BASIC DESIGN STUDY REPORT

ON

IMPROVEMENT PROJECT OF NATIONAL HORTICULTURAL RESEARCH STATION

IN

REPUBLIC OF KENYA

SEPTEMBER 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Kenya, the Government of Japan decided to conduct a Basic Design Study on the Improvement Project of the National Horticultural Research Station and entrusted the Study to the Japan International Cooperation Agency (JICA). JICA sent to Kenya a study team headed by Dr. Yutaka Machida, Chief of Second Breeding Laboratory, Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries, from 15 January to 17 February 1984.

The team had discussions with the officials concerned of the Government of Kenya on the Project and conducted a field survey. After the team returned to Japan, further studies were made and the present Report has been prepared.

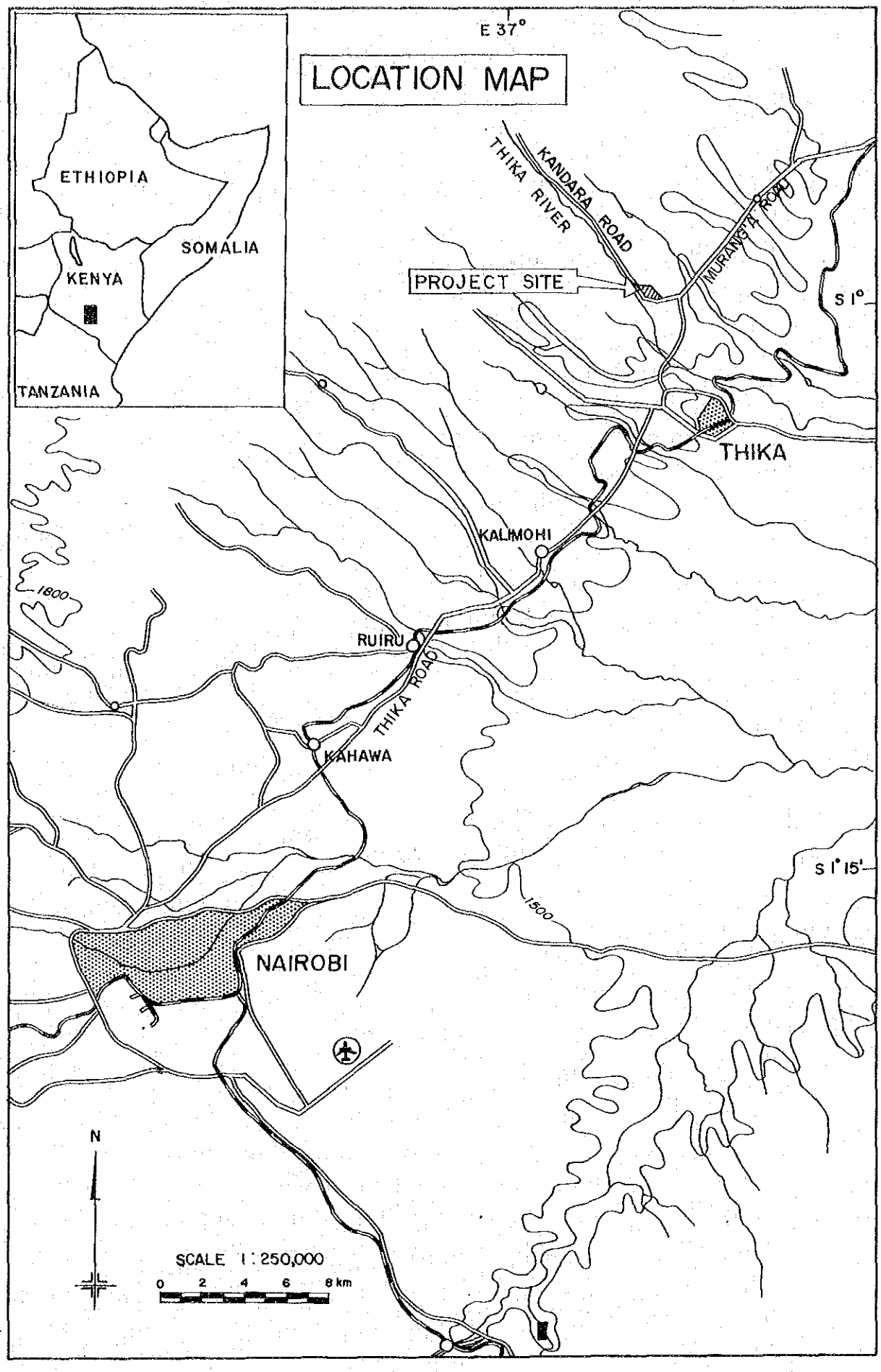
I hope that this Report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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, 1984

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency


LOCATION MAP
E 37°
ETHIOPIA
SOMALIA
KENYA
TANZANIA
THIKA RIVER
KANDARA ROAD
MURANG'A ROAD
PROJECT SITE
S 1°
THIKA
KALIMOHI
1800
RUIRU
THIKA ROAD
KAHAWA
S 1° 15'
1500
NAIROBI
N
SCALE 1 : 250,000
0 2 4 6 8 km

SUMMARY

In the Fourth (1979-83) and Fifth Development Plan (1984-88), two of the main targets for the agricultural sector are: (i) to improve small-scale farmers' income, and (ii) to improve the foreign currency balance by increasing production of export crops. In this regard, increase in, as well as diversification of, agricultural export products is emphasized.

The Government strongly supports development and production of selected perennial crops including fruit trees, which are suitable to soil and weather conditions. In accordance with this policy, the Government established a development plan for Macadamia nuts. The development plan includes not only improvement of production technology, breeding of quality varieties, and development of suitable cultivation methods, but also multiplication of seedlings.

Macadamia seeds were introduced in 1946 from Hawaii, Australia and South Africa. Between 1964 and 1971, about 800,000 trees were planted. However, as these trees were low-yielding due to seed multiplication, some farmers cut them down, reducing the number of trees to about 600,000.

In this connection, research activities were intensified from 1977 through the combined efforts of the Government of Kenya and technical cooperation of the Government of Japan, and as a result, selection of high yielding varieties and grafting propagation techniques are improving.

Results of the research activities mentioned above confirm that establishment of a nut development center for further research and/or experiments, and for training in grafting techniques, will be required for extension of quality nut seedlings to small holders as a new cash crop.

Based on the above findings, the Government of Kenya requested grant aid from the Government of Japan in 1982. Subsequently, the Government of Japan, through the Japan International Cooperation Agency, dispatched two missions for project finding and preliminary survey. The Preliminary Survey Team discussed the scope of works with government agencies concerned aimed at formulating a project entitled "Improvement Project of National Horticultural Research Station (NHRS)".

