 1976/77 (Provisional) | | | Target 1982/83 | | |
|---|---|---|---|---|---|---|---|
| | Product | Area ($10^3$ fedds) | Yield (kg/ fedds) | Output ($10^3$MT) | Area ($10^3$ feddes) | Yield (kg/ fedds) | Output ($10^3$MT) |
| 1. | Cotton: | | | | | | |
| | Long Staple | 760 | 635 | 483 | 790 | 707 | 559 |
| | Medium Staple | 210 | 500 | 105 | 350 | 849 | 297 |
| | Short Staple | 155 | 122 | 19 | 350 | 200 | 70 |
| | Total | 1,125 | 540 | 607 | 1,490 | 621 | 926 |
| 2. | Sorghum (Dura) | 6,000 | 316 | 1,900 | 9,100 | 411 | 3,740 |
| 3. | Wheat | 622 | 500 | 311 | 890 | 750 | 668 |
| 4. | Millet (Dukhn) | 2,500 | 160 | 400 | 2,800 | 185 | 518 |
| 5. | Rice (Paddy) | 24 | 500 | 12 | 100 | 570 | 57 |
| 6. | Maize | 210 | 250 | 53 | 315 | 380 | 120 |
| 7. | Cassava | 110 | 1,500 | 165 | 180 | 2,000 | 360 |
| 8. | Sesame | 2,200 | 110 | 242 | 2,700 | 140 | 378 |
| 9. | Groundnuts | 1,840 | 456 | 839 | 2,900 | 541 | 1,568 |
| 10. | Coffee | 3 | 500 | 1.5 | 15 | 670 | 10 |
| 11. | Tobacco | 1 | 200 | 0.2 | 8 | 200 | 1.6 |
| 12. | Sugar cane | 40 | 30,230 | 1,200 | 288 | 30,210 | 8,700 |
| 13. | Horsebeans | 36 | 800 | 29 | 55 | 850 | 47 |

### 2.3.2 Strategy and Policies for Development

With adequate and well planned investments the agricultural sector is capable of realizing economic prosperity and welfare of the Sudanese people, and can make important contribution to food supplies of the Arab countries. The strategy for agricultural development in the Six-Year Plan is briefly described as follows:

Vertical Expansion

Vertical expansion aims at optimizing resource utilization and making various projects economically competitive. It is to be achieved through:-

a) the optimal utilization of irrigated lands.

b) consolidation, grouping and electrification of pumping schemes on the White and Blue Nile.

c) integrating livestock in crop production schemes.

d) adequate provision of fertilizers, insecticides, agricultural machinery, modern equipment and other inputs essential for raising productivity in existing projects.

e) raising effectiveness of agricultural extension and research services.

f) developing an efficient primary marketing system for all agricultural products.

g) introduction of high yielding drought resistant varieties of crops in rainfed regions.

Horizontal Expansion

With vast untapped land resources in the country, horizontal expansion of agricultural production holds promise for quick and economical increase in production. It has three important elements: general strategy for horizontal expansion, mechanized farming and modernization of traditional farming.

a) Improving an increasing the supply of both surface and underground water so as to facilitate irrigation of new lands and to increase drinking water supply.

b) Reclamation of arable lands with heavy machinery.

c) Making available agricultural machinery to small farmers in rainfed areas to enable them to cultivate more lands.

# III. THE PROJECT AREA

## III. THE PROJECT AREA

### 3.1 Location

Most of the strips along the both banks of the lower reaches of the White Nile, have already been developed for the irrigated agricultural projects, excluding the area inundated as the result of the operation of Jebel Aulia Dam. The project area is one of the said inundated strips, still remaining undeveloped.

The project area is located about 200 km south of Khartoum along the White Nile; it is 40 km south of Ed Dueim, the capital of the White Nile Province. The gross area approximately 23,000 ha. (54,800 fedds), of which about 17,000 ha. (40,500 fedds), excluding terraces and forests, are considered available for rice cultivation.

Administratively, the project area is commanded under two districts of the White Nile Province, namely, Ed Dueim and Kosti. Socially, 50 agrarian communities are located around the area but no community at all in the area. A number of nomadic people is seasonally camping there for animal grazing during the low water season of the White Nile. A most of the area has been abondoned so far without being cultivated, mainly due to the habitual inundation.

## 3.2 Infrastructures

### 1) Road Network

The area is connected to Khartoum by an unpaved road about 200 km long, a part of the Rabak/Khartoum provincial road. A improvement project of the road has been studied and will be commenced before long, coupled with the construction of the bridge to cross the White Nile at Ed Dueim. A new super highway about 800 km long now under construction will be completed within a few years to run between Khartoum and Port Sudan.

Many provincial roads stretch from the project area through Ed Dueim and Kosti, linking the area with many local markets. Most of the roads are not provided for all weather conditions at present.

### 2) Railway Network

There are two railway lines running between Kosti and Port Sudan; the one with a total length of 1,180 km is to Port Sudan via Sennar, Khartoum and Atbara, and the other is 1,130 km long via Sennar and Kassala. These railway lines are heavily burdened at present, resulting in a considerable delay in cargo-transportation between these cities. This phenomeon is most conspicuous during the cotton export season.

### 3) Navigation

The White Nile is being utilized for the transportation of goods and passengers around the project area. Between Ed Dueim and Kosti, a couple of steamers are in service during rainy season. To the south of Kosti up to Juba, waterway is playing a key role as a transport means.

### 4) Electricity

Power supply in Ed Dueim is dependent upon three small engine generators with a total installed capacity of 900 kW and the electric destribution lines of about 200 km in total length are networked over the limited urban area in Ed Dueim. Electricity in Kosti is supplied from Sennar power station. Total power supply allowed for the town is approximately 15,000 KVA at present, but it will be increased to 30,000 KVA next year to meet the growing power demand around the town.

3.3 Human Resources

The total population of the Blue Nile[/1] Province was approximately 4.2 million, according to the 1973 census and the labour resources of the province are estimated at 2.1 million on the basis of the estimated percentage of employment of the labourers.

The total population of the 50 villages around the project area is about 110,000; about 50,000 are living in the area along the western boundary of the project area, about 40,000 in the Um Jerr Island and the remaining 20,000 in the eastern area across the White Nile. Out of the total population, the potential labour force comprising 45,000 is conservatively assessed for the project area. (see 6.2 of Annex VI)

Agricultural sector is predominant around the project area. About three fourths of the labour force in the villages are mainly engaged in the said sector. As for the industrial sector, a cement plant is operating in Rabak[/2] and a large scaled sugar factory will commence its full operation before 1983 in Kenana.[/2] No other industrial plants have been developed so far except some sorghum processing mills

The farmers around the project area are engaged in the production of agricultural products, cotton and sorghum in particular, as well as livestock breeding. The average net cash income per family derived from farming and livestock breeding are £s. 119 per year and £s. 89 per year, respectively. Under rather low income condition, a standard livelihood is sustained by additional revenue obtained from outside works and by borrowing from relatives and/or local merchants.

---

/1: The White Nile Province was administratively included in the former Blue Nile Province before 1974. The Blue Nile Province was administratively divided into three provinces i.e., Blue Nile Province, White Nile Province and Gezira Province in the year.

/2: Both towns are located in the vicinity of Kosti.

According to the information obtained through the Kosti Labour Office, the prevailing wage rates in private sector are £s. 0.63 per day for a common laborer, £s. 1.20 per day for the semi-skilled and £s. 1.82 per day for the skilled. As of July, 1977, the total number of registered laborers is 5,800 at the Dueim Labour Office; 3,900 unskilled, 100 semi-skilled and 1,800 skilled. The total number of laborers registered at the Kosti Labour Office was 15,000 comprising 4,000 unskilled, 6,000 semi-skilled and 5,000 skilled.

The anticipated labor requirement for the rice production in the project area is about 1,600 including unskilled, semi-skilled and skilled labor. Meanwhile, the large-scaled Kenana sugar project will additionally employ about 10,000 laborers in its coming stage. The supply of labor around the project area seems to be adequate to meet the labor requirement for the unskilled and semi-skilled labor for the projects. Some of the skilled labor might also be found around the project area.

## 3.4 Natural Resources

### 3.4.1 Topography

The project area is located on a considerably fertile alluvial depression gently slanting from west to east on the western boundary of the project area and the riverside of the White Nile, but is mostly flat in the middle of the area. Low and slender shaped levees are naturally composed along the riverside and numerous hilly expanses or terrace are scattering all over the area; most of them are never subjected to the flooding during the high water season of the White Nile. Excluding these terrace, the area seems to be suitable for rice field development in view of its topography.

In the course of the project studies, a topographic map of a scale of 1 to 50,000 with 50-cm contour lines was collected from the Survey Department, Ministry of Defence; the map had been prepared by the Egyptian Authorities before the construction of Jebel Aulia Dam.

