THE REPUBLIC OF KENYA

MINISTRY OF HIGHER EDUCATION

BASIC DESIGN STUDY REPORT ON THE IMPROVEMENT PROJECT OF THE PILOT FARM OF JOMO KENYATTA COLLEGE OF AGRICULTURE AND TECHNOLOGY

SEPTEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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PREFACE

In response to the request of the Government of the Republic of Kenya, the Government of Japan decided to conduct a basic design study on the Improvement Project of the Pilot Farm in Jomo Kenyatta College of Agriculture and Technology and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to Kenya a study team headed by Kazuo SHIMAMURA, Professor of the Faculty of Agriculture, Okayama University from May 22 to June 20, 1983.

The team had discussions with the officials concerned of the Government of Kenya and conducted a study necessary for basic design of the Project.

After the team returned to Japan, further studies were made 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 deep appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

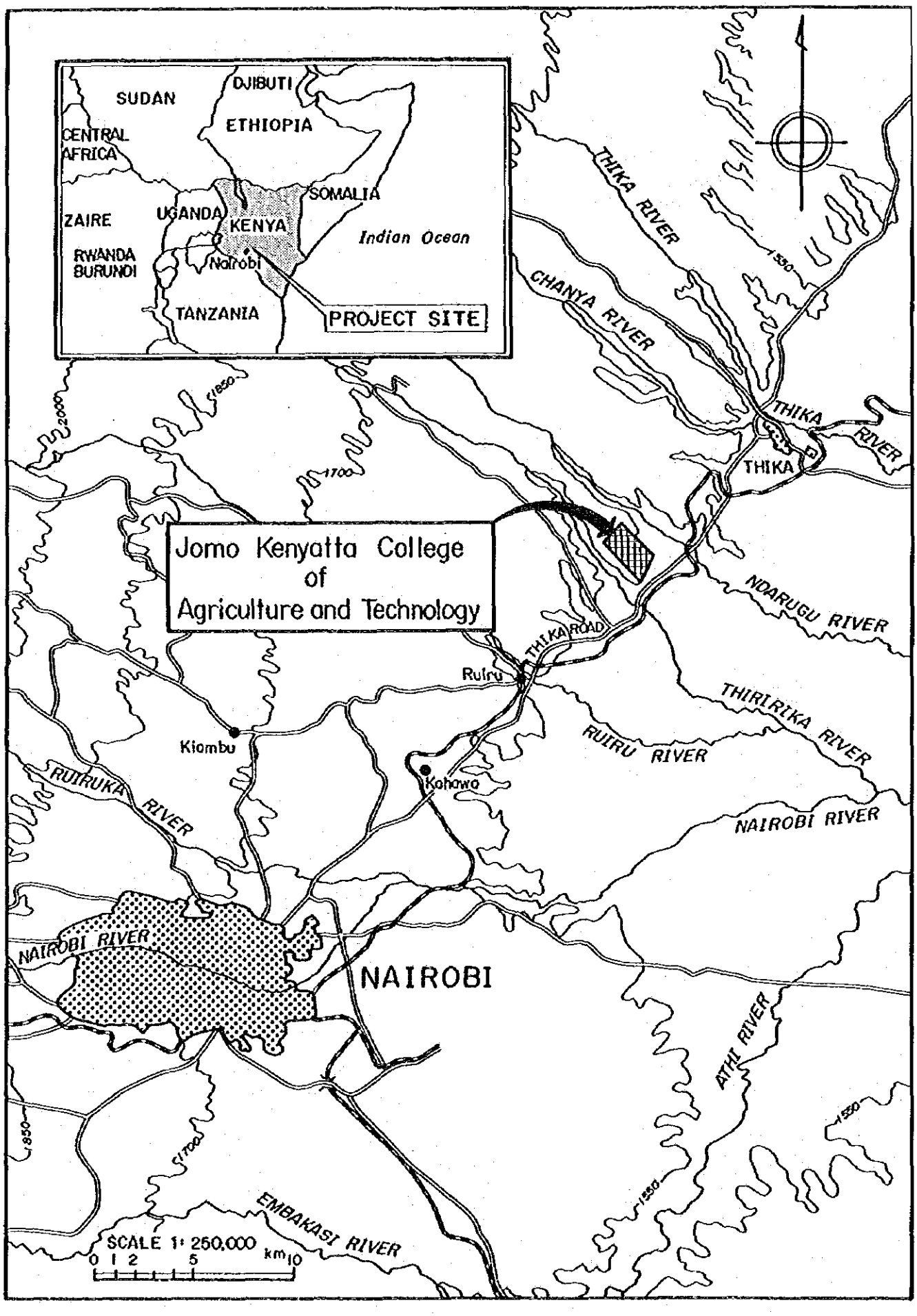
September 1983

Keisuke Arita
President
Japan International Cooperation Agency

Proposed Site of the Pilot Farm

Ndarugu River and Intake Site

LOCATION MAP



ABBREVIATIONS

Length

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer

Area

m^2	:	square meter
km^2	:	square kilometer
ha	:	hectare

Volume

mℓ	:	milliliter
ℓ	:	liter
m^3	:	cubic meter

Weight

g	:	gram
kg	:	kilogram
ton (t)	:	ton

Time

sec (s)	:	second
min.	:	minute
hr	:	hour

Other measures

%	:	percent
HP	:	horsepower
°C	:	centigrade
mm/hr	:	millimeter per hour
mm/day	:	millimeter per day
mm/month	:	millimeter per month
m/sec	:	meter per second
m^3/sec	:	cubic meter per second
m^3/ha	:	cubic meter per hectare
m^3/day	:	cubic meter per day
m^3/min	:	cubic meter per minute
ℓ/sec	:	liter per second
ℓ/sec/ha	:	liter per second per hectare
t/ha	:	ton per hectare
m.d.	:	man day
r.p.m.	:	revolutions per minutes
p.a.	:	per annum
kW	:	Kilowatt
Hz	:	Hertz
V	:	Voltage
El.	:	Elevation above mean sea level

Currency

K. Sh.	:	Kenya Shilling
K. £	:	Kenya Pound
US$	:	US Dollar
¥	:	Japanese Yen
K.£ 1.0	=	K. Sh. 20.0
US$1.0	=	K. Sh. 12.0
K. Sh. 1.0	=	¥20.0

Others

JKCAT	:	Jomo Kenyatta College of Agriculture and Technology
GDP	:	Gross Domestic Product
FAO	:	Food and Agriculture Organization of the United Nations
USDA	:	United States Department of Agriculture
JICA	:	Japan International Cooperation Agency

SUMMARY

The Government of the Republic of Kenya has been putting special emphasis on intensification of technical education necessary for the national development. The Government of Kenya requested the Government of Japan the financial assistance as to establishment of Jomo Kenyatta College of Agriculture and Technology, which is one of the high educational institutions for training engineers and technicians in the fields of agriculture and industry. In response to the request, the Japanese Government provided the grant aid for the construction of necessary buildings including supply of various equipment. The construction works were started in 1978 and completed in 1981. In addition, the Japanese Government has been providing the Kenyan Government with a technical cooperation for five years since 1980. In 1983, the College has about 600 students under the Kenyan staffs, and the Japanese experts and volunteers despatched under the technical cooperation.

As far as the agricultural education in the College is concerned, it is essential to establish a pilot farm for the purposes of the experiments on crops and the practical training of students. The Government of Kenya has recognized the importance of the establishment of a pilot farm since the opening of the College, and has set up a farm with an area of about 25 ha in the College campus. However, the farm is not functioning well as the pilot farm because no infrastructural facilities are provided due mainly to the financial problems and, therefore, cultivation of crops is made rather extensively under the rainfed conditions.

Under these circumstances, the Government of Kenya has requested the Japanese Government the financial assistance under the grant aid for the improvement of the Pilot Farm in the College. In response, the Japanese Government has

despatched to Kenya the Basic Design Study Team during the period from May 22 to June 20, 1983. The team has carried out a field investigation for preparing the basic design of the Pilot Farm.

The object of the project is to improve the Pilot Farm which will serve for (1) experiments and practices required in curricula, (2) supply of materials necessary for experiments and practice to be carried out in the class rooms and (3) fundamental research to develop necessary techniques for agricultural development.

The Jomo Kenyatta College has a land of 144 ha in its northwestern part. The Pilot Farm is proposed to be sited in the central part of the land and have a net area of 20 ha. The site selection was made taking into consideration the following factors: (1) the land shows typical characteristics from the pedologic and topographic viewpoints, (2) it is easy to develop the adjacent lands in future, (3) it is possible to drain the excess water from the Pilot Farm, (4) it is easy of access from and to the College buildings, (5) farm operation has no bad influence on the existing facilities and classes and (6) the proposed size of the farm is considered sufficient for the execution of the training activities envisaged at present by the College.

The proposed Pilot Farm has the rectangular shape (800 m x 250 m wide), which will be divided into five irrigation blocks, each with a dimension of 250 m x 160 m. Under the project, the soil dressing will be made in one irrigation block so that the intensive cropping will be possible in that block. As to the remaining four blocks, subsoil ploughing will be carried out to loose the compact subsoil, and stones which disturb operation of farm machinery will be removed away.

Irrigation water for the Pilot Farm will be pumped up from the Ndarugu river running in the east side of the College and conveyed to a storage pond. For the distribution of the irrigation water to farm lands, a booster pumping station will be provided at the storage pond, pipelines will be constructed between the booster pumping station and the farm lands, and application of irrigation water to the farm lands will be made principally with sprinklers.

The drainage system for the Pilot Farm will consist of main, collector and catch drains. The main and collector drains will serve for the drainage of farm lands, while the catch drain will intercept runoff due to rainfall from the outside of the farm. The drainage water is planned to be evacuated to the existing open ditch. The proposed road network consists of main, connecting and farm roads, and a perimeter road. The main roads will run along the boundary of the Pilot Farm. The farm roads will branch off from the main roads and will be provided perpendicularly to the main roads. The perimeter road will be constructed along the proposed catch drain and connected to the main roads through the connecting roads. Supply of potable water will be made by use of two boreholes to be constructed in the College area.

The buildings to be constructed under the project will consist of a farm management building, a workshop, a warehouse and two farm huts. The buildings except farm huts will be built in a compound located southeast of the Pilot Farm and the farm huts will be constructed beside the Pilot Farm.

Ministry of Higher Education including the College will be given the function of an executing body for the project and the project implementation committee will be established to smoothly implement the project. After the implementation, the project will be transferred to the existing organization formed in the College. For taking charge of all the works

related to the operation and maintenance of the Pilot Farm, it is required to strengthen the collaboration between the staff of the Farm Section and respective chief of other sections of the Faculty of Agriculture.

The implementation of the project is expected to have the following major effects: (1) with the establishment of irrigation and drainage systems and a road network, the Pilot Farm can be irrigated throughout a year and a flexible farm operation will be secured, (2) practical education will be intensified through the implementation of the project, (3) the project will contribute to the regional development through the improvement of farming techniques and the extension of such improved techniques, (4) the project will make more effective the technical cooperation which is carried out by the Japanese experts and volunteers.

Taking into consideration the mentioned above, it is recommended to implement the project as early as possible.

The principal features of the facilities to be implemented under the project are as summarized below:

Principal Features of the Project

I. Irrigation and drainage systems and the farm

1.	Pumping station:	floor area	40 m^2
		pump and motor	3 sets
		discharge pipeline	1.4 km
2.	Storage pond:		82,000 m^3
3.	Booster pumping station:	floor area	40 m^2
		pump and motor	3 sets
		pressure tank	18 m^3
		pipeline	4.2 km

4.	Drains:	catch drain	3,970 m
		main drain	2,350 m
		collector drain	2,270 m
		related structures	30 Nos.
5.	Farm roads:	perimeter road	5,630 m
		main road	2,500 m
		connecting road	1,560 m
		farm road	1,000 m
6.	Farm:	net area	20 ha
7.	Farm pond:		7,700 m^3

II. Building and related facilities

1.	Farm management building:	800 m^2
2.	Workshop:	300 m^2
3.	Warehouse:	200 m^2
4.	Farm hut (2 Nos.):	100 m^2
5.	Related facilities:	1 set
6.	Boreholes:	2 Nos.

III. Farm machinery and equipment

1.	Farm machinery for maintenance:	1 set
2.	Machinery and equipment for operation:	1 set

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1. INTRODUCTION

The Government of the Republic of Kenya decided to establish the Jomo Kenyatta College of Agriculture and Technology ("the College") in order to train engineers necessary for the national development, and requested the Japanese Government the technical and financial assistance for establishment of the said College. In response to the request, the Japanese Government provided the Grant Aid for the construction of necessary buildings including supply of various teaching equipment. The construction works were started in 1978 and completed in 1981. In addition, the Japanese Government, since 1980, has been providing the Kenyan Government with a technical assistance by despatching experts and volunteers to the College to assist and advise it in various educational activities.

For further effective operation of the College, the Kenyan Government has planned to improve a demonstrational and experimental farm in the College ("the Pilot Farm"), and has requested the Japanese Government the financial assistance for this purpose. In response to the request, Japan International Cooperation Agency, the executing agency of the Government of Japan, has despatched to Kenya the Basic Design Study Team headed by Professor K. Shimamura during the period from May 22 to June 20, 1983. The team has carried out various investigations and studies at the site for the preparation of the basic design of the Pilot Farm.

The works performed by the team are divided into the field investigations in Kenya and the study and design works in Japan. The detailed items and programme of those works are given in Annex 1.

2. BACKGROUND

2-1 General

The land of the Republic of Kenya extends from 4°N to 4°S latitude and from 34°E to 42°E longitude. Kenya comprises a total area of about 582,650 km^2 including lakes and rivers. It borders to the east on Somalia, to the north on Ethiopia and Sudan, to the west on Uganda and to the south on Tanzania. The capital of the country is Nairobi.

Kenya has an estimated population of about 15.9 million in 1980, and the population density is 28.9 persons/km^2. The growth rate of the population was 3.9%/year during the period from 1970 to 1980. Out of the total population, about 85% lives in rural areas, and is dependent directly or indirectly on agriculture. The population in urban areas is only 15% of the total population, but it rapidly increases at an average of about 5%/year. Especially, the population in two big cities i.e. Nairobi and Monbasa has an extremely high growth rate of 7%/year. This rapid growth is ascribed to migration of people from rural areas.