In response to the agreement of scope of works with the Kenyan Government, the Government of Japan sent a Basic Survey Team to Kenya, through the Japan International Cooperation Agency. The Team visited the relevant areas of the Project from 15 January to 17 February 1984 to carry out the study and to hold necessary discussions with Kenyan Government officials concerned.

The scope of the Study includes principally the following: (i) dicussion with officials concerned of the Government of Kenya, (ii) collection of necessary information and data, (iii) site survey, and (iv) basic design for facilities, etc.

After preparation of a draft basic design study report, the Government of Japan, through the Japan International Cooperation Agency, sent a Team to Kenya from 15 July to 26 July 1984 for explanation of the draft report and final confirmation of the Project.

According to the final confirmation, the Project objective is to establish the Nut Research Unit in the National Horticultural Research Station at Thika for promotion of further research and experiment, and extension of nut cultivation.

The main activities of the proposed Unit will concentrate on basic research and experiments in pomology, especially of nut trees, mainly macadamia. Within this overall framework: (i) breeding of selected varieties for yield and quality, (ii) technical improvement of grafting and top-working, and (iii) establishment of basic cultivation techniques including plant protection, irrigation, inter-cultivation, etc., will be presumed. In addition, technical training in grafting techniques will be executed as a second priority activity.

Mass production of quality seedlings and their distribution will be conducted with technical support of the Unit through a nursery center, which will be established separately by the Government of Kenya for smooth and effective extension and promotion of macadamia production.

The Unit will be under the supervision of the Scientific Research Division with cooperation of the Crop Production Division, and execution of the Project will be the responsibility of the Director of Agriculture, Ministry of Agriculture and Livestock Development.

The Unit will be composed of a Research Section, a Training and Nursery Section, an Experimental Farm and an Administration Section to carry out the main activities. A Project Management/Advisory Committee to manage the Center will also be considered.

The proposed main facilities of the Project are briefly listed below:

- Main building:	Administration, laboratory, training, etc.
- Horticultural facilities:	Grafting workshop, greenhouse, shadehouse, etc.
- Experimental farm:	Experimental farm, scion garden, etc.
- Water Supply:	Intake facility for farm irrigation and domestic use
- Hostel:	For trainees

The proposed Project site is located within the National Horticultural Research Station (NHRS), which is situated 42km northeast of the capital, Nairobi, while Thika Town, with a population of 60,000, is located 4km south of the site. Administratively, the site belongs to Muranga District.

The gross area of the site is about 30ha consisting of an experimental farm, coppice and bush. The altitude is about 1,500m above sea level, and the gently undulating slopes have a maximum height difference of 10m which could be utilized in the layout of the proposed buildings.

West of the site, the Thika River flows in a north-south direction. Water level of the river is 45m lower than the site, and the riverbank has a slope of 10^{o} between the riverbed and the top of the bank. The water resources of the river will be utilized for irrigation and domestic use in the Project.

The soil of the Project area is classified into reddish laterite derived from pyroclastic flow of tuffs. The depth of the soil layer ranges from 0-120cm and soil in the upland area on the left bank of the Thika River is well-drained. The lower area is generally considered unsuitable for farming due to poor drainage. Alluvial and upland soils are dark red to dark brown and overall soils are slightly acidic and relatively poor in humus.

The climate of the Project area is divided into four seasons; namely, a warm dry season (mid-December - mid-March), main rainy season (mid-March - May), cool dry season (June - mid-October) and secondary rainy season (mid-October - mid-December).

Average maximum and minimum temperatures recorded are 27.7°C and 12.5°C respectively in the past 10 years. However, maximum and minimum temperatures recorded during the past 22 years at the Project site are 33.3°C in February and 5.6°C in January and August. The average annual rainfall at the site is about 950mm but the actual amount varies from less than 700mm to more than 1,200mm.

Project implementation will proceed under the general direction of the Kenyan Ministry of Agriculture and Livestock Development. Project implementation consists of detailed design and construction phases, and a total 18 months of Project time after the exchange of notes by both Governments is estimated at present.

As a result of Project activities, small holders will receive some surplus from their farm income through nut cultivation, while the Government will be expected to obtain foreign exchange from exported products in this sector. About 750 technical personnel will be trained within five (5) years in nut tree cultivation and grafting techniques at the Unit. It is expected that these technical personnel will contribute to agricultural production in Kenya in general, and in particularly with regards to fruit production and seedling propagation not only of nut trees but also of other kinds of fruit trees, in spite of a shortage of technical personnel in this field at present.

To realise the aims of the Government, through the Project entitled "Improvement of the National Horticultural Research Station", the Nut Research Unit will play a key role in successful implementation of nut development in Kenya. According to project planning, the Government target for replacement of low yielding nut varieties with 1,000,000 trees of high yielding varieties within 10 years would be attainable.

A technical cooperation program for the Project could be recommended for smooth and effective operation of the Unit upon its establishment. The Unit could be operational within five years, the duration of the first stage of the Project. However, activities will be

limited compared to the wide extension area for nut cultivation. Therefore, after the initial stage of the Project, certain sub-centers should be established in some districts for expansion of Unit activities.

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CHAPTER I

INTRODUCTION

CHAPTER I: INTRODUCTION

The macadamia nut was introduced into Kenya from Hawaii, Australia and South Africa in 1946 and from 1964 to 1971 about 800,000 trees were planted in the fields of small-scale farmers under Government encouragement. However, these were by seed and thus a substantial portion of these plantings proved to be low yielding. As a result, new planting almost ceased in 1972 and a selection program commenced with technical cooperation provided by the Government of Japan at the National Horticultural Research Station. Under this program many efforts have been made and recently some clones of high yielding varieties were selected and are about to be multiplied through grafted seedlings and top working of low yielding mature trees.

In this way, the Government intends to boost to the same level as Hawaii, the yield and production of macadamia nuts at the earliest possible date in competition with other countries such as Australia, Brazil and South Africa where interest in macadamia development has intensified. The Government of Kenya attaches great importance to the macadamia and other nut industry (almond, pecan, oyster nuts, etc.) as a future cash crop for small land-holders and also as an export crop to increase foreign currency earnings.

Nut development will require the establishment of a nut development center in which agronomic and other technical field research work will be carried out in collaboration with the existing National Horticultural Research Station, Ministry of Agriculture and Livestock Development. It is envisioned that the Center will provide facilities for breeding and agronomic research as well as for study of plant protection and training in grafting techniques for the purposes of propagation and extension of nut trees.

Based on this background, in June 1982 the Government of Kenya requested the Government of Japan to provide grant aid for establishing a center aimed at improving macadamia nut development. The request included a development center and sub-center with activities of research, experiment, propagation, and training.

Immediately after receipt of the request, the Government of Japan sent a Project Finding Team to Kenya in October 1982. Subsequently, in May 1983, a revised project plan for the center prepared by the Crop Production Division, Ministry of Agriculture was submitted to the Government of Japan in the same manner as the original request.