After checking the map, it was found out that the map collected was required to be examined in the field. The map, therefore, was revised throughout the topographic survey. Detailed topographic surveys were also carried out for the sites for major structures and the proposed pilot farm.

### 3.4.2 Geology and Soil Mechanics

The geological formation of the Abu Gasaba area primarily consists of the fluvial deposits originated from the Quarternary periods. The geological profile of the area is broadly classified as alluvial clay layer forming the surface and subsurface, and the sand layer underlying the clay layer. The clay layer with remarkably low water content is gray-colored and is spreading over the area. In the upland somewhere near the Araki island, the said clay layer reveals a similar feature to that of soft rock. The clay layer with high water content lies mostly along the riverside of the White Nile. The sand layer is excessively compacted with high bearing capacity and broadly underlies at 7.0 to 8.5 m below the ground surface.

The ground water table in the area is topographically variable; 5 m or so in the terraces and natural levees, and approximately 2 m in the depressions. A considerable bearing capacity is expectable on the subsurface layer, judging from the sounding test undertaken in the field. The soil mechanical test carried out at the laboratory to evidently clarifies that the physical properties of soil materials obtained in the area do not technically constrain the construction of the protection dikes. The detailed studies on the geology and soil mechanics are given in the Annex-IV.

### 3.4.3 Soil and land classification

The soils in the project area are derived from the old clayey alluvium deeply deposited by the White Nile. The clayey alluvium generally contains more than 60 percent of clayey fractions and a few percent of organic carbon throughout the profile, and such conditions uniformly extend all over the project area.

Under the seasonal water stagnation caused by the operation of the Jebel Aulia Dam, most soils in the project area have been put under the process of the hydromorphic weathering caused by the waterlogging and the rising groundwater.

According to the Soil Taxonomy system by U.S. Department of Agriculture, the four soil groups are identified in the project area. The first soils of group I and II are classified into the Vertisols in order which have been developed under the arid climate. They are correlated with the Torrerts in Sub-order, the Typic Torrerts in Great Soil Group, the Peleustollic Torrerts in Sub-group at the higher category of soil class, and then the former soils (I) are correlated with the Very fine clayey-Mixed-Deeply cracked-Hyperthermic-Peleustollic Torrerts and the latter soils (II) are correlated with the Very fine clayey-Mixed-Shallowly cracked-Thermic-Peleustollic Torrerts in Family at the lower category of soil classification.

While, the both soils of groups III and IV are classified into the Entisols in Order. Then, the soils of group III are correlated with the Aquents in Sub-order, the Fluvaquents in Great Soil Group, the Vertic

Fluvaquents in Sub-group, and the Very fine clayey-Mixed-Thermic-Vertic Fluvaquent in Family. The soils of group IV are correlated with the Fluvents in Sub-order, the Udifluvents in Great Soil Group, the Vertic Udifluvents in Sub-group, and the Fine clayey-Mixed-Thermic-Vertic Udifluvents in Family.

The soils of group I mainly develop over the lands in the vicinity of the project area. In the project area, the soils are only found spottily on the old remnant levees with elevation of 376.7 m or more. Most lands of this soil group are sparsely covered by acacia scrub with some cover grasses, and are mostly free from the flooding or very shallowly submerged in a short period when the White Nile is high in flood.

The soils of group II extend over the land where the elevation ranges between 376.2 m and 376.7 m. The lands are, more or less, submerged with stagnant flood water from August to the end of March. Since the soils mostly hold favorable moisture level for vegetation during the non-flood period, all the land of this soil group are densely covered by short wild grasses.

The soils of group III are primarily wet soils which mainly extend over the low lying area where the terrain of the land is nearly level with partial depression and the flood water deeply stand for 8 months from August to March. At present, most of the land is covered with swampy grasses, such as reed, reed-mace, sedge, etc. and water hyacinth in the depressed land.

The soils of group IV are the recent alluvial soils which are mainly developed narrowly along the White Nile. The lands of this soil group are usually flooded deeply for about 9.5 months from August to mid-April. For only about a short period of 2.5 months, the land is covered by velvet grasses.

The development of the soils identified hereabove is shown in Tables 3.1 and 3.2.

To speak in general, the soils in the project area have no big differences in their characteristics, so far as the agricultural soil util-

ization is concerned. The soils are very compact and firmly consolidated throughout the profile except thin top soil with rather friable consistence owing to self-churning and self-multing specific to the Vertisols or the Vertisolic soils. They are extremely hard when dry, while friable and soft when wet. They have very high water holding capacity, while their permeability is very low ranging between $10^{-5}$ cm/sec and $10^{-6}$ cm/sec in percolation speed. The soils are slightly to moderately strong alkaline with pH values ranging between 7.8 and 8.5 throughout the profile. Total organic carbon is of a rather small quantity of around 2 % in surface soils but less than 0.5 % in sub-soils. EC values are mostly less than 1.0 m.mho/cm/25°C throughout the profile. Cation exchange capacity ranges between 35 and 50 m.eq and its capacity is mostly saturated by the bases in which calcium is dominant. It is noteworthy that most Vertisols have common specific characteristics of making cracks and gilgai micro-relief on the surface where the lands are dried up.

Of all the specification of land evaluation defined in the Manual for Land Suitability Classification for Agriculture, Part II, Guide Line for Soil Survey Party, Wad Medani, 1976, the following factors are taken up as the essentials on evaluating the land suitability in the project area.

| | | |
|---|---|---|
| 1) | Inundation (i); | limitation caused by the seasonal flooding. |
| 2) | Topography (t); | limitation mainly by the unsuitable land elevation for the economical gravity irrigation. |
| 3) | Alkalinity (a); | limitation due to alkaline reaction of soils. No sodic constraint exists in the project area. |
| 4) | Fertility (f); | limitation due to deficiency of nitrogen and humus in soils. |
| 5) | Vertisolic (v); | limitation due to high contents of clay in soil matrix which have large swelling characteristics and friable, very plastic and very sticky consistence when wet, while shrinking characteristics and very hard and very firm consistence, when dry. |

Some agronomic constraints such as low humid climate (c) and successive wetness or low permeability(w) are also found in the project

area. However, as far as the irrigated rice cultivation is concerned, these conditions will be negligible for this land classification.

In the light of soil chemical and physical characteristics, all the lands in the project area are estimated as highly (S1) to moderately suitable (S2) for irrigated rice cultivation. While, in view of their usability for farm machanization, their land grades might be down into moderately (S2) to marginally suitable (S3) in land grade due to limitation caused by the soils having very hard consistence when dry, and very plastic and sticky consistence when wet. Besides, from the irrigation engineering point of view, the land at an elevation more than 376.7 m is considered economically unsuitable ($N_1$) for gravity irrigation. In the low lying area, the land which is also expected to be marginally suitable (S3) and/or conditionally suitable (Sc) in land grade because of high capital investment required for flood protection and rather expensive management cost for surface drainage during the cropping season.

From the above land evaluation, the lands in the project area are classified into four suitable land classes as shown in Table 3.3.

The first class is the Moderately Suitable Land (S2) in which sufficiently high productivity and profitability can be expected from the land. There are moderate limitations mainly caused by alkaline-reaction and vertisolic soil character. Both factors are likely to reduce crop-yield and to increase recurrent cost for production and conservation of soil and land.

The second class is the Marginally Suitable Land (S3). The lands of this class are also expected to have sufficient productivity for the defined rice cultivation, although there are limitations which in aggregate considerably reduce the crop yield and/or increase recurrent cost for production and soil conservation. Seasonal inundation(i) inclusive of inland flooding due to low lying topography is the biggest constraint in this land class.

The third is the Conditionally Suitable Land (Sc). The lands of this class are also expected to obtain sufficient crop yield in the defined land use, if the flood control is properly made by diking. However, it would require a large capital investment for this purpose.

The last class is the Currently Unsuitable Land ($N_1$) in which rather high productivity similar to that in land class S2 can be expected. However, the topographic condition is unsuitable for the gravity irrigation system specified in this development plan. Thus, the land graded into this class is excluded from the arable land.

### 3.4.4 Climate

The project area has substantially favourable climatic conditions for the growth of paddy rice, except some meteorological limitations.

The general trend of seasonal temperature is characterized by its sharp variation in the project area. The maximum monthly mean temperature during the summer season ranges from 33°C to 41°C, while the minimum, from 20°C to 25°C. During the winter season, the maximum monthly mean temperature varies from 33°C to 35°C, while the minimum, from 17°C to 18°C. The comperatively lower temperature in January of 17°C at minimum monthly mean will exert an unfavorable influence on the growing stage of paddy rice.

A consideration was given to the cropping pattern to be proposed, so as to exclude the said month from the growing stage of paddy rice (See the relevant Chapter in Annex).