Since independence in 1963, Kenya's political freedom and economic stability have been well established. GDP during the 1964 - 1973 period grew at 6.6%/annum and during 1970 - 1979, despite the oil crisis, it grew at 5.1%. But subsequently it declined to 2.4%/annum in 1980 for a direct reason of a strong adverse movement in its international trade as the results of petroleum price increase and rapidly declining coffee prices. Per-capita GDP is about US$378 in 1980.

The Kenya's economy is mostly dependent on the agricultural sector. Farm production and related activities account for about 34% of GDP, over 70% of labor force and about 60% of export earnings. The Kenya's labor force in 1980 is numbered slightly less than 7 million, out of which one million or 14% are in modern sector wage employment and the remaining 6 million or 86% in nonwage employment, mostly in agriculture. For the last decade, the Kenya's external trade has become increasingly dependent on the agricultural export. The major items of the agricultural export are coffee and tea, the share of which in the total export rapidly increased from 34% in 1970 to 51% in 1978.

In 1979, Kenya launched an ambitious Fourth National Development Plan (1979 - 83). The Development Plan emphasizes the alleviation of poverty throughout the nation by means of the development and intensification of; (1) agriculture; (2) manufacturing; (3) education; (4) infrastructure and (5) national defence. The Plan placed strong emphasis on agriculture for the following reasons:

(1) Over 85 per cent of the nation's population lives in rural areas,

(2) The rapidly growing urban sector depends on food supplies and raw materials produced by agriculture, and

(3) Industrial development depends on the growth of purchasing power in rural areas.

Agricultural objectives were designed to reach through improvement of agricultural land and its related infrastructures, and supply of trained agricultural manpower. The former comprises: (1) intensive use of high potential lands; (2) development of swampy areas and valley bottoms; (3) land use in arid and semi-arid areas and (4) effective utilization of related infrastructures. The latter includes:

(1) expansion of training centers for giving agricultural techniques to the farmers; (2) expansion and establishment of agricultural institutes and colleges for training agricultural technicians and (3) introduction of new courses in Faculty of Agriculture at the University of Nairobi for increasing skilled agricultural engineers. Total number of enrollees at the above training institutes was anticipated to increase.

The manufacturing sector ranks second in importance after agriculture in Kenya's economy, both in terms of employment and contribution to GDP. The Plan placed special emphasis on intensifying agro- and mineral-resources based industries and developing small scale industries in the rural areas.

2-2 Jomo Kenyatta College of Agriculture and Technology

For the promotion of agricultural development, the Government recognized an acute shortage of trained agricultural manpower at all levels, and a number of steps have been taken to improve the quality and size of agricultural education programmes and facilities such as the Farmers Training Center Programme, expanding of existing Institute of Agriculture, and new course setting in the Faculty of Agriculture at the University of Nairobi, etc. The establishment of the Jomo Kenyatta College of Agriculture and Technology was conceived as one of these facilities to reinforce a substantial expansion of technical education.

However, the expansion and establishment of those institutions was hampered by shortage of available funds. In order to surmount this difficulty, the Government of Kenya requested the Japanese Government the financial and technical assistance for the establishment of the Jomo Kenyatta College of Agriculture and Technology ("the College").

In response to the request, the Japanese Government provided the Grant Aid for the construction of necessary buildings including supply of various teaching equipment. The construction of the College facilities was made in three years, lasting from 1978 to 1981, and the College started taking students from May 1981. In March 1982 an official opening ceremony was held in a honourable participation of the President Daniel T. arap Moi in the presence of officials from both Japanese and Kenyan Governments.

Since 1980, the Japanese Government has been providing the Kenyan Government with a technical cooperation by despatching experts and volunteers to the College to assist and advise it in various educational activities.

The aims and objectives of the studies offered in the College are oriented to the following points:

(1) To provide young Kenyans with technical skills and abilities necessary in making them useful citizens,

(2) To prepare young Kenyans for productive employment of self-employment, especially in the rural areas,

(3) To train young Kenyans to fill the manpower gaps and to ensure rapid development of the national economy, and

(4) To re-orientate the attitude of youth in Kenya towards productive activities.

To accomplish the above purposes, the College has two faculties, i.e. agriculture and engineering. The faculty of agriculture consists of three departments of horticulture, agricultural engineering and food processing, and a farm for experiment and training covering about 144 ha of land. The faculty of engineering includes three departments of mechanical engineering, civil and architectural engineering, and electrical engineering.

The details of the courses and organization of the College are shown in Fig. 2-1.

The College was designed to have 120 training staff, about 700 students and 150 administrative staff. In 1983, it has about 600 students, 75 Kenyan training staff and about 30 Japanese experts and volunteers. The Board of Governors as shown in Table 2-1 was established as the final decision making body responsible to the Minister of Higher Education for the administration and control of the institution.

According to the result of national examination carried out in late 1982, the students of this College showed a good examination result.

2-3 Characteristics of the Faculty of Agriculture of Jomo Kenyatta College

As mentioned above, the Jomo Kenyatta College of Agriculture and Technology was established as one of high educational institutions for training engineers and technicians necessary for the national development. Kenya already has the Faculty of Agriculture in the Nairobi University and the Egerton College besides the Jomo Kenyatta College. These three institutions have different characteristics and are expected to coordinate and complement each other in order to promote the agricultural development in Kenya.

The Faculty of Agriculture of the Nairobi University was established as the highest institution for professional education. It has about 170 students and offers education, placing emphasis on basic researches rather than practical training. The Faculty has a 200 ha tuition farm at Lower Kabete, the northwestern part of Nairobi City. Out of the 200 ha, 110 ha is used for crop cultivation such as coffee (53 ha), banana and other fruits (50 ha), vegetables (5 ha), exhibition plot for collected plants and crops (2 ha). The management staff of the farm consists of one farm manager,

6 technicians, 15 mechanics and other artisans. This tuition farm is utilized mainly for research works by professors and students of the Faculty.

The Egerton College is located at the high potential agricultural area with over 2,000 m of altitude. Taking advantage of such a favourable location, the College educates technicians in a large scale farming of food crop production and dairy, using a 400 ha exhibition farm and 1,100 ha commercial farm. It has about 700 students at present.

The Faculty of Agriculture of the Jomo Kenyatta College is equivalent to the Egerton College to such an extent that it educates technicians for Diploma and Higher Diploma levels. This Faculty sets importance on schooling of fundamental theories, practical experiments and researches, and practical training. The College is located nearer to Nairobi and at lower altitude than the Egerton College. To cope with such a locality, this Faculty comprises three departments, i.e. Horticulture, Food Process and Agricultural Engineering, each providing the following courses:

- Horticultural Department

  Essential Nutrition, Power & Machinery, Soil Fertilizer, Principal Crop Production, Plant Morcytology, Market and Price, etc.

- Food Process Department

  Physics, Elementary Food Science, Analytical Chemistry, Math, Biology, General Study, Food Process Practice.

- Agricultural Engineering Department

  Survey, Drawing, Fluid Mechanics, Farm Power and Machinery, General Study.

2-4 Background of Improvement of the Pilot Farm

Since the establishment of the College, the Kenyan Government has recognized the importance and urgency of the improvement of the Pilot Farm. However, due mainly to the financial problem, the construction plan of the Pilot Farm has not been realized, and this has adversely affected the operation of the College. Further, the lack of the Pilot Farm has hindered the technical cooperation programme which has been executed by Japanese experts and volunteers.

The syllabus of the Faculty of Agriculture comprises about 130 subjects in total, of which 40 subjects will require practices in the Pilot Farm as summarized below.

	1st Year	2nd Year	3rd Year	Total
I. Agr. Engin. Dept.				
1. Total No. of Subjects	16	16	15	47
Total Hour	920	900	720	2,540
2. No. of Subjects Relating to the Farm	2	4	10	16
Total Hour	120	260	540	920
II. Horticulture Dept.				
1. Total No. of Subjects	19	18	16	53
Total Hour	920	920	610	2,450
2. No. of Subjects Relating to the Farm	7	9	5	21
Total Hour	420	640	340	1,400

Source: Syllabi for the Faculty of Agriculture, March 1983, JKCAT.

Demonstration Farm Report IV, March 1983, JKCAT.

Further, many subjects in the Department of Food Processing require practices and experiments on the farm products to be obtained in the Pilot Farm.

The Faculty of Agriculture presently has students of up to the graduating class (3rd year class), and the experiments and practical training included in the above-mentioned syllabus are partly being carried out mainly by means of visiting existing national institutions such as the Coffee Research Institute, Thika Horticulture, etc., but the results are not satisfactory due to the limited time of practices and the insufficient facilities of the institutions.

Under these circumstances, the Kenyan Government has requested the Japanese Government the financial assistance for the early improvement of the Pilot Farm in the College.

3. THE PROJECT

3-1 Project Area

(1) Location of the College

The College is located at Juja Division in Kiambu District of Central Province, about 40 km northeast of Nairobi on the Nairobi-Thika Highway. The altitude of this area is about 1,550 m.

The College is situated on the lower slope which extends from the Aberdare mountains to the Yatta Plateau. The land use on the slope is broadly classified into three categories; the higher part with an altitude between 1,600 and 2,200 m adjacent to the forest near the top of the mountain slope is densely populated and labour intensive agriculture is prevailing owing to favourable conditions of rainfall and soils. Further down slope extending between 1,500 and 1,700 m in altitude has a low density of population and is mainly used as coffee plantations. The slope lower than the coffee plantation area is mainly used as sisal plantations due to unfavourable rainfall and poor soil conditions. The College is located on an abandoned sisal plantation farm which is located at the transitional area to the coffee plantation area.

The College area has an acrage of 205 ha and extends from northeast to southwest. The farm area occupies the northwestern part of the College area and has an approximate area of 144 ha.

(2) Soils

According to the soil studies made by the Kenyan Soil Survey and the subsequent field investigations carried out by the Basic Design Team, the soils in the farm area are in general shallow to moderately deep, friable and well drained with gravelly sandy clay to clay texture. Most of them are underlain by petroplinthite (indurated murram) or pisoferric

material (loose murram) at the depth ranging from 10 to 80 cm, and such petroplinthite are spodically exposed. Out of the total area of 144 ha, about 75 ha would be usable for the economical cultivation of various crops with some soil improvement.

The detailed description on soils are given in Annex 3.

(3) Climate

The Juja area is situated in a transitional climatic zone between the high rainfall and the low rainfall area. The climate of this area is characterized by relatively constant air temperature throughout a year and bimodal distribution of rainfall with the primary peak in April and the secondary one in November. There is a dry period of about 4 months from June to October and a relatively shorter one from December to February. The annual rainfall in this area is averaged at about 900 mm, and more than 80% of the annual rainfall occurs in the wet seasons. There are no great variations in temperature, March is the hottest month with 28.2°C of mean monthly maximum, and the coldest month is August with 12.5°C of mean monthly minimum temperature. The monthly mean temperature ranges from 20.6°C of March to 17.8°C of July. The details of meteorological data are shown in Fig. 3-1.

3-2 Project Concepts

3-2-1 Functions of the Pilot Farm

The Pilot Farm is essential for the effective operation of the College, especially to achieve objectives of the faculty of agriculture which conducts education and training on agriculture. In detail, the Pilot Farm will serve for the following:

(1) Experiments and practices required for curricula. The number of subjects that require the practical training in the farm are about 40 in the faculty of agriculture and 20 in the faculty of engineering. These subjects are listed in Table 3-1,

(2) Research to develop necessary techniques for the agricultural development, especially practical research such as farming systems, selection of suitable crops and varieties, etc. suitable for arid and semi-arid zones. And basic research for the technical improvement, such as plant pathology, plant protection, plant nutrition, irrigation, drainage, etc.,

(3) Supply of materials necessary for experiments and practice to be carried out in the College. Many dubjects require experiment materials. For the experiment of food processing, a considerable amount of vegetables, food grains, fruits and dairy products are needed, and

(4) Demonstration of farming activities to farmers and technicians, which may contribute to the Kenyan agricultural development.

3-2-2 Proposed farm development plan

The Jomo Kenyatta College has a land of 144 ha in its northwestern part, and a farm with an area of about 25 ha has been established in the central part of the land for cultivation of maize, beans, potatoes, etc. However, the farm is not functioning well as the Pilot Farm, because i) the cultivation is made rather extensively under the rainfed conditions without any infrastructural facilities, ii) no soil improvement is made despite of the poor chemical and physical properties of the soils, and iii) the present organization is not effective for the farm management, being

insufficiently staffed as shown in Table 3-2. Taking into account these constraints, it is proposed to set up the Pilot Farm as mentioned hereinafter.

The soil survey revealed that, out of the total area of 144 ha, about 75 ha would be suitable for the economical cultivation of various crops with some improvement, whilst the remaining area would be usable only for pasture, wind-break, tractor training yard, etc. Accordingly, the proposed Pilot Farm are to be located in the said 75 ha area.

It is proposed to develop the Pilot Farm stagewise. At the initial stage, the Pilot Farm is proposed to have a net area of 20 ha. This proposed size of the farm is considered sufficient for the execution of the envisaged training and research activities in the College, due reference being made to the size of the below-mentioned tuition farms of Universities in Japan which have similar purposes and function as for the Pilot Farm.

Name of University	Gross Area of Farm (ha)	Net Area/1 (ha)	Road and Others (ha)
University of Tokyo	27.4	19.9	7.5
Tokyo University of Agriculture	32.5	20.2	12.3
Tsukuba University	51.0	20.1	30.9

Remarks: /1 = The net area includes the areas such as grass house, mist house, etc., but excludes experimental plantation of forestry.

The infrastructural facilities, equipment and others necessary for the improvement of the Pilot Farm are as listed below.

(1) Irrigation and drainage systems.

(2) Farm road network for effective and safety operation of the farm.

(3) Water supply system for daily use for cattles and etc.

(4) Buildings necessary for farm management, warehouse, workshop and etc.

(5) Equipment and machinery for routine operation work and training.

(6) Strengthening of the farm management organization.

(7) Soil improvement for intensive land use with crop cultivation.

The detailed plan and design on the above items are described hereinafter.