Based on the results of the Project Finding Team and the revised plan, a Preliminary Survey Team was sent to Kenya from 19-29 October 1983. The Team carried out a field study, held a series of disoussions and exchanged views with Kenyan authorities concerned on the proposed grant aid request. As a result of the study and discussions, the Team and the Kenyan authorities concerned confirmed the following:

Project Title

The title of the project is to be "The Project for Improvement of the National Horticultural Research Station"

Objective

The objective of the Project is to provide necessary buildings, facilities and equipment for establishing a nut research and development center, mainly Macadamia nut, at the National Horticultural Research Station on condition that grant aid by the Government of Japan is extended to the Project.

Project Components

1. Center building
   (a) administration
   (b) breeding, agronomy, soils and plant nutrition, and crop protection
   (c) training
2. Nursery workshop
3. Greenhouse and shadehouse
4. Storehouse and workshop
5. Water supply and drainage system including irrigation facilities
6. Development of demonstration farm (approx. 3.5ha)
7. Machinery and equipment necessary for Center activities

In response to the minutes of the Preliminary Survey Team dated October 1983, a Basic Design Survey Team, headed by Dr. Yutaka MACHIDA, Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries, Japan, was dispatched by the Government of Japan, through the Japan International Cooperation Agency (JICA) from 15 January to 17 February 1984. The Team carried out data and information collection, site survey and necessary studies, and exchanged views with officials concerned aimed at formulating the Project.

After preparation of the draft basic design study report, the Government of Japan, through JICA, sent a Team to Kenya from 15 July to 26 July 1984 for explanation of the draft report and final confirmation of the Project.

The member lists of the Basic Design Survey Team and Explanatory Team, itinerary of the same and minutes are presented as APPENDIX-I and APPENDIX-II.

CHAPTER II

BACKGROUND OF THE PROJECT

CHAPTER II: BACKGROUND OF THE PROJECT

2.1 General Economy

2.1.1 Economic Growth

Since Independence in 1963, the Government of Kenya has emphasized industrial development in order to move away from a colonial economic system based on agriculture. As a result of this emphasis, successful industrialization has been achieved in Kenya.

In this connection, the first reason for success is that the Government policy of Africanization has promoted a moderate and realistic basis on which free economic activities, especially in the sector of industry can be conducted. Secondly, the Government adopted an aggressive policy on the introduction of foreign capital in the early stage of economic development, and investment and technical cooperation from advanced countries has been actively implemented.

Kenya's Fourth Development Plan (1979-83) was drafted during the coffee boom of 1976-77 and reflected the optimism of that period. However, the country experienced a sharp deterioration in its international terms of trade beginning in 1978, as a result of increases of petroleum prices and a precipitous decline in coffee prices from their peak levels. Adverse climatic conditions during 1979-80 further affected the nation's economic situation. Accordingly, GDP growth was relatively low, falling from 6.6% in 1978 to 4.2% in 1979 and 3.3% in 1980.

The austerity program is having an inevitable negative impact on domestic production. Growth of manufacturing declined to 2.7% in 1982 and there was a drop in construction activity. Growth of service sectors also suffered. Fortunately, good weather contributed to a recovery of agricultural output, which increased by 6.2% in 1981 and 4.4% in 1982. This resulted in an increase in GDP of 5.5% in 1981 and 3.3% in 1982, despite weakness in other sectors. The table presented on the following page demonstrates these increases.

REAL GROWTH OF GDP BY SECTOR, 1978-82

unit: %

Sector	Long Run Trend Growth Rate 1972-78	1979	1980	1981	1982	Share of Total GDP 1982
Agriculture, Forestry, Fishing	2.6	-0.7	-1.1	6.2	4.4	34.8
Mining and Quarrying	7.1	-1.4	-0.7	-18.0	0.0	0.2
Manufacturing	10.7	7.1	5.7	5.0	2.7	13.3
Electricity	8.0	6.6	6.2	6.1	3.6	2.0
Construction	-0.4	6.5	6.3	5.8	-6.8	5.1
Trade, Restaurants and Hotels	3.3	6.1	3.5	0.0	-1.4	9.7
Transportation	3.5	7.2	7.1	1.5	4.6	5.7
Finance	10.2	9.9	7.8	21.9	11.5	4.1
Ownership of Dwelling	5.1	5.8	4.7	7.7	6.3	6.9
Other Services	8.0	11.0	11.9	7.3	6.2	3.6
Government	6.3	7.1	5.6	5.3	3.4	14.6
Total GDP at Factor Cost	5.0	4.2	3.3	5.5	3.3	100.0

Source: Economic Survey, various issues

Note: 1972-78 trend is based on 1972 prices;
growth rates for 1979-82 are based on 1979 prices.

According to the GDP in 1982, the economic contribution of each sector was 34.8% for agriculture including forestry and fishery, 13.3% for manufacturing, 9.7% for the commercial sector, 17.1% for transportation, etc. These sectors represent 74.9% of the total.

The growth of GDP in 1983 is expected to be the same as 1982 (3%), with the growth rate of the agricultural sector remaining at about 4.5% under the same climatic conditions. With the sharp reduction in Government expenditure in 1982/83 and the continuing restraints on the 1983/84 budget, growth in GDP is expected to be somewhat lower than in 1982 at 3.3%. As the population growth rate is approximately the same, growth of per capita income for the Plan period (1979-83) would be marginal.

2.1.2 Financial Conditions

On the basis of preliminary estimates, the 1982/83 fiscal year was a difficult one. Some progress was made however in achieving a better balance between revenues and expenditures. While current revenues grew by 6% current expenditures are estimated to have increased by nearly 15%, leaving a large budget deficit on current account. Development and investment expenditures were reduced appreciably. There was also a significant increase in receipt from external grants and loans (Table II-1).

Although 1982 was another difficult year for Kenya's balance of payments, there were also some positive features. The chief of these was a significant improvement in the balance of trade as a result of tighter growth in export receipts than in import payments as shown below.

BALANCE OF TRADE

Unit: KL million

Item	1978	1979	1980	1981	1982*
Exports	395.7	412.8	515.7	537.1	569.5
Imports	661.1	620.2	959.0	931.8	945.2
Total	-265.4	-207.4	-443.3	-394.7	-375.7

* provisional
Source: Economic Survey, 1983

The foreign exchange reserves of the monetary authorities declined sharply between the end of 1979 and late 1981 and continued to decline during much of 1982 (Table II-2).

The per capita income has been reported at US$420 in 1980 as presented below.

PER CAPITA INCOME (MARKET PRICE)

Unit: US$

Year	1976	1977	1978	1979	1980
Income	240	270	330	380	420

Source: IBRD

2.1.3 Population and Employment

Rapid population growth is probably the most important obstacle to raising living standards in Kenya over the long term. It is intimately linked to the problems of land use, adequacy of food supply, opportunities for productive employment and the ability of the society to satisfy elementary basic needs. The growth of the country's population has been accelerating with reduced mortality and increased fertility rates. The dramatic decline in the mortality rate is mostly attributable to extensive improvements in public health measures as well as the general rise in the standard of living throughout the country since Independence in 1963.