The relative humidity rises sharply from May, attains the maximum in August, falls sharply till November and, then, drops gradually to the lowest in April. The monthly mean relative humidity at the Kosti station ranges from 22% to 71%, and is about 42% on an average. The lowest humidity, however, will not substantially disturb growth of rice.

The annual rainfall observed at the Dueim meteorological station over 74 years shows a wide range of 101 mm to 606 mm; 296 mm on an average. The annual evaporation from lakesurface is estimated at approximately 2,200 mm,

on the basis of the values measured by the Piche. Irrigation is a requisite for the development of rice cultivation in the project area.

Other meteorological factors, such as the relative humidity, radiation, sunshine hours and wind speed do not hamper seriously the rice cultivation. The meteorological data are tabulated in Annex XXI and outlined in Table 3.4.(1), (2).

### 3.4.5 Water Resources and Hydrology

The White Nile is the major water source for the project area. The river rises from the equatorial lakes on the lake plateau, flows through rocky rapids for over 170 km and thereafter through the swampy Sudd region. After it emerges from the swamps, it is joined by Bahr El Ghazal river on the west and by Sabat river on the east. Furthermore, it joins the Blue Nile at Khartoum and the River Atbara at Atbara and finally pours into the Main Nile.

Sudan's share of the Nile system is 20.5 milliard $m^3$ at Sennar, according to the water agreement signed between the Sudan and Egypt in 1959. The present water consumption in the Sudan from the Nile system including the consumption by the projects under construction is approximately 18.3 milliard $m^3$. The remaining assigned share of Sudan is about 2.1 milliard $m^3$ at present.

Some irrigation projects are included in the prospective short and medium term development plans of the Sudan. To meet the anticipated demand for water for these projects, many projects for the development of water resources have been formulated and some of them have already been launched. (refer to the relevant Chapter in Annex III)

The project area having a net area of 15,600 ha requires about 460 million $m^3$ of water for rice cultivation to produce two crops a year. Evaporation from the Abu Gasaba basin to be reduced by land reclamation is assessed at about 250 million $m^3$. Furthermore, about 90 million $m^3$ of the lossed water during irrigation period and about 40 million $m^3$ of the rain water fallen in the project area will return to the intake through drainage canals. These water would be circularly used for irrigation purpose by pumping, so as to save the water resource

of the White Nile. Hence, only about 80 million $m^3$ would be additionally dependent upon the water resources of the White Nile (See Chapter III in Annex).

Eversince the completion of the Jebel Aulia Dam in 1937, the hydrological regime of the river was completely changed; a part on the lower reaches was converted into artificial reservoir, including the Abu Gasaba swamp. Normally, the filling of the reservoir is conducted in two phases, based on the operation criteria of the dam. The first filling to 376.50 m above MSL begins in mid-July; the second filling to 377.20 m above MSL starts in mid-September. The water level of the 377.20 m is continuously maintained until mid-February.

The water stored in the reservoir is gradually released from mid-February until the reservoir is completely emptied by the end of May. Fig. 3.1 shows the water-level fluctuation of the White Nile at Ed Dueim. In view of the fluctuation, the year-round irrigation by gravity in the strips like the project area seems to be physically unfavourable, due to the lack of available head.

## 3.5 Existing Irrigation and Drainage Facilities

In 1931, the Sudan Government started the development of the livelihood schemes. Many livelihood schemes irrigated by pumping units were developed then in Dueim and other strips along the White Nile. The construction of the Jebel Aulia Dam in 1937, provided lower lifting head for pumping unit during the period of irrigation and encouraged the private sector to invest their capital in the development of pumping schemes in Dueim and Kosti areas.

Existing pumping schemes on the White Nile have been extended up to a strip about 380 km south of the Jebel Aulia Dam. The total number of schemes on the both banks of White Nile under direct administration of the Agricultural Corporation is 186 with gross acreage ranging from 200 fedds to 18,600 fedds; 89 schemes are located on the east bank and the remaining 97 schemes on the west bank. The gross area of the existing schemes is nearly 420,000 fedds.

Out of the total schemes on the west bank of the White Nile, 28 government schemes are located along the Abu Gasaba swamp; 16 schemes are scattered in the Ed Dueim district and the remaining 12 schemes in the Kosti district. In addition to the government schemes, numerous small sized schemes have been developed by the private sectors around the Abu Gasaba swamp. The number of pumping schemes is 218 in total; 116 schemes within the Ed Dueim District and the remaining 102 schemes within the Kosti District. The total capacity of pumping units in the Abu Gasaba is estimated at about 18 $m^3$/sec and the gross annual water demand in cropped area is approximately 123 million $m^3$. The breakdown of the pumping capacity and the seasonal requirement is as given below.

Breakdown of Existing Pumping Schemes

| District & Type of Schemes | Nos. of Scheme | Pump. Capacity ($m^3/sec$) | Water Requirement ($10^3 m^3$) | Gross Area (fedds) |
|---|---|---|---|---|
| Dueim | | | | |
| Government | 16 | 9.53 | 85,973 | 33,702 |
| Private | 116 | 3.21 | 6,365 | 9,760 |
| Sub-total | 132 | 12.74 | 92,338 | 43,462 |
| Kosti | | | | |
| Government | 12 | 3.42 | 25,113 | 10,449 |
| Private | 102 | 2.16 | 5,676 | 6,789 |
| Sub-total | 114 | 5.58 | 30,789 | 17,238 |
| Total | 246 | 18.32 | 123,127 | 60,700 (25,500 ha) |

Since the construction of Jebel Aulia Dam in 1937, the Abu Gasaba area has been seasonally waterlogged. No perennial irrigation and drainage system has been developed here.

## 3.6 Land Use and Agricultural Production

### 3.6.1 Land Use

Since the Jebel Aulia Dam was constructed in 1937, the project area has been inundated from August to March as the result of the dam operation. Most of the area lies waste and is presently covered with swampy grass. Only a small part of the area is being used for growing some vegetables during the period of low water level of the White Nile from April to July. Rice is cultivated in the very limited area during the flood season. Acacia trees are grown on some elevated land along the western bank of the project area. The grasses grown in the project area are used as livestock feed during the low water season. The following table shows the summary of the present land use in the area.

| | Land Categories | Area (ha) | Proportional Extent (%) |
|---|---|---|---|
| 1. | Forest land (Acacia and shrubs) | 2,950 | 14.8 |
| 2. | Grass land | 16,800 | 83.9 |
| | Swampy grasses | 12,800 | 63.8 |
| | Reed mace | 4,000 | 20.1 |
| 3. | Cultivated land | 250 | 1.3 |
| | Vegetables | 210 | 1.1 |
| | Rice | 40 | 0.2 |
| | Total | 20,000 | 100 |

Two types of farming are mainly practiced in the area adjacent to the project area. One is the cultivation of cotton, wheat, onion, etc. under irrigation. The other is the cultivation of sorghum under rainfed condition. About 25,500 ha of irrigated land ajacent to the project area are provided with pump irrigation facilities which comprise 28 Governmental and 218 private schemes.

### 3.6.2 Cropping Pattern and Production

i) Project area (see Annex VII)

The farming practices are rather primitive, and the conventional method of farming is practiced. Floating rice is grown in the rather

shallow area by using the flood water from the White Nile. Seeding is carried out in June and July and paddy is harvested in November. Local varieties of semi-floating rice are mainly used. Due to non-application of fertilizers and chemicals and without proper water control, the yield of paddy is quite low, about 0.6 to 1.0 ton/ha. The total production of paddy in the project area is estimated at about 30 to 40 tons which is negligibly small.

Vegetables such as okra, water melon, etc. are usually grown during the dry season of April to July. No fertilizers and chemicals are used. No hired labour is used. The average yield of okra and water melon estimated at about 3.5 t/ha and 1,000 fruits/ha respectively according to the results of the field survey conducted.

Animal products form another important cash source in the Gasaba area. At present, sedentary livestocks and migrating animals from outside area are being grazed in the project area during nonflooding season from April to July. They mainly consist of sheep, goats and cattles. The number of animals owned by the farmers in the surrounding area of the Abu Gasaba basin, is estimated at about 140,000 heads, through farm survey. However, the number owned by nomads is not obtainable. The acreage of wild grass land which is available for grazing in the project area is about 9,000 ha or about 45% of the project area.

ii) Adjacent area (see Annex VII)

In the irrigated pump scheme, three-year crop rotation farming is practiced. Namely, cotton is grown during the period of August to February in the first year, then followed by sorghum from August to November in the second year and the land is fallowed in the third year. Recently, groundnut has been introduced into the rotation instead of sorghum. Winter crops such as wheat and onion are also grown to some extent after harvesting sorghum. The cropping intensity is estimated at about 67 % so far, but increasing gradually.