3-3 Irrigation and Drainage Plan

3-3-1 Water Sources

The Pilot Farm is located on a plateau extending between the Ndarugu and the Thiririka rivers. Gaging stations operated near the Pilot Farm are 3CB5 for the Ndarugu river and 3BD5 for the Thiririka river. 3CB5 is located about 15 km downstream of Juja city and water levels have been observed since 1957. 3BD5 for the Thiririka river is situated about 5 km downstream of the above city and observation of water level was commenced in 1956. Collected data on discharges of the two rivers indicate that the Thiririka river sometimes dries up during the dry season, while the Ndarugu river has a perennial flow. Furthermore, the water of the Thiririka river is being taken by the existing eighteen pumping stations with a total amount of 66 ℓ/sec and there will be little opportunity for the College to obtain a new water abstraction right in the Thiririka river. Taking into consideration these conditions, the irrigation water for the Pilot Farm is planned to be supplied from the Ndarugu river.

The Ndarugu river originates in the Kinangop plateau located in the northwest of the Jomo Kenyatta College. The river runs southeastward for a distance of about 50 km in the valley developing on the slopes of Mt. Aberdare and after passing near the College, it crosses the Thika road. The river stretches 15 km eastward from there and joins the Athi river in the south of Munyu village. The drainage area of the Ndarugu river is 312 km^2 at the gaging station of 3CB5 and the mean gradient between its origin and the above station is 1/65.

Mean monthly discharges at 3CB5 for a period of 26 years are shown below.

Mean Monthly Discharge at 3CB5

Unit: m^3/sec

Month	1	2	3	4	5	6	7	8	9	10	11	12	Mean
Discharge	1.46	1.36	1.55	4.88	8.87	4.57	2.44	1.51	1.13	1.34	3.57	3.61	3.00

As seen above, minimum mean monthly discharge is 1.13 m^3/sec occurring in September and maximum of 8.87 m^3/sec in May. Mean annual runoff is estimated at 94,610,000 m^3.

3-3-2 Available discharge

As no gaging station is located near the envisaged pumping site, available water for the irrigation of the Pilot Farm is estimated based on the discharges observed at 3CB5, about 17 km downstream from the Jomo Kenyatta College. Gumbel minimum distribution method is adopted to evaluate available discharge of the Ndarugu river, using the collected monthly minimum discharges for a period from 1971 to 1982. The results are as follows:

Probable Monthly Minimum Discharges at 3CB5
(Return period: 10 years)

Unit: m^3/sec

Month	1	2	3	4	5	6	7	8	9	10	11	12
Discharge	0.409	0.296	0.364	0.381	0.869	1.199	0.884	0.742	0.580	0.337	0.503	0.655

The above discharges are converted to the discharges at the pumping site by use of the ratio of catchment areas. Estimated probable monthly minimum discharges at the pumping site are shown below.

Estimated Probably Monthly Minimum Discharges at Pumping Site

(Return period: 10 years)

Unit: m^3/sec

Month	1	2	3	4	5	6	7	8	9	10	11	12
Discharge	0.271	0.196	0.242	0.253	0.577	0.795	0.587	0.492	0.385	0.224	0.334	0.435

Survey on water abstraction rights carried out during the field investigation of the basic design study indicates that there exist four intakes in the section from the Thika bridge to 3CB5. Total abstraction discharge of these four intakes is 0.024 m^3/sec during the dry seasons from January to March and from August to October, and 0.038 m^3/sec during the rainy seasons from April to July and from November to December. The above existing water abstraction should never be disturbed by this project.

According to the information of the Ministry of Water Development, Juja city located downstream of the Thika bridge has a water supply plan for domestic use. After the completion of the water supply project of Juja, an amount of 2,300 m^3 will be daily pumped up from the Ndarugu river. This discharge should be taken into consideration for estimating the available water at the envisaged pumping site.

In order to ensure the irrigation of the Pilot Farm, Jomo Kenyatta College made an application related to water abstraction from the Ndarugu river to the Ministry of Water Development. The application form indicates that abstraction discharge is 1,000 m^3/day during the dry seasons from January to March and from August to October.

Availability of the discharge of 1,000 m^3/day is assessed by means of the water balance between the probable discharges at the pumping site of this project and the discharges of

existing and new abstraction envisaged downstream of the Nairobi-Thika road as follows:

Water Balance between Discharges of Ndarugu and Abstracted Discharges

(Return period: 10 years)

Unit: m^3/sec

Month	1	2	3	4	5	6	7	8	9	10	11	12
Discharge of Ndarugu	0.271	0.196	0.242	0.253	0.577	0.795	0.587	0.492	0.385	0.224	0.334	0.435
Abstraction/1	0.102	0.102	0.102	0.130	0.130	0.130	0.130	0.102	0.102	0.102	0.130	0.130
Abstraction/2	0.023	0.023	0.023	-	-	-	-	0.023	0.023	0.023	-	-
Balance	0.146	0.071	0.117	-	-	-	-	0.367	0.260	0.099	-	-

Remarks: /1 = Sum of existing water rights, demand for domestic water supply in Juja city
/2 = Water right of the Pilot Farm

As seen in the above table, the Ndarugu river has an ample flow to supply the irrigation water to the Pilot Farm even in a drought year with a return period of 10 years.

3-3-3 Flood analysis

As no recorded data on the flood pattern of the Ndarugu river are available, flood analysis is made based on the flood mark survey and the recorded data on the water level at 3CB5. The flood discharge at the pumping site with a probability of occurrence of 1% is estimated at 45.2 m^3/sec by use of the Gumbel distribution method. The flood level is estimated to be 1,501.0 m, which is adopted in designing the pumping station.

3-3-4 Irrigation water requirement

The irrigation water requirements for the Pilot Farm are estimated on a monthly basis, using an empirical formula. Crop water consumption is estimated as a product of potential evapotranspiration (PET) and crop coefficients (Kc). The modified Penman method, being generally accepted as the most accurate prediction method, is adopted in estimating potential evapotranspiration. Based on the climatic data observed at the Thika meteorological station located about 10 km northeast of the Pilot Farm, potential evapotranspiration is estimated as follows:

Potential Evapotranspiration

Unit: mm/day

Month	1	2	3	4	5	6	7	8	9	10	11	12
PET	5.5	6.2	6.2	4.7	4.3	3.9	3.4	3.8	4.7	5.4	5.0	5.5

The crop coefficient is decided to be 1.15, assuming that crop development is in full stage throughout the year.

The effective rainfall for crops is estimated on a monthly basis. Estimation is made for the reference year satisfying the following condition:

- Consecutive drought days are 90 days, which correspond to the drought year with a probability of occurrence of 10%.

With regard to the irrigation method to be applied for the Pilot Farm, sprinkler irrigation method is selected as the most favourable in view of topography, soil texture and easiness of operation. Various losses occurring in the irrigation are decided as follows:

Application and operation efficiency	85%
Conveyance efficiency	95%
Overall efficiency	80%

The diversion requirement is computed by dividing the net water requirement by the overall irrigation efficiency. The results are shown below.

Diversion Water Requirements

Month	11	12	1	2	3	4	5	6	7	8	9	10	Total
Season	Rainy			Dry			Rainy				Dry		
PET (mm/day)	5.0	5.5	5.5	6.2	6.2	4.7	4.3	3.9	3.4	3.8	4.7	5.4	
Kc	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	
Daily consumptive use (mm/day)	5.8	6.3	6.3	7.1	7.1	5.4	4.9	4.5	3.9	4.4	5.4	6.2	
Monthly consumptive use (mm/month)	174	195	196	199	220	162	152	135	121	137	162	192	2,045
Effective rainfall (mm/month)	46	53	0	0	0	116	49	11	10	8	11	114	418
Net water requirement (mm/month)	128	142	196	199	220	46	103	124	111	129	151	78	1,627
Gross water requirement (mm/month)	160	178	245	249	275	58	129	155	139	161	189	98	2,036
Diversion requirement (m^3/day)	1067	1148	1580	1779	1775	387	832	1033	897	1039	1260	632	

3-3-5 Irrigation method and irrigation schedule

The irrigation method to be applied to the Pilot Farm is decided, taking mainly into consideration soil characteristics, topography, and kinds of crops to be grown.

The soils in the Pilot Farm consist mainly of medium textured fine sandy loams with a relatively high water intake rate, and the topography is characterized by steep

undulation with an average land slope of 6%. In the farm, various upland crops are planned to be grown for an experimental purpose, and therefore the irrigation method to be applied should be suitable for those crops. Further, the irrigation water losses have to be kept minimum since the available river water is quite limited as mentioned in the foregoing section. Taking collectively into account all these factors, the sprinkling irrigation method is recommended to be applied to the project.

Irrigation schedule is determined based on total readily available soil moisture, the evaporation rate and the basic intake rate. As no data on total readily available soil moisture (T.R.A.M.) are available for the project, net depth of irrigation application is estimated by means of the "Methods for evaluating irrigation systems" published by the United States Department of Agriculture. Estimation is made under the following conditions:

- Available moisture holding capacity is 1.67 cm/10 cm,
- Mean root zone depth is about 40 cm, and
- Available moisture holding capacity of the top fourth of the root zone is assumed to be about 40 percent of the total readily available moisture.

Estimated net depth of irrigation application is 41.8 mm.

Irrigation intervals can be calculated based on the above net depth of irrigation application and the rate of evapotranspiration as follows:

$$\text{Irrigation interval (days)} = \frac{\text{Net depth of irrigation application (mm)}}{\text{Evapotranspiration rate (mm/day)}}$$

Where: Net depth of irrigation application = 41.8 mm
Evapotranspiration rate = 7.1 mm/day

Calculated irrigation interval is 5 days. Gross depth of irrigation application is calculated dividing net depth of irrigation application by application and operation efficiency. Estimated gross depth of irrigation application is 49.2 mm.

Irrigation application intensity is determined to be 12.3 mm/hr according to the following conditions:

- Gross depth of irrigation application is 49.2 mm,
- Sprinklers are operated on a four-hour/shift and two shifts/day basis, and
- Estimated basic intake rate is 12.7 mm/hr according to the "Methods for evaluating irrigation systems" published by the United States Department of Agriculture.

3-3-6 Drainage water requirement

Surface drains are provided so as to remove the excess runoff from 5-year, 1-hour storm rainfall. Estimation of probable storm rainfall is made based on the daily rainfall data recorded at the Thika Karaini rainfall station located about 6 km northwest of the Jomo Kenyatta College.

Drainage water requirements are estimated using the McMath formula/1 as shown below.

$$Q = 2.3 \cdot C \cdot i \cdot S^{1/5} \cdot A^{4/5}$$

where, Q: Flood discharge (ℓ/sec)
C: Coefficient representing the basin characteristics (= 0.3)
i: Rate of rainfall for the time of concentration and frequency (mm/hr)

/1: "Drainage Manual", U.S. Department of the Interior, Bureau of Reclamation, first edition, 1978.

S: Fall of main channel between the farthest contributing point and the point of concentration

A: Area of drainage basin (ha)

Equation is applied to each drainage area shown in the General Plan. Estimated drainage water requirements are shown below.

Drainage Water Requirements

Location of the Catchment Area	Design Rainfall (mm/hr)	Catchment Area (ha)	Drainage Requirement (m^3/sec)
(Outside of the farm)			
Northwest of the College	19.6	165	1.11
Vee and Benvar farm area, northeast of the College	19.6	70	0.56
(Inside of the farm)			
Northeast side of the farm	19.6	65	0.53
Southwest side of the farm	19.6	54	0.45

The above drainage requirements are adopted for designing the drainage system.

3-4 Irrigation and Drainage Systems

3-4-1 Storage pond

(1) Storage capacity

As is clear in Chapter 3-3-4, the permitted abstraction discharge of 1,000 m^3/day is not sufficient for irrigating the Pilot Farm during the dry seasons from January to March and from August to October. In order to surmount this difficulty, a storage pond will be provided in the farm area.

Required capacity of the storage pond is estimated based on the diversion water requirements mentioned in Chapter 3-3-4, evaporation from the water surface of the storage pond, rainfall and leakage loss. Estimation is made on a monthly basis by means of a water balance method as shown in the following table:

Water Balance
(20 ha)

Month	11	12	1	2	3	4	5	6	7	8	9	10
Season	Rainy		Dry			Rainy				Dry		
Gross water requirement (mm/month)	160	178	245	249	275	58	129	155	139	161	189	98
Gross water requirement (m^3/day)	1,067	1,148	1,580	1,779	1,775	387	832	1,033	897	1,039	1,260	632
Evaporation/1 (m^3/day)	123	129	148	162	168	120	106	92	78	92	126	146
Leakage/2 loss (m^3/day)	40	40	40	40	40	40	40	40	40	40	40	40
Rainfall/3 (m^3/day)	88	93	0	0	0	258	94	17	20	16	19	225
Sub-total (m^3/day)	1,142	1,224	1,768	1,981	1,983	289	884	1,148	995	1,155	1,407	593
Permitted abstraction discharge (m^3/day)			1,000	1,000	1,000					1,000	1,000	1,000
Deficiency (m^3/day)			768	981	983					155	407	0
Gross pumping discharge (m^3/day)	2,486	2,568	1,000	1,000	1,000	289	884	1,148	1,544	1,000	1,000	1,000

Remarks: /1 = Evaporation from the storage pond is estimated multiplying the observed class A pan evaporation by 0.7.

/2 = Leakage loss from bottom and lateral of the storage pond is assumed to be 1 mm/day.

/3 = Rainfall captured by the storage pond is estimated based on the rainfall data recorded from November 1981 to October 1982; surface area of the said pond is decided to be 41,000 m^2.

The capacity of the storage pond is determined to be 82,000 m^3 corresponding to the total deficiency occurring from January to March.

(2) Design of the storage pond

In order to economize the construction cost, the storage pond will be constructed utilizing the existing excavated site located behind the dormitory of the Jomo Kenyatta College.

The storage pond consists of a pond, a spillway, a wasteway, an outlet structure of the pipeline and a suction pit for booster pumps. Principal features of the storage pond are shown below.

(a) Bottom area of the pond; 41,000 m^2.

(b) High water elevation; 1,550 m.

(c) Low water elevation; 1,548 m.

(d) Mean effective water depth; 2.0 m.

(e) Crest elevation of the embankment: 1,550.50 m; crest width: 9.0 m; inner and outer side slope: 1:2; the length of the embankment: 900 m. The inner lateral side is protected with concrete lining.

(f) Crest elevation and crest width of the spillway are 1,550 m and 2.0 m respectively.

Related structures of the storage pond are shown in the Drawings.