The 1979 Population Census assumes a growth rate of 3.8%. According to this, the population in 1983 has been estimated at 18.8 million. The high rate of population growth reflects strong social and economic preferences for large families, and a rapid decline in fertility does not appear imminent. If the fertility rate declined from the present level of 3.8 to 3.6, Kenya's population would still increase to 32.5 million by the end of the century. Even if the decreased rate of fertility were halved, the population would approach 30 million by the year 2000.

In any case, the nation's output of goods and services must grow at a faster rate than the population if there is to be any improvement in the average standard of living. In 1981, the output of about 40% of the population had to support the remaining 60%. At the same time, employment has grown over the period from 1976-81 at an annual average rate of only 3%, which is lower than the growth rates of population and labor force as shown in the tables presented on the following page.

TOTAL POPULATION AND POPULATION OF WORKING AGE

Unit: millions

Item	1964[1/]	1972	1981
Total Population	9.104	12.067	16.514
Population of Working Age[2/]	4.461	5.551	7.762
Labor Force[3/]	3.792	4.718	6.598

Source: Development Plan 1984-88

Note: 1/ The 1964 and 1972 figures are taken from Statistical Abstract for the years 1972 and 1974. The 1981 figure is estimated applying the annual growth rate of 3.8% to 1979 Census figures.

2/ Population in the age-group of 15-59. The age distribution of 1962, 1969 and 1979 Censuses respectively, have been used for 1964, 1972 and 1981.

3/ Taken as 85% of Population of Working Age (c.f. Development Plan, 1979-83).

EMPLOYMENT AND UNEMPLOYMENT

Unit: millions

Item	1976[1/]	1981	Growth Rate (1976-81)
Labor Force	5.473	6.598	3.8
Employment			
Small-scale agriculture	2.665	3.040	2.7
Pastoralists	0.390	0.445	2.7
Modern sector	0.915	1.086	3.5
Rural: non-farm	0.990	1.180	3.6
Urban: informal	0.125	0.157	4.7
Total Employment	5.085	5.908	3.0
Residual	0.388	0.690	12.2
Residual as % of Labor Force	7.1	10.5	-

Source: Development Plan, 1984-88

Note: 1/ The figures in this colomn have been taken from Development Plan, 1979-83 Table 2.1. However, the estimate of the labor force given has been revised in the light of 1979 Census data on total population and age distribution.

2.2 Present Agricultural Conditions

2.2.1 General

The Republic of Kenya, with a land area of 575,000km^2, is a country of contrasts in climate, topography and agricultural systems. Despite its large land area, the diversity of ecological and climatic conditions in the country limit the amount of good quality agricultural land. Only about 7% can be described as highly suitable land for agriculture, possessing adequate and reliable rainfall and good soils, while another 11% is of medium adaptability and an additional 4.5% is arable, but subject to periodic drought and crop failure. The remaining land area is suitable only for livestock. Kenya's population in 1983 is estimated at about 18.8 million, with a growth rate of 3.8% per year. The high rate of population growth has caused increasing pressure on supplies of arable land. Kenya's relative progress in industrialization belies the extent to which the economy is fundamentally based on agriculture. Agriculture accounts for about 34% of GDP, and about 85% of the population live and work in rural areas. Agriculture also provides over 50% of export earnings (mainly coffee and tea), nearly all domestic food supplies, and raw materials for Kenya's industries.

Kenya's agricultural structure has undergone considerable change since Independence in 1963, but is still characterized by a degree of dualism. A broad distinction can be made between the large-scale farmers and small holders which includes the great majority of the rural population. Of the total farmed area of 6.2 million ha (including ranches), large farms cover about 1.6 million ha (25% of the area), small holdings (less than 20ha) about 3.5 million ha (60%), and ranches 1.1 million ha (15%). With the continuing subdivision of large group-owned farms, the proportion of land owned and operated by small holders is increasing.

Small-scale agriculture is the dominant mode of production in Kenya, accounting for an estimated 75% of production and 85% of total agricultural employment. There are more than 1.7 million small holdings in Kenya accounting for an estimated 95% of Kenya's farming population. The average size of these holdings is 2.3ha but over 75% of all small holdings are under 2ha. Although small holders consume much of their own

output, they also play a crucial role in commercial production of both export crops, and domestic cash and food crops.

2.2.2 Main Crops

Main crops are maize, wheat, barley, pulses, sorghum, sugarcane, coffee, tea, sisal, cotton, etc., however, the irrigated area is only 0.4% of total cultivation area. Productivity of the main crops are at a very low level compared with world averages, except rice, sugarcane, tea and sisal, owing to traditional farming practices.

The harvested area, production and yield of the main crops are tabled below:

PRODUCTION OF THE MAIN CROPS (1982)

Crops	Harvested Area ('000ha)	Production ('000ton)	Yield (kg/ha)	Average Yield in the World (kg/ha)
Wheat	100	250	2,500	2,009
Rice	9	43	4,886	2,871
Barley	90	100	1,111	2,068
Maize	1,300	2,300	1,769	3,465
Sorghum	210	220	1,048	1,447
Pulses	560	250	446	674
Cotton	121	30	250	1,286
Vegetable	440	15	621	301,740
Sugarcane	42	4,695	111,610	58,682
Coffee	130	95	729	499
Tea	69	96	1,395	764
Sisal	40	42	1,050	692

Source: FAO Production Yearbook, 1982

2.2.3 Problems in Agriculture

In contrast to earlier years, the recent performance of both the large farm and small holder sectors has been disappointing. In the period between 1964 and 1972, agriculture increased at a growth rate of 4.6% per annum, fueled by the rapid small holder adoption of previously restricted high-value cash crops (coffee, tea, etc.), the expansion of cultivated land as large farms were subdivided, and the spread of hybrid maize. Between 1974 and 1979, agricultural growth slowed to about 3.6% per annum

according to GDP estimated by the Government, less than the population growth rate. This average growth rate, however, makes considerable difference in performance among commodities. While the growth of production of coffee, tea and sugarcane has been particularly strong in the last decade, production of maize, wheat, pulses and dairy products has slowed. This trend is particularly serious given the importance of maize and pulses in the diet of the majority of the population.

Reasons for poor performance include drought in several years, with a particularly severe drought period in some areas of the country in 1979 and 1980; the withdrawal of the crop insurance scheme and reorganization of the seasonal credit scheme; and poor pricing and marketing incentives, particularly for key domestic food crops. As a result of crop failures in 1979/80, massive grain imports, totalling US$71.2 million, were necessary.

