BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
MWEA IRRIGATION SETTLEMENT
SCHEME DEVELOPMENT
IN
THE REPUBLIC OF KENYA

JUNE 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Kenya, the Government of Japan has decided to conduct a Basic Design Study on the Project for Mwea Irrigation Settlement Scheme Development and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a survey team headed by Mr. Katsuhide Kondo, Deputy Director, Construction Department, Chugoku-Shikoku Agricultural Administration Office, Ministry of Agriculture, Forestry and Fishery from January 20 to February 25, 1989.

The team exchanged views with the officials concerned of the Government of Kenya and conducted a field survey. After the team returned to Japan, further studies were made. Then, a mission was sent to Kenya in order to discuss a draft report and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

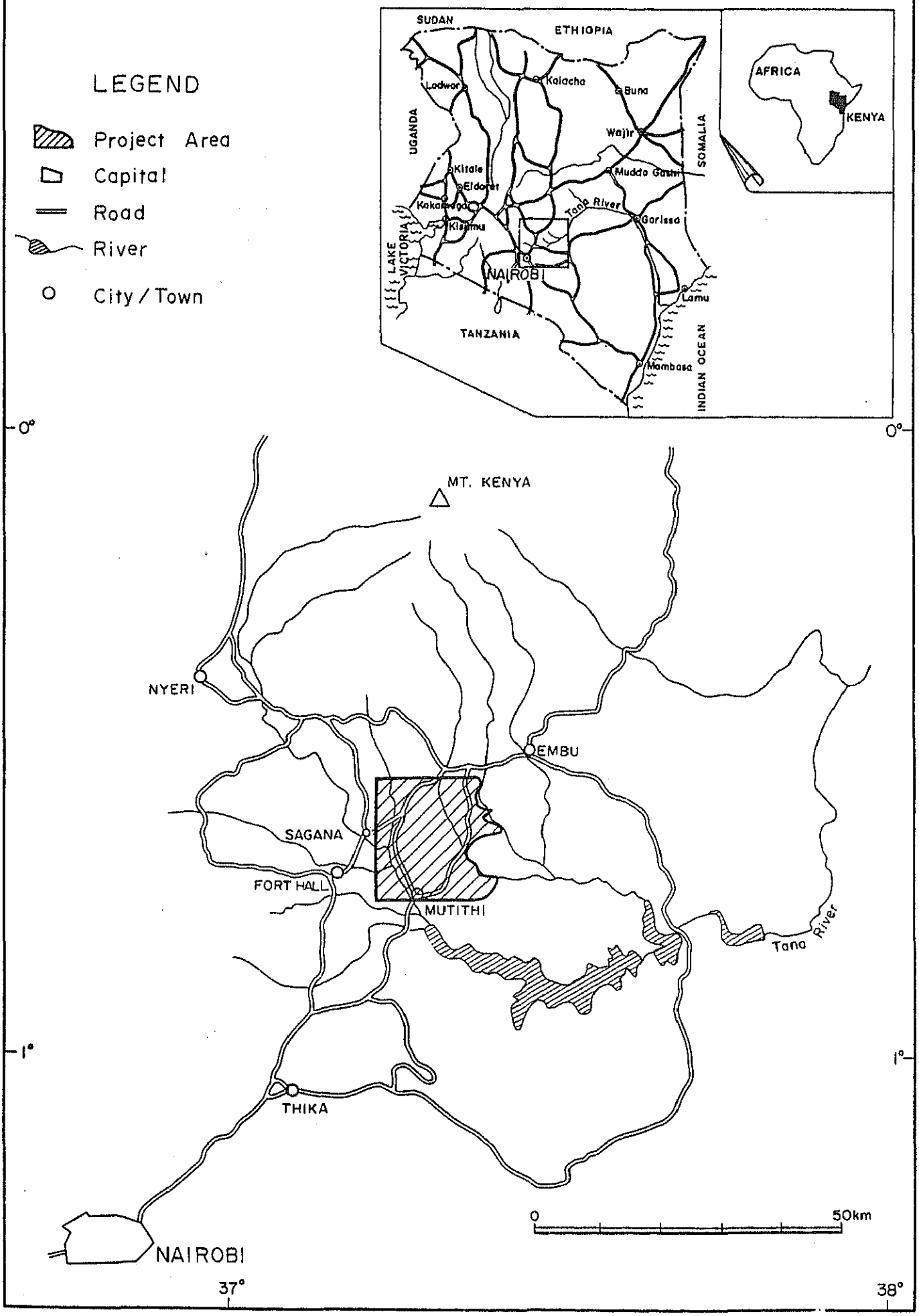
I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

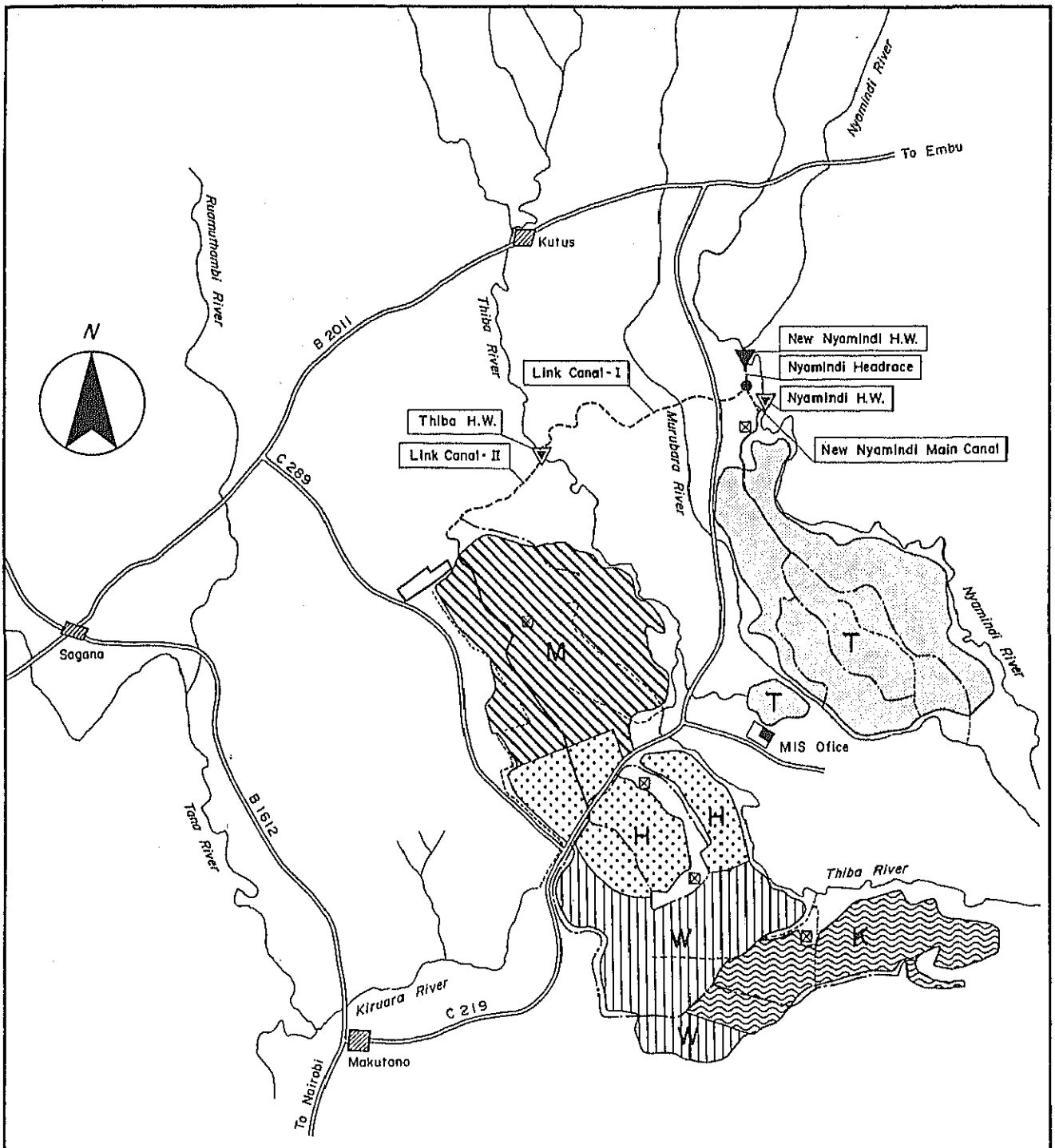
June 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

LOCATION MAP





KEY

Project Facilities

- ▼ : New Headworks
- ▽ : Existing Headworks
- ◉ : Diversion Works
- ○ : Regulating Basin
- ------ : Link Canal or Headrace
- ——— : Main Canal
- —·—·— : Branch Canal
- ..... : Drainage Canal
- ⊠ : Existing Reception Centre
- ■ : Machine Center

Existing Irrigation Area (5,860 ha)

T	:	Tebere Section	1,300 ha
M	:	Mwea Section	1,220 ha
H	:	Thiba Section	1,150 ha
W	:	Wamumu Section	1,120 ha
K	:	Karaba Section	1,070 ha

: Pilot Farm (40 ha)

SCALE

0 1 2 km

GENERAL PLAN OF THE PROJECT

SUMMARY

SUMMARY

Agriculture is the mainstay of Kenya's economy sharing 30 % of the gross domestic product (GDP) and 50 % of the total export amount. As well, 80 % of the Kenyan population is engaged in agricultural sector.

The arable land is limited to 19 % of the national land due to insuficient rainfall. The total cultivated land of Kenya is 2,370,000 ha, of which the total irrigation land occupies only 1.6 %. The agriculture of Kenya is highly dependent upon climatic conditions. Therefore, crop production has fluctuated year by year resulting in unstable domestic food supply and food import consisting of considerable amounts of cereals, i.e. wheat and rice. Due to such unstable food supply conditions and rapidly increasing population with a growth rate of 3.8 % per annum, Kenya is now facing an imbalance of demand-supply of food.

With view of attaining food self-sufficiency, the Government of Kenya (GOK) is placing a great emphasis on agricultural development by setting up several policies and targets, among which the highest priority is given to rehabilitation and improvement of the existing irrigation schemes. The Mwea Irrigation Settlement (MIS) Scheme is the leading irrigation scheme in Kenya with the total area of 5,860 ha and is producing 27,000 tons of paddy a year which corresponds to 66 % tons of the total national production of 41,000. However, MIS now suffers from the following technical constraints after 30 years of operation.

- Lower irrigation efficiency, i.e. 70 % of the design capacity, due mainly to deterioration of facilities
- Inadequate water distribution to the irrigation areas even though water is available
- Insufficient farm machinery and implements for proper farm operation
- Decreasing unit yield of paddy at a pace of 0.13 ton/ha a year due to the constraints mentioned above

In addition, lack of techniques prevent the Government from introducing double cropping system to the existing irrigation schemes including MIS, though it is directed by the government policy.

In January 1988, GOK requested the Government of Japan (GOJ) to extend both grant aid and technical cooperation to the rehabilitation and improvement of MIS including establishment of a pilot farm (the Project) for enhancing the productivity of paddy in MIS.

In response to the GOK's request, GOJ decided to execute the basic design study of the Project to assess its appropriateness and prepare the basic design. The Japan International Cooperation Agency (JICA) then dispatched a Basic Design Study Team (the Study Team) to Kenya during the period from 20th January to 25th February, 1989.

On the basis of the survey results in Kenya, the Study Team worked out the optimum development plan through detailed study of the project viability, design of project facilities, selection of machinery and equipment, cost estimate and establishment of operation and management plan which are compiled into the draft Basic Design Study Report on the Mwea Irrigation Settlement Scheme Development Project. JICA sent a Draft Report Explanation Team to Kenya from May 12 to may 24, 1989. The team explained the study result and had a discussions with the authority concerned of Kenya. This final report is prepared taking the discussion into account. The study results and the project features are summarized below.

(1) According to the GOK's request, the survey and investigation were carried out in terms of the project background, i.e. the national and agricultural development policies, food demand-supply conditions, the current situation of irrigation development in Kenya, the present conditions in the project site. As a result, it was recognized that the project viability, the GOK's institutional capacity and the project benefit are highly suitable for application of the Japanese Grant Aid Programme.

(2) Under the conditions of the Japanese Grant Aid Programme, the development plan was formulated and the basic design was carried out. The features of the Project are outlined below.

a) Executing agency : National Irrigation Board (NIB)

b) The Project consists of the following components, through which adequate irrigation water supply will be ensured and double cropping system will be introduced in certain part of MIS, for stabilization and increase of the paddy production in MIS.
- Rehabilitation and improvement of the existing irrigation facilities of MIS
- Provision of O&M equipment for the irrigation facilities of MIS
- Provision of farm machinery
- Construction of Pilot Farm

c) Salient features of facilities and equipment :

Rehabilitation and improvement of irrigation and drainage facilities

a. New Nyamindi headworks : 1 no.

b. Thiba headworks : 1 no.
c. Nyamindi headrace and main canal : 5.7 km
d. Link canals-I and -II : 12.4 km
e. Thiba main canal : 8.9 km
f. Related structures : diversion works, drop, etc.
g. Farm road : 42.9 km

Construction of buildings

a. Machine center : 1 no.
b. Pilot Farm
- Management office
- Lodging facilities
- Multi-purpose warehouse
- Drying yard
- Others

Machinery and equipment

a. O&M equipment
- Backhoe shovels
- Bulldozer
- Others

b. Farm machinery
- Tractors
- Rotavators
- Others

c. Equipment and tools for machine center
- Engine services
- Battery and electric services
- Tools
- Others

d. Pilot Farm
- Tractor and attachments
- Meteorological station
- Others

The construction of the Project is to be divided into three (3) stages, taking into account (a) scale of the project works, (b) work quantities, (c) construction period, (d) maximum performance period under the Japanese Grant Aid Program, and (e) meteorological and social conditions in the project area. The main components of the works to be executed in the respective stages are as follows;

Stages	Period for D/D	Period for Construction	Components
1st Stage	4.5 months	12 months	Rehabilitation of Thiba headworks Rehabilitation of Link canal-II Rehabilitation of Thiba main canal Construction of Pilot Farm
2nd Stage	4.5 months	13 months	Construction of Nyamindi headworks Construction of Nyamindi headrace Construction of new Nyamindi main canal Rehabilitation of Link canal-I
3rd Stage	3.5 months	8.5 months	Rehabilitation of Nyamindi main canal Rehabilitation of related structures in Thiba branch canal-IV Rehabilitation of related structures in other branch irrigation canals and drainage canals

The project cost is estimated to be Yen million for Japanese portion and KShs 717,000 for Kenyan portion. The cost allocated to each phase is tabulated below.

Phase	Project Cost	
	Japanese portion (Yen million)	Kenyan portion (KShs thousand)
1st Phase		717
2nd Phase		-
3rd Phase		-
Total		717

The direct benefits to be derived from the Project are increase of rice production, improvement of farm income and saving of foreign currency required for food import as follows.

(1) The annual paddy production will decline by 24% from 27,000 tons of the current production to 20,500 tons under the without project condition. In contrast, that will increase to about 41,200 tons or 1.5 times the current production under the with project condition.

(2) The country has imported 23,900 tons of rice annually for half a decade (1982-1986). This means that the country can save US$ 8.3 million in foreign currency

per year by the Project on the basis of the 1995 projected CIF Mombasa price of milled rice: US$ 345.8/ton.

(3) Increase of the future gross farm income level is estimated to be 1.3 times (KShs. 35,800) the present income by single cropping and 2.5 times (KShs. 69,400) by double cropping. The farm budget will be remarkably improved by the Project.

In addition to the direct benefits mentioned above, the following secondary benefits can be expected.

(1) Improvement of working environment of the local farmers through improving the farm road and providing farm equipment
(2) Contribution to paddy production in Kenya through introduction of rice farming technique in MIS

As a result of the field survey and study in Japan, the Project is expected to bring both direct and indirect benefits. In addition the Project will contribute to improvement of living standard of farmers. It is concluded that the Project is favorable and appropriate for Japanese grant aid programme. It is also recognized that the Kenyan authorities concerned are well organized with sufficient number of staff and financial resources to manage and control the Project. As for the management of the Pilot Farm, an agreement on technical cooperation between GOK and GOJ is expected to be made since for indispensable for smooth management.

The Study Team recommends that GOK will undertake the following in order to implement the Project smoothly and to operate and maintain the project facilities satisfactorily.

(1) To carry out the rehabilitation works excluded from the Project, i.e. rehabilitation of the existing irrigation canals with the design discharge of less than 2 m^3/sec and desilting of the drainage canals, in the earliest time by using O&M equipment to be provided under the Project.

(2) To improve the reception centres according to the expansion of the paddy production in future.

(3) To execute approproate operation and maintenance of the irrigation facilities as well as the pilot farm after the completion of the project

(5) To arrange financial budget and to educate and train required staff for the Project. Particularly operators and mechanics additionally required in accordance with the increase in number of agricultural machinery are to be recruited and trained.

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SETTLEMENT SCHEME DEVELOPMENT

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CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

The development of the Mwea Irrigation Settlement Scheme (hereinafter referred to as MIS) was embarked in 1953 and the scheme is now he largest one of its kind in Kenya. The construction of the irrigation facilities started in 1954. The Nyamindi headworks was completed in 1956 and the Thiba headworks in 1957. The on-farm development of about 2,000 ha was subsequently completed in 1960. At present, the irrigated paddy field extends to 5,860 ha. MIS had been organized under the Ministry of Agriculture until 1966, when the National Irrigation Board (NIB) was established under the Irrigation Act (CAP 347), and was taken over by NIB in the same year. Due to the serious deterioration of irrigation facilities used for 30 years and the extension of irrigation area, MIS is now facing the insufficiency of irrigation water supply.

In May 1985, the Government of Kenya (GOK) requested the Government of Japan (GOJ) to carry out the feasibility study of rehabilitation and extension of MIS under the technical cooperation of Japan. In response to this request, GOJ through the Japan International Cooperation Agency (JICA) sent a Preliminary Study Team to Kenya for discussing the details of the said feasibility study and the scope of work was concluded between JICA and NIB. From June 1986 to September 1987, the feasibility study team carried out the study and submitted the Feasibility Report on the Mwea Irrigation Development Project (F/S) in March 1988.

In January 1988, on the basis of the conclusion of F/S, GOK requested GOJ to extend a grant aid and a technical cooperation for rehabilitation and improvement of irrigation and other facilities of MIS for enhancing the rice productivity in MIS scheme.

In response to the GOK's request, GOJ decided to execute the preliminary survey to examine the possibility and basic scope of the cooperation. JICA dispatched the Preliminary Survey Team headed by Mr. Katsuhide Kondo, Deputy Director, Construction Department, Chugoku-Shikoku Agricultural Administration Office, Ministry of Agriculture, Fishery and Forestry, to Kenya from 11th October to 24th October, 1988. The Team reported that the Mwea Irrigation Settlement Scheme Development Project (the Project) is generally appropriate for implementation under the Japanese Grant Aid because the objectives of the Project are in conformity with the basic policy of agricultural development set up in line with the national development plan of Kenya and the technical support to NIB under the Japanese Technical Cooperation will play an important role to raise the benefit of the Project.

In accordance with the conclusion by the Preliminary Study Team, GOJ decided to execute the basic design study of the Project in order to assess the viability of the Project and to

prepare its basic design. JICA dispatched the Basic Design Study Team headed by Mr. K. Kondo from 20th January to 25th February, 1989.

The Study Team reviewed the background of the Project and studied the details of the GOK's request in addition to a field investigation for clarifying the actual conditions in the project area. The Study Team held discussions with government officials concerned on outline of the Project and exchanged the minutes of discussions. After returning to Japan, the Study Team formulated the optimum development plan on the basis of the data and information obtained in the field survey, carried out the basic design study including design work of the project facilities, selection of machinery and equipment, estimation of the project cost and establishment of operation and maintenance plan. The Study Team prepared the Basic Design Study Report on the Mwea Irrigation Settlement Scheme Development Project (draft), which presents the results of the basic design study of the Project.

JICA sent a Draft Report Explanation Team to Kenya from May 12 to May 24, 1989. The team explained the study result and had a discussions with the authorities concerned of Kenya. As a result of the discussion, an agreed minutes was made, signed and exchanged. This report was finally prepared taking into account the comments made by the Government of Kenya on the said Draft Report.

The list of the team members, itinerary of the Study Team, list of personnel contacted and minutes of discussions are presented in Appendices 1 to 4.

CHAPTER 2
BACKGROUND OF THE PROJECT

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2.1 Agriculture in Kenya

The agricultural sector shares about 30% of the gross domestic product (GDP) in Kenya's economy and accounts for about 50% of the national total export earning. About 80 % of the national labor force is engaged in agricultural sector and the same rate of population is economically dependent on the agricultural sector.

The farms in Kenya are categorized into two groups; small farms and the large farms. Small farms are in majority and are producing foodstuffs for self-consumption at subsistence level. On the other hand, large farms produce both cash crops and food crops for domestic and foreign markets. Under the government policy focusing on large farms have been sub-divided into small farms. Although the number of large farms is gradually decreasing, they are still dominant in farm land area.