3-4-2 Pumping station

A pumping station will be constructed on the right bank of the Ndarugu river, 1.3 km upstream from the Thika bridge. As no data on the water levels at the pumping site are available, the design flood levels are determined based on the results obtained through flood mark survey in the field

investigation and the probability analysis of water levels recorded at 3CB5. For designing the pumping station, the following water levels are adopted as mentioned in Chapter 3-3-3.

Flood level : 1,501.0 m with a return period of 100 years

Low water level: 1,496.7 m with a return period of 10 years

The proposed pumping station consists of pumps, a pump house, a suction pit, suction pipes, a discharge pipeline, a switchboard and auxiliary apparatus to protect the pumping system. The layout of the pumping station is shown in the Drawing.

The maximum water requirement of 1.78 m^3/min occurs in December on 24-hr basis. The pumps will be operated for 12 hrs/day from an economical viewpoint. The design discharge of the pumps is, therefore, determined to be 3.56 m^3/min. It is proposed to install three units of pumping equipment including one standby unit, each with a rated discharge of 1.78 m^3/min.

The loss heads to determine the rated pump head are influenced by the diameter of discharge pipeline. Thus, the economical diameters of the discharge pipeline is determined as shown in the succeeding section. According to the results, the rated total head for the design of pumps are as shown below.

Rated discharge per unit	:	1.78 m^3/min
Length of discharge pipeline	:	1,400 m
Diameter of discharge pipeline	:	300 mm
Length of suction pipe	:	20 m
Diameter of suction pipe	:	200 mm
Total loss head	:	6.7 m

Actual static head	:	53.3 m
Rated head	:	60.0 m

Three types of pumps are considered applicable, taking into account the total head and the discharge of pump unit, i.e. (1) single suction volute pump, (2) double suction volute pump and (3) single suction multistage volute pump. The economic and technical comparison is made among the three types, and the horizontal shaft single suction volute pump is adopted, since it has the following advantages:

(1) High pumping efficiency, which can be maintained even under the wide range of discharge,

(2) Simple and easy maintenance and replacement because of the simplified structure of the pump and horizontal installation of pump shaft, and

(3) High adaptability for pumping up the water containing mud.

Two kinds of valves will be provided in the pump station. At the delivery side of each pump, a check valve will be installed to protect the pump from shock and impact caused by back-flow of the water in the discharge pipe. The other is a sluice valve which will be installed at the delivery side of the check valve.

The pump will be driven with an electric motor, since electricity of 11,000 V is available. The motor is directly connected to the pump and started by use of an electronical reactor circuit to regulate starting current with high intensity. The general features of the motor are as follows:

Output	:	37 kW
Voltage	:	380 V
Frequency	:	50 Hz
Synchronous speed	:	1,500 r.p.m.

Type	:	Three phase induction motor
Enclosure	:	Closed type

The control system will be of one-man control, i.e. the pumps are manually switched on and stopped on the control panel in the pumping station. In starting pumps, it is required to prime the pumps by use of a head tank installed in the pump house. A flow meter will be installed in the delivery side of the pump to control the discharge. High tension electricity will be stepped down with a receiving system to be provided in the pump house. The pump house has a floor area of 40 m^2, and its layout is shown in the Drawing.

3-4-3 Discharge pipeline

The irrigation water delivered from the pumps is transported to the storage pond by pipes. The route of pipeline is shown in the attached Drawing. The total length of the pipeline is about 1,400 m. For a stretch from the pumping station to the end point of the flat extension of the existing road, the pipeline is left uncovered and fixed on the rock with saddle supports. For a stretch from the end point of the flat extension of the existing road to the storage pond, the pipeline is buried alongside the said road.

The diameter of pipeline greatly affects the initial investment of pumps and pipeline as well as the operation cost. Three different pipes, i.e. 250,300 and 350 mm are considered in the economic comparative study, among which the pipe of 300 mm is adopted as the most economical. Pipeline material is of steel for a length of 500 m where the pipeline is exposed, and of ductile iron pipe for 900 m where the pipeline is placed under the ground.

The water hammer in the pipeline is analyzed to confirm pipe safety against extraordinary hydraulic pressure. Based on the characteristics of pumps, motors and pipeline as determined above, the maximum and minimum water head are

calculated. The results show that negative pressure would occurs in the pipeline, and therefore, a surge tank is required to be installed near the end point of the flat extension of the existing road as shown in the Drawing.

3-4-4 Sprinkler system

(1) Sprinkler

As mentioned in Chapter 3-3-5, sprinkler irrigation method is adopted to supply the Pilot Farm with water. The sprinkler system consists of main, secondary and lateral pipelines. The main and secondary pipelines will be of fixed type, while the lateral lines will be of movable type. The Pilot Farm consists of five blocks with an area of 4 ha and irrigation is applied to one fifth of each block in a day. For this purpose, lateral lines will be moved twice every day. One irrigation application will be finished in 4 hours. Spacings of lateral lines and sprinkler heads are designed to be 12.5 m and 10 m respectively, taking into consideration irrigation application intensity, covering area by one sprinkler head and hours required to move lateral lines. Sprinkler head suitable for envisaged irrigation is of intermediate pressure type with a discharge of about 26 ℓ/min. Gross water requirement for the sprinkler system is estimated at 4,300 ℓ/min.

The layout of the pipelines is shown in the attached Drawing. Main pipelines are composed of two pipelines; one is buried alongside the northeast boundary of the Pilot Farm and the other is placed under the ground alongside the southwest boundary. Pipelines are installed more than 0.6 m below the ground surface. One main pipeline is connected with the other by five secondary pipelines which are installed perpendicularly to the main pipelines and alongside the farm roads. Out of two main pipelines, one pipeline which is provided at the northeast side crosses the perimeter road behind the farm building compound and runs along the existing

fence. In front of the open ditch, it turns to the east and is connected to the booster pumping system after stretching over about 350 m.

With regard to the material of pipelines, vinyl chloride pipes are adopted for main and secondary pipelines and aluminium pipes for lateral lines. Facilities related to the pipeline are hydrants, check valves, air valves and blow-off valves. Location of related facilities is shown in the Drawings, and main features of the pipelines are as follows:

Main Features of Pipelines

Item	Description	Number or Length
Main pipeline	Vinyl chloride pipe	2,870 m
Secondary pipeline	"	1,330 m
Lateral line	Aluminium pipe	1,640 m
Hydrant		100 nos.
Check valve		15 nos.
Air valve		6 nos.
Blow-off valve		3 nos.

(2) Booster pumping station

A booster pumping station will be provided on the southwest corner of the storage pond to deliver the irrigation water to the pipeline. In order to generate the pressure required for sprinkler irrigation, there exist three methods to be considered i.e. (1) distributing head tank method, (2) direct pumping method and (3) pressure tank method. Based on economic and technical comparative studies, the pressure tank method is adopted for this project. This method has the following advantages:

(1) It is easy to start and stop the booster pumps,

(2) Nozzle pressure of the sprinkler is kept almost constant during irrigation,

(3) The pressure tank can absorb the shock and impact which may be excited by water hammer, and

(4) Heavy load on motors occurring at very low discharge of irrigation water is relieved by installation of a pressure tank.

The booster pumping station consists of pumps, a pump house, suction pipes, a suction pit, a pressure tank and a control panel. The layout of the pumping station is shown in the attached drawing.

The design discharge is determined as follows:

Daily operation hours	:	8 hours
Rated discharge	:	4.3 m^3/min
Rated head	:	50 m

Two sets of pump with a design discharge of 2.15 m^3/min and one standby will be installed in the pump house from economical and technical viewpoint. Adopted pump is of single suction volute type, and the pump is drived with an electric motor. The general features of the motor are as follows:

Output	:	37 kW
Voltage	:	380 V
Frequency	:	50 Hz
Synchronous speed	:	1,500 r.p.m.
Type	:	Three phase induction motor
Enclosure	:	Closed type

Booster pumps will be manually switched on and, once started, operation of pumps will be automatically controled. Pressure and water volume inside the tank are indicated on the control panel to be installed in the pump house and, in an emergency, the whole system will be automatically stopped. The pump house has a floor area of 40 m^2 and its layout is shown in the drawing. Close to the pump house, a pressure tank will be installed. Total volume of the tank is determined to be 18 m^3.

3-4-5 Drainage system

The proposed drainage system consists of two main drains and eight collector drains to remove the excess water from the farm area, and two catch drains to collect the runoff from the outside basins. The capacities of the drains are determined by use of the drainage requirement mentioned in Chapter 3-3-6. Layout of the drains are shown in the General Plan.

Out of two catch drains, catch drain No.1 will be installed along the northeast boundary of the College area and connected to the existing open ditch after running beside the storage pond. Catch drain No.2 will be provided along the northwest and southwest boundary of the College area and evacuate the drainage water into a farm pond with a total volume of 7,700 m^3 to be constructed near the existing nursery area. In order to drain the excess water from the inside and outside of the Pilot Farm, two main drains and eight collector drains will be provided. Each main drain and one collector drain will be connected to the existing open ditch. Remaining seven collector drains are to be joined to the main drain to evacuate the drainage water coming from the inside of the Pilot Farm.

The drainage canal section is designed on the following conditions:

Type : Trapezoidal earth canal

Permissible velocity : Max. 0.9 m/sec
Min. 0.3 m/sec

Roughness coefficient for use of Manning's formula : 0.035

Side slope : 1:1.5

Principal hydraulic properties of the drains are as follows:

Hydraulic Properties of the Drains

Canal Name	Discharge (m^3/sec)	Canal Base Width (m)	Canal Depth (m)	Hydraulic Gradient	Length (m)
Catch drain No.1	0.56	0.8	0.7	1/300	1,810
Catch drain No.2	1.11	1.5	0.8-0.9	1/400-1/800	2,155
Sub-total					3,965
Main drain No.1	0.28-0.53	0.6-0.8	0.6-0.7	1/300	1,405
Main drain No.2	0.28-0.52	0.6-0.8	0.6-0.7	1/300	945
Sub-total					2,350
Collector drains No.1-No.6	0.057	0.5	0.4	1/50-1/500	250 each
Collector drain No.7	0.21	0.6	0.5	1/300	390
Collector drain No.8	0.15	0.6	0.5	1/100-1/400	375
Sub-total					2,265

The structures related to the drainage network are culverts and drops. Culvert of precast concrete type will be provided where the drain crosses the road. The diameter of culvert ranges from 300 to 700 mm, and number of culverts to be provided are twenty one.

The drop will be installed where the natural ground slopes are more than the canal gradients, in order to keep the velocities below the maximum permissible velocity. All the drops are of inclined type, consisting of inlet, throat and stilling pool. Numbers of drops to be provided are nine.

3-5 Farm Layout and Soil Improvement

The Pilot Farm has the rectangular shape (800 m long x 250 m wide), which will be divided into five blocks with an area of 4 ha. Soil improvement will be made by applying fertilizers i.e. nitrogen, phosphorus, and organic manures. Subsoil ploughing will also be carried out with chisel plough to loose the compact subsoil, and stones which disturb operation of farm machinery will be removed away. The soil improvement for the farm is planned to be executed in about 5 years. Enlargement of the area for horticulture and food crops by this soil improvement will gradually be made, reducing the cultivation area for feed crops and green manure as shown in the table below. However, the production of feed crops and green manure will be continued on the land outside the 20 ha farm, taking into consideration the numbers of the cattles to be raised. The proposed soil improvement and planting schedule for the farm is shown below.

Unit: ha

Year	Horticulture, Food Crops (inside 20 ha)	Feed Crops, Green Manure (inside 20 ha)
1st	4/1	16
2nd	8	12
3rd	12	8
4th	16	4
5th	20	0

Remarks: /1 = The 4 ha for first year is soiled with good clay loam brought from outside the farm.

3-6 Farm Roads

The proposed road network consists of perimeter road, main road, connecting road and farm road. The perimeter road will be provided alongside the catch drain and connected to the existing roads of the College. The main roads will run on the outer boundary of the Pilot Farm, and it will be connected with the perimeter road by four connecting roads. Four farm roads will be provided perpendicularly to the main road at an interval of about 170 m. The road network is shown in the General Plan, and the principal features are as follows:

Principal Features of Roads

Name of Raod	Total Length (m)	Effective Width (m)	Pavement
Perimeter road	5,625	7.0	Laterite
Main road	2,500	7.0	"
Connecting road	1,560	7.0	"
Farm road	1,000	5.0	"

3-7 Water Supply System

It is required to install a water supply system, enabling to supply potable water to the proposed cattle raising yard, experimental food processing factory, workshop, etc. For this purpose, the groundwater is used. A survey on groundwater was carried out in and around the College area during the field investigation. The results obtained indicate that the yield of twelve boreholes ranges from 1 m^3/hr to 55 m^3/hr. Out of twelve, six boreholes record the discharge of less than 10 m^3/hr. For designing the borehole, the average yield i.e. 4.7 m^3/hr of the above six boreholes is adopted. Water requirement is estimated at about 100 m^3/day based on the results of the survey on water requirement and the basic plan elaborated by Japanese experts. It is tentatively proposed to install two boreholes in the College area. The site and boring depth should be determined after the detailed geohydrological investigation to be made in the next stage. The lifted water from boreholes will be led to a high level water tank to be placed and, then, distributed through a pipeline.

3-8 Buildings

3-8-1 Farm building

It is necessary to build farm buildings such as a farm management building, a workshop, a warehouse and two farm huts for the smooth farm operation and the effective execution of the experiment and training.

The scale and number of each building are decided taking into account the function of each building, the frequency of the farm training and/or the kind and number of the farm machinery to be used in the Pilot Farm.

In accordance with the request by the Government of Kenya, design of some farm buildings is modified in view of the effective operation of the Pilot Farm and the concentrated management of farm products, fertilizer, farm instrument and etc.

(1) Farm management building

Farm management building will be built in a compound located near the farm. This building will consist of a manager room, three staff rooms, two class rooms (each with a floor area of 64 m^2), and four storage rooms with a total floor area of about 800 m^2. The building will be provided with electrical facilities, and water supply and sewerage facilities.

(2) Workshop

Workshop will be provided for repairing and maintenance of agricultural equipment to be used in the farm. This building will have a total floor area of 300 m^2 and consist of a working floor, one office room, one engine room, one tool room and battery room. The building will be equipped with a hoist monorail, repairing equipment, and electrical and water supply facilities.