The Government places great importance on reversing these downward trends and on achieving food self-sufficiency. Given Kenya's limited land supplies and rapidly growing population, however, production increase will not be as easily achieved as in the past, since there are no new technological developments available such as hybrid seeds to promote rapid growth. Thus, in the future, Kenya must rely mainly on the intensification of small holder agricultural services and price incentives, to realize its sectoral targets and achieve food self-sufficiency.

2.2.4 Development Strategy

In the Fourth and Fifth National Economic Development Plan (1979/83, 1984/88), the strategy for the agricultural sector is: (i) to improve small-scale farmers' income, (ii) to increase agricultural products in relation to population growth, and (iii) to improve the foreign currency balance by means of increasing production of import-substitutional crops and export crops, etc. In this regard, increase in as well as diversification of agricultural export products are as important.

Most of the nation's food requirements must continue to be met from domestic supplies and therefore, a major strategy of the Fifth Plan is to maintain general self sufficiency in basic food stuffs. At the same time,

agricultural export earnings will be expanded by promoting exports of fruits, livestock and horticultural products, and by increasing production and improving the quality of livestock products, and coffee and tea exports. Agricultural employment will be increased through more intensive husbandry, an expansion in agro-industrial processing activities and extension of more labor intensive crops.

According to the Fifth Plan (1984/88), target growth for agricultural production is 4.5% annually for the first four years, rising to 5.0% in 1988, for an average annual growth rate of 4.6%. Of the total planned increase in agricultural output, just over one third is expected to result from increased crop area. Much of this will come from grazing lands in the drier zones where yields are below the national average. The remaining two-thirds of the increase is expected to result from higher yields reflecting the emphasis in the Plan on intensification of land use.

2.2.5 Present Research Activities

Research in the agricultural sector is carried out by a number of ministries and institutions. The Science and Technology Act, passed in 1977, created mechanisms for advising on research and technology related issues and for coordinating research, including; (i) the National Council for Science and Technology, to establish research policy; (ii) Advisory Research Committees (ARCs) to manage research programs; and (iii) Stationary Research Institutes (SRIs) to execute policies and programs.

The Kenya Agricultural Research Institute (KARI) was established in 1979 under MOA, and was supposed to evolve into a comprehensive research organization providing national coordination, execution and management of agricultural research. In 1982, the Ministry of Regional Development, Science & Technology (MRDST) was created and the research councils and KARI were transferred to MRDT's responsibility.

The research organization of the research system is currently in a state of transition, due to combining of the Ministry of Agriculture and Ministry of Livestock Development in 1983.

The national research stations are oriented generally towords research for specific crops, whereas regional research institutes research for a specific agro-ecological or regional area. A summary of major research institutes is presented in Table II-3 and Fig. II-1.

2.3 National Horticultural Research Station

2.3.1 History

In 1957 the Government of Kenya decided to initiate horticultural research in Thika, mainly to research pineapple cultivation given the availability of a canning factory located thereat. In the early 1960s, horticultural research in Thika was expanded to include research on other fruits and vegetables. In 1974 the existing research station became the National Horticultural Research Station (NHRS), and by late 1975 horticultural research offices were moved from the old station site to their present location at the NHRS.

Currently all horticultural research is concentrated and coordinated at the NHRS and a number of sub-stations selected for climatic suitability for cultivation of a variety of crops. The Station is conducting a number of projects on research of fruits, vegetables, plant protection, grain, legumes and sericulture, and advises the Government about development of the horticultural industry. Over the years, the NHRS has also received international assistance for some research and development projects based at the Station.

Macadamia farming in Kenya started in 1946 around Thika and flourished in coffee growing areas. However, when commercial growing by small-scale farmers was begun in 1964 it was soon discovered that original seeds were not suitable for production due to low yield. Since the crop has good potential, and a processing factory has already been established, it was decided in 1971 to embark on an improvement program for the existing plantations through selection and vegetative propagation. In 1977 and 1978, two Japanese experts came as part of a Japanese technical cooperation program to reinforce selection and propagation activities.

Research on legumes was initiated at the NHRS in 1972, with the assistance of Dutch bilateral aid. The first phase of this project, which focused on beans for canning purposes, ended in 1975. The second phase (1975-80) focused on beans as a food crop and will be continued in the third phase of the project which began in May 1980.

In 1978 under FAO/UNDP assistance a project on horticultural research and development commenced. This project aims at strengthening present research on fruits, vegetables and plant protection problems.

2.3.2 Facilities

Main offices for research on fruits, vegetables, sericulture, grain, and legumes, and for general administration are located at the NHRS, while the office for macadamia research is at the old station. A facility has been completed as a Horticultural Training Unit Station under the Grant Aid Program of West Germany, and two new greenhouses were built at the NHRS under Japanese cooperation. Several small laboratories already exist; namely, those for entomology, plant pathology, vegetables and food science and technology.

Two pumphouses provide irrigation water for the station; one situated near the dam to supply the NHRS, and another small capacity pump situated near Thika River to supply the old station. Stores for irrigation equipment, tools, chemicals and other inputs are found at different places while a central store for the entire Station is located at the old station.

Finally, the Station also has a photography unit (fully equipped for the processing and printing of black and white film and the preparation of teaching aids) and a main library. Smaller libraries are operated by different sections. However, at present the Station receives only a limited budget and material support from the national headquarters (Table II-4).

2.3.3 Research Work

The main research activities of the NHRS concern fruits, vegetables and ornamentals. Macadamia nut research programs on the selection of high yielding clones and vegetative propagation are being conducted on a minor scale at the old station area.

At present, the main research programs are being conducted as follows:

Fruits

- Rootstock and fertilizer requirement for citrus
- Rootstock and variety selection of avocado
- Cropping system for passion fruits
- Variety selection for apple and pineapple
- Pruning for grapes
- Selection of high yielding clones and vegetative propagation for macadamia

Vegetables

- Fertilizer and water requirement for tomato, onion, eggplant, etc.
- Gibberellic and effect on flowering for carrots
- Post vernalization for onion
- Seed yield evaluation for chilies and cucumber
- Variety evaluation for onion, cucumber, tomato, melon, etc.

Ornamentals

- Propagation technique and nutrition requirement for carnation
- Photoperiodism for chrysanthemum
- Temperature and light influence for garbera and gladiolus

2.4 Present Stage of Macadamia Nut Production

Macadamia nuts were introduced into Kenya from Hawaii, Australia and South Africa in 1946 in the coffee zone. Between 1964 and 1971, about 814,400 trees were planted (Table II-5). It was realized later that most of the trees planted were inferior varieties and, since they were planted as non-grafted seedlings from seeds, would lead to variations.