Fertilizers are used only on cotton and wheat at the rate of about 190 kg/ha (80 kg/fed.) of urea. Agricultural chemicals are used on cotton by the Plant Protection Office, but very little on wheat and groundnut so far. Hired labours are recruited locally among the landless and

the smaller tenant farmers. The following table shows the average production cost of major crops in the adjacent area (see details in Annex VII).

| Description | Cotton (£s/ha) | Sorghum (£s/ha) | Wheat (£s/ha) | Legume (£s/ha) |
|---|---|---|---|---|
| Field preparation | 15.1 | 7.2 | 7.2 | 7.2 |
| Farm inputs | 35.1 | 1.5 | 21.8 | 8.0 |
| Labour charge | 27.1 | 13.2 | 11.2 | 20.5 |
| Total | 77.3 | 21.9 | 40.2 | 35.7 |

According to the data provided by the authorities concerend, the average yield and the total production of major crops around Gasaba area are as follows:

| | Government Scheme | | | Private Scheme | | |
|---|---|---|---|---|---|---|
| Crops | Area (ha) | Yield (t/ha) | Production (t) | Area (ha) | Yield (t/ha) | Production (t) |
| Cotton | 6,480 | 0.78 | 5,054 | 1,580 | 0.48 | 758 |
| Sorghum | 5,780 | 1.02 | 5,896 | 1,060 | 1.35 | 1,431 |
| Wheat | 1,600 | 0.44 | 704 | - | - | - |
| Legume | 290 | 0.57 | 165 | - | - | - |
| Onion | - | - | - | 340 | 5.13 | 1,744 |

### 3.6.3 Livestock

The project area plays an important role as grazing land for livestock during the period of April to August. Livestock substantially migrate to the project area from the western arid zone in the abovementioned period. The following table shows the number of livestock in and around the project area in 1977, which does not include the number of livestock migrated from outside the Gasaba area.

| Kind of Animals | Number (head) |
|---|---|
| Cattle | 42,800 |
| Sheep | 54,800 |
| Goat | 34,200 |
| Camel | 150 |
| Donkey | 5,200 |
| Horse | 160 |
| Total | 137,200 |

## 3.7 Land Tenure and Farm Size

The landowners were compensated for the cultivation right in the project area by the Government when the Jebel Aulia Dam was constructed. However, the land is still being owned by the local inhabitants. The following table illustrates the land tenure situation in the project area based on results of the farm sample survey.

| Holding size (ha) | <10 | 10 - 20 | 20 - 30 | 30 - 45 | Total |
|---|---|---|---|---|---|
| Proportion (%) | 78.7 | 7.2 | 8.1 | 6.0 | 100 |

The land tenure situation in the area adjacent to the project area is illustrated in the following table. An average size of land holding in the existing small pump scheme is about 33 ha per household.

| Land holding(ha) | <10 | 10-20 | 20-30 | 30-45 | 45-60 | 60> | Total |
|---|---|---|---|---|---|---|---|
| Ed Dueim(%) | 3.5 | 0.9 | 34.5 | 37.2 | 8.9 | 15.0 | 100 |
| Kosti(%) | 8.3 | 11.5 | 56.2 | 21.9 | 2.0 | 0 | 100 |

In the large government operated irrigation schemes (corporation schemes), the farmers cultivate the land as tenants, and enjoy full security under the tenure arrangement. The tenants are entitled to receive full income derived from all crops other than cotton. In the case of cotton production, the joint cost is subtracted from the gross value of the output, and the balance is shared among the tenants and the corporation in proportion of 50 to 50 %.

## 3.8 Regional Agricultural Support Services

### 3.8.1 Agricultural Research

No regional stations nor substations exist near the project area and in the White Nile Province. The research activities are carried out only by the Agricultural Extension Department and the liaison offices in Ed Dueim and Kosti in cooperation with the nearest regional research station, i.e., the Gezira Regional Research Station. No research activities for rice production are carried out around the project area and in the White Nile Province.

### 3.8.2 Extension Services

There are two regional branches for the Agricultural Extension Department, Plant Protection Administration, Horticulture Administration around the project area. One is located in Ed Dueim and the other is in Kosti. In Ed Dueim Branch, the Agricultural Extension Department possesses five staffs consisting of university graduates and senior high school graduates. The Kosti Branch has ten staffs. All Departments are encountered by the problem of shortage of the staffs of the said regional branches. Transportation facilities (automobiles) are not adequate, either Budget appropriated is not sufficient to achieve the objectives. The officials can not find farmers during their visits quite often. Farmers sometimes do not pay attention to the information which are of vital importance to their farming activities.

### 3.8.3 Credit and Inputs

In the Dueim office of the Agricultural Bank, £s. 185,000 is allocated annually for loans. Greater portion is usually advanced to the cotton producers. In the year 1974/75 £s. 169,000 was lent and £s. 137,000 in the year 1975/76. In 1976/77 limited cotton was grown in Dueim area. Consequently, only £s. 22,000 was advanced through the office.

### 3.8.4 Plant Protection

The Dueim Branch of the Plant Protection Administration has 167 staffs, 5 land-rovers, 2 lorries and one tractor. The amount of the

budget appropriated is sufficient. The number of vehicles will be sufficient with one or two additional cars. The number of staffs is, however, not adequate. Moreover, all the staffs and the facilities are located in the Dueim office and the Kosti office, preventing free use in the distant places in the area. Establishment of additional branches would be desirable.

### 3.8.5 Public Corporation for Agricultural Production

There are about 28 public schemes around the project area, sixteen of which belong to the Dueim Agricultural Corporation and the rest to the Kosti El Renk Agricultural Corporation. Total acreage of the 28 schemes amounts to about 25,500 ha. The average size of tenancy in these schemes ranges between 5 ha and 6.3 ha. Main crops are cotton, sorghum and wheat which are cultivated according to the annual rotation system. Vegetables in some cases are grown in a relatively small area.

### 3.8.6 Cooperative Movement

In the surrounding area of the project area lying in the Dueim District, there are 9 cooperatives of various kinds handling agricultural production, flour milling, dairy, bakery and passenger transportation. The number of participants in these cooperatives totals 1,393 in 1977. In the surrounding area of the project area in the Kosti District, there are 8 multi-purpose cooperatives and one flour milling cooperative. Two agricultural production cooperatives are under construction.

# IV. THE PROJECT

## IV. THE PROJECT

### 4.1 Project Concept

The project area is located about 1,000 km away from Port Sudan, the only international port of the Sudan. Transportation cost of the output of the project area to Port Sudan will be considerably costly where it has to depend on road and railway transportation. In this view, the project area must produce profitable products.

A huge amount of water resources evaporating from Abu Gasaba swamp at present will be curtailed with the project through land reclamation. While, a fair amount of water resources lossed during irrigation period will be circularly utilized for irrigation purpose, since most of the said resources will finally return to the intake structures through drainage canals. Hence, the comparatively small amount of water resources will be substantially consumed in the project area, even though twice rice cultivation will be proposed. As mentioned in Annex IX, rice production is the most feasible in the Abu Gasaba area in particular, in view of water economy.

The project area is swampy and is considerably flat. The area is more favourable for the development of the paddy field than the upland field in view of the topography. The area is mostly covered with alluvial heavy clay soils. The cultivation of upland crops in the project area unquestionably requires a large amount of expenditure for the improvement of the drainage condition. The pedolological condition in the area is generally favourable for rice cultivation. Furthermore, the area is endowed with substantially favourable climatic conditions to permit the growth of paddy rice. Double cropping of rice is meteorologically feasible.

The long-range policy of the rice development in the Sudan is based on the export of surplus rice after attaining self-sufficiency. Recently, the rice production is also being encouraged as one of the eligible crops for export, in the Six-Year Development Plan for Agriculture. The international prices of rice forecasted by the relevant international authorities are remarkably stable compared with those of other agricultural products.

All the land in the area submerged as the result of operation of the Jebel Aulia Dam has already been compensated for by the Egyptian Government.

Only about one percent of the land is still being cultivated at present only during the low water season. The ownership of the land will not hamper the redevelopment of the area.

Both the colonization of new farmers and the settlement of the nomadic graziers in the project area are sociologically hard to attain. Moreover the casual labourers and the operators of farm-machinery are employable around the project area, from the availability standpoint of the labour resources.

On the basis of the abovementioned current situation surrounding the project area, the basic concepts of the project are grasped as described hereinafter:-

- The redevelopment of the submerged land in the Abu Gasaba swamp will be commenced with the construction of the polder dikes to prevent the land from inundation.

- The year-round irrigation and fully controllable drainage system are provided for high yielding rice cultivation.

- Systematic service road networks are provided to introduce modernized farming practices, better water management and to transport large amounts of inputs and outputs.

- At present, the irrigation water sources for a number of pumping schemes around the project area is dependent on the Abu Gasaba swamp during high water season. The implementation of the project will necessarily result in the exhaustion of water source for the existing schemes around the project area. Special measures are taken to secure their water source.