The total area of arable land in Kenya is 2,370,000 ha. The land suitable for agriculture is limited. In view of rainfall amount, which is a critical factor in crop production, only 19% of the total land is classified as suitable for agricultural purposes. Crops are generally planted under rain-fed conditions in Kenya and irrigated area is extremely limited, i.e. only 1.6% of the total arable land, and hence the crop production largely fluctuates year by year depending on climatic changes as presented in the following table.

Production of Main Crops

(Unit: 1,000 tons)

Crops	1982	1983	1984	1985	1986	Average
Food crops						
Maize	2,340	2,178	1,422	2,750	2,825	2,303
Wheat	251	251	144	279	260	237
Sorghum	131	35	98	120	130	103
Millet	66	15	21	60	65	45
Paddy	43	36	21	52	54	41
Beans	225	200	188	432	518	313
Potato	350	265	280	330	350	315
Cassava	645	250	612	450	500	491
Cash crops						
Coffee	95	87	111	94	116	121
Tea	96	119	116	147	143	124
Sugarcane	3,628	3,846	4,171	4,023	3,887	3,911
Cotton	24	26	23	23	N.A.	24
Vegetables	18	12	11	10	12	13

Source: FAO Production Yearbook, 1985-1987

Among food crops, maize leads the other crops in production accounting for 67% of the total production value of cereals (KShs. 2.02 billion in 1987) followed by wheat (21%) and rice. Self-sufficiency in cereals has not been attained yet and the country partly relies on imported food to make up the deficit. Increased food production is crucial taking future population increase into account. In particular, rice production is needed to be increased at a rate of 16.4% per annum in order to meet the growing demand.

The important cash crops are coffee, tea, sugarcane, sisal and pyrethrum. The combined production of these crops is equivalent to about 60% of the total value of agricultural produce.

As mentioned above, the Kenyan agricultural production largely fluctuates, and as a result self-sufficiency of foodstuffs is unsustainable. Therefore, Kenya depends on food import in order to make up the shortage as presented in the following table. The rice import in 1984 and 1985 was outstandingly lower since the priority was given to maize and wheat to cover food shortage due to crop failure by drought.

Import of Food Crops

(Unit: ton)

Crops	1982	1983	1984	1985	1986	Average
Maize	89,056	-	405,443	125,454	700	124,130
Wheat	139,326	81,946	149,906	143,793	115,281	126,050
Paddy	11,880	44,768	507	562	61,745	23,892
Total	240,262	126,714	555,856	269,809	177,726	274,072

Source: FAO Production Yearbook, 1985-1987

2.2 Agricultural Administrative Organizations of Kenya

The administrative organization of Kenya consists of two offices and 28 ministries under the Office of the President. The Ministry of Finance is responsible for establishment of national economic policies as well as for coordination of foreign aid. The Ministry of Planning and National Development is responsible for planning and designing national development plans.

The government agencies concerned with agricultural development are the Ministry of Agriculture (MOA), the Ministry of Livestock Development (MOLD), the Ministry of Supplies

and Marketing (MOSM), the Ministry of Water Development (MOWD) and the Ministry of Regional Development (MORD). Their main roles and functions are outlined below.

(1) Ministry of Agriculture
- Agricultural policy making
- Crop production and marketing
- Land use
- Agricultural finance
- Agricultural research

(2) Ministry of Livestock Development
- Production, processing and marketing of livestock
- Sanitation and research of livestock

(3) Ministry of Supplies and Marketing
- Policy making for marketing and distribution of food
- Controlling activities of the National Cereals and Produce Board

(4) Ministry of Water Development
- Development of water resources and water supply
- Quality and pollution of water

(5) Ministry of Regional Development
- Policy making for regional development
- Controlling activities of regional development authorities (Tana and Athi Rivers Development Authority, Lake Basin Development Authority and Kerio Valley Development Authority)
- Irrigation and dam
- National Irrigation Schemes
- Fishery development

The Project aims to develop MIS, which is one of the National Irrigation Schemes under the jurisdiction of MORD and under the management of NIB.

2.3 Development Plans Concerned with the Project

2.3.1 National Development Plans

The current Fifth National Development Plan for the years of 1984 - 1988 was published in 1983. The main objective of the Plan is to balance the economic disparity between sectors and regions as well as to exploit domestic resources. The Government places higher priority on reduction of foreign debt, increased share of the private sector in GDP and promotion of District Focus.

The Plan targets an annual economic growth rate of 4.9 % for the period of 1984 - 1988. This target could not be achieved due to the lower growth performance in the early years of the said period. However, the windfall gains from the hike in coffee prices and the slump in crude oil prices could put the Plan back on course in 1986-1988.

The target growth rate for agricultural sector in the Plan is set at 4.6% per annum. Actual annual growth rate, however, had been less than 4% except that in 1986 when coffee prices soared.

The Government's long-term strategy is set out in the Sessional Paper No.1 of 1986 entitled "Economic Management for Renewed Growth" (SP1). It targets an annual economic growth rate of 5.6% on an average in 1984 - 2000. The most rapid expansion is to be sought in manufacturing sector with an annual growth rate of 7.2%. The agricultural sector targets 5.0% annual average growth rate for the same period. SP1 describes that the target is to be achieved mainly through improving productivity and further introducing selected crops of high value-added such as fruits and vegetables.

2.3.2 Government Policy on Agricultural Development

(1) Outline of the basic policy of agricultural development

Over the past two decades, the agricultural production of Kenya as a whole has doubled, growing at an average rate of 3.5% per annum. The country has been able to rely on the domestic agriculture for the majority of her basic food requirements in most years. Nevertheless, the yearly fluctuation of agricultural production has never warranted the self-sufficiency of food in all years and substantial imports of basic foodstuffs are required to make up the domestic deficits.

In recent years, the rapid expansion of population and unstable production of basic foodstuffs are beginning to expose a potentially dangerous imbalance between national supply and demand of food.

Under such conditions, GOK has set up various policies. Following are the national plans in the 1980s.

National Food Policy (NFP)

The National Food Policy (NFP) was formulated in 1981 aiming at securing food supply, after the serious shortage of food caused by the drought in the previous year. NFP defines a guideline for policy decision concerning every aspect of agricultural production and marketing until 1989. The main directions of NFP comprise:

1) To attain self-sufficiency in staple foods for preventing the nation from spending scarce foreign exchange on food import;
2) To secure sufficient food supply within every region of the country; and
3) To improve the marketing of staple foods to make it possible for all people to take satisfactory nutrient.

As staple foods, nine products are listed: maize, wheat flour, sorghum/millet, beans, potatoes, sugar, beef and milk. The annual increase rates necessary to realize the targeted production by 1989 are shown below. Rice production is needed to be increased at a remarkably higher rate of 16.4% per annum.

Items	Target Production (1,000 tons)	Per capita Consumption (kg)	Annual Increase Rate (%)
Maize	3,514	152.1	6.8
Wheat	493	21.3	14.8
Rice	90	3.9	16.4
Sugar	371	16.1	4.0
Beef	314	13.6	8.8
Milk	1,058	45.8	5.6

National Development Plan

The goals of development in agricultural sector set in the Fifth National Development Plan are as follows:

1) To attain self-sufficiency in food and to increase production of vegetable oil and rice for abating dependency on import of these products;
2) To create job opportunities for absorbing expanding labour force;
3) To increase production of cash crops for earning foreign exchange;
4) To conserve natural resources, and
5) To alleviate poverty.

Of the goals mentioned above, increase of food production is planned to be achieved by the following strategies:

1) To introduce improved varieties and appropriate farming practices for maize and wheat under rain-fed condition;
2) To rehabilitate and improve the existing irrigation systems;
3) To reclaim potential agricultural land; and
4) To expand irrigation area particularly for rice production.

The subsequent Sixth National Development Plan for 1988-1993 is scheduled to be published before long.

Economic Management for Renewed Growth (Sessional Paper No.1 of 1986)

SP1 was formulated in 1986 for the purpose of modifying the current Fifth National Development Plan and setting forth the targets of economic growth and its growth rate for the year of 2000. The annual growth rate of the whole economy is set at 5.6% on an average and that of agricultural sector at 5.0%. The following are the principal targets given in SP1:

1) To supply food to sufficiently meet the demand of the forecast population of 35 million in 2000;
2) To raise farm income at a rate of 5.0% per annum;
3) To create more job opportunities in agricultural sector at a rate of 3% per annum;
4) To increase production of export crops to augment the agricultural export value by 150% by the year of 2000;

In order to achieve the goals above, three strategies are set out in SP No.1: first to raise the unit yield through improving farming practices and increasing agricultural input;

second to give incentive to farmers through raising prices and improving marketing system; third to reinforce agricultural experiment and promote introduction of high-yielding varieties.

Summarily the basic policy on rice as mentioned above is to minimize the import of rice, to cope with the growing demand for rice and to increase the income of farmers through reinforcing and extending irrigation and raising unit yield of rice.

(2) Irrigation development in Kenya

According to the estimate shown in the "National Master Water Plan, 1979" prepared by MOWD, there exists potential irrigation area of 540,000 ha over the country, as shown below:

Potential Development Area	Area (ha)
Lake Basin	200,000
Athi River Basin	70,000
Tana River Basin	200,000
Ewaso Ngiro River Basin	30,000
Total	540,000

Out of the above potential irrigation areas, the plan of irrigation development for rice cultivation in the Tana River Basin (Mutithi; 2,470 ha, Tana Delta; 5,000 ha) has been formulated. The development plans for other areas including Lake Basin are also under preparation. Nevertheless, it is considered that the implementation of those projects will take a long time mainly due to large fund requirement.

The basic policy on irrigation development in Kenya as defined in SP No.1 and National Development Plans is summarized as follows:

1) To accord priority on rehabilitation and improvement of the existing irrigation schemes because large scale irrigation development, in particular pump irrigation, requires huge fund, and
2) To set up a Task Force in the Government consisting of representatives of the ministries concerned for the purpose of formulating basic policy on future irrigation development. Further clarification and study will be required for the following aspects.

- Further investigation of potential irrigation area
- Economical development of potential area
- Proper management of land and water

The total area of the existing irrigation schemes is approximately 35,600 ha, which is equivalent to about 7% of the total potential irrigation area in Kenya. This includes the communal irrigated land of 12,600 ha consisting of 8,800 ha under NIB and 3,800 ha supported by MOA and other public agencies, and the remaining 23,000 ha managed by private bodies and farmers.

Of all the irrigated area, paddy field is estimated to occupy 8,600 ha, 7,560 ha of which are managed by NIB and about 1,000 ha by MOA. The other irrigation areas are utilized for cultivation of sugarcane, cotton, coffee and vegetables.

As described above, the large portion of irrigated areas in Kenya is controlled and managed by NIB which is a parastatal agency established under the Irrigation Act enacted in 1966. It is responsible for a broad spectrum of irrigation activities including new development, management and improvement of national irrigation schemes in Kenya. NIB functioned under MOA until June 1987 when it was re-organized to be under the Ministry of Energy and Regional Development (at present Ministry of Regional Development).

At present, NIB is responsible for the operation of the following six irrigation schemes:

Irrigation schemes	Area (ha)	Nos. of settlement households (No.)	Crops cultivated
Mwea	5,860	3,236	Paddy
Ahero	1,070	519	Paddy
West Kano	670	553	Paddy, Sugarcane
Bunyala	210	131	Paddy
Perkerra	100	342	Onion, Chile
Tana	872	606	Cotton
Total	8,782	5,387	Paddy (7,560 ha) Others (1,222 ha)

NIB is operating four schemes for irrigated rice cultivation with a total area of 7,560 ha. NIB supplies the tenant farmers with various services such as land preparation as well as supply of irrigation water, fertilizer, insecticides and transport. Farmers pay a Service

Charge to NIB for those services at a fixed rate. The Service Charge is sometimes rather lower than the actual cost of the services provided. The Service Charge is to be paid in the form of harvested crops.

Farmers in NIB schemes are settled by NIB and allotted 3-4 acres (1.2 - 1.6 ha) of irrigated land on rental basis.

MIS is the largest scheme for irrigated rice cultivation in Kenya with a total area of 5,860 ha sharing 68% of all the irrigated rice area of 8,600 ha. The irrigated area and production of rice in each NIB scheme are shown below:

Schemes	Planted Area (ha)	(%)	Paddy Production (ton)	(%)
Mwea	5,860	(77.5%)	27,011	(78.7%)
Ahero	1,070	(14.2%)	3,700	(10.8%)
West Kano	420	(5.5%)	2,330	(6.8%)
Bunyala	210	(2.8%)	1,257	(3.7%)
Total	7,560	(100.0%)	34,271	(100.0%)

As shown in the above table, MIS shares a large portion of paddy production in Kenya.

(3) Trend of foreign aid to Kenya

The financial aids from foreign donors to Kenya amounted to US$ 417 million in 1985 on the basis of net disbursed amount consisting of US$ 106 million (25.4%) of loan, US$ 199 million(47.7%) of grant aid and US$ 112 million (26.9%) of technical cooperation. The main donor countries were the United States (US$ 7.3 million; 17.5%), the Federal Republic of Germany (US$ 3.5 million; 8.4%), the United Kingdom (US$ 3.2 million; 7.7%), Japan (US$ 3.0 million; 7.2%) and Denmark (US$ 2.5 million; 6.0%).

These foreign aids were allocated to the sectors of infrastructure (22%), agriculture (18%), urban water supply (16%), energy (11%), public welfare and population (9%), education and training (7%) and others.

The Japanese foreign aid to Kenya has been rapidly increasing. In 1986, the net disbursed aid amount was US$ 5.0 million (loan: US$ 1.7 million, grant: US$ 1.8

million, technical cooperation: US$ 1.5 million) and the amount committed by E/N was 7.1 million (loan: US$ 3.5 million, grant: US$ 2.0 million, technical cooperation; US$ 1.6 million). This amount has been expected to increase since 1987, though the actual figure is not yet announced.

NIB has received only two foreign aids during the last decade. One was for the Feasibility Study on the Mwea Irrigation Development Project by GOJ through JICA and the other was the grant aid given by the Dutch government. The Dutch aid is outlined below:

1) Project Title	:	Operational Research and Training Project (ORTP)
2) Project period	:	1979 - 1988
3) Objective	:	Cooperation for reinforcement and improvement of experiment and research at experimental stations located in Mwea (rice), Ahero (rice) and Hola (subsistence crops such as cotton, maize and beans)
4) Activities	:	To send experts, to provide machinery and equipment including agricultural machinery and to train NIB staff both in Kenya and abroad

This project was executed mainly for the Ahero Irrigation Research Station (AIRS) and the main experiments of irrigated rice farming involved selection of varieties with high yield and high disease tolerance and trial application of fertilizers and agro-chemicals.

The varieties presently grown in the NIB schemes and the fertilization standard applied to the selected varieties are based on the experiment results. ORTP has thus contributed to rice cultivation in Kenya. Almost all of the agronomists in NIB have experience in taking part in ORTP as counterparts, trainees or participants in seminars, and have thereby improved their skill.

The problems in ORTP were that machinery and equipment were mostly provided to Ahero scheme and none to Mwea scheme and that the double cropping trial executed in Mwea scheme could not give the good experimental results as expected.

2.4 Rice Marketing and Demand and Supply Balance

2.4.1 Rice Marketing

Maize, wheat and such specific crops as rice, sorghum, millet, cashew nut and beans are imported, exported and marketed under the sole responsibility of the National Cereals and Produce Board (NCPB) in line with the NCPB Act. The functions of NCPB are as follows:

i. To regulate and control the collection, transference, storage, sale, purchase, transport, marketing, processing, import and export of maize, wheat and specific crops;
ii. To purchase, store, sell, import and export maize, wheat and specific crops for the sake of ensuring larger benefit for domestic producers and consumers; and
iii. To advise the Minister on the matters concerned with appropriate production, import and export of the aforementioned crops according to the domestic needs.

The main roles of NCPB on rice marketing are as follows:

i. To purchase paddy from NIB;
ii. To sell paddy to rice mills;
iii. To re-purchase milled rice from rice mills;
iv. To transport rice to storage facilities of NCPB in every district where rice will be consumed and to store it;
v. To sell rice to registered traders; and
vi. To import rice.

Rice purchased by registered traders is finally sold to consumers through retail dealers. The marketing channels of rice from registered traders to consumers are regulated under the Price Control Act. Paddy is to be milled at licensed rice mills. Two corporations are licensed at present. One is Mwea Rice Mill Limited which is a co-financed company of NIB and Mwea Amalgamated Rice Growers Cooperative and the other is United Millers Limited which is a private company in Kisumu, the city near Ahero.

2.4.2 Demand and Supply of Rice

The annual average production of cereals as a whole during 1982 - 1986 was 2,729,000 tons as shown in the table presented in page 3. Out of the cereals, maize was the leading crop accounting for 84% of the total cereal production followed by wheat accounting for 8.7%. Paddy production was 41,000 tons and shared 1.5% of the total cereals.

The annual average amount of rice purchased by NCPB during the same period was 983,000 tons. The difference between the produced amount and purchased amount is represented the amounts of self-consumption by farmers, reservation for seeds and post-harvest losses. The percentages of maize, wheat and rice of the total NCPB purchase amount were 61%, 21% and 18% respectively. The share of rice in the purchased cereals was relatively high as compared with that in the produced amount.

The annual import amount of cereals as a whole during 1982 - 1986 was 274,000 tons, consisting of 124,000 tons of maize, 126,000 tons of wheat and 24,000 tons of rice as shown in the table presented in page 4. The import amount fluctuated much year by year and reached 560,000 tons in 1984 when Kenya suffered from drought. Rice was mainly imported from the United States, Thailand and Italy.

The official long term forecast of demand and supply of rice is not available in Kenya. The only estimation announced is the production target of 90,000 tons by 1989 and the requested production increase at an average rate of 16.4% per annum to meet the target, as shown in the aforesaid NFP. The rice demand is forecasted for the year of 2000 in this Basic Design Study, and the result is summarized as follows:

(1) Conditions of estimation

i. Population: Population projection authorized by GOK is used:

Year	Population (million)
1984	19.5
1988	22.7
1990	25.2
1995	31.1
2000	38.5

As for ratios of urban and rural populations, the ratio applied in SP1 is used. The urban population will increase from 2.8 million in 1984 to 9.9 million in 2000.

ii. Annual per capita consumption of rice:

Case-1:	Average of 1982-1986; (national consumption/population)	3.3 kg
Case-2:	Consumption targeted in NFP;	3.9 kg
Case-3:	Consumption in urban area and rural area; (estimated from areal sales amount of NCPB)	10.2 kg and 0.7 kg

The annual total consumption amounts derived from the above are as follows:

(unit: 1000 tons)

Case	1990	1995	2000
1	83	103	127
2	98	121	150
3	-	-	120

iii. Forecast of production: For this analysis, it is assumed that the current production level of rice, i.e. 27,000 tons is to be maintained.

(2) Forecasted deficit of rice

(unit: 1000 tons)

Case	1990	1995	2000
1	56	76	100
2	71	94	123
3	-	-	93

No data are available for forecast of national income and income elasticity of demand for rice. However, the income elasticity is deemed to be relatively high in Kenya since the remarkable difference in per capita consumptions is recognized between urban area, where large number of people falls in high income class, and rural area. This implies that the future demand for rice would depend much on the growth of national income.

2.5 Outline of the Request and Preliminary Survey

2.5.1 Outline of the Request

GOK places a higher priority on rehabilitation and improvement of the existing irrigation schemes in its agricultural development policy. MIS, which is the largest and the oldest irrigation scheme in Kenya, has been constructed 30 years ago and has not been sufficiently maintained since its completion. As a result, MIS is facing insufficient irrigation water and relapse of productivity due to the deterioration of its facilities and the gradual expansion of its irrigated area in course of time.

Under such a circumstance, the GOK requested the GOJ to execute a feasibility study on rehabilitation of MIS and further development of the Mutithi extension area. The GOJ agreed to execute the study and JICA carried out the survey during the period from January 1987 to March 1988. All the results are compiled into the study report entitled "The Feasibility Study Report on The Mwea Irrigation Development Project".

Outline of the development plan set up in the report is described below:

i. Double cropping of rice by irrigation will be introduced by maximum exploitation of land and water resources,
ii. Irrigation development area has the total extent of 9,560 ha consisting of the following sub-areas:

<u>MIS area</u>		
a. Existing irrigated paddy fields on black cotton soils	:	5,860 ha
b. Rain-fed upland fields on red soils	:	800 ha
<u>Mutithi extension area</u>		
a. uncultivated black cotton soils	:	2,470 ha
b. rain-fed red soils	:	430 ha
Total	:	9,560 ha

iii. The Project will be implemented in two Phases, i.e. Phase-1 consisting of rehabilitation of the existing MIS and Phase-2 comprising dam construction and development of the Mutithi extension area.