(3) Warehouse

Warehouse will be provided for storage of agricultural machinery. It will have a total floor area of 200 m^2.

(4) Farm hut

Two farm huts, each with a floor area of 50 m^2, will be built in the farm in order to provide farm workers and trainees with shelters in case of sudden storms. These buildings will also be used as temporary stores for farm inputs and outputs.

3-8-2 Utility facilities

The utility facilities related to the buildings will consist of water supply facilities, sewerage and drainage facilities, electrical facilities and service roads.

(1) Water supply facilities

Water supply facilities will be provided to supply the aforementioned buildings, the cattle house (to be built by the College) and the existing milk plant with a potable water.

The design daily water consumption is computed as follows:

(a) For the farm management building

Daily water consumption per one person; 100 ℓ/day
Number of persons; 200 person
Daily water consumption; 100 x 200 = 20,000 ℓ/day
= 20 m^3/day

(b) For cattle house

The College has a plan to raise various cattles in the farm. Numbers and kinds of cattles, and water consumption for each cattle are as listed below.

Description	Nos.	Water Consump. (ℓ/day/head)	Total (ℓ/day)
Cow	50	450	22,500
Ox	50	150	7,500
Goat, Sheep	100 each	30	6,000
Pig	50	60	3,000
Others			1,000
Total			40,000

Total water consumption for the cattle house is estimated at 40 m^3/day.

(c) For milk plant

The existing milk plant is also required to be supplied with potable water for milk production. Daily water consumption for the milk plant is estimated at 10 m^3/day.

(d) For others

The daily water consumption for washing farming facilities and agricultural machinery, for workshop, etc. is estimated at 30 m^3/day in total.

Thus, the design water consumption for water supply facilities is calculated to be 100 m^3/day in total. Based on this design water consumption, the water supply facilities are designed as follows:

(a) Water reservoir

One water reservoir will be placed to receive the water taken from deep wells. The water reservoir will have an effective capacity of 40 m^3.

(b) High level water tank

A high level water tank with a 10-m high tower will be constructed near the water reservoir. The water tank will be made of FRP and have a capacity of 6 m^3.

(c) Water supply pipeline

To distribute water to each building, a water supply pipeline with a diameter ranging from 25 mm to 50 mm will be installed. The total length of water supply pipeline is estimated at 200 m.

(2) Sewerage and drainage facilities

The sewerage and drainage facilities are to drain sewerage and waste water from the buildings. The building sewerage and waste water will be collected into a sewerage tank and led to the existing sewerage disposal plant in the college compound.

The proposed sewerage and drainage facilities are as explained below.

(a) Sewerage tank

To collect the building sewerage, one sewerage tank with a capacity of 7 m^3 will be constructed. The sewerage tank will be equipped with a water pump to send the sewerage to the disposal plant through a pipeline.

(b) Drainage pipeline

Waste water from buildings will be drained out to nearby drainage ditches through a waste water pipeline. Sewerage water is planned to be separated from waste water and led to the sewerage tank through the sewerage pipeline. Total length of drainage pipeline is 250 m.

(3) Electrical facilities

The electrical facilities will be provided for lighting as well as for operation of workshop equipment. The electric power will be supplied from the existing electric facilities located in the college compound and distributed to each building with 500 m-long power distribution line. The electric power is rated at 380/230 V, 50 Hz.

(4) Service road

The service road within the building compound will be surfaced with asphalt concrete to secure a smooth traffic in the compound. The area to be paved with asphalt-concrete is estimated at 2,000 m^2 in total.

3-9 Farm Machinery

The following machinery are required for maintenance of the farm and for the future expansion of the Pilot Farm:

One bulldozer of 12-ton class
One wheel loader with backhoe, 75 HP class
One dump truck, 6-ton class

For the routine operation of the farm, the machinery and equipment shown in Table 3-3 will be required. Selection of these machinery and equipment is made to meet the requirements for the major farm operation, such as horticulture and ordinary crop farming.

4. ORGANIZATION AND IMPLEMENTATION SCHEDULE

4-1 Organization for Project Implementation

Ministry of Higher Education will be given the function of the executing body for the Project. It will assume the overall responsibility for both engineering and construction works of the Project and coordinate with relevant Government agencies and regional administrative organizations in connection with the project execution. The implementation committee will be established to smoothly execute the Project works including the detailed design and construction supervision.

4-2 Construction Plan

4-2-1 Detail design

For the successful implementation, the following works are to be carried out before the commencement of the construction works. These works are to be completed within 4 months.

(1) Survey and investigation

- Plane table survey for major structures,
- Longitudinal and cross section surveys, for the pipelines, drainage canals and farm roads,
- Investigation of groundwater by means of an electric resistivity survey, and
- Soil survey on the Pilot Farm and investigation on the foundation of the main structures.

(2) Detail design and tender documents

- Detail design and bill of quantities,
- Preparation of tender drawings, and
- Preparation of tender documents.

4-2-2 Construction schedule

The construction works will be carried out by a contractor selected through a competitive bidding. The construction period is estimated to be 10 months including preparatory works. The proposed construction schedule is shown in Fig. 4-1.

4-2-3 Construction method

The construction works are divided into four major works, i.e. earthworks, concrete works, piping works and building works as mentioned below.

(1) Earthworks

Major earthworks have to be completed during the period from the end of May to the beginning of October to secure effective performance and proper quality control. Major earthworks consist of the construction of farm roads, and excavation of storage pond and drainage canals. Since the project area is covered with shrub and light forest, clearing and grubbing will be carried out mainly by use of bulldozer. Drainage canals will be excavated by backhoe and the excavated soil will be placed on nearby farm road sites or conveyed to the spoil-bank. The storage pond, located at the southeast side of the College, will be excavated by the use of bulldozer and backhoe, and the excavated soils will be used as pavement materials of farm roads.

(2) Concrete works

Main concrete works comprise construction of the suction pit of the pumping station and lining of the inside slope of the storage pond. Concrete for these works is prepared in situ by concrete mixer with a mixing capacity of 0.4 m^3. Placing concrete on the slope of the storage pond is carried out without forms because of the gentle slope gradient of 1:2 and the surface is manually finished by use of wooden trowel.

(3) Piping works

Piping works are required for the discharge pipes of the pumping station and the pipelines for sprinkler irrigation. The discharge pipe will be installed and fixed on the rock foundation for a stretch of 500 m from the pumping station to the top of the slope. Installation of pipes for this portion will be made by use of cranes. For a stretch of 900 m from the top of the slope to the storage pond, the ground will be excavated by backhoes along the route of pipeline with a depth of about 1 m and backfilled by bulldozers after installation of the pipes. The vinyl chloride pipes used for sprinkler irrigation will be buried at about 0.6 m below the ground surface, and excavation and backfilling for these pipelines will be made in the same manner as for the pump discharge pipe.

(4) Building works

The building works comprise construction of farm management building, warehouse, workshop and farm huts. Construction will be commenced at the same time for all the buildings. For the foundation of the buildings, excavation will be made by backhoe to a depth of about 1 m, and this will be immediately followed by placing forms and reinforcement bars and concreting. The superstructure is composed of reinforced concrete columns forming a rigid frame and of iron roof trusses. The walls will be constructed with stone masonry. The roof trusses will be manufactured locally and placed by use of cranes.

4-2-4 Construction work quantities

Quantities of the major construction works required for the project are estimated as follows:

A) Civil works

1) Pumping station

Excavation	900 m^3
Backfill	100 m^3
Concrete	145 m^3
Reinforcement bar	11.6 t
Form	1,160 m^2
Pump house	40 m^2

2) Discharge pipeline

Excavation common soil	800 m^3
Excavation rock soil	10 m^3
Backfill	800 m^3
Ductile iron pipe	1,400 m
Concrete	10 m^3
Reinforcement bars	0.8 t
Form	80 m^2
Power distribution line	2,000 m

3) Storage pond

Excavation	12,000 m^3
Embankment	19,500 m^3
Concrete	680 m^3
Reinforcement bar	16.2 t
Form	520 m^2
Pump house	40 m^2
Power distribution line	500 m

4) Farm pond

Excavation	11,100 m^3
Safety facility	400 m

5) Irrigation pipeline

Excavation	1,000 m^3
Backfill	1,000 m^3
P.V.C. pipe (ø75 - ø300)	4,200 m
Sprinkler set	15 sets

6) Drainage system

Excavation		28,500 m^3
Backfill		400 m^3
Concrete		240 m^3
Reinforcement bar		19.2 t
Form		1,920 m^2
Precast concrete pipe	ø700	65 m
	ø500	50 m
	ø300	160 m

7) Laterite pavement 21,830 m^2

8) Soil improvement

Soil dressing	12,000 m^3
Deep tillage	16 ha

9) Borehole about 360 m

B) Building works

1) Buildings

Farm management building	800 m^2
Workshop	300 m^2
Warehouse	200 m^2
Huts (2 Nos.)	100 m^2

2) Utility facilities

Water reservoir	40 m^3
High level water tank	6 m^3
Water supply pipeline	200 m
Sewerage tank	7 m^3
Drainage pipeline	250 m
Power distribution line	500 m
Asphalt-concrete pavement	2,000 m^2

4-2-5 Construction material

Quantities of major materials required for the construction works are as follows:

(a)	Portland cement		550 ton
(b)	Aggregates, fine		800 m^3
			1,350 m^3
(c)	Timbers		200 m^3
(d)	Reinforcement bars		90 ton
(e)	Structural steels		50 ton
(f)	Precast concrete pipe	ø700	75 m
		ø 500	50 m
		ø 300	160 m
(g)	Stone masonry (t = 200 mm)		1,270 m^2

4-3 Plan of Operation and Maintenance

4-3-1 Organization for operation and maintenance

The College has organized Pilot Farm Committee under the Vice Principal, which consists of Vice Principal as the chairman, Dean of Faculty of Agriculture, Head of every Department of the faculty of agriculture and Japanese experts, farm manager and others as shown in Fig. 4-2. Under the committee, the farm manager is responsible for operation and maintenance of the Pilot Farm. Under the farm manager, 9 sections are proposed to be organized to execute various kind of activities required for routine operation of the farm including training of students and maintenance of the farm facilities. The Pilot Farm activities are allocated to these sections.

4-3-2 Operation and maintenance cost

The annual cost for operation and maintenance consists of personal cost, electric charge, operation cost of machinery required for maintenance of the Pilot Farm, and others. The cost is estimated at 625,490 K.Sh. as shown below.

Annual Operation and Maintenance Cost for the Pilot Farm

Unit: K.Sh.

Item	Unit	Quantity	Unit Price	Amount
1. Personal cost				
Pump operator	man/day	740	74	54,760
Assistant	man/day	730	50	36,500
Labour	man/day	1,220	35	42,700
2. Electric charge				
Pumping station	K.W.H	174,000	1	174,000
Booster pumping station	K.W.H.	170,000	1	170,000
3. Operation cost of maintenance machinery	L.S.			8,860
4. Materials for maintenance and repair	L.S.			138,670
Total				625,490

4-3-3 Contribution by the Government of Kenya

It is required to construct a wire-net fence around the Pilot Farm in order to protect crops from wild animals. The fence would be 2.5 m high and 4,000 m long, and its construction cost is roughly estimated at 1,080,000 K.Sh. It is recommended that the construction of the wire-net fence will be made by the Government of Kenya.

5. PROJECT BENEFIT

The project is not aiming at the development of commercial farm which directly brings economic benefits, but the improvement of the Pilot Farm necessary for experiment and training in the College.

The major direct benefits to be born by the project are as follows:

(1) The flexible experiment and training become possible with the installation of the year-round irrigation facilities,

(2) Safety and effective operation of farm machinery is ensured by the construction of farm road and drainage system,

(3) The irrigation by sprinkler system not only makes various experiment and training possible but also saves operation and maintenance expenditure,

(4) The facilities installed enable the farm to introduce an intensive farming system, which is expected to be developed in Kenya, and

(5) The Pilot Farm will enable the students to obtain not only fundamental and theoretical knowledge but also practical one.

6. CONCLUSION AND RECOMMENDATION

The College has been planned as one of higher technical education institutions for promoting the increase of skilled technical manpower in Kenya, and established by much effort of Kenya with the financial and technical cooperation of Japan. Two years have passed since the opening of the College and then the students of the College showed a good examination result in the national examination carried out recently.

The project is to construct necessary facilities to provide the College with the Pilot Farm which is essential for the education. The Pilot Farm will be utilized not only for the training and education but also as the demonstration of the development method in the land with a similar condition.

The scale of the project is considered appropriate for the envisaged activities to be executed in the Pilot Farm, and both the construction cost and the operation and maintenance expenses necessary for the project are judged to be reasonable. Taking collectively into accounts these factors as well as the urgent necessity of the Pilot Farm in the College, the earliest implementation of the project is recommended.

For smooth implementation and operation of the project, it is further recommended to:

(1) prepare a detailed plan of operation of the Pilot Farm,

(2) make an effort to have a sufficient number of staffs necessary for operation of the Pilot Farm,

(3) carry out a detailed soil survey of the Pilot Farm and prepare its soil map with an appropriate scale (1/5,000, for example),

(4) re-examine the location of cattle raising shed taking into account the sanitary conditions of cattles,

(5) rationally utilize the water by installation of the discharge measurement apparatus in the existing water supply system, and

(6) provide a water level recorder at the proposed intake site in the Ndarugu river for the purpose of smooth operation of the pumps.