- Intensively mechanized farming practices are introduced in the project, taking into account the labourers' lack of experience in rice cultivation.

- Prior to the implementation of the project, a pilot scheme was formulated to dispel many uncertainties in the technology of rice cultivation. The operation of the scheme will commence in 1979 at latest. Research and training are also undertaken in the scheme.

## 4.2 Project Description

The gross project area of 20,000 ha (47,600 fedds) is delineated, out of the Abu Gasaba swamp with a extent of about 23,000 ha. Excluding numerous hilly terraces, scattering in the swamp and the sites for major irrigation and drainage system, road system and onfarm facilities, the net cultivation area of 15,600 ha (37,100 fedds) is isolated from the gross area by the lengthy polder dikes.

The major components incorporated in the project are briefly described as i) construction of perennial irrigation and drainage system and onfarm development work to permit the introduction of double cropping of rice, ii) construction of rice processing and storage facilities, and iii) managing an organization of the project and its operation. The components are further described in details as follows:-

A) Construction of infrastructures

i. Embankment of polder dike,
ii. Excavation of feeder channel,
iii. Construction of intake and pumping station
iv. Excavation of main and lateral irrigation canals
v. Excavation of main and lateral drainage canals
vi. Onfarm development work
vii. Construction of service road network

B) Construction of processing and storage facilities

C) Organizational setup for the operation and maintenance of the project

i. Operation and maintenance of irrigation and drainage system
ii. Farming operation of rice
iii. Processing, storing and selling of rice

The project cost and the operation/maintenance cost and the project benefit for the whole project area are financially outlined as shown below:-

(Unit: £s.$10^3$)

1. Cost

| | | |
|---|---|---|
| | Project cost | |
| i) | Base cost | 51,447 |
| ii) | Contingencies | 31,203 |
| | Total project cost | 82,650 |
| | Production cost | |
| i) | O/M cost of irrigation & drainage facilities | 2,439 |
| ii) | O/M cost of processing & storage facilities | 2,834 |
| iii) | Administration cost | 422 |
| iv) | Farming expenditure | 6,207 |
| | Total production cost | 11,902 |

2. Benefit

| | | |
|---|---|---|
| i) | Gross value | 25,455 |
| ii) | Net value | 13,553 |

In view of the construction plan and project economy, the project is divided into four phases; the phase-2 is further subdivided into two stages, as shown in the General Layout (DWG NO.01) The phase-wise acreage is summarized below:-

| (Phase & Stage) | (Hectareage) |
|---|---|
| 1 | 3,000 |
| 2 | |
| 2-1 | 3,200 |
| 2-2 | 3,200 |
| (Sub total) | 6,400 |
| 3 | 3,000 |
| 4 | 3,200 |
| Whole project | 15,600 |

Preparatory works such as engineering works, procurement of equipment, land acquisition and administrative facilities will be commenced immediately after obtaining loans for the project, and will be followed by the major construction works. The whole construction

works will be implemented by contract basis, and will be completed within about 8 (eight) years after their commencement, in due consideration of the project economy.

A double rice cropping pattern is proposed to reap full benefit from the project. An intensive agricultural mechanization plan is incorporated, together with the establishment of the rice processing centers.

## 4.3 Agricultural Development

### 4.3.1 Cropping Pattern and Yield

The following three alternative cropping patterns are thoroughly, examined from the view points of plant physiological characteristics of rice, anticipated yield and construction costs of irrigation water supply system as shown in Fig. 4.1 (see details in Annex XII).

(1) Alternative I

Most of the project area is flooded during the period of September to February. Water level of the White Nile is controled to maintain EL. 377.30 m to EL. 377.50 m during the above period. Rice is grown during a period of mid September to mid April (about 180 days). Irrigation for rice cultivation can be the gravity irrigation so that no pump facilities are required to be constructed.

Yield of rice would be lower than that of the summer crop due to cool conditions in winter and poor drainability in the paddy field. According to the results of trial cultivation conducted by the Agricultural Service Office, White Nile Province in 1973/74, the yield of rice ranged from 3 to 4 tons/ha. With the introduction of improved rice varieties, appropriate fertilizer application and proper water control, the anticipated yield could be 4.0 t/ha of paddy at the full development stage for the Alternative I.

The merits and demerits of this Alternative are the following.

a) Merits:

It is not necessary to provide pumping facilities for irrigation but some drainage pumps are required. Therefore, a certain amount of construction cost of pumping station as well as its operation and maintenance cost can be saved.

b) Demerits:

i) Because of the limited head between the high water level of the White Nile and the project area, width of main canal to the inner area is required to be widened, which result in certain cost increase.

ii) Amount of evapo-transpiration loss is considerably larger than that of the rainy season crop due to the longer growing period.

iii) Only one crop of rice a year can be grown and the yield would be as low as about 4.0 ton/ha.

iv) Drainage pumps are still required during the rainy season and the paddy growing season.

v) The project is not economically sound due to the smaller total production.

(2) Alternative II

Alternative II is the cropping pattern based on the production of two rice crops a year. The first cropping is conceptionally similar to that of Alternative I. The second cropping will take place during the hot summer season of May to September (about 120 days). Similar second cropping was carried out in Gezira and it was recognized that the yield was relatively normal ranging from 7.6 tons to 4.0 tons of paddy per ha according to the Report on Rice Trial-Planting in Gezira Area in 1973. With the introduction of improved varieties, appropriate fertilizer application and proper water management, the yield of 4.0 ton/ha for the first cropping and 5.5 ton/ha for the second cropping can be expected in the full development stage of the project.

The major merits and demerits of this alternative are as shown below.

a) Merit:

The project area will increase the yield to about 9.5 tons/ha of paddy by producting two crops of rice in a year, but substantially a large amount of construction cost is further required for the pumping facilities.

b) Demerit:

i) In the first cropping, the evapo-transpiration loss is considerably larger than that of the second cropping due to the longer growing period.

ii) Additional investment in a substantial amount is required for the construction of the irrigation pumping station as well as its operation and maintenance.

(3) Alternative III

This alternative is prepared based on the results of the experiment carried out in the Sudan. As seen in Fig. 4.1, the coolest season (December and January) is excluded from the cropping programme in due consideration of the ill-effects on rice growing caused by low temperature. The first cropping will be carried out during the period from February to June (about 110 days) and the second cropping from mid July to mid December (about 110 days).

Data on the yield from the second cropping have been obtained from the Gezira scheme. Furthermore, the trial rice cultivation was carried out at the project site in 1977 recorded an yield of more than 6 tons/ha. On the other hand no data on the yield from the first cropping is available in Sudan so far. However, it could be estimated at 4.0 to 5.0 tons/ha on the basis of the result of the cultivation trial carried out in Nigeria where agroclimatic conditions are similar to those in the growing period of the first cropping. Therefore, the yields of 4.0 tons/ha for the first cropping and 6.0 tons/ha for the second cropping in and after the 5-year development period have been estimated respectively with proper water management and appropriate fertilizer application. Both merits and demerits of the cropping pattern in this alternative are as follows:

a) Merits:

i) The project area to be benefited by producing two crops of rice a year will produce about 10 tons/ha of unhulled rice annually though a certain amount of construction cost is further required for the pumping facilities.

ii) As the winter season is excluded, a certain amount of evapotranspiration loss can be saved.

b) Demerits:

Additional investment costs are required for the construction of pumping facilities as well as for their operation and maintenance.

The following table shows the anticipated yield of rice, production value, construction cost of irrigation facilities and the results of economic evaluation of each alternative. (see details in Annex X).

| | Unit | Alt. I | Alt. II | Alt. III |
|---|---|---|---|---|
| Anticipated yield/year | ton/ha | 4.0 | 9.5 | 10.0 |
| Gross production value | $10^3$/£s | 7,688 | 18,258 | 19,219 |
| Production cost | $10^3$/£s | 2,600 | 5,500 | 5,600 |
| Net production value | $10^3$/£s | 5,088 | 12,758 | 13,619 |
| Construction cost | $10^3$/£s | 62,600 | 95,600 | 77,600 |
| IRR | % | 8.0 | 13.0 | 17.0 |

The above table clearly shows that Alternative III is most economical. In addition, the cropping pattern in Alternative III is determined to be introduced in this project from the view point of economical water utilization. The cropping intensity of Alternative III is 2.0.