GOK requested GOJ to extend grant aid as well as technical cooperation for implementation of above-mentioned Phase-1. The project components in the GOK's request are listed as follows:

(1) Request for grant aid
   1) Construction of New Nyamindi headworks and rehabilitation of Thiba headworks,
   2) Construction of Nyamindi headreach and diversion weir,
   3) Construction of Link Canal-I and rehabilitation of Link Canal-II
   4) Rehabilitation of irrigation facilities of MIS and farm roads and land consolidation of upland fields
   5) Extension of five reception centers, construction of machine center, provision of O&M equipment and farm machinery
   6) Construction of pilot farm (50 ha)

(2) Request for technical cooperation
   1) Sending Japanese experts both on long-term and short-term
   2) Training of counterpart personnel in Kenya and/or Japan

2.5.2 Findings of the Preliminary Survey Team

JICA dispatched the Preliminary Survey Team in October 1988. The Team made a field investigation, studied the information and data collected and had a series of discussions on the GOK's request with Kenyan authorities.

Through the study and discussions, it was concluded that the Project is generally appropriate for Japanese Grant Aid and Technical Cooperation since it is firmly in line with the government policy on agricultural development. The team also recommended that further studies be made on the following aspects in subsequent basic design study.

Components for grant aid

- It seems difficult to introduce double cropping system to MIS for all of the existing paddy fields of 5,860 ha within a short period. It is more practical that the system is to be gradually extended. Therefore, the GOK's request is to be reviewed from this technical viewpoint.
- Demarcation between the existing research station in MIS and the proposed Pilot Farm as well as the following technical cooperation is to be clarified.

- Request for water management system includes that of advanced technology, e.g. application of telemeter. Those are to be reconsidered due to their difficulty of operation and maintenance.

Components for technical cooperation

- Technical Cooperation for increased rice production in MIS is expected to play an important role to reinforce the Grant Aid.
- Technical Cooperation in a form of "project type" is recommendable. One or two long-term experts will be needed for a preparatory study.
- Main fields for the technical cooperation will consist of (i) water management and irrigation, (ii) soils and plant nutrition, (iii) plant protection, and (iv) farm mechanization.

CHAPTER 3
PRESENT CONDITIONS IN THE PROJECT AREA

CHAPTER 3 PRESENT CONDITIONS OF THE PROJECT AREA

3.1 Location

The project area is located in the eastern part of Central Province (Kirinyaga District), with a total area of 12,000 ha. It extends over the flat terrain on the outskirts of Mt. Kenya, ranging between El. 1,100 m and El. 1,200 m. The project area stretches between latitudes 0°37'S and 0°45'S and longitudes 37°14'E and 37°26'E.

3.2 Topography and River System

The project area has a gently undulating topography. Broad ridges with slight slopes are interspersed and stretch down to almost flat bottomlands in the Mwea plain. The land slopes in the direction of northwest to southeast with an average gradient of about 1:140.

The major rivers flowing through the project area are the Nyamindi and the Thiba, which are the water source for MIS. In addition, some small streams such as Kiwe, Murubara and Nyaikungu also run through the project area. These small streams constitute minor irrigation water sources and/or natural drains (Figure 3.1).

3.3 Climate

The project area climatically falls in equatorial tropical zone, and is dominated by prominent dry and rainy seasons. The rainfall pattern in the project area is characterized by bimodal rainy seasons, i.e. the long rainy season from March to May and the short rainy season from October to November. The annual mean rainfall is about 930 mm, of which about 510 mm concentrate in the long rainy season and 290 mm in the short rainy season.

The mean air temperature is 22°C with a wide range between mean maximum temperature of 28°C and minimum of 17°C. The mean monthly maximum of 32°C is recorded in March and minimum of 15°C in January. Two periods of high temperature and low temperature are observed. The high temperature periods are from February to April and from September to November, while the low temperature periods are from June to August and December to

January. There is a considerable change in temperature between day and night. The monthly meteorological data of the MIS area are shown in Table 3.1.

3.4 Hydrology

3.4.1 RiverDischarge

The annual mean discharges at following discharge gauging station are as follows:

River	Station	Drainage Area (km^2)	Annual Mean Discharge (m^3/sec)
Thiba	4DA10	353	11.8
Nyamindi	4DB5	283	6.6

3.4.2 WaterQuality

According to the water quality analysis for the related rivers and canals, all the water is suitable for irrigation.

3.4.3 LoadTransports

The sampling of suspended load and bed load was carried out at 4DB5 on the Nyamindi and 4DA10 on the Thiba during F/S. The results are as follows:

Station	Drainage Area (km^2)	Bed Load (m^3/year)	Suspended Load (m^3/year)	Sampling Date
4DB5	283	6,300	100	Apr - June, 1987
4DA10	353	6,500	180	Sep. 1987

3.5 Geology and Soil Mechanics

3.5.1 Geological Condition

The Cenozoic volcanic materials cover the whole MIS area on the basement of gneisses. The geological conditions at the proposed sites of the major structures are summarized as follows:

Structure		Geological Condition
New Nyamindi Headworks	:	Pleistocene basalts are out-cropped on the river bed.
Murubara Syphon	:	Muddy soils are accumulated on the foundation rocks of Pleistocene basalts.
Nyamindi Diversion Works	:	Pleistocene basalts are out-cropped at the site.

3.5.2 Soil Mechanics

(1) Black cotton soils

The black cotton soils have generally high water retention capacity. They shrink and make deep open cracks when dried, and swell when wet. Inside slopes of canals being composed of the black cotton soils are likely to slide down due to alteration of shrinking and swelling. Due to such an inherent soil characteristic, the soils are unfavourable as foundation of buildings and replacement of earth is to be required although they are suitable for irrigated paddy from the viewpoint of agronomy.

(2) Red soils

The water retention capacity of red soils is lower than that of black cotton soils. The bearing capacity of the red soils is around $Q_a = 20$ t/m^2. Permeability of the red soils is higher, i.e. n x 10^{-4}, and soils are cohesionless; therefore, inside slopes of canals composed of the red soils are susceptive to soil erosion.

3.6 Soils and Land Use

3.6.1 Soil Classification

All the irrigated soils of the project area are classified into typical black cotton soils characterized by black cracking clay. According to the soil suitability classification standard given in the Kenya Soil Survey of MOA, they are suitable for irrigation. The brownish red soils are used for production of vegetables. The other soils are not suitable for irrigation development due to poor soil nature and undulating topography. The extent of soils in and around the project is as follows:

Soil Group	Area (ha)
Typical black cotton soils	8,500
Shallow, stony black cotton soils	700
Typical red soils	750
Brownish red soils	2,000
Swampy peat soils	50
Total	12,000

3.6.2 Land Use

Several land use categories are identified in the project area. They are irrigated rice, upland crops, grassland, forest and villages as illustrated in Fig. 3.2.

Land Use	Area(ha)
Rice Field	6,900/1
Upland Field	2,200
Grass Land	2,200
Villages & others	700
Total	12,000

/1: Rice field includes gross irrigation area including canals, bands, etc.

3.7 Infrastructures

The project area is connected with Nairobi city and other major towns by the asphalt-paved National Trunk Roads B6 and B20/1. B6 runs in north-south direction in the project area

and the network of secondary roads branching off from B6 and B20/1 is also well-developed. In the project area, about 60 km of settlement roads have been constructed and are connected with the major national roads.

The major public services such as electricity supplies, post and telephone services, hospitals, schools, etc. are rather developed in the project area. Therefore, the project area can not be seen as a remote rural area. Although water is supplied to a part of the project area, e.g. the MIS office, most of the farmers usually use water from irrigation canals without any treatment. Shallow wells are also one of local water sources. Since the existing networks of irrigation and drainage systems are separated, no water pollution has occurred in the project area.

3.8 Existing Irrigation and Drainage Systems

3.8.1 Mwea Irrigation Settlement Scheme

(1) Scheme area

The Mwea Irrigation Settlement (MIS) Scheme area is divided into two parts, i.e. Nyamindi part and Thiba part (Fig. 3.1). Nyamindi part has only one sub-scheme, i.e. Tebere Section. Thiba part is composed of four (4) sub-schemes, namely Mwea, Thiba, Wamumu and Karaba Sections. Each Section comprises a number of tertiary units.

(Unit: ha)

Section	Irrigation Area		Other Area	Total
	Net Area	Gross Area	Gross	Gross
Nyamindi part				
Tebere	1,300	1,600	1,700	3,300
Thiba part				
Mwea	1,220	1,400	900	2,300
Thiba	1,150	1,400	900	2,300
Wamumu	1,120	1,300	500	1,800
Karaba	1,070	1,200	700	1,900
Total	5,860	6,900	4,700	11,600

(2) Irrigation system

MIS has two (2) different irrigation systems which are dependent on the water supply of two major rivers, Nyamindi river and Thiba river. The Nyamindi irrigation system consists of

headworks, main canal, three (3) branch canals and related structures, and supplies irrigation water to Tebere Section. The Thiba irrigation system comprises headworks, main canal, four (4) branch canals and related structures, and distributes water to Mwea, Thiba, Wamumu and Karaba Sections. The irrigation water taken from offtakes of main and branch canals flows into the main feeder canal and its feeder canals which distribute irrigation water to individual plots.

(3) Drainage system

MIS has four (4) rivers which act as drains, i.e. Nyamindi, Murubara, Thiba and Kiruara rivers. Some units which are located along the rivers have field drains flowing directly into the rivers.

There are three (3) main drains in the Nyamindi system which collect excess water from two or more units and evacuate water to one of the above rivers. The Thiba system has five (5) main drains and two (2) branch drains. The field drain runs almost along the opposite side of field to feeder canal. Drainage water from field drain is collected in a collector drain and is evacuated out of the Unit. The irrigation and drainage diagrams of the existing MIS area are presented in Fig. 3.3 and Fig. 3.4.

(4) Prevailing constraints

In the MIS area, the irrational irrigation water distribution is the biggest development constraint. Water balance at the weir sites of the Nyamindi and the Thiba was calculated for the end of September when the water requirement is at maximum as shown below:

(Unit: ton/sec.)

Weir site	Drought Discharge	Available Drought Discharge	Diversion Requirement	Surplus/ Deficit
Nyamindi	4.41	4.09	2.27	1.82
Thiba	5.59	4.69	6.90	- 2.21

As can be seen, the surplus of irrigation water occurs in Tebere Section, while the deficit in Mwea, Thiba, Wamumu and Karaba sections. It is necessary that this water deficit will be improved by means of rehabilitation and improvement of the existing irrigation and drainage facilities mentioned in the following paragraphs.

3.8.2 Irrigation and Drainage Facilities

The present conditions of the major irrigation and drainage facilities are described below:

(1) Nyamindi headworks

The Nyamindi headworks was completed in 1956 and commands the irrigation area of Tebere Section. The headworks is constructed on stable rock foundation and properly maintained. It is not subject to much deterioration from structural viewpoint. However, the protection works for side slopes are much deteriorated and the ones along both of upstream and downstream sides of headworks are removed. The existing scouring sluiceway cannot function well for flushing siltation out due to inappropriate location of the retaining wall, which is just in front of the scouring sluiceway. The new Nyamindi headworks should be constructed at 2.1 km upstream of the existing Nyamindi headworks. The scouring sluiceway should be properly designed to flush the siltation out.

(2) Thiba headworks

The Thiba headworks was completed in 1957 and distributes irrigation water to Mwea, Thiba, Wamumu and Karaba Sections. The headworks is provided at a suitable location on the stable rock foundation and functions well. The protection works of side slopes are destroyed and sedimentation is found along the upstream left side of the weir. The protection works for left side slope and downstream river bed should be rehabilitated.

(3) Irrigation and drainage canals

The total length of irrigation and drainage canals in the Nyamindi and Thiba systems is summarized as follows:

(Unit: km)

	Canal Name	Nyamindi System	Thiba System
a.	Main irrigation canal	4.5	12.4
b.	Branch irrigation canals	16.6	30.2
c.	Main drains	5.9	23.5
d.	Branch drains	-	3.4

The type of both irrigation and drainage canals is unlined open channel with trapezoidal section. Both inside slopes of irrigation and drainage canals are eroded to some extent in most

routes of canals. As a result of inside slope erosion, the irrigation canals are silted in large part of canal routes. In order to maintain the design discharge, therefore, canal bottom should be excavated. The protection works for the eroded side slopes should also be rehabilitated.

(4) Related structures

Many kinds of related structures such as turnout or offtake, check structure and horse shoe weir, drop and chute, culvert, etc., are provided for distribution of irrigation water, regulation of discharge and water level and crossing with road and rivers. The total number of existing structures is 400 consisting of 350 irrigation facilities and 50 drainage facilities. Out of 400 structures, 140 or 35% are seriously deteriorated and need rehabilitation work.

(5) Farm roads

Farm roads in the Scheme are sufficiently developed with enough road width. However the ground level of roads is mostly lower than that of the paddy field. The roads are sometimes flooded by overflow from canals and interrupt the smooth traffic. They need rehabilitation by embankment.

(6) On-farm facilities

Main feeder and feeder canals are properly maintained. Field drain and collector drain are more or less silted.

3.8.3 Present Water Management

Water management is undertaken by the MIS staff, not the farmers. MIS has 320 staff members in total, comprising 16 senior staff (management staff, engineers, etc), 152 intermediate staff (secretary, operators, mechanics) and 152 subordinates (drivers, office boys), out of which the water management staff was limited to only 42 as of 1987. In the MIS office, the Department of Works is responsible for allocation and distribution of water and maintenance of irrigation facilities.

MIS is divided into five (5) Sections, each of which is self-contained with its staff responsible for water management. Each Section has an Irrigation Officer in charge assisted by a Head Field Assistant, 5 to 7 Field Assistants, a Head Water Guard, 7 to 8 Water Guards and

other intermediate staff and subordinates. Liaison with the tenant farmers is maintained via the head cultivator who represents the farmers.

The irrigation officer is a senior staff under the Production Department and is responsible for preparation of cropping schedule in his Section. He asks the Scheme Manager to allocate the irrigation water based on his cropping schedule. The Scheme Manager informs his decision to the weir inspector through the Department of Works.

The weir inspector prepares, in accordance with the directive from the Scheme Manager, the irrigation schedule on the basis of his experiences and operates the gate of the headworks accordingly by himself and gives necessary instructions to the head water guard for operation of all the gates in each section.

The head water guard controls the gate operation in his Section. No one else can open the gates along the main and branch canals. The water guard takes care of the respective irrigation units assigned to him and is responsible for application of irrigation water to the fields.

The maintenance works for irrigation and drainage facilities are composed of repairing, desilting and weeding. The weeding of feeder canals and levee of paddy field is carried out periodically by farmers. The desilting and weeding of main and branch irrigation canals are conducted intermittently.

3.9 Present MIS Operational Activities

3.9.1 Organization Set-up

The MIS office has eight (8) departments as shown in Fig. 3.5. The Department of Production has responsibility for farm operation. Each Section has an irrigation officer who controls the farm management for rice production in the respective section. Each section is staffed with Head Field Assistant, Field Assistant, Head Water Guard and Water Guard.

All of the farmers in MIS are "Tenants" who have settled under the Irrigation Regulation, 1977. The number of tenant farmers has been gradually increasing with the expansion of irrigated paddy field and accounted to 3,236 as of 1986.

The tenant farmers communicate with the MIS office and NIB Management through:

(a) Mwea Irrigation Scheme Committee
(b) Mwea Irrigation Scheme Sub-Committee
(c) Tenants Advisory Committee
(d) Tenants Liaison Council
(e) Tenants Meeting

3.9.2 Operational Regulation

The activities of MIS and tenant farmers are regulated under the Irrigation Act (Cap.347). Major regulations concerned with farming practices are as follows:

(1) Regulations for MIS Office

a. MIS office supplies the following services to the tenant farmers
   - Rotavation by tractors, and
   - Farm inputs such as fertilizer and insecticide.

b. MIS office purchases necessary farm inputs through NIB Headquarters and distribute them to each tenant farmer.

c. MIS office is responsible for collection of harvested paddy, drying, bagging and sales to NCPB. MIS office collects payments for sales of paddy on behalf of the farmers and makes payments to each farmer, deducting the service charge and costs of farm inputs that the farmer had used for production of his paddy.

(2) Regulations for tenant farmers

a. Tenant farmers follow the Irrigation Regulation, 1977 and all instructions given by the MIS office.

b. Tenant farmers deliver all paddy harvested to the MIS reception center. The farmers are, however, allowed to keep some bags of paddy for their own consumption with permission from the office.

c. Tenant farmers maintain at all times their holding and all field feeders and drainage channels in satisfactory condition.

d. Tenant farmers are not allowed to hire or employ stock/machinery for cultural operations. The farmers are requested to accept all the services offered by the MIS office.

3.9.3 Current Situation of Rice Production

(1) Farming practices

The farming practices are conducted according to the cropping programme prepared by the MIS office (see Fig. 4.1). However, the planting time schedule has been hardly kept due to the delay of rotavation and the shortage of irrigation water supply. The farming schedule is briefly as follows:

1)	Land preparation and puddling	March - Mid-September
2)	Transplanting	August - September
3)	Field maintenance	Mid-September - November
4)	Harvesting	December - January

In order to facilitate the farming practices and to standardize the production, the Basmati and Sindano varieties recommended by NIB are planted.

Fertilizer is applied before transplanting by broadcasting, in the form of triple superphosphate (TSP) at the rate of 125 kg/ha. Top dressing with nitrogen as a form of Ammonium Sulphate is done 42 days after transplanting at the rate of 52 kg/ha. These amounts of fertilizers are relatively insufficient. The application of fertilizers, however, should be optimized on the basis of fertilizer response to unit yield, prices of fertilizer and selling price of paddy.

(2) Rice production

Since its commencement in 1957, rice production by MIS has increased about 2.3 times from 10,887 tons (1960/61) to 26,408 tons (1985/86) with the expansion of paddy fields. The unit yield per ha, however, has been decreasing gradually from 6.0 tons in the early 1970s to 5.0 tons in the early 1980s. The major reasons would be the shortage of irrigation water caused by overaged irrigation facilities, delay of planting period due to lack of tractors, decline of soil fertility, etc.

The variation in unit yield in the MIS area between 1976/77 and 1985/86 is expressed by the following equation:

Unit yield = 5.9 - 0.13 x period(years)

This means that the unit yield has decreased by 0.13 tons each year, and the unit yield can be estimated to decline by 3.5 tons/ha in 1995 if the condition will not be changed. This trend of yield decline will cause big problems both on the national economy and farm economy.

3.9.4 Farm Economy

By 1986, 3,236 farmers have been settled in the MIS area. These farmers were allocated 1.6 ha of irrigated paddy field consisting of four plots of one acre and 0.2 ha of rain-fed farmland in and around the irrigation area. The average farm family size is 9.5 persons, of which 2.7 males and 3.0 females fall in the working age group, i.e. from 15 years old to 60 years old. According to the farm economic survey carried out in the F/S stage and the supplemental survey conducted in the present Basic Design Study, the farm economic condition for the average settler who does not cultivate further farmland than allocated is summarized as follows (details are given in Annex-8)

(Unit: KShs)

Items	Amount
Gross farm income	28,800
Farm income	27,300
Non-farm income	1,500
Farm expenditure	12,600
Net farm income	16,200

Under the "with project" condition, the net farm income will remarkably increase to KShs 23,900 and KShs 42,900 for single and double cropping farmers, respectively. Under the "without project" condition, it will decrease to KShs 10,700 due to the decline in unit yield projected and the farmers will be forced to reduce their living expenditures.

3.9.5 Processing and Marketing of Rice

After being bagged in the field, paddy is transported by lorries to each reception centers. The paddy is spread and dried on concrete floor of the reception centers in each respective section up to 14 % in moisture content, then re-bagged at a standard weight of 75 kg per bag and temporally stored there. Paddy is milled at the Mwea Rice Mill Ltd., which is located within the MIS area. Milled rice is marketed under the sole responsibility of NCPB.

Payment to farmers organized into societies is made through the Mwea Amalgamate Rice Growers Cooperative Society Ltd. established in 1984, while to the other farmers through the Commercial Bank. The purchasing price of paddy is fixed under the Agricultural Produce Marketing Regulations every year. The 1988 purchasing prices of paddy are KShs. 4.00 for Basmati and KShs. 3.00 for Sindano.

The Mwea Rice Mill is equipped with four rice mills with a total milling capacity of 14 tons/hr, i.e. two with 5 tons/hr capacity and two with 2 tons/hr capacity. The total processing capacity of the Mill is around 28,000 to 32,000 tons per annum under 2-shift operation. There is no special problem on rice milling unless double cropping of paddy will spread to the whole area.

Milled rice is shipped to the depot of NCPB at Sagana and later sold to consumers, through another depot of NCPB. The actual selling prices as of February 1987 were KShs.9.05/kg for Basmati and KShs.7.30/kg for Sindano.