New planting was stopped in 1971 to allow for more research work owing to recommendations of FAO Consultant, Prof. Dr. R.A. Hamilton (APPENDIX III). Research was intensified around 1977 through the combined efforts of the Ministry, and Kenya Nut Company Ltd., with technical cooperation from the government of Japan. The research results were very encouraging. High yielding varieties were identified and propagated, and seedlings will be distributed to farmers for planting. In addition, old trees are now being top-worked as an experiment in increasing the yield and producing good quality nuts.

Farmers were frustrated at the beginning of macadamia development because their trees were low yielding with poor quality nuts which were

rejected by processors. As a result, some farmers cut down their trees and thus the number of trees estimated by the Ministry of Agriculture was reduced to about 600,000.

According to the Province and District Annual Reports of 1979, planted area of macadamia nuts is only 2,620ha mainly in the Central and Eastern Provinces. This indicates that actually only about 530,000 trees exist in the field. However, due to top-working, new high yielding trees, and an improved marketing system, the farmers are once again interested in macadamia production. The demand for high quality grafted seedlings is very high and hence there is need to expand in this area.

Yield from the new varieties is about 40kg as compared to 5kg from the original trees. Also, after top-working, the original trees' productivity is improved and hence the same need not be uprooted. With the cooperation of experts from Japan it has now been established that most of these mixed plantations can be greatly improved through top-working with scions from selected trees of good quality and yield. At the same time it has been shown that all future plantings must be based on selected vegetatively propagated material.

Buying and processing of raw nuts is carried out by the Kenya Nut Company Ltd. which was established in 1975 through a joint venture between Japanese enterprise and the Horticultural Crops Development Authority and I.C.A of Nairobi. In 1983, the Company received 1,245 tons of raw nuts, equivalent to about 300 tons of processed nuts, with a net payment of K£ 150,030.4 to the farmers (Table II-6).

According to the trade statistics, export of shelled macadamia nuts is increasing year by year.

EXPORT OF SHELLED MACADAMIA NUT

	Quantity (kg)	Value (1,000 Ksh)	Remarks
1980	154,441	4,842,739	
1981	156,594	6,816,321	
1982	203,320	9,381,515	
1983	38,720	2,409,425	Jan. - Jun.

Source: Annual Trade Report, 1982

CHAPTER III

BASIC CONCEPT OF THE PROJECT

CHAPTER III: BASIC CONCEPT OF THE PROJECT

3.1 Introduction

As mentioned before, the strategy of the National Economic Development Plan strongly supports the development and production of selected perennial crops including fruit trees, especially nut trees. According to this policy, the Government established a development plan for Macadamia nuts. The development plan includes not only basic research for improvement of production technology, breeding of quality varieties, and development of suitable cultivation methods, but also multiplication of seedlings.

3.2 Objectives of the Project

3.2.1 Long Term Objectives

The long term objective of the Project is to establish a center for nut development where the major crop will be macadamia nuts, with a view to replacing the existing low yielding varieties and to expand new planted areas where rainfall is about 1,200mm (50 inches) or more in temperate areas and to achieve one million trees of new varieties in total within 10 years through top-working and grafted seedlings (Fig. III-1). Therefore the acreage under macadamia cultivation will be expanded and also new nut varieties introduced. As a result of Project activities, small holders will recieve some surplus from their farm income through nut cultivation, while the processed nuts will be exported and thus contribute to increase the country's foreign exchange.

3.2.2 Short Term Objectives

The most immediate objectives are to improve the existing experimental and research facilities including the nursery, to promote basic research of nut propagation and cultivation at the National Horticultural Research Station through the establishement of the Nut Research Unit, and to increase the production of grafted seedlings of new selected varieties for multiplication at the nursery center, which will be established separately by the Government of Kenya. Research and development work on new nut varieties, together with their appropriate intercropping and irrigation systems, will also be carried out.

Furthermore, staff members of the Unit will give technical training in grafting to Government officers and selected farmers.

3.3 Outline of the Project

3.3.1 Scope of the Project

The Nut Development Project has broadly divergent facilities, extension area and a wide range of activities. However, according to the characteristics of the Grant Aid Program, aid will be provided only in the field of urgent needs and/or minimum facilities which fulfill short term objectives. Taking into consideration these factors, the facilities and other related activities of the envisioned Project retain only the minimum requirement that will achieve the desired performance of the Project.

According to this approach, the activities, organization and facilities of the Project are envisaged and drafted on the basis of an initial 5 year period. Therefore, the establishment of sub-centers in the respective districts for local production of seedlings and nursery centers for propagation of grafted seedlings are not included in the Project.

3.3.2 Activities

As mentioned under Project objectives, the main activities of the Unit will be concentrated on basic research and experiments in nut trees especially macadamia. Besides these activities, technical training on grafting will be executed as the second most important activity.

Mass production of quality seedlings and their distribution will be undertaken by the nursery center, which will be established separately by the Government of Kenya, through the technical guidance, research and training activities of the Unit.

(1) Research and Experiment Activities

The main research and experiment activities of the Unit will include the following:

- To select scion mother trees and stocks for vegetative propagation;
- To study characteristics and adaptabilities of selected clones;
- To study and improve suitable nut cultivation methods;

- To study the physiological characteristics of the relationship between soil and plant nutrition;
- To study the physiological and/or plant tissue affinity between stocks and scions for improvement of grafting and top-working technique; and,
- To study insects, pests and disease control.

(2) Training Program

A training program for grafting will be included in the Project activities since no training course is provided by the NHRS at present. Training for government officers and selected farmers will consist of instruction in practical cultivation of nuts, and grafting theory and techniques by on-the-job training, and will be conducted at the Unit which is equipped with a classroom, hostel, grafting exercise facilities, and experienced staff members.

Training will be classified into five courses as follows:

Course	Duration	Trainees
A	1 week	Provincial Crop Officers (PCO)
		District Horticultural Crop Officers (DHCO)
B	2 weeks	Divisional Extension Officers (DEO)
C	3 week	Locational Extension Officers (LEO)
D	1 weeks	Farmers Training Center Officers
E	Temporary	Selected Farmers and others

Trainees will participate from those districts suitable for nut growing; namely, Kiambu, Muranga, Nyeri, Kirinyaga, Embu, Meru, Machacos, Taita-Tabeta, Kitale, Kisii, Kakamega, Bungoma, etc. In the initial stage of 5 years, a total of about 750 trainees will be expected. (Table III-1).

(3) Production Program of Seedlings

To support the production of grafted seedlings with high yielding scions at the nursery center is also one of the very important activities in the Unit. Quality seedlings will also be produced through on-the-job training and research activities, and these seedlings will be handed over to the nursery center for distribution.

According to estimation, the production capacity of grafted seedlings in Unit facilities will be about 10,000 trees per annum. Under this condition, utilization of greenhouses will be 4 times per annum; in other words, a 4 lot production system will be established. Accordingly, with a survival ratio of 70%, about 3,600 scions should be grafted within three months, or about 60 scions should be produced per day with 60 net working days.