4.3.2 Selection of Variety

One of the most important things to be observed for obtaining high yield is to use improved varieties suitable to the project area under proper mechanized farming and irrigation. The data obtained at the experiments conducted in Gezira and the results of the variety trial conducted at the project site in 1977 as well as those of variety tests conducted in Nigeria, the following varieties have been selected as recommendable varieties for the project area so far, but re-examination and confirmation are required through future experiments in the project area.

| Varieties | Yield of Varieties (t/ha) | | |
|---|---|---|---|
| | Ed Dueim /1 | Gezira /2 | Nigeria /3 |
| IR-28 | - | - | 6.0 |
| TOS-103 | - | - | 7.0 |
| C-11 | 6.8 | 7.8 | - |
| C-15 | 9.0 | 8.7 | - |
| IR-22 | 6.8 | 7.7 | - |
| IR-5 | 7.3 | - | 8.0 |
| IR-298 | 7.9 | - | - |
| BG-34 | 8.0 | - | - |
| BG-90 | 9.8 | - | 7.5 |
| IR-8 | 8.7 | - | 8.0 |
| C-6 | - | - | - |
| C-9 | - | 6.3 | - |
| IR | 8.1 | - | - |

/1: tested at project site on June to October, 1977

/2: tested at Gezira Scheme in 1972 - 1974 by Chinese Rice Growing Technical Team

/3: tested at Uzo-Uwani Pilot-Scheme in 1976 - 1977

### 4.3.3 Proposed Farming Practices

Full mechanized farming is proposed throughout the rice cultivation from the land preparation to harvesting in due consideration of the soil conditions and shortage of familiarized farmers and labourers for rice cultivation in and around the project area. From the careful study on rice cultivation method the direct seeding method in dry condition of land is proposed and after the germination the rice field will be flooded until the milk ripening stage of rice. (see detail in Annex XII).

### 4.3.4 Farm Inputs

The results of experiments carried out at the research institutes in Gezira and other rice producing countries as well as in the project area indicate that the improved varieties proposed require timely application of fertilizers and chemicals to obtain high yields.

Based on the chemical properties of soils, proposed application of fertilizers is estimated in each crop as follows:

| | Urea (Nequiv.) (kg/ha) | | T.S.P./1 ($P_2O_5$) (kg/ha) | |
|---|---|---|---|---|
| First paddy | 150 | (70) | 75 | (35) |
| Second paddy | 200 | (90) | 100 | (45) |

In addition to the above, some 5 to 10 tons/ha of rice straw will be applied into the soil not only for improving the physical conditions of soils but for supplying humus and other minor elements in the soils. Fertilizer application is made by the following procedures:

| Fertilizer | Stage | First paddy (kg/ha) | Second paddy (kg/ha) |
|---|---|---|---|
| Urea | | | |
| Basic | | 45 | 60 |
| First top-dressing | Before most active tillering | 30 | 40 |
| Second top-dressing | Before most active reduction division | 45 | 60 |
| Third top-dressing | Full heading | 30 | 40 |
| T.S.P. | | | |
| Basic | | 75 | 100 |

No remarkable damages to rice due to pests and diseases are observed at present in the Sudan. Owing to the expansion of rice cultivation, however, the damages will difinitly be caused. Therefore, the plant protection program will be incorporated in this project. About 30 kg/ha each of insecticides and fungicides will be used in the respective crop season.

Weed control in rice cultivation is most important particularly in case the direct sowing method is employed. About 30 kg/ha of herbicides will be applied two times, first at just after seeding and second at about 30 days after seeding.

---

/1 Triple-super phosphate.

### 4.3.5 Agricultural Mechanization

In view of the very hard soil conditions, suitability of mechanized rice cultivation and limited labour force in the project area, the irrigation farming will be fully made by mechanical operation.

The flood rice cultivation practices are usually made under submerged soil conditions. Due to the very low trafficability in the submerged conditions, the land preparation and sowing will be carried out under the dry field.

The selection of farm machinery required is carefully made in due consideration of soil conditions in the project area and the present farming practices in the Sudan. In order to determine the most appropriate and economical number of tractors and combines which are the essential machinery for the project, a comparative study was made on three alternatives from the viewpoints of cropping pattern, workable days as well as the actual field capacity of the machinery. The following table shows the appropriate quantity of tractors and combines for an operation group and the whole project. Details are given in Annex XIII.

| | Type | Operation Unit of 400 ha (Nos.) | Whole Area 15,600 ha (Nos.) /1 |
|---|---|---|---|
| Wheel tractor | 75 ps class | 5 | 210 |
| Crawler tractor | 60 ps class | - | 25 |
| Combine harvestor | 100 ps class | 1 | 43 |

### 4.3.6 Farm Output

The yield will increase year after year through the improved field conditions and farming techniques and the target yield will be attained in the 5th year after the introduction of the irrigation farming. The following table shows the anticipated yields during the build up period.

---

/1: 15 wheel tractors, 25 crawler-tractors and 4 combine harvestors are added as a standby.

| | Build-up period (year) | | | | Unit: ton/ha |
|---|---|---|---|---|---|
| Cropping | 1st | 2nd | 3rd | 4th | 5th |
| 1st crop | 3 | 3.3 | 3.5 | 3.8 | 4.0 |
| 2nd crop | 4.5 | 4.9 | 5.3 | 5.6 | 6.0 |
| (Total) | 7.5 | 8.2 | 8.8 | 9.4 | 10.0 |

Total production from project activities at full development stage (5 year after the commencement of the work) is shown below.

Rice Production at Full Development Stage

| Tract | Phase | Planted Area (ha) | Harvested Paddy 1st Crop (ton) | 2nd Crop (ton) | Total (ton) |
|---|---|---|---|---|---|
| I | 1 | 3,000 | 12,000 | 18,000 | 30,000 |
| II | 2 | 3,200 | 12,800 | 19,200 | 32,000 |
| II | 3 | 3,200 | 12,800 | 19,200 | 32,000 |
| III | 4 | 3,000 | 12,000 | 18,000 | 30,000 |
| IV | 5 | 3,200 | 12,800 | 19,200 | 32,000 |
| Total | | 15,600 | 62,400 | 93,600 | 156,000 |

In addition to the above, approximately 230,000 tons of rice straw would be produced as by-product, out of which about 80% will be used as fodder substituting for the natural grass to be grown in the project area and the remainder will be returned to soil to improve the land.

### 4.3.7 Processing of Farm Product

No rice processing plant is available in and around the project area. Since rice produced would be exported abroad, the paddy rice will be milled at the project area to minimize the transportation cost from the project area to Port Sudan, the only sea port in the Sudan.

The rice processing plant will be established at five stations, respectively at each tract, according to the implementation schedule of the agricultural development plan. The rice processing plant with parboiling system will be introduced in the project area from the following points of view.

i) The rice produced is expected to be exported to the Arab countries because the people are quite familiar with the parboiled rice.

ii) Grains produced in the project area are liable to crack due to low relative humidity and broken rice may be produced in the course of processing.

The milling capacity is determined by the total number of operating days and the production for a season. The following table shows the principal features of the major equipment in each station.

| | Description | Capacity | Quantity (set) |
|---|---|---|---|
| 1. | Receiving and cleaning paddy | 20 t/hr | $\frac{1}{4}$ |
| 2. | Grain storage bin | 1,500 ton | 12 |
| 3. | Parboiling equipment | 144 ton/day | 1 |
| 4. | Milling equipment | 2 tons/hr | 3 |
| 5. | Power station | 250 kVA | 5 /1 |
| 6. | Fuel tank | 20,000 ℓ/tank | 4 |

---

/1: Including a standby.

## 4.4 Irrigation and Drainage Requirements

### 4.4.1 Irrigation

Since no field data on the irrigation requirement for rice cropping are available in and around the project area, the requirement is estimated from the climatic data. The maximum and minimum potential evaporations are estimated at 8.6 mm/day in April, 5.3 mm/day in August on the basis of the authorized empirical formula.

Pre-irrigation requirement, instead of puddling requirement, is incorporated in the water requirement, in due consideration of the proposed direct sowing practice and soil moisture condition at the initial stage of land preparation. The requirement is assessed at 105 mm for first cropping and 90 mm for second cropping, respectively, inclusive of the germination water of 45 mm.

Such factors as consumotive use, percolation, effective rainfall and irrigation efficiency are examined in detail and mentioned in the relevant chapter of Annex IX. Table-4.1(1), (2) show the estimated value of each factor. Seasonal diversion requirements in $m^3$/sec are tabulated below; the peak diversion requirement of 28.9 $m^3$/sec occurs in April and the minimum requirement of 3.3 $m^3$/sec in July, for the whole project area.

($m^3$/sec)

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tract-1 | 0.7 | 1.7 | 4.6 | 5.6 | 4.3 | 1.6 | 0.6 | 1.7 | 3.4 | 4.0 | 3.9 | 1.4 |
| -2 | 1.4 | 3.7 | 9.8 | 11.8 | 9.1 | 3.5 | 1.4 | 3.7 | 7.2 | 8.5 | 8.2 | 3.1 |
| -3 | 0.7 | 1.7 | 4.6 | 5.6 | 4.3 | 1.6 | 0.6 | 1.7 | 3.4 | 4.0 | 3.9 | 1.4 |
| -4 | 0.7 | 1.8 | 4.9 | 5.9 | 4.6 | 1.8 | 0.7 | 1.8 | 3.6 | 4.3 | 4.1 | 1.6 |
| Total | 3.5 | 8.9 | 23.9 | 28.9 | 22.3 | 8.5 | 3.3 | 8.9 | 17.6 | 20.8 | 20.1 | 7.5 |

Total amount of annual requirement is estimated at 460 million $m^3$ on an average for the whole project area, based on the seasonal diversion requirement in the above table.