3.10 Constraints

Constraints to the development of MIS are summarized as follows:

(1) The basic and the biggest problem in the MIS area is the shortage of irrigation water in 70% of the area due to overage facilities as well as irrational water distribution because no proper rehabilitation of the facilities has been made in the past 30 years. Inside slopes of most of irrigation and drainage canals, i.e.63.7 km of irrigation canals and 32.8 km of drainage canals, are eroded and siltated to some extent and irrigation canals cannot convey the design discharge. Out of the 350 and 50 existing irrigation and drainage related facilities, about 35% and 55% respectively are seriously deteriorated and necessitate rehabilitation.

Maintenance works for minor irrigation and drainage facilities are carried out by farmers. However, since the rehabilitation of major irrigation and drainage canals and related structures requires large amount of cost and many construction equipment, the MIS Office has no capability to commence the large-scale rehabilitation.

(2) Irrational water distribution is the next constraint. Irrigation water is in surplus in Tebere Section but in deficit in Mwea, Thiba, Wamumu and Karabe Sections.

It is necessary to realize the proper water distribution by dissolving the gap of available drought discharge between both rivers, i.e. 3.15 lit/sec/ha in the Nyamindi headworks and 1.03 lit/sec/ha in the Thiba headworks.

(3) Though farming operations are basically done by tenant farmers in MIS, NIB also undertakes a part of operations such as land preparation. Facilities and equipment owned by NIB are in short for adequate operations in 5,860 ha of paddy fields, and this interferes with on proper timing of farm operations: The transplantation period in the NIB cropping calender is from September to December, while the actual period is sifted to from November to February.

(4) Farmers in the MIS area have cultivated only rice for a long time, and application of organic manure has been scarcely made. This causes decline in soil fertility as well as low unit yield. To solve the problems, application of chemical fertilizers, crop rotation with legumes, introduction of high yield varieties, etc.,should be carried out. Experimental research is necessary to demonstrate and extend the new farming techniques and varieties to farmers. Especially in increase of fertilizer application, the experiment should be focused on tits effect on the production and be conducted from economic point of view.

The unit yield of paddy in the MIS area has decreased by 0.13 tons/ha per year and will decline to 3.5 tons/ha without any countermeasures. This situation will seriously damage the national economy as well as farm economy, and will necessitate solution.

(5) In addition to the above-mentioned problems, there is big technical difficulty of introducing of double cropping of paddy in the area. Double cropping trials on a commercial scale were conducted three times in the past, but those trials ended in total failure. Possible explanation for poor performance of double cropping may be as follows:

- Cold tolerant, early matured, disease resistant and high yield varieties suitable for double cropping have never been available.
- Deterioration of irrigation facilities causes water shortage, and water management system for double cropping is not set up.

- Shortage of agro-machinery to solve labor deficit.
- Bogging-down problems of tractors caused by continuous flooding for double cropping have never been settled.

Double cropping will succeed with the solution of the problems mentioned above, taking account of the favorable natural conditions in the MIS area. To extend the double cropping to the whole area, it is indispensable to establish reliable cultivation method through research and trials.

CHAPTER 4
OUTLINE OF THE PROJECT

CHAPTER 4 OUTLINE OF THE PROJECT

4.1 Objectives of the Project

The construction of MIS was embarked in 1953. Following its completion, the settlement of farmers was commenced and paddy production started in 1957. The irrigation area has been successively expanded from 2,000 ha in 1957 to 5,860 ha at present. The irrigation facilities are seriously deteriorated such a long period of 30 years of service. Under such conditions, water shortage and gradually decreasing productivity are now crucial.

The objectives of the Project are to rehabilitate and improve the existing facilities of MIS, to provide machinery and equipment and to construct a pilot farm. They are expected to contribute to a betterment of the above-mentioned unfavorable conditions of MIS in terms of stabilization and increase of rice production.

4.2 Study and Examination of the Request

The request made by GOK for the Project was studied and examined. The results are as follows.

4.2.1 Necessity of the Project

The GOK request is outlined in Section 2.5.1. From several standpoints of national development policies, agricultural development plans, food demand-supply balance, the current conditions of irrigation in Kenya and the present situation of MIS, the necessity of the Project is assessed below.

Necessity for national economic policy

(1) From the viewpoint of national and agricultural development policies

GOK gives the highest priority to agricultural sector in the Fifth National Development Plan (1984-1988) for the purpose of attaining of food self-sufficiency. In the Plan the following measures are set up for expansion of food production.

- Introduction of improved varieties and extension of appropriate farming technology

- Rehabilitation and improvement of the existing irrigation facilities
- Development of potential arable land
- Expansion of irrigated land, in particular irrigated paddy field

The Government places the great emphasis upon irrigation development including rehabilitation of the existing schemes. It is apparent that the Project is planned in line with the said governmental policy.

(2) For the purpose of stabilized food supply for meeting the rapidly increasing food demand

The total population of Kenya has grown to 20.6 million with a growth rate of 3.8 % per annum as of 1985. The Government projected that the population will expand to 38.5 million in the year 2000.

Kenyan agriculture has supplied sufficient foodstuffs to local markets to meet the domestic demand over the past two decades. However, imbalance between supply and demand of foodstuffs has recently appeared due to rapidly increasing population and unstable food production.

The annual cereals production of Kenya amounts to 2,729,000 tons on an average in the period from 1982 to 1986. Out of this total production, 84 % is shared by maize, 9 % by wheat and 1.5 % by rice. In the same period, Kenya imported 274,000 tons of cereals, of which rice shared 24,000 tons.

The per capita consumption of cereals is 145.0 kg per annum consisting of 124.5 kg of maize, 18.6 kg of wheat, 3.3 kg of rice and 7.6 kg of sorghum and millet. Large difference is observed in per capita consumption of rice between urban and rural areas, i.e. 10.2 kg in urban areas and 0.7 kg in rural areas. It is evident that the domestic rice demand and urban-rural imbalance in rice consumption will be steadily increasing taking into consideration the increased population, the influx of rural population to urban areas, the change of food preference due to increased income level.

Based on population projection, per capita consumption and current rice production, the future demand and supply balance of rice was analyzed. As presented in the following table, it is projected that the rice demand will attain 109,000 tons per annum in the year 2000 in case the demographic data in SP1 are applied.

Year	Population (million)	Per capita consumption (kg/person/year)	Demand (1000t)	Supply (1000t)	Shortage (1000t)
1990	25.2	3.9	98	41	57
2000	38.5	3.9	150	41	109

Kenya spends a considerable amount of foreign exchange to import rice every year in order to make up its chronic shortage. It is crucial to continue the import of staple grains, i.e. maize and wheat. As well, it is also unfavourable to keep the present situation of rice import from the viewpoint of food security. The Project will contribute to the attainment of food self-sufficiency by improving the imbalance of demand-supply of rice.

(3) Contribution to improvement of balance of payment

The balance of payment of Kenya has been chronically in deficit resulting in large amount of accumulated debts. In 1986, the import value of agro-products amounted to KShs. 7.4 million or 2.8 % of the total import, of which KShs. 3.86 million or 52 % were for 61,700 tons of rice.

Upon realization of the Project, rice production in MIS will be increased by 10,000 tons, which correspond to 42 % of 23,900 tons of imported rice on an average in the period from 1982 to 1986. The said increased amount will contribute to foreign exchange saving by KShs. 6.01 million.

Necessity of irrigation development in Kenya

(1) Roles of MIS in the national irrigation development

The existing irrigated area in Kenya is 36,000 ha in total, which corresponds only to 1.5 % of 2,370,000 ha of the existing farmland. Out of the total irrigated area of 36,000 ha, 7,560 ha managed by NIB and 1,040 ha by MOA are planted with rice, while the remaining 27,400 ha are cultivated mainly with coffee, sugarcane and vegetables by private farmers.

It is estimated that the potential area for irrigation development extends to 540,000 ha in total, of which parts of both the Tana river basin and the Victoria lake basin are under planning. Because mainly of large capital requirement, it would take a long period until embarkation of the irrigation development in further potential areas.

Under the current Five Year Development Plan (1984 - 1988), higher priority is given to rehabilitation of the existing schemes and further development of small-scale schemes with gravity irrigation system. MIS is the leading irrigation scheme in Kenya with a total irrigation area of 5,860 ha, which represents 68 % of the total area of irrigated rice fields of 8,600 ha in the nation. The total paddy production of MIS attains 30,000 tons corresponding to 65 % of the total national production of 41,000 tons . However, it is pointed out that MIS has recently faced the lowering irrigation efficiency due to the deterioration of the existing irrigation facilities constructed 30 years ago and the water shortage as a result of the gradual expansion of irrigation area in course of time.

As mentioned above, the Government places higher priority on rehabilitation and improvement of the existing schemes and new development of small-scale schemes. The Project is the first one in Kenya as a comprehensive rehabilitation project of the existing large-scale irrigation scheme with high expectation of the Government.

(2) Precedent roles for further expansion of Mutithi area

The JICA F/S clarified that there is a future extension area of 2,900 ha, i.e. the Mutithi area, neighbouring with the existing MIS area. Water supply to the Mutithi irrigation system of 2,900 ha will be realized by means of a newly constructed headworks on the Ruamuthambi river and its headrace, link canal to the Mutithi area and a dam on the upper Thiba river. In addition, the construction of a new Nyamindi headworks as a part of the Project will be required. The Project is defined as Phase-1 of the entire development plan set up in F/S and the extension of the Mutithi area as Phase-2. In view of the phased development plan, the Project can be recognized as the precedent development for the Mutithi area.

Other necessity

(1) Improvement of farm economy

With the expansion of the irrigated area, the paddy production has increased up to 30,000 tons which are 2.3 times as much as the production in 1957 when MIS started its operation. However, the unit yield has been gradually declining from 6.0 tons/ha in the 1970s to 4.5 tons/ha in the early 1980s. The major constraints identified are (i) water shortage due to deterioration of irrigation facilities, (ii) delay and elongation of cropping season due to shortage of farm machinery, and (iii) degradation of soil fertility.

It is expected that, through implementation of the Project, the income of tenant farmers will be substantially increased providing an impetus to the regional economy. According to the farm budget analysis, it is verified that the increment of farm income will be KShs. 7,700 in case of single cropping of rice and KShs. 26,700 in double cropping under the "with-project" condition. The result of farm budget analysis is presented in Appendix-8. On the other hand, under "without-project" condition, the unit yield of paddy will decline to 3.5 tons/ha and the farmer economy will be worsened.

(2) Development of paddy cultivation technique in Kenya

Considering the technical and financial constraints in irrigation development in Kenya, it is urgent to enhance the productivity of rice including realization of double cropping system in the existing irrigation schemes.

It is important for MIS to establish the rice farming technique for overcoming the prevailing constraints in MIS. The rice farming technique to be established through the activities and experiment in the Pilot Farm, i.e. rice agronomy, farm mechanization and water management, will highly contribute to not only MIS but also irrigated rice cultivation in Kenya.

(3) Other effects

The machines and other equipment to be provided under the Project will play an important role to enhance the functions of the MIS office.

4.2.2 Examination of the Request

In the background of the GOK's request, there is its expectation of introducing the double cropping of rice in MIS under the Project. However, as pointed out by the JICA Preliminary Study Team, it is highly difficult to realize the double cropping in the whole scheme area of 5,860 ha within a limited period in view of the prevailing constraints mentioned in Section 3.10 (5). NIB agrees with such opinion and intends to realize the double cropping of rice under a long-term programme.

With such a technical point of view, the proposed cropping pattern was set up as illustrated in Figure 4.1, which was worked out through technical discussions with NIB. The double cropping will be introduced in a part of MIS with about 1,000 ha. For the remaining 4,860 ha, the working periods of rotavation and paddy drying practices will be shortened by NIB in order to facilitate the introduction of double cropping system in future.

Taking the basic concept of the Project mentioned above into consideration, the GOK's request was assessed as spelled out in the following paragraphs.

(1) Rehabilitation and new construction of irrigation facilities

The GOK's request consists of (i) enhancement of irrigation efficiency by rehabilitation of the deteriorated irrigation and drainage facilities, (ii) adequate water supply to Mwea, Thiba, Wamumu and Karaba Sections and (iii) improvement of farm road network.

The source of irrigation water supply to Mwea Section is the Nyamindi and Thiba rivers at present. Irrigation water is diverted by the headworks constructed on both rivers and distributed by main and branch canals.

Although these irrigation facilities are operated and maintained by NIB and tenant farmers, they have been seriously deteriorated during the past 30 years and irrigation efficiency is considerably low. Therefore their rehabilitation is urgently required. In addition, water supply to Thiba Section is in chronic shortage as a result of the extension of irrigated area. It is indispensable for MIS to eliminate such a constraint.

In order to overcome such technical constraints mentioned above, the following rehabilitation works will be required.

- Excavation of irrigation canals and re-embankment of their inside slopes
- Canal lining for preventing deterioration of irrigation canals and leakage of irrigation water
- Excavation of drainage canals
- Rehabilitation and improvement of related structures

Following the above-mentioned works, supplemental water supply to Tebere Section can be realized by the new headworks to be constructed on the Nyamindi river, which has ample discharge for such a purpose, and diverted by the new Nyamindi diversion weir. The remaining water after diverting to Tebere Section will be conveyed to the Thiba headworks by the newly constructed link canal. This water will be further conveyed to Thiba Section by the existing link canal to be rehabilitated and distributed to Mwea, Thiba and Wamumu and Karaba Sections which need supplemental water supply for making up water shortage.

However, it is not appropriate and justifiable to take up all the irrigation facilities covering 5,860 ha within the framework of the Japanese Grant Aid Programme. Depending upon the importance of the relevant facilities, the condition of their deterioration, and the size and technical difficulty of the works to be required, some facilities can be allocated to the works to be carried out by NIB. As for rehabilitation of the drainage facilities, in particular, this is not urgent compared with that of the irrigation facilities although the drainage facilitates are not functioning well at present. Therefore, it is justified that the following irrigation and drainage works will be selected and taken up under the present Grant Aid.

1) New construction
   - Nyamindi headworks
   - Nyamindi diversion weir, Nyamindi headrace and inspection road
   - Link canal-I and inspection road
   - Related structures for the above

2) Rehabilitation of Existing Facilities
   - Thiba headworks
   - Link canal-II and inspection road
   - Main irrigation canals and their inspection roads
   - Related structures for main irrigation canals and secondary irrigation canals to be selected according to the size of facilities and the condition of deterioration

In addition, other irrigation facilities will be selected on the basis of the inventory survey of the existing facilities made through the previous F/S, and those selected facilities will be rehabilitated by using the O&M equipment which will be provided within the present Grant Aid package. It is favourable to commence those rehabilitation works under the responsibility of NIB at the earliest possible time.

Since the consolidation of irrigated upland field mentioned in the GOK's request should be embarked under the condition that the Thiba dam is to be constructed in Phase-2, which will be able to supply irrigation water meeting water demand for upland irrigation, this aspect was excluded from the scope of the present basic design survey.

(2) Provision of O&M equipment

In principle, the operation and maintenance of the main irrigation and drainage facilities are done by NIB and the maintenance of on-farm facilities, i.e. desilting and weeding of tertiary canals, is carried out by tenant farmers. Due to lack of O&M equipment in comparison with the

diversity and size of facilities, however, proper maintenance has not been sufficiently carried out. Therefore, the maintenance of facilities is occasionally done only by desilting and weeding of main and branch canals, and other necessary maintenance work cannot be done at present.

Under such conditions, the irrigation facilities will not be adequately maintained and will not be able to function as expected even though they will be rehabilitated and improved without needing O&M equipment.

According to the principles mentioned in Section 4.2.2 (1), no proper maintenance of the irrigation and drainage facilities allotted to NIB can be expected without the necessary measures.

Taking into account two aspects mentioned above, it is necessary to provide the following O&M equipment under the present Grant Aid for execution of adequate maintenance of the irrigation and drainage facilities and the other infrastructure.

1) O&M equipment necessary for rehabilitation of irrigation and drainage facilities
   - Backhoe shovel
   - Bulldozer
   - Wheel loader
   - Motor grader
   - Road roller
   - Vibrating plate

2) O&M equipment necessary for rehabilitation of related structures
   - Submergible pump
   - Cargo truck with 3-ton crane

3) Vehicles
   - Truck
   - Jeep
   - Motorcycle

In addition, the GOK's request mentions the arrangement of the following aspects in order to utilize the water resource to the maximum after the implementation of the Project.

- Water measurement facilities and equipment, i.e. current meter, water level recorder, etc.

- Telecommunications system and data processing system for data and information collected
- Organization for proper operation and management of irrigation and drainage facilities based on the analysis of data and information collected.

Since the aspects mentioned above are inter-related with each other, they will not adequately function even if only the technical aspect is settled. Therefore, the above facilities and equipment will be selected on the basis of the study results to be worked out by the research activities of water management in the Pilot Farm. They are excluded from the present basic design study.

(3) Provision of farm machinery

The farmers in MIS are tenant farmers, i.e. contract farmers, settled by NIB to the villages located within the MIS area. The farming practices are carried out according to the cropping schedule set up by the MIS office. NIB executes mechanized land preparation instead of individual farmers, supplies farm inputs, provides extension services and ensures irrigation water supply. The farming practices from transplanting to harvesting are scheduled to be completed within the period agro-climatically suitable for rice production. For ensuring transplanting within the optimum period according to the cropping schedule, the land preparation is completed by using the existing tractors. However, since there is shortage of tractors and the useful life of most of the available tractors is already over, the farming practices cannot be executed as scheduled resulting in delay of the planting period and lower unit yield.

The provision of farm machinery is, therefore, highly effective for improvement of the current situation mentioned above. The farm machinery requirement was estimated under the condition that the period of land preparation is to be shortened from six months to two months. For estimating the total number of farm machinery to be provided under the Grant Aid, furthermore, the number of machinery to be provided under KR-2 is deducted from the total machinery requirement.

The farm machinery to be provided under the present Grant Aid consists of:
- 4-wheel drive tractor (60 HP)
- Rotavator (2 m wide)
- Cage wheels
- Knapsack type sprayer

(4) Expansion of reception centers

Owing to the rehabilitation and improvement of irrigation and drainage facilities as well as the provision of O&M equipment,sufficient irrigation water supply will be stabilized. In addition, the optimum cropping schedule will be ensured by provision of farm machinery. It can be expected that the unit yield of paddy will be considerably increased as a result of realization of the Project mentioned above and the target paddy yield of 6 tons/ha will be achieved by execution of farm input supply and extension services by NIB.

Farmers generally harvest paddy in the field when the moisture content decreases to less than 20 %. After being harvested, paddy is threshed, winnowed and bagged in 75 kg-bags and transported to the reception centers under the management of NIB. The bagged grains are weighed and registered at receiving pits. They are unbagged, spread out at a thickness of 10 cm and kept for two days on the drying yard until the moisture content is reduced to 14 %. The dry paddy is temporarily stored in the reception centers and transported to the rice mills. After being milled, it is purchased by NCPB. The reception centers also store fertilizers, agro-chemicals and gunny bags to be supplied to tenant farmers.

The reception centers are installed in each of the five Sections. Among them, the centers built in the 1950s are overaged and the capacities of drying yard, farm input storage and temporary paddy storage are remarkably lower than those required. In particular, the capacities of the reception centers installed in 1953 in Tebere section and in 1957 in Mwea section are critically small and their expansion is indispensable to the future increase in of paddy production.

It is recognized that the expansion of the reception center is indispensable for MIS. However, it is more appropriate to realize this component by NIB itself according to the increased paddy production in future.

(5) Expansion of machine center

At present, the MIS office has a small-scale machine center for daily maintenance of the existing tractors as mentioned in Appendix-5. In order to perform the necessary maintenance of O&M equipment including heavy machines and numbers of tractors, a comprehensive improvement by means of installation of a new machine center is required.

After the commencement of land preparation period, the farm machinery is distributed to each of the five Sections. The daily maintenance of farm machinery is carried out by one mobile workshop. However, the existing mobile workshop is already overage, and not sufficient for

the adequate daily maintenance of farm machinery. The provision of mobile workshop is required under the Project.

(6) Establishment of pilot farm

Under the Project, several constraints such as deterioration of irrigation and drainage facilities, shortage of irrigation water, and low capability of farm operation facilities and equipment prevailing in MIS will be eliminated. For enhancement of rice yield in MIS, however, the new farming techniques have to be established in several technical fields such as farm operation, water management, etc. The Japanese Technical Cooperation requested by GOK is proposed to meet such a requirement.

Rice research in Kenya is performed under the sole responsibility of NIB in the main station located in Ahero and its branch in Mwea as described in Appendix-6. Due to the limitation of staff and budget, only some research aspects, e.g. variety selection, fertilization trial and agro-chemicals application test, are focused on and have provided valuable information on these research aspects. However, the research on double cropping of rice, farm mechanization and water management was not actually started yet.