Table 2-1 Member List of Board of Governors

CHAIRMAN	Prof. P. M. Githinji, University of Nairobi
SECRETARY	Mr. J. M. Githaiga, Principal, JKCAT
GOVERNORS	Prof. R. S. Musangi, Principal, Egerton College
	Mr. A. K. Kandie, Permanent Secretary/Director, Directorate of Personnel Management
	Mr. J. K. Muthama, Director, Ministry of Agriculture
	Dr. David Ng'ang'a Ngugu, Dean Faculty of Agriculture, University of Nairobi
	Mr. T. D. Owuor, Executive Director, Federation of Kenya Employers
	Mr. Odera Oteng, Director, National Industrial Training School
	Mr. Peter Oloo Okaka, Principal, Kenya Polytechnic
	Mr. R. G. Mwai, General Manager, East African Bag & Cordage Co., Ltd.
	Mr. P. E. N. Thiong'o, Clerk to the Council, Kiambu Country Council
	Mr. Watson Murigo
	Mr. Karuga Wandai, Thika Municipality
	H. E. Miss Margaret Kenyatta
EX OFFICIO	Mr. Charles Kasina, D.D.H.E. (TAE), Ministry of Higher Education
	The Provincial Higher Education Officer, Central Province
	Mr. Daniel Moiti, P.F. & E.O., Ministry of Higher Education

Table 3-1 The Subjects Relating to the Farm

1. Faculty of Agriculture

Department of Horticulture:

1st Year:
Soil science, tractor operation, crops work, entomology

2nd Year:
Annual crops, perennial crops, horticultural experiment, field instruction, special project plant pathology, vegetable growing, fruit growing, plant breeding, flower growing and landscaping, propagation

3rd Year:
Plant protection, seed production, irrigation, surface irrigation, overhead irrigation, field instruction

Department of Agricultural Engineering:

1st Year:
Tractor servicing, farm machinery I

2nd Year:
Farm machinery II, III, hydrology, water supply and drainage, field experience I

3rd Year:
Farm machinery repair, land development machinery, farm machinery management, overhead irrigation, surface irrigation, plant layout, process engineering, building design engineering, field experience II, III

Department of Food Processing:

2nd, 3rd Year:
Food processing practicals (Product from the farm)
Products from the farm necessary for processing practicals are such as milk, food grains, vegetables, meat, fruits and some industrial crops.

2. Faculty of Engineering

Department of Mechanical Engineering:

Agricultural Machinery Course:

Part I:
Farm machinery, processing machinery, crops tractor operation, tractor overhaul

Part II:
Farm machinery, conveyer, storage, animal husbandry, tractor operation, tractor overhaul, tractor performance test

Part III:
Farm mechanization, farm facilities, land engineering, irrigation and drainage, field performance test

Construction Machinery Course:

Part II:
Construction machinery practicals

Department of Civil Engineering & Architecture:

Irrigation Course:

Part I:
Hydrology

Part II:
Hydrology, farm irrigation practicals

Table 3-2 Present Staff and Proposed Staff of the Farm

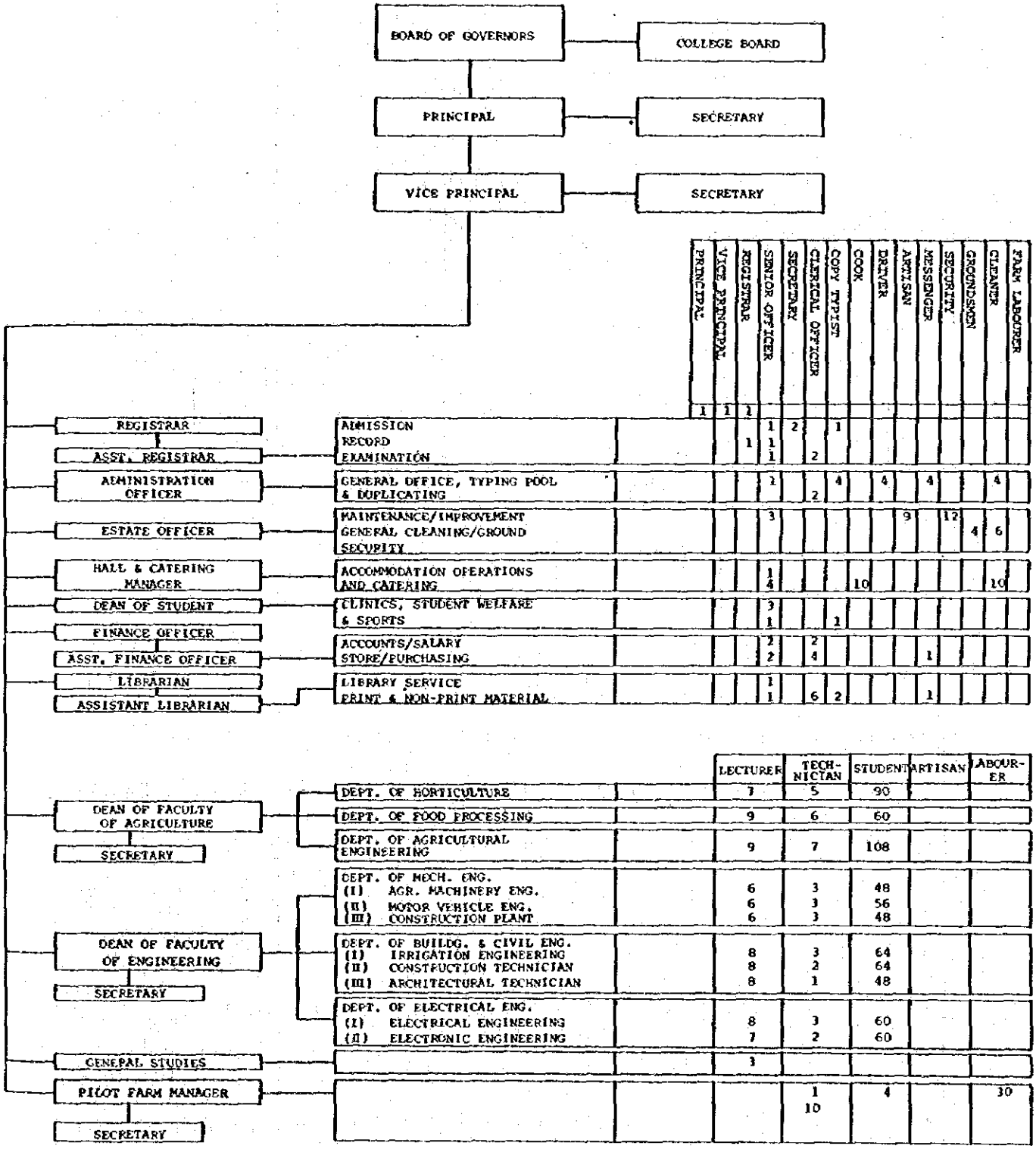
Designation	Present Staff		Proposed Staff	
	Class	Number	Class	Number
Farm Manager	Technician	1	Technician	1
Ass. Farm Manager	Ass. Technician	1	Ass. Technician	1
Farm Demonstrator	Ass. Technician	3	Ass. Technician	10
Tractor Operator		1		3
Farm Workers		17		20
Pump Attendants		-		2
Clerk/Storeman		1		1
Cleaner		-		1
Copy Typist		-		1
Casuals		25		Not fixed

Source: JKCAT, 1983/84 Staff Estimates, Feb. 1983.
The present staff shown is as of June 1, 1983.

Table 3-3 Farm Machinery

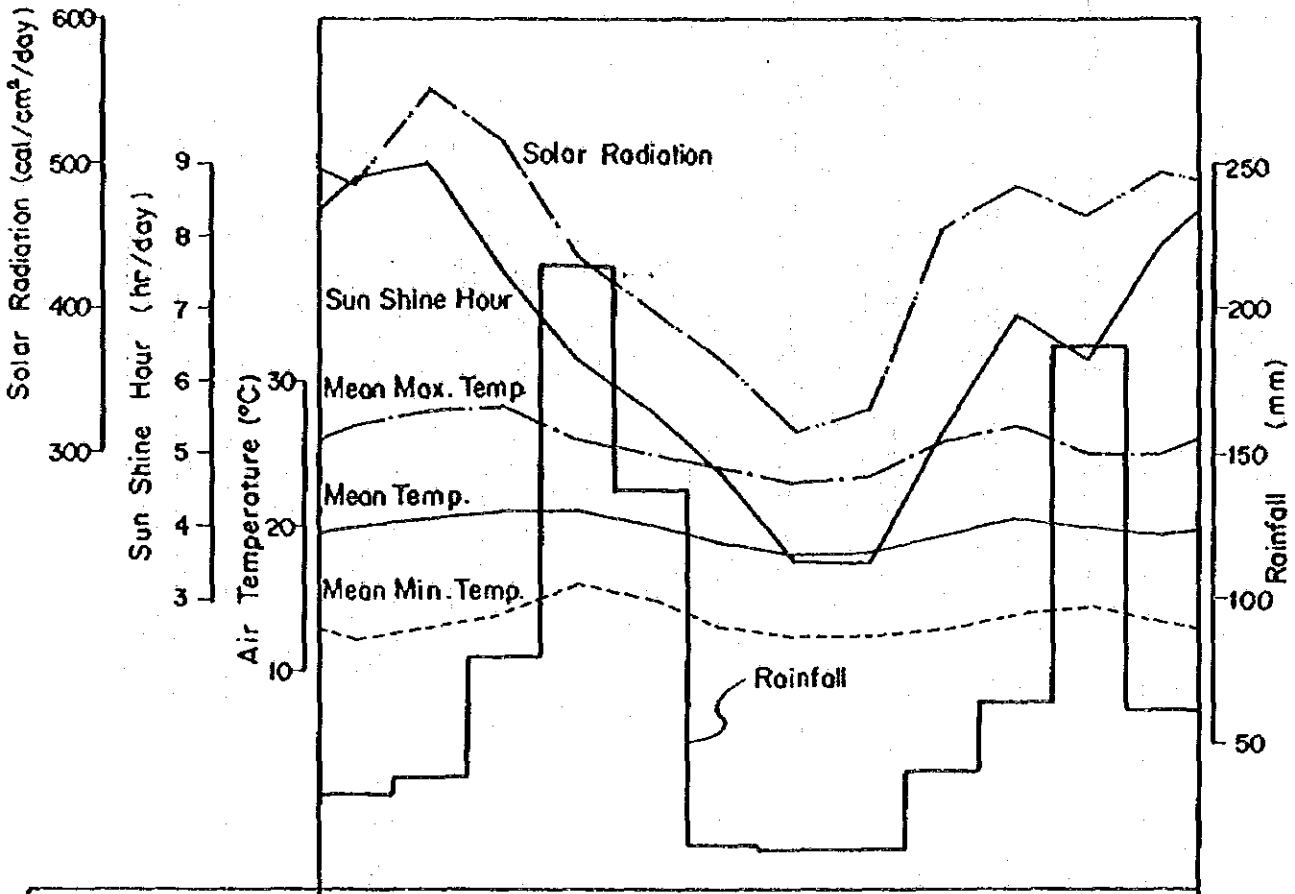
	Machinery	Specification	Quantity
I.	Tractors:		
	1. Tractor	60 HP class, 4WD with front loader	2
	2. Tractor	40 HP class, 4WD	2
II.	Ploughing, Soil Preparation:		
	1. Bottom plough	16" x 1	1
	2. Latice plough	16" x 2	1
	3. Slick plough	18" x 1	1
	4. Chisel plough	7 tines, for 55 - 80 HP tractor	1
	5. Culti-packer	Width 200 mm, for 60 - 80 HP tractor	1
	6. Disc harrow	Tandem type, 18" x 24	1
	7. Disc harrow	Offset type, 18" x 16	1
III.	Planting:		
	1. Planter	Pressurized jet method, 4-raws	1
	2. Grain drill	14-rows, with fertilizer applicator	1
IV.	Crop Protection:		
	1. Cultivator	No. of tine, 4 x 5 = 20, furrow width 600 - 758 mm	1
	2. Boom sprayer	Tank capacity of 500 lit., 6 m coverage	1
	3. Soil sterilizer	Tiller type injector, injection depth of 100 - 200 mm	1
	4. Brush cutter	Float type, approx. 40 m(displacement	10
V.	Harvesting:		
	1. Bean thresher	0.2 - 0.3 ha/hr w/engine of 4 HP	1
	2. Bean harvester	0.2 - 0.3 ha/hr 5 HP class	
	3. Corn sheller	Approx. 1,000 kg/hr, w/engine of 3 HP	1
VI.	Spare Parts	For about one year	L.S

Fig. 2-1 Organization of College



Remarks: Number of staff of General Studies Department means the present staff number, and the staff number of the pilot farm is present number as of June, 1983.

Fig. 3-1 Meteorological Condition of JKCAT Area



Month	J	F	M	A	M	J	J	A	S	O	N	D
Mean Max. Temp. (°C)	27.0	27.9	28.2	26.1	25.1	24.2	23.0	23.6	26.2	27.0	25.2	25.2
Mean Min. Temp (°C)	12.3	13.2	14.2	16.1	14.9	13.2	12.5	12.4	12.9	14.0	14.7	13.6
Mean Temp. (°C)	19.7	20.6	21.2	21.1	20.0	18.7	17.8	18.0	19.6	20.5	20.0	19.4
Relative Humidity at 9:00 a.m. (%)	73	74	77	83	81	81	84	83	80	74	81	79
Relative Humidity at 3:00 p.m. (%)	44	40	43	53	56	53	56	53	44	40	49	52
Evaporation (mm/day) class A pan	5.3	5.8	6.0	4.3	3.8	3.3	2.8	3.3	4.5	5.2	4.4	4.6
Sun Shine Hour (hr/day)	8.8	9.0	7.5	6.3	5.6	4.7	3.5	3.5	5.3	6.9	6.3	7.9
Radiation (cal/cm²/day)	485	550	514	435	399	367	315	339	453	486	465	495
Rainfall (mm)	34	39	81	214	136	15	14	14	41	65	188	62

Remarks: Meteorological data shown above are mean values for years '73 - '83, observed at Thika meteorological station and rainfall data recorded at Thika Karamaini rainfall station.