Actually however, about 90 million $m^3$, out of the lossed water during irrigation period and about 40 million $m^3$, out of the drained rain water during rainy season will return to the intake of the project

through drainage canals and will be circularly diverted for irrigation purpose by pumping. Furthermore, about 250 million $m^3$ of water resource will be saved since the evaporation from the swamp will be reduced by the land reclamation of the project. The net annual consumption of water resources is estimated at only 80 million $m^3$ for the whole project area. (See Annex IX)

4.4.2 Drainage

Drainage systems consist of onfarm drains, drainage laterals and main drainage canals. The runoff by the rainfall is directly drained into onfarm drains and then collected to laterals and subsequently main drains. Generally, the water level of the White Nile during a period from August to March is higher than the ground level of the project area. The runoff in the Project area is gradually removed to the White Nile by the pump with dual purpose for irrigation and drainage, after once detained into the drainage canals and paddy field.

The daily maximum rainfall with 10 years probability is estimated at 79 mm/day. While, the frequency of the consecutive drought days after the cease of the comparatively high intensive rainfall, i.e. greater than 40 mm/day, is statistically examined. The consecutive drought days with 10% probability is estimated at 4 days. It is decided from this result that the runoff is removed to outside of the project area within 4 days against the coming rainfall.

The total amount of runoff based on the said daily maximum rainfall is figured out, deducting the amount of evaporation during 4 days, as follows.

Total Amount of Runoff

| | Tract-1 | Tract-2 | Tract-3 | Tract-4 | (Whole area) |
|---|---|---|---|---|---|
| Catchment Area (ha) | 3,450 | 7,770 | 3,600 | 3,800 | 18,620 |
| Gross amount of runoff ($10^3m^3$) | 2,726 | 6,138 | 2,844 | 3,002 | 14,710 |
| Evaporation ($10^3m^3$) | 731 | 1,647 | 763 | 802 | 3,947 |
| Net amount of runoff ($10^3m^3$) | 1,995 | 4,491 | 2,081 | 2,196 | 10,763 |

According to the drainage method mentioned above, some amount of the runoff water is detained in the paddy field during a period of 2 days in due consideration of the growing stage of rice plant, and subsequently drained into the laterals and the main canals through the onfarm drains. The required storage capacity and drainage requirement are, respectively, estimated as follows, based on the total amount of the runoff mentioned above.

Storage Capacity and Drainage Requirement

| | Tract-1($10^3 m^3$) | -2($10^3 m^3$) | -3($10^3 m^3$) | -4($10^3 m^3$) | Whole Area |
|---|---|---|---|---|---|
| Paddy field | 998 | 2,246 | 1,041 | 1,098 | 5,383 |
| Onfarm drain | 203 | 432 | 203 | 216 | 1,054 |
| Drainage lateral | 155 | 471 | 188 | 198 | 1,012 |
| Main drainage canal | 639 | 1,342 | 649 | 684 | 3,314 |
| Total storage capacity ($m^3$) | 1,995 | 4,491 | 2,081 | 2,196 | 10,763 |
| Drainage requirement ($m^3$/sec) | 5.8 | 13.0 | 6.0 | 6.4 | 31.2 |

A considerable portion of the waste water from the irrigation system during dry season, about 94 million $m^3$, emerges ultimately in the drainage system. The total amount of evaporation from the surface of the drainage canals throughout the year is estimated at about 4 million $m^3$.

The drainage requirement during the dry season is assessed at about 4.3 $m^3$/sec or about 90 million $m^3$; the unit requirement per ha is equivalent to about 0.22 ℓ/sec/ha. (See Annex IX)

## 4.5 Project Works

### 4.5.1 Irrigation and Drainage System

Irrigation

The year-round pumping irrigation system is economically and technically justified as the result of the comparative study. (See details in Annex-X) The irrigation canals are designated as main canals and laterals according to the respective functions.

Unlined canals with trapezoidal cross section are proposed for all the irrigation canals. In tracts-1 and -2, the main irrigation canals are aligned along the western boundary of the project area at an elevation of about 376.70 m above MSL. The irrigation laterals stretch out from the main irrigation canals on one side at regular intervals of 2.0 km. The entire reach of the main canals is considerably embanked. While, in tracts-3 and -4, the main irrigation canals are extending from the pumping station westward at somewhere near the center of the tracts. The irrigation laterals branch away from the main irrigation canals like in tracts-1 and -2.

The assigned discharge of each canal is calculated and summarized in Fig. 4.2(1)-(4), on the basis of the irrigation requirement and the canal network diagram. The typical cross section of the respective canals is as illustrated in Fig. 4.3.

The hydraulic gradient of the main canals and the laterals ranges from 1/70,000 to 1/20,000 and from 1/30,000 to 1/1,500, respectively. The total lengths of the proposed canals are as shown below:-

| | Tract-1 | -2 | -3 | -4 | (Total) km |
|---|---|---|---|---|---|
| i) Main irrigation canal | 15.5 | 27.6 | 4.2 | 4.6 | 51.9 |
| ii) Irrigation lateral | 19.0 | 46.2 | 23.7 | 31.9 | 120.8 |

The canal density of the proposed irrigation system inclusive of onfarm ditches is equivalent to about 60 m per ha.

Drainage

The drainage facilities are classified as the main canal, drainage lateral and onfarm drain, according to the respective function. During the high water season, some amount of rain water in the project area is detained in the paddy field during a period of 2 days, in due consideration of the growing stage of rice. The remaining amount is stored in the laterals and the main canals during a period of 4 days, taking the consecutive drought days into account (refer to the "drainage requirement"). While, during the low water season, the runoff water from the project area is directly drained into the onfarm drains to be released into the main drainage canals through the drainage laterals by gravity. The runoff water from the Um Jerr Island and the vast table land extending to the west of the project area is directly drained into the While Nile by gravity through the feeder channels /1 aligned along the boundary of the project area.

In tracts-1 and -2, the main drainage canals are aligned on the periphery of the Um Jerr Island. The periphery is located on the low-lying depression at an elevation less than 376.0 m above MSL. on an average. The drainage laterals branch away on one side at regular intervals of 2.0 km, alternating with the irrigation laterals. In tracts-3 and -4, the main drainage canals are aligned along the polder dikes and the drainage laterals are proposed at the depressed sites in each tract.

Unlined canals with trapezoidal cross section are designed for all drainage canals, based on the storage capacity estimated (see "the drainage requirement"). The typical cross section of the respective canals is illustrated in Fig. 4.3. The hydraulic gradients of the main canal and the lateral ranges from level to 1/3,500 and from 1/15,000 to 1/2,000, respectively. The total lengths of the proposed canals are as shown below:-

---

/1: Refer to 4.5.6 Compensatory Work

| | Tract-1 | -2 | -3 | -4 | (Total) km |
|---|---|---|---|---|---|
| i) Main drainage canal | 17.0 | 27.1 | 15.5 | 13.7 | 73.3 |
| ii) Drainage lateral | 19.1 | 39.2 | 20.5 | 24.5 | 103.3 |

The canal density of the proposed drainage system, inclusive of the onfarm drains is equivalent to about 40-m per ha.

4.5.2 Road Network

All weather road networks are proposed to be provided for farm-to-market and market-to-farm access to allow the truckage of new project inputs and outputs, and to facilitate the O & M of irrigation and drainage system.

The main roads are mostly aligned on the top of the polder dikes and the feeder channel dikes; some of them are supplementarily aligned at somewhere near the center of each tract. The farm roads stretching out from the main roads are aligned along the irrigation laterals arranged at 2 km intervals, provided with the inspection roads for the operation and maintenance of the irrigation laterals.

Both roads are paved with well compacted laterite soil. The density of the road networks inclusive of the onfarm road, is equivalent to 50 m/ha. The main features and the total lengths of the proposed roads are summarized below:-

Main Features of Roads

| | Main Road | Farm Road |
|---|---|---|
| 1. Total width | 10 m | 8 m |
| 2. Effective width | 7 m | 6 m |
| 3. Height to be embanked | 0.5 m | 0.3 m |
| 4. Percentage of camber | 3 % | 3 % |

Total Length of Roads

| | Tract-1 | Tract-2 | Tract-3 | Tract-4 | (Total) km |
|---|---|---|---|---|---|
| Main Road | 39.8 | 87.2 | 38.4 | 41.0 | 206.4 |
| Farm Road | 55.4 | 110.8 | 47.4 | 46.6 | 260.2 |

4.5.3 Flood Protection Work

The polder dikes are aligned along the boundary of the project area.