MIS is the leading rice producing scheme in Kenya by achieving the highest unit yield under the management by NIB, although MIS faces several constraints. Taking the extent of potential irrigation development area and the technical difficulties of new irrigation development into consideration, the increase of yield and introduction of double cropping system in the existing schemes are urgently required for increased paddy production. Therefore, GOK places the highest priority on realization of these conditions. In order to eliminate the prevailing constraints stagnating the current productivity in MIS, the establishment of appropriate farming techniques is indispensable. The techniques thus established are expected to contribute to other irrigated rice scheme as well as to the potential irrigation area to be developed in future.

From this viewpoint, it is highly important to install the Pilot Farm aimed at introducing the farming technique for yield enhancement.

On the other hand, the Pilot Farm will provide the main field for the Japanese Technical Cooperation. Therefore, the construction of necessary facilities and provision of necessary equipment have to be ensured for smooth operation of the Pilot Farm. The scope of the Japanese Technical Cooperation will be defined through discussions to be held between the JICA Technical Cooperation Study Team to be dispatched within 1989 and GOK. However, the concept and framework of the Technical Cooperation to be provided to Kenya were preliminarily

agreed between the ministries concerned and JICA. The following concept and framework were fully taken into consideration for plan formulation and basic design.

- Objectives of Technical Cooperation: the following aspects will be dealt with under the Japanese Technical Cooperation.
  a. Establishment of water management system (water management system, O&M of irrigation and drainage facilities and organization of water users)
  b. Establishment of rice farming technique (variety selection, soil management, plant protection, double cropping system)
  c. Farm mechanization (adaptability test, O&M of farm machinery and O&M equipment)
  d. Training (preparation of training programme, curriculum and training materials)

- Outline of the Japanese Technical Cooperation:
  a. Dispatch of Experts (6 persons for long-term assignment and short-term assignment as required within the available fund)
  b. Training
  c. Provision of farm machinery (machinery essential for execution of the Technical Cooperation within the available fund)

- Undertaking by GOK:
  a. Acquisition and provision of land and buildings necessary for the execution of the Project
  b. Assignment of counterpart personnel
  c. Budgetary arrangement and disbursement of local currency portion of the Project

According to the basic concept mentioned above, at least the following facilities and equipment will be required for the Project.

- Irrigated plots with a total area of 35 ha and related facilities required for these plots for carrying out the field research on water management system.
- Office building (including laboratories, lecture and training rooms)
- Accommodation for long-term experts
- Accommodation for short-term experts and Kenyan lecturers
- Multipurpose storages for farm inputs and machinery
- Paddy drying yard
- Farm machinery and equipment for ensuring the mechanized farming practices from land preparation, seeding, harvesting and drying

4.2.3 Organization for Project Execution

The executing agency of the Project is NIB and the existing MIS office is responsible for the scheme management, but the operation and management of the Pilot Farm will be excluded from the responsibility of the MIS scheme.

The organization charts of NIB and MIS are illustrated in Figure 3.5 and 4.2. Since the organizational and staffing structures are judged to be appropriate and these organizations have had sufficient experience, neither amendment nor re-organization is to be required for successful project execution. However, some tractor operators and mechanics will be additionally required.

It is necessary to establish a new office for management of the Pilot Farm. The organizational and staffing structures will be confirmed through discussions held between the Technical Cooperation Study Team and GOK. The organization chart conceivable is preliminarily prepared as presented in Figure 4.3.

A part of the NIB budget for 1987/88 allocated to the MIS office is tabulated below. The local budget of the Project is already approved by the Treasury.

Description	1987/88 (actual)		1988/89 (estimated)	
	KShs.1000	%	KShs.1000	%
1. Salary and welfare	7,133	27.3	7,667	25.9
2. Repair of vehicles	2,919	11.2	3,214	10.9
3. Repair of tractors	5,450	20.8	6,666	22.6
4. Repair of plants and machines	1,429	5.5	1,627	5.5
5. O&M of irrigation and drainage facilities	1,046	4.0	1,184	4.0
6. Repair of buildings	773	3.0	866	2.9
7. Fuel	3,262	12.5	3,982	13.5
8. Stationery and others	4,107	15.71	4.331	14.7
Total	26,119	100.0	29,537	100.0

Data source: MIS internal document

4.2.4 Basic Concept of Project Implementation

The Project was judged to be suitable for the Japanese Grant Aid Programme by examining the project benefit and the capability of GOK for project implementation, . Therefore, the basic design study was carried out in line with the conditions under the Japanese Grant Aid Programme. However, a part of the said request was modified according to the assessment of the GOK's request as mentioned in Section 4.2.2.

4.3 Project Description

4.3.1 Executing Agency and Organizational Structure

The executing agency of the Project is NIB and the direct management of the Project is entrusted to the existing MIS office. This current situation will not be changed. However, the operation and management of the Pilot Farm will be undertaken by the Pilot Farm Office to be newly installed under the direct management of NIB. The organization charts of NIB, MIS and the Pilot Farm Office are presented in Figures 4.2, 3.5 and 4.3.

4.3.2 Project Components

The Project consists of the following components.

- Rehabilitation and improvement of irrigation and drainage facilities
- Provision of O&M equipment for maintenance of irrigation and drainage facilities
- Provision of farm machinery for farm operation
- Establishment of Pilot Farm

Through introduction of double cropping of rice in the Mwea Section and through stabilized irrigation water supply, it is expected that the paddy production will be steadily increased.

4.3.3 Maintenance Plan

The organizational and staffing structures are assessed to be appropriate for operating and maintaining the facilities and equipment to be provided under the Project.

However, recruitment of additional operators and other staff as well as budgetary arrangement for covering the recurrent running cost have to be ensured in order to carry out the proper operation and maintenance of the facilities and equipment. The following table presents the amounts to be required after completion of the Project.

	Description	Annual requirement (KShs.1000)	(Additional requirement) (KShs.1000)	Remarks
1.	Salary and welfare	8,067	400	5 management staff and 60 tractor operators
2.	Repair of vehicles	3,854	640	equiv. to 20 % of the current budget
3.	Repair of tractors	7,996	1,330	equiv. to 20 % of the current budget
4.	Repair of plants and machines	1,957	330	equiv. to 20 % of the current budget
5.	O&M of irrigation and drainage facilities	1,776	592	equiv. to 50 % of the current budget
6.	Repair of buildings	866		
7.	Fuel	3,982		
8.	Stationery and others	4.778	796	equiv. to 20 % of the current budget
	Total	34,625	5,088	

4.3.4 Outline of Facilities and Equipment

The outlines of the facilities and equipment to be provided under the Project are presented in the following tables.

Outlines of Facilities and Equipment

1.	Rehabilitation and Improvement of Irrigation and Drainage Facilities				
	(1) Nyamindi headworks	-	Length of weir	:	45 m
		-	Height of weir	:	4.5 m
		-	Intake capacity	:	7.01 m^3/sec
	(2) Thiba headworks	-	Length of weir	:	29 m
		-	Height of weir	:	2.6 m
		-	Intake capacity	:	11.12 m^3/sec
	(3) Nyamindi Headrace	-	Length	:	0.6 km
		-	Concrete lining canal		(t = 0.1 m)
		-	Design discharge	:	7.01 m^3
	(4) New Nyamindi main canal	-	Length	:	0.6 km
		-	Concrete lining canal		(t = 0.1 m)
		-	Design discharge	:	2.28 m^3
	(5) Nyamindi main canal	-	Length	:	4.5 km
		-	Including existing concrete lining canal		(t = 0.1 m)
		-	Design discharge	:	2.28 m^3
	(6) Link canal - I	-	Length	:	8.9 km
		-	Design discharge	:	4.91 m^3
	(7) Link canal - II	-	Length	:	3.5 km
		-	Design discharge	:	11.12 m^3

(8)	Thiba main canal	-	Length	:	8.9 km
(9)	Thiba branch canal - IV	-	Drop, diversion works, culverts, others		
(10)	Related structures	-	diversion works, drop, culvert, others		
(11)	Farm road	-	Rehabilitation	:	32.8 km
		-	Newly constructed	:	10.3 km

2. Buildings

2.1	Machine Center	-	Floor area	:	310 m2
2.2.	Pilot Farm				
2.2.1	Management offices				
(1)	Offices	-	Floor area	:	480 m2
(2)	Training rooms	-	Floor area	:	280 m2 + breeze way 20 m2
(3)	Laboratories	-	Floor area	:	280 m2 + breeze way 20 m2
2.2.2	Lecturers' offices	-	Floor area	:	355.5 m2
2.2.3	Expert offices	-	Floor area	:	704.4 m2
2.2.4	Farm input storage	-	Floor area	:	35.0 m2
2.2.5	Equipment storage	-	Floor area	:	49.4 m2
2.2.6	Drying yard	-	Floor area	:	378 m2

3. Equipment

3.1	O&M Equipment		
(1)	Backhoe shovel (0.3 m3)	1 unit	
(2)	Bulldozer (11 tons)	1 unit	
(3)	Wheel roader (1.0 m3)	1 unit	
(4)	Motor grader (3.7 m wide)	1 unit	
(5)	Road roller (5 ton)	1 unit	
(6)	Vibrating plate (3 PS)	2 units	
(7)	Submergible pump	2 units	
(8)	Truck	Dump 2 units, Cargo 4 units, Pickup 3 units)	
(9))	Jeep	2 units	
3.2	Farm Machinery		
(1)	Tractor (4WD, 60 HP)	17 units	
(2)	Rotavator (2 m wide)	9 units	
(3)	Cage wheels	17 pairs	
(4)	Knapsack type sprayer (manual, 15 lit.)	42 units	
3.3	Machine Center		
(1)	Lubrication		
(2)	Wheel and brake repairs		
(3)	Engine repairs		
(4)	General service		
(5)	Battery and electric shop		
(6)	Body and painting		
(7)	Air compressor		
(8)	Tool room		
(9)	Inspection		
(10)	Mobile workshop		
3.4	Farm Machinery for Pilot Farm		
(1)	Tractors	3 units (wheel driven type, crawler type, tiller type)	
(2)	Plow	2 units (disc type, chisel type)	
(3)	Harrow	3 units (disc type, rotavator, paddy harrow)	
(4)	Cage wheels	1 pair	
(5)	Float strake	1 pair	
(6)	Broadcaster	1 unit	
(7)	Speed sprayer	1 unit	
(8)	Others		
3.5	Meteo-instruments for Pilot Farm		
(1)	Recording raingauge		
(2)	Hydro-thermograph		
(3)	Anemometer		
(4)	Evaporation pan		

(5) Sunshine recorder
(6) Actinograph
(7) Others

4.3.5 Technical Cooperation

The Pilot Farm to be constructed within the framework of the present Grant Aid is planned under the conditions that the Japanese Technical Cooperation will be provided in future. The research and training to be carried out in the Pilot Farm are outlined below.

- Establishment of water management system (water management system, O&M of irrigation and drainage facilities and organization of water users)
- Introduction of rice farming techniques (variety selection, soil management, plant protection, double cropping system)
- Farm mechanization (adaptability test, O&M of farm machinery and O&M equipment)
- Training (preparation of training programme, curriculum and training materials)

The Technical Cooperation to be provided by Japan will consist of:

- Dispatch of Experts (6 persons for long-term assignment and short term assignment as required within the available fund),
- Training, and
- Provision of farm machinery (machinery essential for execution of the Technical Cooperation within the available fund)

CHAPTER 5
BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5.1 Rehabilitation and Improvement of Irrigation and Drainage Facilities

5.1.1 Design Policy

This component consists of the new construction of irrigation facilities for diverting surplus water from the Nyamindi river to the Thiba part comprising four Sections and the rehabilitation of the deteriorated irrigation facilities which cause water shortage and lower irrigation efficiency. The new facilities were designed to be of technically and economically optimum and feasible scales and to bring benefits to the region, e.g. domestic water supply to inhabitants and livestock by means of construction of washing steps and cattle basins. In addition, the existing irrigation canals and related structures were designed to be rehabilitated at the minimum scale for cost saving by avoiding drastic changes of canal routes, scales and structures of canals and facilities. The design policy for the above works is spelled out in the following paragraphs.

(1) Irrigation plan

The water resources of the Project are the runoffs of both the Nyamindi and the Thiba rivers. For their maximum exploitation, it is necessary to prepare the suitable cropping pattern taking into account such meteo-hydrological conditions as rainfall pattern, river runoff, etc. , as well as the proper selection and allocation of facilities. The basic concept of irrigation development plan is as below;

- The objective area of the Project coincides with the existing paddy fields in MIS Scheme, i.e. 5,860 ha.
- The runoff of both the Nyamindi and the Thiba rivers will be effectively utilized at maximum.
- The irrigation plan shall be formulated taking into account the present irrigation method and the simplified operation and maintenance system of the facilities.
- The construction costs shall be reduced as much as possible by maximum use of the existing irrigation facilities.
- The irrigation facilities shall be so designed as to maximize the operational effects of the facilities such as irrigation efficiency. In addition, the cost performance and the degree of difficulty of construction works are also taken into consideration.

- The natural conditions such as geology and topography of the project area and the degree of difficulty in procurement of construction materials shall be taken into account in structural design of the facilities

The rehabilitation works of branch irrigation canals with a maximum discharge of less than 2 m^3/sec were excluded from the project works due to the following reasons.

- It is easy to carry out the rehabilitation of the existing canals with a maximum discharge of less than 2 m^3/sec under the direct management by NIB.
- The rehabilitation works will not affect the overall works of the Project.

(2) Drainage plan

The major drainage rivers in MIS are the Nyamindi and the Thiba rivers as well as the Murubara river which runs between and in parallel with the two former rivers. The existing drainage canals in MIS are properly arranged and evacuate drainage water to the rivers mentioned above. However, some drainage canals are functioning poorly because of narrowed canal section as a result of soil sediment and thick weeds. The re-use structures are provided to utilize the drainage water in the Thiba part, i.e. Mwea, Thiba, Wamumu and Karaba Sections. However, the efficiency of the re-use structures is lowered due to the deterioration of these structures. Based on these observations, the basic concept of drainage plan was set up as follows:

- The existing drainage networks will be utilized to the maximum extent.
- The re-use structures shall be rehabilitated for improvement of the inefficiency.

Enlargement of canal section and removal of thick weeds were excluded from the project works because of easiness of these works and no effects on the overall works of the Project. The works concerning the drainage plan were limited to the rehabilitation of the existing re-use structures.

(3) Farm road development

The present farm roads in MIS are well developed along irrigation and drainage canals, and utilized for operation and maintenance of irrigation facilities and transportation of agricultural inputs and products. Some parts of the farm road are not passable in rainy season due to poor drainage of road surface as a result of relatively lower elevation of road surface caused by the

past road maintenance, e.g. grading of road surface by scraper. Taking into account such present conditions, the basic concept of farm road development was set up as follows;

- The present farm road networks shall be used to the maximum extent.
- The farm roads shall be connected to the national road (C219) which runs through the center of the project area, for smooth transportation of farm inputs and products.
- The farm roads shall be embanked and paved by laterite for protection against water impounding, in order to enable smooth transportation in rainy seasons.

In line with the basic concepts, the farm roads development of the Project was planned to be limited to the new construction of operation roads along the Link canal-I, Link canal-II, Nyamindi headrace and new Nyamindi main canal and the rehabilitation of operation roads along the Nyamindi main canal, Thiba main canal, Thiba branch canal-IV, and Link canal-II.

5.1.2 Study and Examination of Design Criteria

(1) River runoff

The discharge measurement of water resources, i.e. the Nyamindi and the Thiba rivers, was carried out at the gauging stations located 5 km upstream of the proposed site of the new Nyamindi headworks (4DB5) and 0.5 km upstream from the existing Thiba headworks (4DA10). The average annual runoffs of both rivers are mentioned in Section 3.4.1.

The design discharge is computed based on the condition of a drought with a 5-year return period, i.e. 1/5 drought year. For selection of the 1/5 drought year, a probability analysis was made by use of hydrological data collected in the previous F/S in 1987/88 and those supplemented in the Basic Design Study. As a result of the analyses, the 1/5 drought year was determined to be 1980. The 1/5 drought discharges of the Nyamindi and the Thiba rivers are as follows;

Month	Nyamindi River			Thiba River		
	Early	Middle	Late	Early	Middle	Late
1	4.96	4.44	4.75	2.81	2.45	2.6
2	4.57	3.68	4.24	3.24	2.65	1.98
3	5.72	5.56	5.35	3.15	2.62	2.22
4	5.52	5.75	7.19	3.28	5.18	8.48
5	7.17	12.84	11.53	15.78	13.88	7.12
6	9.16	7.94	6.98	5.36	4.01	3.29
7	6.83	6.18	5.85	3.01	2.97	2.83
8	7.12	7.77	7.64	3.00	10.22	5.15
9	7.03	6.37	5.59	3.59	3.52	4.41
10	4.48	4.94	6.62	9.03	3.91	6.25
11	9.07	12.15	12.61	7.58	10.22	9.3
12	9.02	7.90	8.01	5.71	4.99	4.25

(2) Irrigation water requirement

The irrigation water requirement was estimated under the following conditions on the basis of the survey results and data collected in F/S and the Basic Design stages.

- The crop water requirement was calculated by multiplying the potential evapotranspiration by the crop coefficient. The potential evapotranspiration was calculated on the basis of meteorological data at Mwea-Embu Meteorological Station by applying the Modified Penman Method, which is recommended by FAO. The crop coefficient was determined on the basis of the actual field investigation in the "Mwea Water Use Study, 1982, NIB" and the results of the "Design Manual for Water supply in Kenya, 1986, MOWD",

- The percolation rate was estimated to be 0.1 mm/day based on the "Mwea Water Study, 1982, NIB" and the actual field measurement results,

- The farm water requirement was obtained on 10-day basis by deducting the effective rainfall from crop water requirement. The effective rainfall was estimated by the daily water depth balance method. The estimated effective rainfall and farm water requirement on 10-day basis are presented in Table 5.1.

- The unit diversion water requirement was estimated by adding application loss, operation loss and conveyance loss to farm water requirement. The efficiencies taken into account are as follows;

Application efficiency	80 %
Operation efficiency	90 %
Conveyance efficiency	76 %
Overall irrigation efficiency	55 %

The peak unit diversion requirement was estimated as shown in the following table.

Crops	Period	Peak unit diversion requirement
Long rain paddy	End of March	1.44 l/s/ha
Short rain paddy	Middle of September	1.74 l/s/ha

(3) Water balance calculation

The calculation of water balance between the 1/5 drought discharge of both the Nyamindi and the Thiba rivers and the diversion requirement was made according to the following procedure.

- The surplus water in the Nyamindi river was estimated by calculation of daily water balance between the 1/5 drought discharge of the Nyamindi river and the diversion requirement for the Nyamindi part, i.e.the Thiba Section of 1,300 ha.

- The irrigable areas in the Thiba part consisting of Mwea, Thiba, Wamumu and Karaba Sections with a total irrigation area of 4,560 ha were assessed by calculation of daily water balance among the surplus water of the Nyamindi river, the 1/5 drought discharge of Thiba river and the diversion requirement for the Thiba part.

As a result of the above water balance study, the irrigable areas in the 1/5 drought year was estimated as follows;

Crops	Irrigable Area	Period
Long rain paddy	4,821 ha	End of March
Short rain paddy	5,448 ha	Middle of September

The irrigable area obtained by the water balance study is 5,448 ha, which is about 400 ha smaller than the present irrigated paddy area of 5,860 ha. However, since this result of water

balance calculation was gathered on the basis of the meteo-hydrological data in the 1/5 drought year, 5,860 ha can be irrigated in ordinary year.