(4) Propagation Program

As mentioned above, the Government has a desire to expand one million trees within 10 years through extension of grafted seedlings and including top-working. A production capacity of 10,000 seedlings per annum for project facilities would be helpful as a base for the Project in the initial period of 5 years. As for other main production activities, seedling production in the nursery center and top-working in the extension area could be kept at a constant pace with continuous efforts on extension activities.

Furthermore, if some sub-centers are established at least in the 6 concerned districts, each with production capacity of 20,000 grafted seedlings per annum, the final target of one million trees may be achieved. An outline of the propagation program will be assumed as follows:

Unit: '000

Year	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
Unit	0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	90.0
Sub-Center	0	0	0	0	0	60.0*	120.0**	120.0	120.0	120.0	540.0
Nursery Center	0	10.0	20.0	40.0	50.0	50.0	50.0	50.0	50.0	50.0	370.0
Total	0	20.0	30.0	50.0	60.0	120.0	180.0	180.0	180.0	180.0	1,000.0

* 3 Districts
** 6 Districts

3.3.3 Organization of the Unit

In order to achieve the stated goals and objectives of the Nut Development Project, the Scientific Research Division (SRD) of the Ministry of Agriculture and Livestock Development (MOALD) headed by the Director of Research will provide overall leadership. The main research activities of the Project will be located and executed by the National Horticultural Research Station (NHRS), Thika (Fig. III-2). Whereas the SRD will provide the overall leadership of the Project, the Crop Production Division (CPD) will have a substantial role to play and more specifically will be responsible in:-

- establishment of linkages with the field staff to the expected target areas of the Project activities;
- selection of farmers for training and dissemination of materials for propagation and other outputs from the research station(s) to the respective farmers through field extension staff; and,
- advising the project management/advisory committee team on matters relating to the project program development

Overall responsibility for Project implementaiton will be with the Director of Agriculture, under the Permanent Secretary, MOALD. The Director of Agriculture is responsible for the general direction of agricultural development including all the technical aspects of all extension and research activities. The SRD and CPD are therefore directly under the Director of Agriculture.

The newly appointed Project manager would be fully responsible for the day-to-day operations and management of both technical and administrative activities through the Director of the National Horticultural Research Station, Thika.

The Unit will be composed of a Research Section, a Training and Nursery Section and an Experimental Farm on which to conduct the main research activities as well as an Administrative Section. A Project management/advisory committee will be instituted to advise on the running of the Unit (Fig. III-3). In future a number of sub-stations will be identified by the Government of Kenya as need arises in order to accelerate the project work in the outlying target districts.

(1) Research Section

The research section will form the core of the Unit, and will be arranged according to four main research activities; namely, Agronomy, Breeding, Soil and Plant Nutrition, and Plant Protection. The same will also have an Experimental Farm for the purposes of research and experiments in the field including study of inter-cropping systems and irrigation effects. The farm will also include a demonstration area and scion garden.

(2) Training and Nursery Section

The main activities of the training and nursery section will be the execution of training programs for government officers and selected farmers in grafting techniques through on-the-job training. It will also be responsible for propagation of selected clones through breeding activities which will be used as scion mother trees. A certain amount of grafted seedlings will be produced continuously through research and training activities. Quality seedlings will be handed over to the nursery center for distribution (Fig. III-4).

(3) Administration Section

Management of the Unit will be covered by the Administration Section. This section, headed by a Section head, will include clerks, secretaries, accountants, a receptionist cum telephone operator, watchmen, hostel inspector, cook, sweeper, etc.

(4) Management/Advisory Committee

A Management/Advisory Committee could be organized in the following manner: The Committee under the Chief of the Scientific Research Division will be connected with the Unit to act as a policy maker and management guide, to approve annual work plans including the budget, and to promote the Project.

The committee will consist of the Chiefs from each of the following: Scientific Research Division (SRD), Crop Production Division (CPD), Extension and Manpower Development Division (EMDP), and will also include the Director of NHRS, representatives of the Treasury, and the Unit Project Manager.

The Chief of SRD and the Project Manager will be appointed as Chairman and Secretary of the Committee, respectively.

3.3.4 Number of Personnel

The number of personnel in the Project at full operation under the institutional framework mentioned above is assumed as an intention of the Government of Kenya.

PERSONNEL

Personnel	Grade	No.	Res. Div.	Trai. & Nurs	Exp. Farm	Administration
Manager	(L)	1	-	-	-	1
Researcher (AO)	(K)	7	5	1	1	-
Asst. Res. (TO)	(G/H)	7	3	3	1	-
Tech. Asst (TA)	(F)	9	5	3	1	-
Subordinate (SS)	(A/B)	20	6	6	8	-
Executive Asst.	(G/H)	1	-	-	-	1
Clerical Officer	(D/F)	2	-	-	-	2
Accountant Clerk	(D/E)	2	-	-	-	2
Copy Typist	(E)	3	1	-	-	2
Tel. Ope./Recept.	(C)	1	-	-	-	1
Watchmen	(C)	3	-	-	-	3
Driver	(C)	3	-	2	1	-
Messengers	(B)	2	-	-	-	2
Hostel Inspector	(F)	1	-	-	-	1
Cook	(E)	2	-	-	-	2
Sweeper	(B)	2	-	-	-	2
Total		66	20	15	12	19

In addition to the regular personnel totaling 66, some temporary and/or seasonal employees would be required on a subordinate level for nursery and grafting works, and the experimental farm.

3.4 Location and Facilities

The Project area is located at the old station area in the existing National Horticultural Research Station near Thika City, 42km northeast of the capital, Nairobi. To achieve the activities mentioned above, the following facilities would be required:

- Main building:	Administration, laboratory, training etc.
- Horticultural facilities:	Grafting workshop, greenhouse shadehouse, etc.
- Experimental farm:	Experimental farm, scion garden, etc.
- Water Supply:	Intake facility for farm irrigation and domestic use
- Hostel	For trainees

Details of said facilities are described in CHAPTER V, BASIC DESIGN.

3.5 Estimated Operation and Maintenance Cost

Very rough estimations of the annual operation and maintenance cost in a normal year for the Project are given in Table III-2. The total cost indicated in the table would be born by the Government of Kenya after commencement of Project operation.

The estimation was calculated without hostel costs such as food, heat and light expenses, which are to be born by the trainees.

The following table presents a summary of Administration Costs.

ESTIMATED ADMINISTRATION COST

	Ksh.'000
A. Staff salaries	1,745
B. Research and Experiments	320
C. Training	285
D. Operation & Maintenance	405
Total	2,755

CHAPTER IV

PROJECT SITE

CHAPTER IV: PROJECT SITE

4.1 Location and General Conditions

The proposed Project site is situated 42km northeast of the capital Nairobi and administratively belongs to Muranga District. The Project site is readily accessible from the capital, the distance between which can be covered by automobile in about 50 minutes via an asphalt paved road which connects Nairobi, Murang'a and Nyeri. The Jomo Kenyatta Institute of Agriculture and Technology which was constructed by Japanese grant aid is also situated along this same road about 14km southwest from the site.