From the Hydrological data recorded at Ed Dueim, the maximum high water level at the project site of EL. 377.74 m above MSL. is assessed for the polder dike. The crest elevation of the dikes proposed is EL. 378.70 m above MSL, including an extra embankment for the settlement and consolidation of the dike, the scramble of wave and some clearance.

An alternative study has been made on the dike alignment along the riverside of the White Nile.. Based on the outcome of the study, the dikes along the riverside are aligned on the contourline of EL. 375.20 m above MSL. The height of dike ranges from 2.5 m to 4.5 m, according to the topographic condition of the sites. The crest width of 10 m is proposed in view of the traffic function of the main road installed on the top of dike. Internal and external side slopes of the dikes proposed are 1:2.0. The typical cross section of the dike is illustrated in Fig. 4.4. The total length of the dikes in each Tract is as shown below:

| | |
|---|---|
| Tract - 1 | 37.4 km |
| " 2 | 61.1 " |
| " 3 | 29.2 " |
| " 4 | 27.0 " |
| Total | 154.7 km |

The embankment materials of the dike are borrowed in the immediate vicinity of the site of the dikes from economical viewpoint. All the borrow pits excavated along the dike alignment function as the main drainage canals.

4.5.4 Irrigation and Drainage Facilities

1) Irrigation

i) Intake structure and pumping station

The maximum and minimum water levels at each intake site of each tract are proposed to be 377.70 m and 372.45 m above MSL, respectively on the basis of the records at the Ed Dueim water gauging station, since 1966. An inlet channel with a depth of 3.5 m and a bottom width of 4.0 m for intake structure is excavated in each tract to divert irrigation water from the main stream of the White Nile during the low water season. The side slope of channel below low water level is lined with rubble masonry. The length of each channel at each tract is around 200 m on an average. The intake structure is equipped with 2-barrel rectangular box culvert of reinforced concrete and a regulator with steel slide gates each at the inlet and the outlet.

A pumping station is installed in each tract for dual purposes, namely, irrigation and drainage. The delivery discharge is estimated from the diversion requirement and the drainage requirement, assumed pumping operation of 20 hrs/day; the irrigation water excessively pumped up due to the shortening of operation hours by 4 hours is regulated within the freeboard of main canals. As for the type of pump, a mixed flow type with a horizontal axis is proposed. A diesel engine is specified as the prime mover of the pumping unit in each station. The main features of the pumping station are summarized as follows:

| (Item) | (Unit) | Tract-1 | Tract-2 | Tract-3 | Tract-4 | Whole area |
|---|---|---|---|---|---|---|
| 1. Command Area | ha | 3,000 | 6,400 | 3,000 | 3,200 | 15,600 |
| 2. Delivery Discharge | $m^3/s$ | 6.72 | 14.28 | 6.72 | 7.08 | 34.8/1 |
| 3. Pumping Bore | mm | 1,000 | 1,100 | 1,000 | 1,000 | - |
| 4. Nos. of Units | No. | 3 | 5 | 3 | 3 | 14 |
| 5. Total Head | m | 7.5 | 7.5 | 7.5 | 7.5 | - |
| 6. Gross Power | P.S. | 900 | 2,100 | 900 | 1,050 | 4,950 |
| (Unit output) | P.S. | 330 | 420 | 330 | 350 | - |

/1: The delivery discharge estimated is enough to meet the amount of the drainage requirement mentioned in 4.4.2.

ii) Turnout

The turnouts are provided to distribute the required water from the parent canal into the offtake canal. Manual slide gates are installed to regulate the amount of required water distributed through the turnout. A Parshall flume is combined with the turnout to be installed on the main irrigation canal.

iii) Check structure

Check structures are proposed for the main canals and laterals to maintain the water level necessary for the diversion of irrigation water. Check structure comprises a reinforced concrete flume and one transition each at upstream and down stream; the flume is equipped with steel slide gates to check water surface in the canal. The inlet and the outlet of the structures are protected with dry rubble masonry. The standardized interval between two check structures is 4 km for the main canal and 2 km for the lateral.

iv) Irrigation culvert

The culverts are provided on the irrigation canals to intersect the road networks. The irrigation culvert is designed with an in-situ concrete barrel with rectangular section for the large scaled one and a precast concrete pipe for the small scaled one. The dry masonry is installed on the upstream and the downstream of the culvert structure to protect the canal surface from scouring and erosion.

The number of canal structures, such as the turnout, the check structure and the irrigation culvert is summarized below:-

| Tract | Turnout | Check Structure | Irrig. Culvert |
|---|---|---|---|
| 1 | 164 | 17 | 34 |
| 2 | 384 | 38 | 84 |
| 3 | 173 | 8 | 24 |
| 4 | 215 | 21 | 47 |
| (Total) | 936 | 84 | 189 |

2) Drainage

i) Drainage culvert

The drainage culverts are provided for the farm road and canal crossing. The culverts are designed with an in-situ concrete barrel with rectangular section for a large scaled one and a precast concrete pipe, for a small scaled one. The protections with dry masonry are installed at both up and down stream of the culvert.

ii) Drainage junction

To protect the canal surface against scouring and erosion, the drainage junction is installed at the connecting point of two drainage canals.

The number of the proposed drainage culverts and junctions is summarized as below:-

| Tract | Drainage culvert | Drainage junction | Total |
|---|---|---|---|
| 1 | 47 | 83 | 130 |
| 2 | 90 | 205 | 295 |
| 3 | 52 | 59 | 111 |
| 4 | 52 | 88 | 140 |
| | 241 | 435 | 676 |

4.5.5 Onfarm Development Work

Onfarm ditch and onfarm drain are separately aligned from the operation and maintenance view points of the terminal system and water management. The onfarm ditch is arranged along the onfarm road at the intervals of 400 m, alternating with the onfarm drain. The arrangement of onfarm facilities is as illustrated in Fig. 4.5.

The size of 0.8 ha and the shape of 40 m x 200 m (width x length of run) for the terminal plot are justified both technically and economically throughout the alternative study (refer to the relevant chapter in Annex). The justified plot is managed by subdividing it

into four (4) or five (5) subplots with tentative ridges to achieve precise water control at the early growing stage of paddy. The terrace at an elevation of more than 377.2 m above MSL. is excluded from the land levelling work to minimize the levelling cost. The farm surface undulation in each terminal plot should be limited to within 10 cm after the completion of the work. The volume of earthwork per ha. of the levelling work is estimated at 320 $m^3$/ha on an average.

At the pre-water stage, 4-day rotational irrigation practice is applied to the 50 plots each commanded by a minor turnout; 12.5 plots (10 ha in total) out of the 50 plots are irrigated each day.

The density of onfarm facilities is tabulated below:

| | |
|---|---|
| Onfarm ditch | 50 m/ha |
| Onfarm drain | 25 m/ha |
| Onfarm road | 21 m/ha |

4.5.6 Compensatory Work

239 pumping schemes all together have been developed in the area along the boundary of the project area, out of which 28 schemes are being operated by the public corporation, and the remaining 211 small scaled schemes by private sectors. In order to supply sufficient irrigation water to the above schemes after implementation of the project, the feeder channels is planned along the outside of the polder dikes.

Feeder channels of 100.0 km long in total are there excavated along the boundary of the project area to divert irrigation water from the White Nile to all the existing schemes after the completion of the project area. Two inlets for the channels are proposed in the vicinity of the Araki Island and Galli villages, respectively. Two inlet channels are supplementarily proposed to dispel such a hydraulic uncertainty, in connection with the demarcation of Tracts-2, -3, and -4.

The bottom of channel is excavated up to the elevation of 376.20 m above MSL.

An unlined canal is proposed throughout the entire reach of the channel. The main features of the channel are summarized below:

| | | | |
|---|---|---|---|
| i. | Average bottom width | : | 40 m |
| ii. | Side slope | : | 1 : 1.5 |
| iii. | Bottom slope | : | level |
| iv. | Total length | : | 100 km |

4.5.7 Offices and Quarters

Office and quarters are proposed for the implementation of the project. These facilities are built initially for the construction works. After completion of the work, they are continuously used for the operation of the project. The head office of the project is built at the compound adjacent to the crossing road to the Um Jerr Island, while the scheme office of each tract, on one of terraces scattering there. The required spaces of offices and quarters are estimated as follows;

i For administration

| | |
|---|---|
| - Head office | 1,200 $m^2$ |
| - Scheme offices (5 Nos) | 600 $m^2$ (in total) |

ii For engineering services

| | |
|---|---|
| - Consultant office | 400 $m^2$ |
| - Quarters | 400 $m^2$ |