(4) Unit drainage water requirement

In order to evaluate the capacity of the existing drainage canals, the unit drainage water requirement was analyzed by the following formulas for the paddy fields and for the land surrounding the irrigated paddy fields

1) Unit drainage water requirement for paddy field

The unit drainage water requirement for the excess rainfall from paddy field was estimated by the following formula;

$$Qp = (R24 \times 1/1000 \times 10000)/(T \times 60 \times 60)$$

where,
- Qp : Unit drainage water requirement ($m^3/s/ha$)
- R24 : Design daily rainfall (Maximum daily rainfall with 5-year return period at Mwea-Embu Meteorological Station, i.e. 100 mm/day)
- T : Drainage period (24 hours)

2) Unit Drainage water requirement for surrounding area

The unit drainage water requirement for the runoff from surrounding area was estimated by the McMath formula stipulated in the "Drainage Manual, USBR";

$$Qs=9.15 \times 1/1000 \times C \times i \times S^{1/5}$$

Where,
- Qs : Unit drainage water requirement for surrounding area (m^3/s)
- C : Coefficient representing the surrounding area's characteristics (0.36)
- i : Rainfall intensity for the time of flood concentration (mm/hr)
  $i = R24 \times (1/24)^k$
- k : Coefficient (0.3)
- S : Average slope (1/150)

3) Design drainage water requirement

The design drainage water requirement at each drainage area was estimated by the following formula;

$$Q=Qp \times Ap + Qs \times As$$

Where Ap : Area of paddy field (ha)

As : Area of surrounding area (ha)

(5) Flood discharge

The design flood discharge of both the Nyamindi and Thiba rivers was assessed as that with a 50-year return period by use of the following formula;

1) Peak flood discharge (Rational Formula)

$$Qp = 1/3.6 \times f \times r \times A$$

Where, Qp : Design flood discharge (m^3/s)

f : Runoff coefficient (0.3)

r : Rainfall intensity for the time of flood concentration time (mm/hr)

2) Rainfall intensity

$$r = R24/T \times (T/24)^k$$

Where, r : Rainfall intensity for T hours (mm/hr)

R24 : Design daily rainfall (mm/day)

T : Flood concentration time (hr)

k : Coefficient (0.3)

The estimated design flood discharge and design conditions for both rivers are as follows;

Items	Unit	Nyamindi	Thiba
Drainage area	km^2	283	354
Design rainfall	mm	190	190
Rainfall intensity	mm/hr	16.5	15.8
Flood concentration time	hr	5.5	6.0
Design flood discharge	m/s	390	470

The design flood discharge for the construction of coffer dam and diversion channel for Nyamindi headworks was to be the third one in order among the observed flood discharges for a decade (1979-1988). The flood discharges up to the fifth one in order for a decade are shown below;

Order	Flood discharge (m^3/s)	Period

1	126.4	May, 1979
2	126.4	May, 1980
3	95.0	May, 1982
4	87.0	October, 1984
5	67.3	May, 1987

5.1.3 Basic Design

(1) Irrigation plan

1) Irrigation system

The irrigation water for Tebere Section of 1,300 ha will be taken from the Nyamindi river and diverted through the existing irrigation canals to each paddy field. On the other hand, the paddy fields of four Sections in the Thiba part, i.e. Mwea, Thiba, Wamumu and Karaba Sections of 4,560 ha, will be irrigated by using both the surplus water of the Nyamindi river and that taken from the Thiba river through the existing irrigation canals.

The Nyamindi irrigation system for Tebere Section will consists of a main canal and three branch canals and some feeder canals for covering 26 terminal units. One unit will have the average area of 50 ha. The Thiba irrigation system for Mwea, Thiba, Wamumu and Karaba Sections will comprise a main canal, four branch canals and some feeder canals for 43 units. One unit will have the average area of 106 ha. The general features of each present system are shown below and the irrigation diagram is presented in Fig.3.3.

System/Section	Area	Unit		Irrigation Canal		
	(ha)	No.	Average Area (ha)	Main Length (m)	Branch (No.)	Branch (m)
Nyamindi system						
Tebere section	1,300	26	50	4,480	3	15,550
Thiba system						
Mwea section	1,220	17	72			
Thiba section	1,150	11	105			
Wamumu section	1,120	7	160			
Karaba section	1,070	8	134			
Sub-total	4,560	43	106	8,850	4	30,030
Grand total	5,860	85	85	13,330	7	45,580

The general features of irrigation canals to be rehabilitated under the present Grant Aid among the systems listed above are as follows;

System/Canal	Length (m)	Max. Design Discharge(m^3/s)
Nyamindi system		
Nyamindi main canal	4,480	2.28
Thiba system		
Thiba main canal	8,850	6.35
Thiba branch canal-IV (structures)	15,880	2.73

A link canal (Link canal-I, 8.9 km) will be constructed between the Nyamindi and the Thiba rivers to divert the surplus water of the Nyamindi river to the Thiba irrigation system. The surplus water will be led down just upstream of the existing Thiba headworks and taken by this headworks. Then, the new Nyamindi headworks will be constructed about 2.1 km upstream of the existing Nyamindi headworks because the intake water level at the existing one is not optimum for diverting water to the Thiba system, and the Nyamindi headrace will be constructed between the new Nyamindi headworks and the Link canal-I. In addition, the new Nyamindi main canal will be constructed from the end of the Nyamindi headrace to the beginning point of the existing Nyamindi main canal in order to distribute water to Nyamindi irrigation system. On the other hand, the existing Thiba headworks will be rehabilitated with enlargement of the intake structure due to the increase of design intake capacity, and the existing Link canal (Link canal-II, 3.5 km) will also be rehabilitated for diverting water from the the Thiba headworks to the beginning point of the existing Thiba main canal.

2) Related structures

Nyamindi headworks

The proposed construction site of Nyamindi headworks is about 2.1 km upstream of the existing Nyamindi headworks, where the river curves to the left. Because the river course will be drawn to the right side after the completion of construction, the sediment in front of the intake structure will be smoothly removed so that stable water will be easily taken. As for the present conditions of geology at the proposed headworks site, the basalts are exposed at the river bed (EL.1205-1206 m) and a layer composed of boulders as large as a man's head is found, ranging between 7-8 m above the basalt layer at both banks. In addition, there is a gravel layer above the boulders and a silting layer called "Red soils" of about 1.5 m depth from the ground surface. Taking into account the above, the weir of headworks was designed to be fixed on the rock for ensuring its stability and preventing water leakage beneath it. The weir of headworks is of fixed type and the scouring gates will be provided at the right side of the weir. Sediment will be

prevented from flowing through the intake gates by operation of scouring gates and stable intake of water will be assured. Downstream of the intake gates, a broad crested weir will be constructed to measure the discharge and a side spillway will also be provided to prevent inflow of excess water into the canals owing to mis-operation of the intake gates.

The general features of Nyamindi headworks are as follows;

Catchment area	:	283 km^2
Design flood discharge	:	390 m^3/s
Design flood level	:	1,212.35 m
Length of weir	:	45.0 m
Height of weir	:	4.5 m
Scouring gate	:	2.0 m x 3.0 m x 2 nos.
Intake water level	:	1,209.50 m
Intake gate	:	1.5 m x 2.0 m x 2 nos.

Thiba headworks

Although the existing Thiba headworks has been constructed about 30 years ago, there is no perceptible deterioration of the headworks body requiring rehabilitation, except for partial damages of the upstream and downstream protection works. Rehabilitation is needed only due to the increased design intake discharge. In the F/S stage, the weir height was designed to be raised to cope with the increased intake capacity because the intake gate of headworks is of orifice type. However, as a result of design analysis in the Basic Design Study stage, the rehabilitation of headworks was designed to cope with the increased intake capacity by enlarging the intake structure for the following reasons.

- In case of raising of the weir height by 0.5 m (F/S stage), the upstream embankment will be flooded by the design flood discharge. The design flood discharge can be controlled by the proposed Thiba dam constructed upstream of the Thiba river in F/S stage. However, the design for rehabilitation was studied in the Basic Design Study stage, assuming that the construction of the proposed Thiba dam would not be implemented for some years.

- As a result of comparison of such economic and technical aspects as construction costs and degree of difficulty of construction works between the designs at F/S stage and at Basic Design Study stage, the rehabilitation works consisting of the enlargement of intake structure was considered to be advantageous.

- Since the inflow velocity at the intake gate is very high in case of the orifice type, much suspended sand will flow into the irrigation canal.

The general features of the Thiba headworks after rehabilitation are as below;

Drainage area	:	353 km^2
Design flood discharge	:	470 m^3/s
Design flood level	:	1,203.90 m
Length of weir	:	27.7 m
Height of weir	:	2.6 m
Scouring gate	:	1.3 m x 1.5 m x 1 No.
Intake water level	:	1,199.40 m
Intake gate	:	1.4 m x 2.2 m x 5 Nos.

Irrigation canal

All the new and existing irrigation canals have a rectangular section. The Nyamindi headrace and the new Nyamindi main canal will be lined with concrete to prevent leakage, since these canals will be running in the area with gravels or boulders. A part of the existing Nyamindi main canal should be designed to be lined with concrete, because the flow velocity in this canal is very high due to its steep gradient. Then it will be necessary to demolish the existing lining and execute the new concrete lining for this part of the canal.

Other irrigation canals were designed to be earth canals. The soils of slopes and bed of the existing Nyamindi main canal will be replaced by red soils or brownish red soils for protection against erosion, because their sections are covered by black cotton soils with poor characteristics such as shrinkage and swelling.

The design condition of above irrigation canals are as follows;

- Design discharge: The design discharge was decided by the following formula;

  $Q = q \times A \times 1/1000$

  Where, Q: Design discharge (m^3/s)

  q: Unit diversion requirement (l/s/ha)

  A: Irrigation area (ha)

- Allowable maximum velocity:

Lining canal : 2.0 m/s

Earth canal : 0.7 m/s

- Allowable minimum velocity:

Lining canal : 0.3 m/s

Earth canal : 0.3 m/s

- Roughness coefficient:

Lining canal : 0.015

Earth canal : 0.030

- Free board:

Design discharge (m^3/s)	Free board (m)
Q<3.0	0.3
3.0<Q<6.0	0.4
6.0<Q	0.5

- Inside slope

Lining canal : 1 : 1.25

Earth canal : 1 : 1.50

Related structures

The following related structures will be provided for measurement, distribution, road or river crossing and safety of canal.

Related structures	Nyamindi. head-branch race	New Nyamindi. branch main canal	Nyamindi. canal	Link main canal	Link canal-I	Thiba canal-II	Thiba canal	Other main canal
Broad crested weir	1	1	-	1	1	2	1	-
Rectangular shape crested weir	-	-	-	-	-	-	-	7
Spillway	1	-	-	-	1	1	-	-
Diversion work	1	-	-	-	-	-	-	
Off-take	-	-	4	-	-	1	1	10
Drop	-	9	18	-	1	10	26	20
Culvert	2	-	2	11	-	-	6	2
Syphon	-	-	-	1	-	-	1	-
Washing step	-	-	2	17	3	3	6	2
Cattle basin	-	-	1	12	2	-	-	-
Check	-	-	4	-	1	1	1	17
Drainage syphon	-	-	-	15	-	-	-	-

(2) Drainage plan

1) Drainage system

The drainage system of the Project will be divided into three systems. The first is the Nyamindi drainage system consisting of three main canals of which parent drainage river is the Murubara. The second is the Thiba drainage system comprising five main canals and two branch canals of which parent river is the Kiruara , a branch of the Tana river. The third is a drainage system composed of some collector drains which evacuate the drainage water directly to the parent rivers of the Nyamindi and Thiba rivers. The length of each canal and the area of the respective drainage blocks are shown below and the drainage diagram is presented in Fig.3.4.

System	Main and branch Length (m)	No. of blocks	Drainage area (ha)		
			Paddy	Upland & Surrounding	Total
Nyamindi	5,850	8	649	258	907
Thiba	26,950	49	3,364	3,64	6,625
Others	-	-	1847	-	1847

2) Drainage canals

The existing drainage canals were designed following the design conditions as shown below;

- Design discharge: The design discharge of drainage canals was calculated by the following formula;

  Qd=Qp x Ap+Qs x As

  The design discharge of each canal is shown in the drainage diagram in Fig.3.4

- Design water level: The water level in main and branch canals was designed to be 0.9 m below the original ground surface elevation at each drain inlet.

- Allowable discharge

  Maximum : 1.0 m/s

  Minimum : 0.3 m/s

- Roughness coefficient : 0.035

- Inside slope: 1 : 1.5

3) Related structures

The related structures to be rehabilitated under the Project are only the re-use structures in order to restore the return flow from the paddy fields and surface drainage water to irrigation canals. The number of re-use structures is as follows;

Canal	Number
Thiba main canal	2
Thiba branch canal-IV	1

(3) Farm road development

The farm roads in the Project area are developed well along main and branch canals allowing not only transportation of agricultural inputs and products and water management but also moving of habitants in the area. The roads rehabilitation plan puts an emphasis on the provision of operation roads along main and branch canals and on the connection of farm roads with the national road (C219) between Makutano and Embu. The Nyamindi headrace, new Nyamindi main canal and Link canal-I will also be provided with operation roads which will play the important role as the trunk roads for daily activities. The following roads will be rehabilitated and newly constructed for the Project.

Rehabilitation

- Operation road for Nyamindi main canal : 4.5 km
- Operation road for Thiba main canal : 8.9 km
- Operation road for Thiba branch canal-IV : 15.9 km
- Operation road for Link canal-II : 3.5 km

New construction

- Operation road for Nyamindi headrace : 0.6 km
- Operation road for new Nyamindi main canal : 0.6 km
- Operation road for Link canal-I : 8.9 km

Total : 42.9 km

1) General features

Total width : 5.0 m

Effective width	:	3.0 m
Embankment height	:	0.4 m (from ground surface after stripping, 10 cm thick)
Outside slope	:	1 : 1.5
Pavement	:	Laterite pavement
Width of pavement	:	3.0 m
Thickness of pavement	:	10 cm

2) Related structures

The related structures are those for crossing rivers and canals. The structure for canal crossing will be a "culvert" mentioned in the previous section. The structure for river crossing will be a drainage syphon with a barrel having the necessary length for the crossing canal or road. A submerged bridge will be provided for crossing the Murubara river. In addition, foot bridges will be constructed at the points where small roads cross canals so as not obstruct traffic for inhabitants. The number of related structure of the Project is as follows;

Related structure	Number
Foot bridge	18
Submerged bridge	1
Culvert	(22)
Drainage syphon	(15)

The outlines of these components can be summarized as follows:

(1)	Nyamindi Headworks	- Length of weir	:	45 m
		- Height of weir	:	4.5 m
		- Intake capacity	:	7.01 m^3/sec
		- Intake water level	:	1,209.50 m
		- Scouring gate	:	2 nos. (2 m x 3 m)
		- Intake gate	:	3 nos. (1.5 m x 2.1 m)
(2)	Thiba Headworks	- Length of weir	:	29 m
		- Height of weir	:	2.6 m
		- Intake capacity	:	11.12 m^3/sec
		- Intake water level	:	1,199.40 m
		- Scouring gate	:	1 no. (1.3 m x 1.5 m)
		- In take gate	:	5 nos. (1.4 m x 1.5 m)
(3)	Nyamindi Headrace	- Length	:	0.6 km
		- Concrete lining canal		(t = 0.1 m)
		- Design discharge	:	7.01 m^3
		- Diversion works		
		- Others: spillway, washing step, cattle basin, etc.		
(4)	New Nyamindi main canal	- Length	:	0.6 km
		- Concrete lining canal		(t = 0.1 m)
		- Design discharge	:	2.28 m3

		- Others, drop, culvert, spillway, washing step, cattle basin, etc.	
(5)	Nyamindi main canal	- Length :	4.5 km
		- Including existing concrete lining canal	(t = 0.1 m)
		- Design discharge :	2.28 m^3
		- Others, drop, culvert, spillway, washing step, cattle basin, etc.	
(6)	Link canal - I	- Length :	8.9 km
		- Design discharge :	4.91 m^3
		- Syphon (200 m), culvert	
		- Others: drop, culvert, spillway, washing step, cattle basin, etc.	
(7)	Link canal - II	- Length :	3.5 km
		- Design discharge :	11.12 m^3
		- washing step, cattle basin, etc.	
(8)	Thiba main canal	- Length :	8.9 km
		- Others: drop, culvert, spillway, washing step, cattle basin, etc.	
(9)	Thiba branch canal - IV	- Drop, culvert, spillway, washing step, cattle basin, etc.	
(10)	Related structures	- Diversion works, drop, culvert, others	
(11)	Farm road	- Rehabilitation :	32.8 km
		- Newly constructed :	10.1 km

5.2 Provision of O&M Equipment

5.2.1 Basic Concept

The selection of O&M equipment and the estimation of its requirement are made around the following concept:

- The equipment is carefully selected according to the minimum requirement for O&M of irrigation and drainage facilities and roads as well as for water management and farm guidance.
- The requirement and technical specification of O&M equipment are determined in accordance with the scope and scale of the O&M works to be required.
- The O&M equipment to be provided are made in Japan according to the design and technical specifications for the size and grade available on the market.
- The O&M equipment to be provided can be easily and economically operated and maintained, and has a high stability.
- Standard models should be adopted, so that the spare parts can be easily procured for future maintenance of O&M equipment.

5.2.2 Study and Examination of Design Criteria

The O&M equipment to be provided will be used for the following purposes:

- For rehabilitation of irrigation/drainage facilities and farm roads, which will be conducted by NIB after completion of the Project, as they are excluded from the scope of the project works
- For operation and maintenance of irrigation facilities and roads
- For water management and farm guidance

A part of the O&M equipment is to be provided under the Japanese KR2 project for 1988. Therefore, the O&M equipment to be provided under the Project was determined by deducting the equipment to be provided under KR2 and the existing one from the total requirement.

5.2.3 Equipment Plan

According to the basic concept, the following O&M equipment was selected.

	O&M Equipment	Speci-. fication	Require-ment (No.)	Existing (No.)	To be pro-vided under KR2 (No.)	To be provided under the Project (No.)
1.	Backhoe shovel	0.3 m3	3		2	1
2.	Backhoe shovel	0.6 m3	1		1	0
3.	Bulldozer	11 tons	1			1
4.	Wheel loader	1.0 m3	1			1
5.	Motor grader	3.7 m width	2		1	1
6.	Road roller	5 tons	1			1
7.	Plate compactor	3 HP	2			2
8.	Submergible pump	ϕ 50 mm	2			2
9.	Dump truck	8 tons	2		1	1
10.	Dump truck	3 tons	1			1
11.	Cargo truck	6 tons	3			3
12.	Cargo truck with 3 tons crane,6 tons		1			1
13.	Pick-up truck	1 ton	3			3
14.	Jeep		6	3	1	2
15.	Motorcycle	100 cc	15		10	5
16.	Spare parts					10% of the above cost

Spare parts will be procured at the amount of 10% of the total direct cost of O&M equipment:

(1) The O&M equipment for irrigation and drainage canals and farm road will be as follows:

- Backhoe, 0.3 m^3: Backhoe will be used for excavation work, particularly for maintenance of secondary irrigation and drainage canals.
- Bulldozer, 11 tons: Bulldozer will be introduced for general excavation and embankment work, pavement leveling and compacting work, etc. Small-sized 11-ton bulldozer will be applicable.
- Wheel loader, 1.0 m^3: Wheel loader will work for collection of embankment material excavated as well as for excavation itself.
- Motor grader: Motor grader will be used for grading of road surface and pavement leveling as well as for grading and shaping of side slopes.
- Road roller, 5 tons: Road roller will work for compaction work of farm roads.
- Plate compactor, 3 HP: Plate compactor will be required for repairs of canals and roads, particularly for compaction of terminal canals and refilled soils of various structures.

(2) The O&M equipment for repairs of related structures will be as follows:

- Submergible pump: Submergible pump will be required for removing water during repair works on drains and related structures.
- Cargo truck, 3t crane: Cargo truck with 3-ton crane will be used for repair works on gates and for transportation of concrete pipes.

(3) Vehicles

- Trucks: Following kinds of trucks will be required for transportation of construction materials:
  - a Dump truck : 8 tons
  - b Dump truck : 3 tons
  - c Cargo truck : 6 tons
  - d Pick-up truck : 1 ton
- Jeep: Jeep will be used for communication with NIB office in Nairobi and with reception centers. In addition, Jeep will be used for field inspection.
- Motorcycle: Motor-cycles will be used for gate operation and field inspection.

Delivery of the O&M equipment to be procured and training programme of operators will be made in the following manner.

- All the equipment and vehicles will be delivered to the MIS office and assembled at the specified places. Then, it will be handed over together with the spare parts to the MIS office after its trial operation.
- For proper operation and maintenance of the O&M equipment, the English operation manuals and parts lists will be given.

5.3 Provision of Farm Machinery

5.3.1 Basic Concept

The selection of farm machinery and the estimation of its requirement were made based on the following concept:

- Mechanized farm practices are to be applied only for land preparation, i.e. puddling, and for plat protection.
- Farm machinery to be provided is to be made in Japan with the size and grade usually applicable.
- Farm machinery to be provided shall enable easy and economical operation and maintenance with high stability.
- Standard models are to be adopted, so that spare parts can be easily obtained for the future maintenance of the machinery.
- Some farm machinery is to be provided under the Japanese KR2 project for 1988. The machinery to be provided under the Project will be decided by deducting the equipment to be provided under KR2 and the existing one from the total requirement.

5.3.2 Consideration on Basic Concept

(1) Selection of Farm Machinery

1) Puddling

After irrigation water is supplied to unploughed paddy fields, these are left for three days under submerged condition and puddled. This method has several advantages. Firstly, the number of tractors and their operators can be minimized due to exclusion of ploughing and harrowing resulting in highly economical operation. Secondly, the farm operation schedule cannot be delayed by erratic rainfalls because puddling work is not dependent on weather conditions. Thirdly, puddling is highly effective for weed control. In view of these advantages, the prevailing land preparation method will also be retained under the Project and the same type of farm machinery was selected as follows.

4-wheel drive tractor, 60 HP

The existing tractors are mainly of Italian made 2-wheel drive 60 HP type and have such constraints as (i) lower trafficability during puddling work, (ii) higher occurrence of bogging-down and (iii) troubles on inlet, outlet and electric systems by water during puddling work. The 4-wheel drive tractors highly resistant against the prevailing constraints mentioned above are to be provided.