Fig. 4-1 Construction Time Schedule

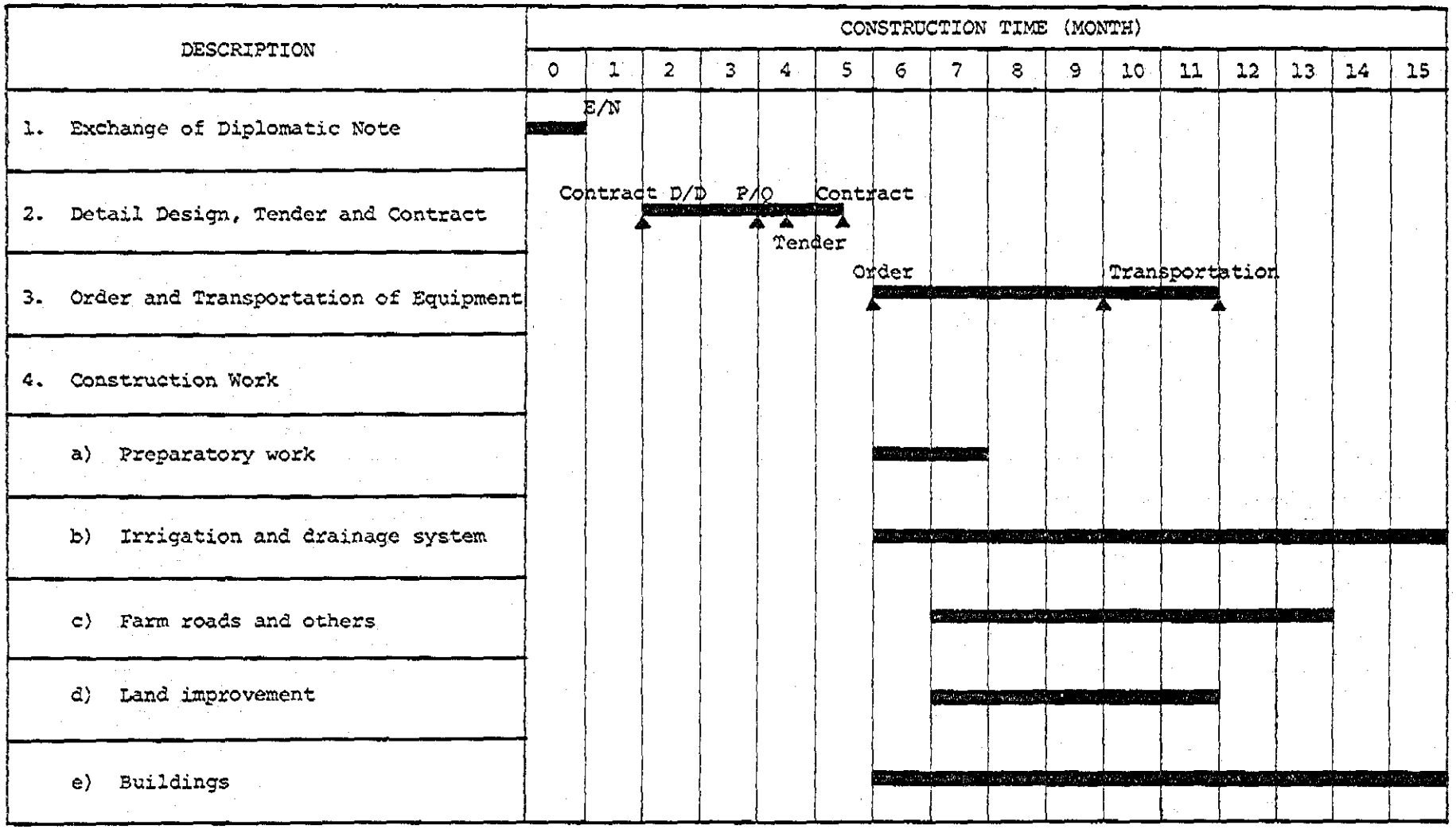
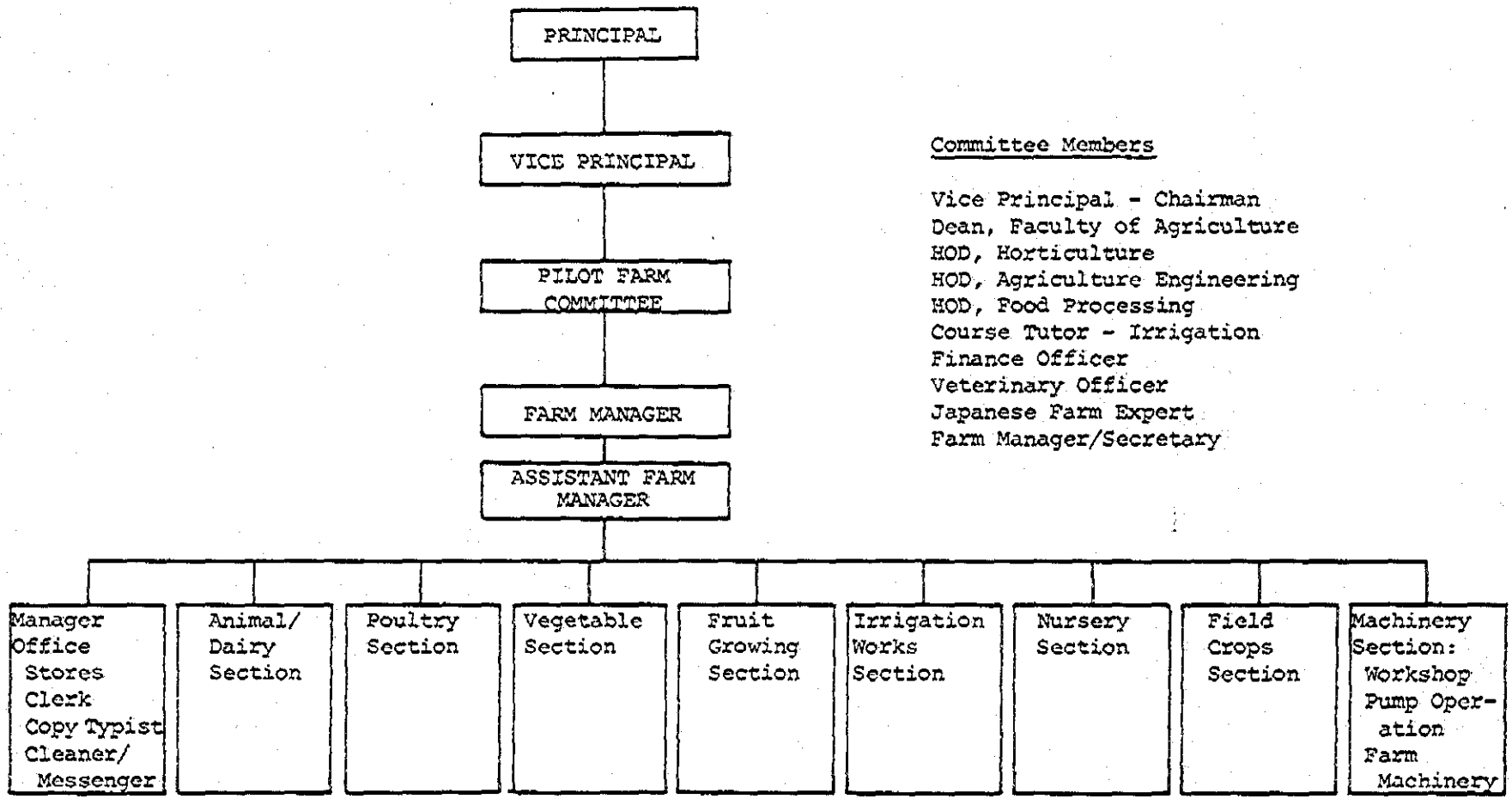


Fig. 4-2 Proposed Organization for Farm Management



Committee Members

Vice Principal - Chairman
Dean, Faculty of Agriculture
HOD, Horticulture
HOD, Agriculture Engineering
HOD, Food Processing
Course Tutor - Irrigation
Finance Officer
Veterinary Officer
Japanese Farm Expert
Farm Manager/Secretary

Remarks: Upto assistant farm manager level from the top has been organized.

ANNEX

LIST OF ANNEXES

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Annex 1 Activities of the Study Team

As shown in Fig. A-1, the field survey work was carried out for one (1) month. Immediately after the field work, home office work was conducted in Japan. All results of these survey and office works were compiled in the final draft report on the Project.

1. Field Survey Work

The work item carried out during the field survey is summarized as follows:

(1) discussion with the government staff on the basic project concept, work programme, operation and maintenance system of the farm, cost allocation, undertaking of the Government, etc.,

(2) reconnaissance of the project area, college compound and possible sites of water sources,

(3) collection of data and information necessary for the basic design of the Project, which includes the following:

- topographic maps (scale: 1/3,000 with a contour interval of 1.0 meter) covering the whole area of the college compound,
- meteo-hydrological data such as rainfall, temperature, river discharge, etc.,
- data and information on present agriculture and soils (present land use, soil map, present and future cropping patterns, etc.),

- data and information on irrigation and drainage system (test result of existing well and/or tubewell, present conditions of irrigation and water supply system, design conditions for related structures, etc.),
- data and information on construction of the farm such as available construction materials, labour, cost data, construction method, law and regulation related to the construction, etc., and
- data and information on the present situation and future programme of the College, particularly for proper operation of the faculty of agriculture including its training farm.

(4) execution of field survey work which includes:

- topographic survey of intake sites, pipeline, canal route, if necessary,
- confirmation of soil conditions in the project area,
- survey for assessment of irrigation water requirement and water supply to the college compound,
- hydrological data collection of possible water sources such as Ndarugu and Thiririka rivers and groundwater,
- survey of the existing water supply facilities and proposed plan of water supply system,
- survey of transportation facility, and
- survey of sites for workshop, office, class room and warehouse related to the Pilot Farm.

(5) preliminary analysis and compilation of collected data and information.

2. Home Office Work

Based on the result of the field work, the following works were carried out in Japan:

(1) finalization of the project concept including the following:

- basic design of the Pilot Farm,
- assessment of irrigation water requirement and water demand, and preparation of water supply plan to the college compound,
- basic design of irrigation plan and drainage plan, and
- preparation of operation and maintenance programme for the farm including its related facilities.

(2) basic design of the project facilities which include intake structure, irrigation and drainage network, road network, water supply system, workshop, farm management building and warehouse,

(3) preparation of construction plan and schedule,

(4) cost estimate,

(5) project evaluation, and

(6) preparation of basic design study report.

Annex 2

MINUTES OF DISCUSSION
ON
THE CONSTRUCTION OF THE DEMONSTRATION FARM OF JOMO KENYATTA COLLEGE OF AGRICULTURE AND TECHNOLOGY IN THE REPUBLIC OF KENYA

In response to the request made by the Government of the Republic of Kenya for the construction of the Demonstration Farm of Jomo Kenyatta College of Agriculture and Technology in Juja (hereinafter referred to as "the Project"), the Government of Japan has sent a team through Japan International Cooperation Agency (JICA) headed by Prof. Kazuo Shimamura, Professor of the Faculty of Agriculture, Okayama University, to conduct a basic design study on the Project from 22nd May, 1983 to 20th June, 1983 (hereinafter referred to as "the Japanese Team"). The Japanese Team has carried out a field survey, held a series of discussions and exchanged views with the Kenyan authorities concerned.

As the result of the study and discussions, the Japanaese Team and the Kenyan Authorities concerned have agreed to recommend to the respective Governments to examine the results of the study attached herewith towards the realization of the Project.

Kazuo Shimamura

PROF., KAZUO SHIMAMURA
Team Leader
The Japanese Team

MR. J.T. ARAP LETING
Permanent Secretary
Ministry of Higher Education
Republic of Kenya

3rd June, 1983
NAIROBI

1. The objective of the Project is to provide necessary facilities, equipment and building for the Demonstration Farm of Jomo Kenyatta College of Agriculture and Technology in Juja (hereinafter referred as "the Farm").

2. The proposed site of the Project is the land in Jomo Kenyatta College of Agriculture and Technology (hereinafter referred to as "the Project Site"). The Project site is shown in General Plan.

3. The Farm will be utilized as follows:

   3-1 To contribute to practice on agricultural technology in accordance with the syllabus.

   3-2 To contribute to study on agricultural development in semi-arid areas similar to most Kenyan arable land.

4. The Japanese Team will convey to the Government of Japan the desire of the Government of the Republic of Kenya that the former takes necessary measures to cooperate in implementing the Project and provides the facilities and other items listed in ATTACHMENT-I within the scope of Japanese economic cooperation programme in grant form.

5. The Japanese Team will convey to the Government of Japan the desire of the Government of the Republic of Kenya that technical cooperation is needed for the smooth and effective operation of the Farm.

6. The Government of the Republic of Kenya will take necessary measures listed in ATTACHMENT-II on condition that the grant assistance by the Government of Japan is extended to the Project.

7. The Japanese Team and the Kenyan authorities concerned have confirmed that Japanese Team has explained Japan's Grant Aid Programme and the Kenyan authorities concerned have understood it.

ATTACHMENT-I

Items requested by the Government of the Republic of Kenya the cost of which will be borne by the Government of Japan:

1. Development of about 20 hectares of Demonstration Farm.
2. Irrigation facilities including farm ponds.
3. Farm roads and drainage.
4. Water intake facilities for the irrigation.
5. Bore holes.
6. Farm building for training and studies.
7. Farm workshop.
8. Farm storage rooms.
9. Equipment for maintenance of the farm.

ATTACHMENT-II

Following arrangements are required to be taken by the Government of the Republic of Kenya:

1. To secure adequate land necessary for the construction of facilities and to clear and level the site as needed before the start of the construction.
2. To provide facilities for distribution of electricity, water supply, drainage and telephone.
3. To ensure prompt unloading, tax exemption, customs clearance at ports of disembarkation in Kenya and prompt internal transportation therein of the products purchased under the grant.
4. To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in Kenya with respect to the supply of the products and services under the verified contracts.
5. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contracts such facilities as may be necessary for their entry into Kenya and stay therein for performance of their work.
6. To maintain and use properly the facilities constructed and equipment purchased under the grant.
7. To bear all expenses, other than those to be borne by the grant, necessary for the construction of the facilities as well as for the internal transportation of the products and services under the grant.
8. To undertake incidental civil works such as fence, if needed.

AGREED MINUTES OF DISCUSSION ON THE PROJECT FOR THE IMPROVEMENT OF THE PILOT FARM OF JOMO KENYATTA COLLEGE OF AGRICULTURE AND TECHNOLOGY

In response to the request of the Government of the Republic of Kenya concerning the execution of the project for the improvement of the Pilot Farm of Jomo Kenyatta College of Agriculture and Technology under the Japanese grant aid up to seven hundred and eighty million yen (¥ 780,000,000), the Government of Japan dispatched a Mission to finalize the Basic Design Study based on the Minutes of Discussion dated 3rd June, 1983 on the project mentioned above through Japan International Cooperation Agency (JICA, from 16th to 27th September, 1983. The Mission had a series of discussions with the Kenyan authorities concerned.

As a result of the discussion on the report, both parties agreed to recommend to their respective Governments that the major points of understanding, attached herewith, be adopted for the implementation of the Project.

MR. J. T. ARAP LETING
PERMANENT SECRETARY
MINISTRY OF HIGHER EDUCATION
THE REPUBLIC OF KENYA

MR. KATSUJI ONODA
TEAM LEADER
THE JAPANESE MISSION
JICA

22nd September, 1983.