Rotavator

The rotavator a with working width of 2 m will be required as an attachment to the tractors for puddling. The rotavator will be of 3-point link type, easy for installation, with simple structure, light weight and high field efficiency.

Cage wheel

Cage wheels will be required to prevent bogging-down.

2) Spraying

Knapsack-type sprayers

Knapsack-type sprayers will be of manual operating type very familiar to farmers.

(2) Work load (daily output per tractor)

1) Puddling

The work load of puddling by use of the combined tractor, rotavator and cage wheels was calculated as follows.

Valid work load = W x S x E
= 2.0 m x 2.0 km/hr x 0.8
= 0.32 ha/hr

Daily work load = Valid work load x WE x working hours
= 0.32 ha/hr x 0.8 x 6 hrs
= 1.536 ha/day
= 1.5 ha/day

where: W: Working width: 2.0 m
S: Working speed: 2.0 km/hr
E: Working efficiency in field: 0.8
WE Daily working efficiency: 0.8

2) Spraying

Agro-chemical application will be made by using knapsack type sprayer. The working efficiency of this operation is expressed by the daily net work load as given below:

Daily work load = (B / Q) x E x H
= (0.5 lit/hr / 1 lit/ha) x 0.8 x 6 hrs
= 0.24 ha/day/unit

where: B: Belching volume per hour; 0.5 lit.
Q: Application quantity per ha; 1 lit.
E: Working efficiency; 0.8
H: Working hours per day; 6

(3) Total working load

Puddling and agro-chemical application for the irrigated paddy field of 5,860 ha will be finished within 60 days. This indicates that the daily work progress in the whole MIS Area averages 98 ha per day that is the same as the total of the work load in each irrigation section shown below.

Irrigation Sections	Daily work load (ha/day)
Tebere	21.7
Mwea	20.3
Thiba	19.2
Wamumu	18.7
Karaba	17.8

5.3.3 Basic Plan

The required number of agro-machinery was determined based on the daily working efficiency as follows.

Irrigation Sections	Tractor, Rotavator and Cage wheels	Knapsack type Sprayer
Tebere	15	9
Mwea	14	9
Thiba	13	8
Wamumu	13	8
Karaba	12	8
Total	67	42

A part of the farm machinery is to be provided under the Japanese KR2 project for 1988. Therefore, the farm machinery to be provided under the Project was decided by deducting the equipment to be provided under KR2 and the existing one from the total requirement as follows.

Machinery	Requirement	Existing	To be provided under KR-2	To be procured under the Project
Tractor	67	26	24	17
Rotavator	67	34	24	9
Cage wheel	67	26	24	17
Knapsack sprayer	42	-	-	42

5.4 Improvement of Machine Center

5.4.1 Basic Concept

The plan for improvement of the existing machine center was made based on the following basic concept:

- The Machine center has to be designed with sufficient size and specifications for ensuring smooth operation and maintenance of the O&M equipment and farm machinery.
- The equipment and tools to be provided for the machine center have to be economically viable, strongly-built and have high stability.

5.4.2 Consideration on basic concept

The existing machine center is equipped with minimum equipment and tools required for maintenance of tractors and vehicles, such as welder, battery charger, air compressor, mobile workshop, etc. Therefore, it is difficult to carry out operation, maintenance and repair of the O&M equipment and farm machinery in the existing center.

A workshop, in which operation, maintenance and repair of the O&M equipment and farm machinery to be provided can be done, will be newly built to supplement the existing center.

5.4.3 Basic Plan

(1) Building site and layout planning

The existing machine center is located within the site of the MIS office. The newly constructed workshop is proposed to be built separately from but next to the existing machine center in order to ensure smooth and safe movement of the O&M equipment and tractors.

There exists a fuel tank with 49,500 lit. capacity, laid underground near the proposed site of workshop. In order to save the replacement cost of the existing fuel tank and to avoid any accident due to mis-use of welders, this site was selected as the best one for building the workshop.

(2) Construction planning

1) Floor plan

The floor plan was formulated taking into account the work efficiency and safety of regular and ordinary inspection of the O&M equipment. The total required floor size is 310 m^2 (frontage of 31 m x 10 m in depth), which will include the following repair shops and rooms:

- Repair shop for construction machines
- Repair shop for vehicles
- Processing plant for spare parts
- Repair shop for tires
- Storage room for oil
- Room for battery charging
- Storage room for spare parts, tires and tools

The floor sizes of the above repair shops and rooms were determined as follows:

Items	Floor size(m^2)		Objectives/Floor size requirement
	Designed	Required	
Repair shop for const. machines	49	42	Work space is available even when the biggest construction machine (11-ton bulldozer) is housed. Bulldozer(3 m X 4 m) + work space around (1.5 m) = 6 m x 7 m = 42 m^2
Repair shop for vehicles	70	61	Work space is available even when cargo truck(6 tons) is housed. Cargo truck(2.5 m x 8 m) + work space around(1.5 m) = 5.5 m x 11 m = 60.5 m^2 ≒ 61 m2
Processing plant for spare parts	70	-	Electric welding machines, gas cutters, grinders and lathes will be installed in the plant for repair of buckets, assembling of engines and parts preparation.
Repair shop for tires	18	-	A diameter of motor grader and dump truck's tire is 1.1 m. A space of 18 m^2 (3 m x 6 m) is required to repair two tires at the same time.
Storage room for oil	10.5	9	20 oil drums, which contain engine oil and hydraulic oils, can be stored. The diameter of the drum is 0.65 m, therefore a space of 9 m^2 (0.65 m x 0.65 m x 20) is necessary.
Room for battery charging	10.5	9	A space of 9 m2(3 m x 3 m) is required for aeration.
Room for storing spare parts, tires and tools	82	80	Weight of spare parts, tires and tools is 60 freight tons. A space of 80 m2 is necessary when these items are received in a shelf with 1.5 m height by kind, considering the space of pathway(the same size as the space for receiving). (60 ÷ 1.5) x 2 = 80 m^2

2) Section plan

The cross section of the building was determined considering the height of construction equipment mentioned below:

	H max	H min
Backhoe, 0.6 m^3	6.0 m	3.1 m
Wheel loader	4.3 m	3.0 m

Overhead crane and gateway shutter are proposed to be installed at the heights of 6.0 m and 4.0 m, respectively. No decoration is proposed on the side of the building, but gateway and windows are to be furnished for lighting and aeration.

3) Structural design

Building structure with relatively big span and high eaves was proposed as follows, in view of its strength, durability and cost.

- Structure : Steel structure
- Roof : Steel plate
- Wall : Under : Concrete or concrete block
  Upper : Steel plate
- Floor : Concrete

Structural design loads such as earthquake load and wind load were estimated according to the technical criteria of Kenya and other structural design loads were estimated based on the Japanese criteria.

- Earthquake load:
  The Mwea area belongs to the earthquake zone VII, for which earthquake-resistant design of building is not required.

- Wind load:
  $F = Cf \times q \times Ae$
  where F : Lateral load
  Cf : Wind force coefficient
  q : Velocity pressure
  Ae : Area of elevation

- Soil bearing capacity:
  The soil bearing capacity in the site is about 20 tons/m^2, which is reasonable.

- Other design loads:

a <u>Fixed load</u>

Reinforced concrete	2.4 tons/m^3
Structural steel	7.85 tons/m^3
Concrete block	1.9 tons/m^3

	Mortar	2.0 tons/m^3
b	Live load	
	Roof	50 kg/m^2
	Floor of office	300 kg/m^2
	Floor of warehouse	3,000 kg/m^2
	Floor of factory	calculated actual load

- Structural materials:
  The allowable unit stress and quality of structural materials are proposed as follows:

Reinforcement bar	Deformed bar SD 30
Concrete	Fe 180 kg/cm^2 (after 4 weeks)
Cement	Normal portland cement
Steel	SS 41 or equal quality

4) Building facility plan

- Electric facilities: Lead-in from the existing facilities. Other conditions are as mentioned in Chapter 5.6.3 (2).2)(g).
- Supply and drainage of water: Water will be supplied from the existing facilities and drained to the ground through catchment box. Rain water will be drained through open drain installed around the roads in the yard.

5) Main building material plan

- Floor : Concrete with trowel finishing
- Skirting : Mortar
- Wainscot : Mortar
- Wall : Vinyl chloride coated channel steel
- Roof : Vinyl chloride coated channel steel
- Door : Steel hanger
- Window : Aluminium sash with iron grille and insecticide net

(3) Equipment plan

The equipment for repairs and tools to be provided in the workshop is listed below (refer to chapter 4.3.3). 10% of the equipment cost is proposed to be allocated for procurement of spare parts.

- Overhead crane, 5 tons
- Oiling equipment, 1 set
- Equipment and tools for tires and brake, 1 set
- Equipment and tools for engine maintenance, 1 set
- General maintenance tools and equipment, 1 set
- Equipment and tools for engine tune up, 1 set
- Equipment and tools for car washing, 1 set
- Equipment and tools for steel painting, 1 set
- Other tools, 1 set
- Measuring meters, 1 set
- Air compressor and the attachment, 1 set
- Maintenance truck, 1 unit

5.5 Basic Design of Pilot Farm

5.5.1 Site Selection for Pilot Farm

A total of 100 ha of grassland, which is adjacent to the M-9 irrigation section in the MIS Area and extends to the right side of the Thiba main canal, was selected as a proposed site of the pilot farm taking account of following conditions:

- Accessibility and road condition are good
- Irrigation water is easily obtainable
- Unused land with required size can be obtained
- Land is covered by Black Cotton Soils

5.5.2 Present Condition of the Site

Land of the proposed pilot farm consists of 35 ha of flat land with Black Cotton Soils and 5 ha of sloped land Red Soils. The present condition of the proposed site of the pilot farm is summarized as follows.

Land type	Topography	Soils	Land use
Flat land	Average slope: 1/200 EL: 1,188 - 1,190 m	Black Cotton Soils	Glassland
Sloped land	Average slope: 1/80 EL: 1,189 - 1,195 m	Red Soils	Upland crop

5.5.3 Basic Design

(1) Basic design of experimental cum demonstration farm

1) Basic concept

- The farm is designed with a minimum size to be required for experiments and training purposes.
- Irrigation water will be obtained through the turnout to be constructed at EL 1,196 m on the Thiba main canal.
- Drainage will be made through a natural stream which flows into the highest part of the existing Kiruara drain located northwest of the M-9 irrigation section (Mwea irrigation section)

2) Consideration on basic concept

The pilot farm will be constructed for execution of experiments on irrigated rice farming techniques for MIS and the staff training, with a view of increasing rice productivity in the MIS area under the Japanese Technical Cooperation.

The pilot farm was designed taking into consideration such experimental aspects as water management, farm mechanization and rice farming techniques.

In the MIS area, on-farm water management has been made in each irrigation unit with an area of 70 to 100 ha, which is the smallest unit of irrigation system. Therefore the experimental farm for on-farm water management should be constructed at the same area size of irrigation unit (about 70 ha). However, the farm size was planned to be 35 ha in view of cost saving. A part of the farm will be used for experiments on farm mechanization and rice farming techniques.

3) Basic plan

a) Irrigation plan

The irrigation system of the pilot farm will consist of one main canal, three branch feeder canals and six feeder canals. The required structures related to the above canals will include a turnout structure on the Thiba main canal, offtake/checks on main feeder canals for diversion of water to branch feeder canals, offtake/checks on branch feeder canals for distribution of water to feeder canals, discharge measurement devices, culverts, drops, aqueduct, spillway and drainage inlets. The proposed irrigation system of the pilot farm is outlined below:

(unit: m)

Canal	Length	Bottom width	Canal height	Others
Main feeder canal	1,630	0.30	0.50	Earth canal
Branch feeder canal No.1	1,240	0.30	0.40	Earth canal
Branch feeder canal No.2	590	0.30	0.40	Earth canal
Branch feeder canal No.3	1,650	0.30	0.30	Earth canal
Feeder canals (6)	2,680	0.30	0.30	Earth canal

Related structures:

Main feeder canal	:	i.	Offtake/Check	: 3 nos.
		ii.	Rectangular sharp-crested weir	: 2 nos.
		iii.	Culvert	: 10 nos.
		iv.	Spillway	: 1 no.
Branch feeder canals	:	i.	Offtake/Check	: 6 nos.
		ii.	Rectangular sharp-crested weir	: 5 nos.
		iii.	Drop	: 3 nos.
		iv.	Culvert	: 12 nos.
		v.	Drainage inlet	: 2 nos.
		vi.	Aqueduct	: 1 no.
Feeder canals	:	i.	Check/drop (stop log type)	: 18 nos.
		ii.	Field inlet	: 28 nos.

Turnout structure	:	Type	:	Double orifice/pipe culvert
		Design intake water level	:	EL 1,196 m
		Design discharge of intake water	:	0.07 m^3/s
		Gate width	:	0.5 m x 0.5 m

b) Drainage plan

The drainage system of the pilot farm will consist of two main collector drains, three collector drains, 10 field drains and four catch drains. The structures related to the drains will include drain inlets, drain junction structures, culverts, drops and cross-drains. The proposed drainage facilities are outlined below:

(Unit: m)

Drains	Length	Bottom width	Canal height
Main collector drain No.1	1,000	0.60-0.30	1.00-0.80
Main collector drain No.2	1,450	1.30-0.50	2.40-1.40
Collector drain No.1	1,150	0.70-0.50	2.40-1.00
Collector drain No.2	320	0.50	2.00-1.20
Collector drain No.3	790	0.40	1.40-0.90
Field drains (10)	4,320	0.30	0.60
Catch drain No.1 (existing)	1,900	1.60-1.30	2.40-1.00
Catch drain No.2	440	1.30	1.20-1.00
Catch drain No.3	750	0.60	1.40-1.20
Catch drain No.4	450	0.40	1.00

Related structures:

Main collector drain	:	Culvert	:	9 nos.
		Drop	:	7 nos.
		Drainage inlet	:	1 no.
		Drainage junction	:	3 nos.
Collector Drains	:	Drainage inlet	:	2 nos.
		Drainage junction	:	17 nos.
		Culvert	:	8 nos.
Catch drains	:	Culvert	:	13 nos.
		Cross-drain	:	1 no.
		Drainage junction	:	2 nos.
		Drainage inlet	:	1 no.

c) Road plan

The proposed road network will include the following operation road, farm roads, on-farm roads and roads in building area.

(Unit: m)

Roads	Length	Total width	Effective width	Pavement
Operation road	3,110	5.0	3.0	Laterite
Farm road	3,190	5.0	3.0	Laterite
Farm road (existing)	1,490	5.0	3.0	Laterite
On-farm roads(7 roads)	3,140	5.0	3.0	Laterite
Roads in building area	695	5.0	3.0	Laterite

Related structures:

Farm roads	:	Cross-drain:	1 no.
		Farm approach:	4 nos.
On-farm roads	:	Farm approach:	24 nos.

d) Paddy field plan

A field plot in the experimental farm will 0.4 ha with 100 m long and 40 m wide. A field block will consist of 7 - 17 field plots and a farm block will comprise two field blocks. A feeder canal will run in the center of the farm block. An offtake/check will be provided at the beginning point of the feeder canal. The water level in the feeder canal will be controlled by a check/drop structure and water will be taken to the field plot through a simple concrete structure arranged at an inlet for every four field plots. No special structure will be provided at the outlet of the field plot like the existing irrigation fields. Field drains and on-farm roads will be constructed both outside of the farm block. A farm approach made of concrete pipes will be installed in the field drain for every four field plots. A culvert will be provided where the farm road crosses the irrigation canal and drainage canal and a drainage inlet will be constructed where the smaller drain crosses the on-farm road just before the crossing point with the parent drain.

f) Layout plan

A layout plan of the field plots and facilities mentioned above is given in the attachments (Plate No. 39).

(2) Architectural design

1) Basic concept

- In the basic design, such natural conditions of the project site as low altitude near the equator, high elevation of 1,200 m, cool and dry weather throughout the year and no earthquake were taken into account.

- The buildings are to be functional in their use with minimum O&M cost. The building style is to be of locally prevailing one. Along this concept, single office rooms are to be provided to senior staff and Japanese experts. Since there are no criteria in Kenya, the Japanese design criteria will be applied for determination of floor area of rooms.

- Domestic materials should be used as much as possible. However, in case the local materials are not adequate in quality, in kind and in quantity and uncertain in procurement, these should be imported from Japan.

2) Consideration on basic design conditions

The construction of the pilot farm is premised on the Japanese Technical Cooperation. The scope of cooperation will be determined through further discussions between the technical cooperation team to be dispatched in 1989 and the GOK. The basic idea of the said Japanese Technical Cooperation, however, was tentatively set up through the study by JICA and the Ministry concerned in Kenya as summarized below. Therefore, the basic design of the pilot farm was worked out in line with this basic idea.

- Objectives of technical cooperation:
  - a Establishment of water management system (including O&M of irrigation and drainage facilities, setting up of organization)
  - b Introduction of rice cultivation technique (cultivation method of irrigated double cropping of rice including selection of seed varieties, improvement of soil fertility and protection from diseases and insects)
  - c Agro-machinery (field adaptation test of machines, operation and maintenance of agricultural and O&M machinery)
  - d Training (training program, development of curriculum and educational materials)

- Scope of the Japanese Technical Cooperation:
  - a Dispatch of Japanese experts (long term: 6 persons, short term: depending on the budget)
  - b Execution of training programme
  - c Provision of equipment essential for activities under the project within the budget

- Undertakings of GOK:
  a Acquisition of land and building to be required for the project
  b. Assignment of counterpart personnel
  c. Budgetary arrangement for the local portion of the project cost

Quarters and related accommodation facilities for Japanese experts have to be constructed because no suitable houses and hotels are available in and around the MIS area.

Taking such conditions mentioned above into consideration, the basic design conditions were set up as follows:

- In the office building, single rooms will be provided to Project Manager, Leader and Japanese short-term experts, and five rooms will be reserved for Japanese experts with their counterpart personnel. Office room for the staff of administration and account, meeting rooms, rooms for stationeries and store room will also be provided.
- The size of training cum meeting room will be so determined as to enable the training and meeting of all the attendants from 78 irrigation unit in MIS.
- In the laboratory building, necessary facilities will be provided for the respective sections of water management, agro-machinery and soils and crop science. The laboratory will be also used for training of counterpart personnel and the NIB staff.
- Six staff quarters for Japanese long-term experts will be constructed.
- A guest house for Japanese short-term experts and Kenyan lecturers will be constructed.
- In addition to the above facilities and buildings, multi-purpose warehouse, drying yard and workshop will be constructed, and meteorological station will be installed in the pilot farm.

3) Basic plan

a) General conditions in the building site

The site is located in the northwestern corner of the pilot farm and covers an area of 51,000 m^2. The shape of the site is a square of which ratio of length and width is 1 : 2, extending from northwest to southeast. There is sufficient space for accommodating all the facilities mentioned above.

The total area of planned facilities is 6,140 m^2 occupying about 12% of the site area. A 6.0 m wide access road connecting with the existing road C 289 will be newly constructed and in-site roads will be arranged according to the layout plan.

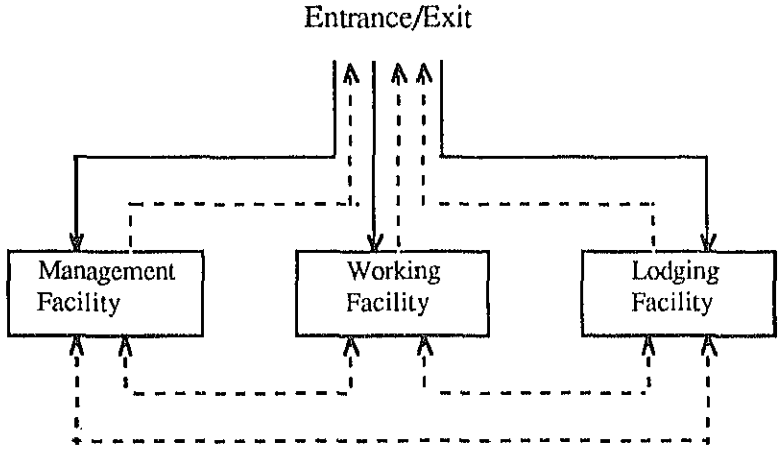
Electricity and telephone circuits are to be extended from the lines along the C 289 road. Water will be supplied from irrigation canal and treated. Sewage and wasted water will be treated within the site following the local practice since there exist no public facilities.

b) Layout plan

The following are taken into consideration for the layout planning:

- The layout is to be planned taking into account the functions of the facilities, which can be categorized into three, i.e., management, working and lodging.
- The buildings are to be laid out at an angle of 45 degrees to the road. The direction of the buildings is planned to avoid facing due west. All buildings should be so located as to minimize the traffic line.
- All the facilities should be located far from road in order to reduce entry of dust from road.
- Buildings will be constructed separately in due consideration of the function of buildings, allocation of machines and equipment, noise and dust. Their floor and height will be determined according to their functions.