MAJOR POINTS OF UNDERSTANDING

1. Both sides agreed in principle to the basic design proposed in the Draft Final Report.

2. The Kenyan authorities desired the modification of the project buildings design to relate to the existing farm stractures for effective utility.

3. The Final Report (20 copies in English) on the Project will be submitted to the Government of the Republic of Kenya through the JICA Office in Nairobi by the end of November 1983.

4. Project Implementation Committee

The Project Implementation Committee should be established by the end of October, 1983 to include the following members:-

Kenyan Side

Permanent Secretary of the Ministry of Higher Education

Director of the Ministry of Higher Education

Principal of Jomo Kenyatta College of Agriculture and Technology - Co-ordinator.

Ministry of Finance

Ministry of Works and Housing

Ministry of Water Development

Ministry of Agriculture

Japanese Side

Official of the Embassy of Japan

Resident Representative of JICA Nairobi Office

Team Leader of Japanese

Project Consultant

Project Contractor

Annex 3 Soils in the Farm

The soils of the farm area were surveyed by Kenya Soil Survey in detail. According to the soil map compiled by Kenya Soil Survey in 1978, eight soil units are identified in the farm area as shown in Fig. A-2. The units are defined on the basis of physiography, geology, drainage condition, soil depth, consistence and texture. The soils in the farm area have developed on the same physiographic unit of plain and derived from the same geology of pyrocrastic rocks of trachytic tuffs. However, they are broadly divided into two groups for the purpose of the practical use of agriculture, i.e., shallow clay soils and deep clay soils. The shallow clay soils consisting of PP1M, PP2M, PP3M, PPC1 and parts of PPC2 occupy about 75 ha in total or 56% of the farm area. In general, the soils are very shallow to moderately deep, friable and well drained with gravelly sandy clay to clay texture. All of them are underlain by petroplinthite (indurated murram) or pisoferric materials (loose murram) at the depth ranging from 10 to 80 cm. The presence of petroplinthite on or near the soil surface inhibits root penetration and may limit the use of mechanized agricultural equipment. The soils of PPM and PPC are correlated with Cambisols in FAO classification system. The deep clay soils consisting of PPd1, PPd2, PPd3 and parts of PPC2 extend over about 57 ha in total or 44% of the farm area. In general, the soils are poorly to very poorly drained, deep to very deep, mottled and cracking when dry. Heavy textured, swelling and cracking properties of the soils may affect the workability especially during the land preparation. The soils of PPd are correlated with Vertisols or Gleysols in FAO system.

The 20 ha area demarcated in the farm area is mainly covered with the mapping unit of PPC1 which is an association of moderately deep to deep soils and shallow to very shallow

soils. The two components of the association distribute in accordance with the microrelief. Since the stone sized blocks of petroplinthite occur on the surface in places, it is necessary to confirm the distribution of each component for the technical design of agricultural use by making more detailed soil survey.

Major characteristics of each mapping unit, which are considered as limitations for arable farming, are summarized in Table A-3. The part other than suitable for crop cultivation can be utilized for pasture, forest of bamboo or trees for wind break, tractor training yard, cattle shed, farmpond and etc.

Table A-1 Member List of Basic Design Study Team and Government Staff Concerned to the Project

Position	Name
1) Basic Design Study Team	
- Team Leader	Professor Kazuo SHIMAMURA
- Project Coordinator	Mr. Katsuji ONODA
- Senior Civil Engineer	Mr. Akira SAMPEI
- Senior Agronomist	Mr. Akio MAEDA
- Irrigation Engineer	Mr. Kazunori KATO
- Irrigation Engineer	Mr. Teruo KAJIMOTO
2) Government Staff Concerned to the Project	
- Principal JKCAT	Mr. J. M. GITHAIGA
- Deputy Principal JKCAT	Dr. G. A. ORIE
- Ministry of Higher Education, Nairobi Headquarters	Mr. A. K. KIBEBE
- Ministry of Water Development, Nairobi Headquarters	Mr. M. MESNY
- Finance Officer, JKCAT	Mr. E. N. NDUATI
- Japanese Team Leader, JKCAT	Mr. T. KAWAGUCHI
- Assistant Japanese Team Leader, JKCAT	Mr. T. NAKANO
- Agriculture Engineering, JKCAT	Mr. K. TSURITA
- Pilot Farm, JKCAT	Mr. N. MORITA
- Horticulture Department, JKCAT	Mr. H. MORIYA
- Course Tutor Irrigation, JKCAT	Mr. M. S. IBRAHIM
- HOD, Horticulture, JKCAT	Mrs. E. M. KAHANGI
- Dean, Agriculture, JKCAT	Mr. S. S. WERU
- Veterinary Officer, JKCAT	Dr. S. G. GICHURU
- HOD, Food Processing Department, JKCAT	Mr. T. SUGIYAMA
- Farm Manager/Secretary, JKCAT	Mr. P. M. SANGURA

Table A-2 Major Limitations for Arable Farming

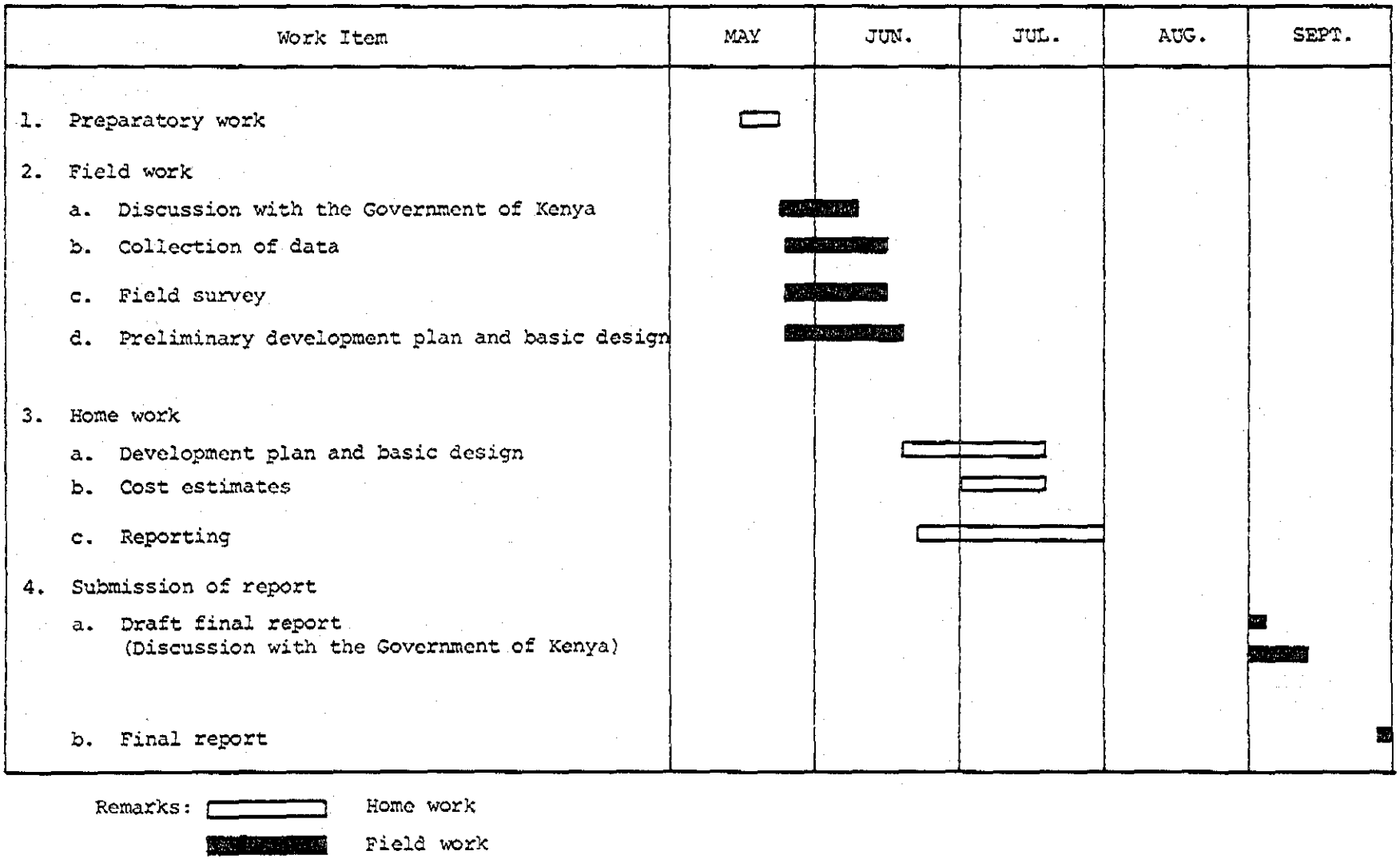
Mapping Unit	Limitations	Extent ha	Extent %
Shallow clay soils			
PP1M	Soil depth (shallow in places), low chemical fertility	2.6	2
PP2M	Soil depth (very shallow to shallow), low chemical fertility	10.5	8
PP3M	Soil depth (very shallow to shallow), low chemical fertility	24.9	19
	Sub-total	38.0	29
Deep clay soils			
PPd1	Drainage (imperfectly drained to poorly drained, seasonally waterlogged), poor workability (swelling and cracking clays), low to moderate chemical soil fertility	11.2	9
PPd2	Drainage (poorly drained to very poorly drained, in places waterlogged), poor workability (swelling and cracking clays), low to moderate chemical soil fertility	0.9	1
PPd3	Drainage (poorly drained to very poorly drained, in places waterlogged), poor workability (swelling and cracking clays), low to moderate chemical soil fertility	42.2	32
	Sub-total	54.3	42
Associated soils			
PPC1	Soil depth (very shallow to shallow in places) low chemical soil fertility	33.2	26
PPC2	Soil depth (shallow in places), drainage (poorly drained in places), low to moderate chemical soil fertility	4.6	3
	Sub-total	37.8	29
	Total	130.1	100

Remarks: P = Plains (Physiography)
P = Soils developed on pyroclastic rocks-trachytic tuff (parent material or geology)
M = Very shallow over petroplinthite (murram)
M = Shallow over petroplinthite (murram)
C = Soil complex or association
d = Dark colour

Very shallow	0 - 25 cm
Shallow	25 - 50 cm
Moderately deep	50 - 80 cm
Deep	80 - 120 cm
Very deep	more than 120 cm

Source: Kenya Soil Survey, 1978

Fig. A-1 Activities of Basic Design Study Team



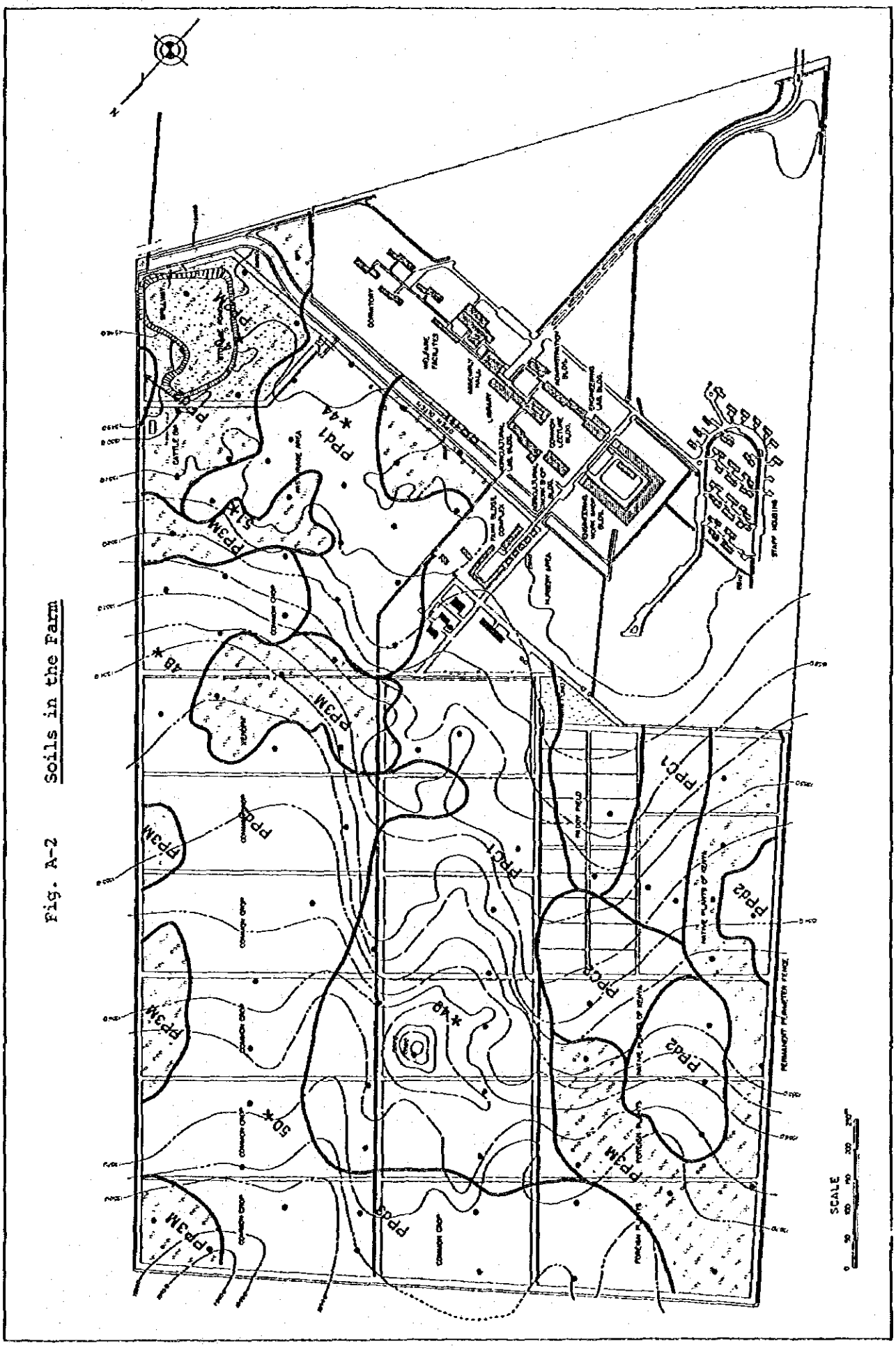


Fig. A-2 Soils in the Farm