The location and flow of the traffic line are shown below:



The layout plan is illustrated in Plate No. 601 in the attached Drawings.

c) Floor plan

Functions , floor areas and their calculation are given in the following table. Data and information below are referred to for the calculation.

- Japan Association of Building and Repairs, *Eizen Keikaku Yoran (Handbook for Building and Repairs Planning)* referred to as "HBRP"
- Japan Society of Architectural Engineering, *Kenchiku Sekkei Shiryou Shuusei (Collection of Materials for Architectural Design)* referred to as "CMAD"
- Japan Association of Research for Rural Improvement, *Nouson Seibi Handbook (Handbook for Rural Improvement)* referred to as "HRI"

Outlines of Pilot Farm Facilities

I. Management Building

I.1 Office Building (480.0 m^2)

Room	Floor Size (m^2)		No. of	Reference	Remarks
	Designed	*Required*	*Personnel*		
Manager's Room (1)	17.5	16.7	1	P.154 of HBRP for section chief of A-class local government	$3.7m^2$ x 4.5 = $16.7m^2$
Leader's Room (1)	17.5	16.7	1	- do -	- do -
Secretary's Room (1)	17.5	15.7	2	P.154 of HBRP for normal officer of A-class local government	$3.7m^2$ x 1.0 x 2 persons + waiting persons
Office (large, 1)	52.5	48.0	8	P.249 of Volume II of HRI medium of required floor of 5 - $7m^2$	
Office (small, 1)	70.0 (17.5x4)	74.0 (18.5x4)	2 x 4	P.154 of HBRP for assistant officer of A-class local government	$3.7m^2$ x 2.5 x 2 persons = $18.5m^2$
Lecturer's Room (1)	17.5	16.7	1	P.154 of HBRP for section chief of A-class local government	$3.7m^2$ x 4.5 = $16.7m^2$
Meeting Room (1)	52.5	50.0	25	P.155 of HBRP Office of more than 25 staffs requires $50m^2$	
Office Equipment Room (1)	17.5	16.7	2		Copying machine $5m^2$ + document space $4m^2$ + working desk $5m^2$ + common use space 15% = $16.1m^2$
Storage (2)	40.0	43.2		P.156 of HBRP 17% of Office floor	$253.9m^2$ x 17% = $43.2m^2$
Kettle Room (1)	12.5	13.0		P.156 of HBRP Office of more than $500m^2$ of effective floor size requires $13m^2$ of kettle room	
Lavatory (2)	35.0	35.0		P.158 of HBRP *Office of more than 25 staffs* requires $35m^2$ of lavatory	
Hall and Corridor	130.0				

I.2 Training Building (280 m^2 + breeze way 20 m^2)

Room	Floor Size (m^2)		No. of	Reference	Remarks
	Designed	Required	Personnel		
Training (1)	152.0	150.0	100	CMAD, standard for primary and secondary school: 1.2-1.6m^2/person	1.5m^2 x 100 = 150m^2
Lecturer's Anteroom (1)	14.0	12.0	2	P.249 of Volume II of HRI medium of required floor of 5 - 7m^2	6m^2 x 2 persons = 12.0m^2
Storage (1)	21.0	27.5		P.156 of 17% of Office floor	162m^2 x 17% = 27.5m^2
Lavatory (2)	35.0	35.0		P.158 of HBRP Office of more than 25 staffs requires 35m^2	Though the standard floor size of lavatory is 46m^2 for the office of more than 100 staffs, a floor size of 35 is set taking the frequency into account.
Corridor	58.0	-			
Connecting Corridor	20.0	-			

I.3 Laboratory Building (280 m^2 + breeze way 20 m^2)

Room	Floor Size (m^2)		No. of	Reference	Remarks
	Designed	Required	Personnel		
Water Management Lab	56.0		5		
Agricultural Machinery Lab	56.0		5		
Crop and Soil Science Lab	70.0		5		
Storage (3)	45.5	30.9		P.156 of 17% of Office floor	182m^2 x 17% = 30.9m^2
Corridor and Hall	52.5				
Connecting Corridor	20.0				

II. House for Lecturers (355.5 m^2)

Room	Floor Size (m^2)		No. of Personnel	Reference	Remarks
	Designed	Required			
Living Room (6)	94.5 (15.75x6)	96.0 (16x6)	6	P.209 of CMAD Volume 3 based on a standard size of twin room of business hotel	16m^2 x 6 rooms = 96m^2
Lavatory for Living Room (6)	27.0 (4.5x6)				4.5m^2 x 6 rooms = 27.0
Saloon (6)	63.0	60.0			5.0m^2/personx12persons
Dining Room (1)	42.0	36.0			3.0m^2/personx12persons
Kitchen (1)	21.0				
Storage (1)	15.8				
Lavatory (1)	7.0				
Corridor and Hall	85.2				

III. House for Experts (117.4 m^2 x 6 houses = 704m^2)

Room	Floor Size (m^2)		No. of Personnel	Reference	Remarks
	Designed	Required			
Living Room (1)	16.8		4	CMAD Volume 6	
Bedroom-A (1)	13.7		1		
Bedroom-B (1)	13.7		1		
Bedroom-C (1)	18.0		2		
Dining Room (1)	14.6		4		
Kitchen (1)	7.5				
Bathroom (1)	5.8				
Lavatory (1)	2.9				
Storage (1)	5.0				
Corridor (1)	19.4				

IV. Warehouse for Farm Inputs

1.	Inputs to be stored			
	- Fertilizers	600 kg/ha x 35 ha	21,000 kg	
	- Farm Chemicals	10 kg/ha x 35 ha	350 kg	
	- Paddy Seed	50 kg x 35 ha	1,750 kg	
	Sub-total		23,100 kg	
	- Sisal Bag	80 bags/ha x 35 ha	2,800 bags	
2.	Storing weight per m^3		0.6 tons	
3.	Average height of storing		2.5 m	
4.	Storing weight per m^2		1.5 tons/m^2	
5	Required floor size			
	- Fertilizer		14.0 m^2	
	- Farm Chemicals		0.2 m^2	
	- Paddy Seed		1.2 m^2	
	- Sisal Bag		11.2 m2	
	Sub-total		26.6 m^2	
	- Passage space and others (20% of total floor size)		6.7 m^2	
	Total		33.3 m^2	(required)
			35.0 m^2	(designed)

V. Storage for Farm Machinery

1.	Farm machinery be stored and required space		
	- Disc Plow	2.0 m x 1.0 m	2.0m^2
	- Chisel Plow	2.5 m x 1.5 m	3.8m^2
	- Disc Harrow	2.5 m x 1.5 m	3.8m^2
	- Rotavator	2.0 m x 1.0 m	2.0m^2
	- Cage Wheel	1.0 m x 1.0 m	1.0m^2
	- Broadcaster	1.5 m x 1.0 m	1.5m^2
	- Speed Sprayer	4.0 m x 3.0 m	12.0m^2
	- Rotary Cutter	2.0 m x 2.0 m	4.0m^2
	- Knapsack Sprayer	0.5 m x 0.5 m x 2	0.5m^2
	- Reaper	2.0 m x 2.0 m	4.0m^2
	Sub-total		34.6m^2
	- Passage space and others (30% of total floor size)		14.8m^2
	Total		49.4m^2

VI. Drying Yard

Area harvested	35 ha ..... (1)
Expected unit yield	6 tons/ha ..... (2)
Paddy production	210 tons ..... (3) = (1) x (2)
Working days for harvesting	30 days ..... (4)
Daily received paddy amount	7 tons/day ..... (5) = (3) ÷ (4)
Drying days	2.5 days ..... (6)
Apparent specific gravity of paddy	0.5 ..... (7)
Thickness of dried paddy	10 cm ..... (8)
Required unit area	50 m^2 ..... (9) = (1ton ÷(8)÷(7)) x (6)
Total floor area	350 m^2 (required) ..... (10) = (9) x (5)
	378 m^2 (designed)

i) Management Office (including facilities for training and research)

Among the typical floor plans for offices such as square type, double loaded corridor type, gallery type and cluster type, the double loaded corridor type was adopted since the office planned is of middle scale and the floor area should be effectively used. The total area including training and research facilities will be of relatively large. Every facility is to be designed in due consideration of its peculiarity to keep its independent function. All rooms will face outside for the sake of ventilation and daylighting.

ii) Warehouses

The warehouses will be used for storing farm inputs and farm machinery of the pilot farm. Partition will be installed according to the materials to be stored. Since the warehouse is of rather small size, the floor was designed to be of square shape. A doorway is to be provided for every division. The warehouse was planned to be located adjacent to the drying yard in order to use its eaves as a shed for drying yard.

iii) Lodging facilities

The houses for experts were designed in such a manner that every room faces outside for the sake of ventilation and daylighting. Bedroom, saloon, kitchen, bathroom, lavatory, etc. are to be provided in each house unit in order to make it possible to cater for all household necessities within a house unit. As for the lecturer's house, a lavatory and a bathroom will be attached to each bedroom. Common saloon and dining room are designed as space for communication. Every room will face outside in the same way as the expert's house.

d) Section plan

i) Management office

This facility will have a large floor area as a whole, but each of the office, training and laboratory buildings was designed at minimum scale. Since the purposes of these facilities are different, the buildings were designed as one storey house for ensuring their effective use.

Because these facilities will be aimed at the core management of the pilot farm, the most important factor is their functional aspect. Accordingly no special architectural arrangement was planned. For getting shade, long eaves were designed.

ii) Warehouses

The floor area and building height were determined taking into account the present conditions of the existing storage in MIS and the storage capacity requirements. Since it will be solely functional in use, no special architectural arrangement will be made except for window for ventilation and daylighting.

iii) Lodging facilities

Since these will be solely functional in use, no special architectural arrangement will be made. For getting shade, long eaves were designed.

(e) Material plan

Finishing schedule:	Floor	:	Concrete trowel finish
	Skirting	:	Cement mortar
	Walls	:	Emulsion paint on cement mortar
	Ceiling	:	Plywood
	Roof	:	Colored formed iron sheet
	Fittings	:	Wood, aluminium, steel

Road pavement: Laterite pavement will be applied from the standpoint of cost saving

(f) Structural design

For buildings such as office and lodges, the reinforced concrete block structures will be used as they are prevailing locally. For foundations and columns, the reinforced concrete will be used. For walls, the concrete blocks will be used. The roof truss will be of timber.

The design criteria are as mentioned in Section 5.4.3.

(g) Building facility plan

Electric system:

- Power characteristics : 3-phase, 4 wires, 230/200 V, 50 Hz
- Power supply : 11,000 V distributed from transmission line along the C 289 road
- Power receiving : Transformer 11,000 V / 400 V
- Distribution line : Overhead line system
- Electrical facilities
  - Motor power supply : Workshop
  - Indoor lighting : Fluorescent or incandescent lamps as required
  - Electric outlets : As required
  - Duct for telephone line : As required
  - Outdoor lighting : Fluorescent lamps

Plumbing system:

- Water supply to site : Irrigation canal
- Water supply system : Gravity supply from an elevated water tank
- Water treatment : Filtering
- Waste drainage : Disposed of in a soakway

Gas Supply system:

- Propane

Air conditioning and ventilation system:

- Air conditioning : None since the local climate is rather mild with air temperature ranging between 20 °C and 25 °C throughout the year
- Ventilation : None. With simple ventilators on the walls, ventilation will be facilitated for workshop and warehouses.

(3) Equipment plan

1) Basic concept

The equipment to be provided will include that for workshop, for experimental purposes, and for meteorological observation.

The equipment for workshop will be selected based on minimum requirement for daily maintenance only for farm machinery and vehicles of the pilot farm.

The farm machinery will be provided for both the farm operation and the experiment, i.e. the same machinery for the main fields of MIS and the machinery for experiment on their future introduction.

2) List of the equipment

The equipment to be provided is listed in the following table. The spare parts will also be provided at an amount of 10 % of the total procurement cost of the equipment.

List of Equipment for Pilot Farm

	Items	Requirement	Specification	Objectives
1.	Farm Machinery			
(1)	Tractor	1	60 HP, 4 WD	Same model to be used in the MIS main fields. Using as main power of plow, harrow and rotavator, the optimum land preparation method will be analyzed including land preparation under dry soil conditions. Besides, tractor will be used as main power for spraying and transportation.
(2)	Crawler	1	65 HP, with bucket	In order to avoid the bogging down problem, the introduction of crawler tractor has been conceived. However, its price is almost twice as much as that of wheel tractor. Therefore, the cost performance of crawler should be carefully examined in comparison with wheel tractors. In addition, the drainage improvement will be analyzed by using sub-soilers which will be drawn by crawler.
(3)	Tiller	1	10.5 HP, with rotary	In small parcels prepared for experiment, tiller with rotary harrow will be used for land preparation and other purposes.
(4)	Disc-plough	1	6" x 3 discs	For experiment of land preparation method under dry soil conditions, disc-plough will be used.
(5)	Chisel plough	1	200 cm wide	As alternative of disc-plough, chisel plough will be applied in view of the advantageous effect of less undulation of topsoil after ploughing.
(6)	Disc-harrow	1	20" x 24 discs	For experiment of land preparation method under dry soil conditions, disc-plough will be used.
(7)	Rotavator	1	200 cm wide	For puddling, rotavator will be provided as an attachment of tractor.
(8)	Paddy harrow	1	360 cm wide	Attachment of crawler for puddling
(9)	Cage wheel	1		For prevention of bogging-down, cage wheels will be provided.
(10)	Float strake	1		As an alternative of cage wheel, float strake which is characterized by its easy handling, will be provided.
(11)	Broadcaster	1	480 l capa.	For mechanical fertilization, the trial of broadcaster will be carried out
(12)	Speed sprayer	1	500 l capa 100 m long pipe	Emulsion of liquid type chemicals will be applied by speed sprayer.
(13)	Power duster	1	60 l capa.	Granular type chemicals will be applied by power duster.
(14)	Knapsack sprayer	1	manual, 15 l	Same model as used in the MIS main fields
(15)	Rotary cutter	1	150 cm wide	Stubbles left and infested weeds after harvesting will be cleared before land preparation by using rotary cutter.
(16)	Trailer	1	5 tons	For transportation of farm inputs and products, trailer is required.
(17)	Reaper	1		As the simplest mechanical harvesting practice, the adaptability of reaper will be examined.
(18)	Subsoiler	1		For drainage improvement in heavy soils, the supplemental internal drainage practices are often carried out by using subsoiler. The possibility of application of subsoiler will be examined.

	Items	Requirement	Specification	Objectives
2.	Meteorological Observation Instrument			
(1)	Recording raingauge	1	Tipping bucket type	For measuring the rainfall\
(2)	Hydro-thermograph	1		For recording air temperature and relative humidity
(3)	Anemometer	1		For recording wind direction and velocity
(4)	Evaporation pan	1	Class A	For measuring evaporation
(5)	Bimetallic sunshine gauge	1		For recording sunshine hours
(6)	Actinograph	1	Robitzsch type	For recording solar radiation
(7)	Wet & dry bulb Thermometer	1	Bar type	For measuring relative humidity with check for item (2)
(8)	Max. & min. thermometer	1	Double tube type	For measuring daily max. and min. temperature with check for item (3)
(9)	Weather instrument shelter	1		For keeping items (2), (7) and (8)
(10)	Steel pole	1		For setting items (2) and (5)
(11)	Fitting flange	1		Part of item (10)
(12)	Fitting arm	1		Part of item (10)
3.	Equipment and Tools for Workshop			
(1)	Lubrication	1 set	grease pump, oil bucket pump, drum pump, drum carrier, drum opener, etc.	
(2)	Engine	1 set	tool set for diesel engine, tool set for gasoline engine, spark plug cleaner and tester, etc.	
(3)	General services	1 set	chain block (15 tons), hydraulic jack (10.15 tons), generator (2 kVA), etc.	
(4)	Battery and electric shop	1 set	battery charger, circuit tester, tune-up tester, etc.	
(5)	Body and painting	1 set	arc welder, gas welder, etc.	
(6)	Tool room	1 set	electric drill, grinder, etc.	
(7)	Inspection	1 set	hydraulic tester, auto megger, etc.	
(8)	Air compressor	1 set	air compressor 2.2 kW	
4.	Office Equipment			
1)	Copy machine	1	max. A3 size	
(2)	Facsimile	1	max. B4 size	

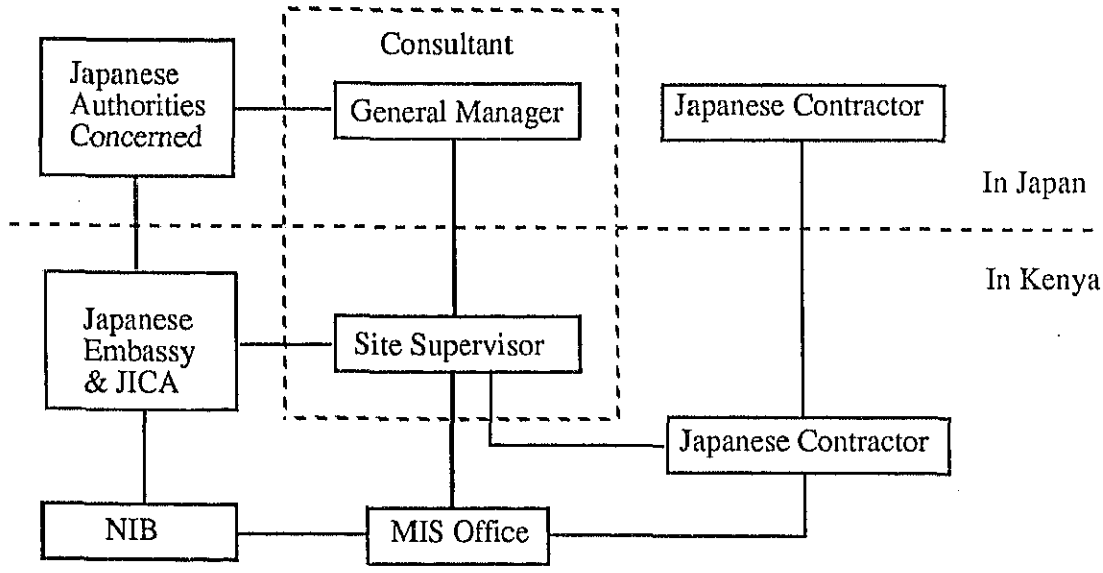
5.6 Execution of the Project

5.6.1 *Organization for Project Execution*

The National Irrigation Board (NIB), under the Ministry of Regional Development, Government of the Republic of Kenya, will become the executing agency of the Project. NIB will be authorized to execute the following work items for construction of the Project.

a) Execution of all construction works,
b) Execution of contracts for consultancy services and construction works,
c) Approval of design,
d) Tendering and evaluation of tenders,
e) Approval of all payments,
f) Management of all contracts,
g) Acceptance of completed works, and
h) Liaison and coordination with other government agencies.

The representative of the Government will be the General Manager of NIB. For the successful implementation of the Project, the Mwea Irrigation Settlement Scheme Office (MIS Office) under NIB will be the actual executing organization during the implementation period and will be in charge of operation/maintenance works after completion of the construction works. The overall organization for the project execution is outlined below.



5.6.2 Scope of Work

The scope of the Mwea Irrigation Settlement Scheme Development Project to be covered by the Japanese Grant Aid Program is shown below.

a) New construction and rehabilitation works of irrigation and drainage facilities and road development for the project area of 5,860 ha,
b) Construction of irrigation and drainage facilities and buildings for the Pilot Farm covering an area of 35 ha, and supply of experimental equipment and tools,
c) Construction of a machine center and supply of necessary equipment and tools,
d) Supply of O/M equipment for irrigation and drainage facilities, and
e) Supply of agricultural machinery

On the other hand, the major works to be undertaken by the Government of the Republic of Kenya will be as follows:

a) To furnish data, drawings and documents necessary for the detailed design,
b) To secure the land for access roads, construction site, borrow pits and spoil bank required for the construction of irrigation and drainage facilities, pilot farm, machine center,
d) To clear and reclaim the land for the pilot farm buildings and machine center,
e) To provide and maintain the security facilities such as surrounding fence,etc. for the pilot farm buildings,
d) To install the electric distribution lines and water supply systems to the pilot farm buildings and machine center,
e) To excavate and reshape the irrigation and drainage canals which will not be included in the Japanese Grant Aid,
f) To bear commissions for the banking services based on the Banking Arrangement,
g) To ensure the prompt unloading, tax exemption and custom clearance at the port of disembarkation in Kenya of the equipment, materials, tools and vehicles required for the Project construction.
h) To ensure the tax exemption for the consultant and contractor to be engaged in the Project execution,
i) To issue visa, traffic certificates and others necessary for execution of the Project to the consultant and contractor,
j) To ensure the payments under the contracts to the consultant and contractor,
k) To bear the expenses to be required for proper and effective maintenance and utilization of the facilities and equipment after completion of the Project, and