Murang'a district is one of the five Districts in Central Province. It has a total area of 2,476km^2 and a population of 648,000 persons giving a density of about 262 persons/km^2. Administratively the District is divided into five divisions namely Kiharu, Kangema, Kigumo, Kandara and Makuyu. The Project site belongs to Kandara Division. Geographically the District can be divided into three zones. The upper zone covers the upper parts of Kigumo, Kiharu and Kangema where tea and maize is grown only once a year. The middle zone is a little warmer than the upper zone, and serves mostly as coffee plantations. The lower zone which covers Makuyu, parts of Kiharu and Kandara is dry. Some parts of this zone are sparsely populated. In this zone sisal and pineapple plantations are predominate.

Approximately 4km south of the Project site Thika Town is located, which belongs to Kiambu District. Thika Town has a population of about 60,000, and covers an area of 9,300ha. Industrial development forms the main employment sector and source of income for most of the population in this area. At present there are about 22 major industries including vehicle assembly, textile, bag production, fruit canning, paper manufacturing, etc., while a town hall, commercial market, sports stadium, hospitals, commercial bank, schools, etc., provide necessary social services. The Project site and its environs is economically and socially influenced by Thika Town.

The gross area of the Project site is about 30ha consisting of an experimental farm, coppice and bush. The altitude of the site is about 1,500m, and the gently undulating slopes have a maximum height difference of 10m which could be utilized in the layout of the proposed buildings.

As soil is generally composed of 0~1m thick surface soil with lava below, no problems for the development of experimental farm and construction of buildings is expected. The topographic map of the entire Project site surveyed by the Team is shown in Fig. IV-1.

West of the Project site, the Thika River flows in a north-south direction. The water level of Thika River is 45m lower than the site, and there is a slope of 10° between the riverbed and the hill where the site is located.

River is rather stable throughout the year and it is estimated that about 0.3t/sec in the dry season of January and February will be available. Regarding groundwater, the Team conducted an electric resistivity survey at six points in the Project site. According to the results of the survey, a shallow well seems to be conceivable at the depth of around 50m. However, any confirmation of existence of groundwater or its location in the Project site can not be made until further electric resistivity surveys, test borings, and examination of water quality and quantity by test pumping have been conducted.

Accordingly, the Thika River is expected to be used as a water source for domestic water and irrigation of the proposed Project since the flow of the same would be sufficient and a purifier system would make it possible for the river water to be used for domestic water.

Detailed physical conditions of the Project site, such as topography and geology, soil, meteorology, Thika River and groundwater are described in APPENDIX IV.

4.2 Infrastructural Conditions

4.2.1 Roads

As stated earlier, Thika Town is easily accessible throughout the year via the high standard dual-carriageway constructed in the early seventies. It is only minutes by car from Thika Town to the Project site over the Kandara road. The Project site is situated along the latter, a 2-lane asphalt paved road 10m wide. It would thus be most advantageous to construct an access road to the main building, from Kandara Road.

Asphalt paved roads leading from Thika to other places such as Nyeri, Garissa, Gatanga, Githumu, etc. have also been constructed and accordingly lack of transportation facilities should pose no problem to the distribution of seedlings.

4.2.2 Electricity and Telephone System

The existing power line runs along the Kandara road and the service wire can thus easily be led to the site. In Kenya, the Kenya Power and Lighting Co., Ltd. is usually responsible for installation of transformers and service wires to the main switches. For this Project likewise, the Thika office of the said company will be in charge of the service under the head office in Nairobi.

The existing telephone line also runs along the Kandara road. Installation of telephones and related facilities will be undertaken by the Thika office of Kenya Posts and Telecommunications Corporation.

4.2.3 Water Supply, Sewerage and Gas Supply

About 2.0 million gallons (9,100m^3) of domestic water per day is presently supplied to Thika Town through a treatment plant which utilizes the Chinia River flow. This water supply however is not extended to the Project site and no extension program presently exists. Hence, a domestic water supply for the Project site must be developed under the Project.

Likewise the sewage system for Thika Town does not extend to the site. The existing sewage system for Thika Town is comprised of a network of sewer reticulation and pond sewage treatment works. Under the Project, a sewage and drainage system must be independently facilitated.

A city gas supply system in Thika Town or around the Project site does not exist and thus cylinder gas or electricity is used for laboratories and/or kitchen facilities, as required.

CHAPTER V

BASIC DESIGN

CHAPTER V: BASIC DESIGN

5.1 Basic Plan

5.1.1 General

Buildings, horticultural facilities, experimental farm and water supply system for irrigation and domestic use will be designed in accordance with the requirements of the Project activity and program which is defined in the Basic Concept of the Project, Chapter III of this report.

5.1.2 Master Plan

The master plan of the Project may include the following additional facilities other than the facilities of the present Project described in Chapter III:

- Staff housings
- Farm road
- Other facilities such as car shed, etc.

Accordingly, the master plan including the above facilities has been taken into consideration in layout planning.

5.1.3 Layout Planning

The layout of the present Project will be made based on the topographic survey map to minimize earth moving work. All necessary horticultural facilities enclosed by chain link net fence will be provided along the existing farm road between the experimental farm and the main building. The main building, consisting of administration, research and training sections will be located at the highest area of the Project site and a new access road from Kandara Road will be provided to lead to the main building. A hostel for trainees will be located in the area east of the main building.

A part of the water supply system such as pump station, settling basin, etc., will be located in the old station and a purifier and elevated water tank for domestic water will be located near the main building. The experimental farm will be located on the north side of and along the existing farm road.

The area for staff housing would be located on the east side of the present building area and extension of the horticultural facilities and experimental farm, if required, would be made in the northeast side of the present area.

5.2 Architectural Planning

5.2.1 Basic Design Guidelines

(1) General

Buildings and horticultural facilities will consist of the following structures:

- Main Building
- Nursery Facilities
  Nursery workshop
  Greenhouse/shadehouse
- Farm Building
- Pump Station
- Hostel

(2) Basic Approach

Particular attention during planning will be given to the items below:

a) The existing topography will be fully utilized to minimize the necessity for earth moving work.

b) Layout will be such that administrative, maintenance and operations are simplified and costs are minimized.

c) Layout of horticultural facilities will be made with due consideration of the work process.

d) Design of buildings will be made with due consideration of the local climate including avoidance of direct exposure to sunlight especially from the west and provision of cross ventilation without mechanical means.

e) Construction materials and methods will be selected principally on the basis of ease of procurement, cost, performance capabilities, durablity and local practice.

5.2.2 Architectural Basic Plan

(1) Main Building

The main building, consisting of administration, research and training sections, will be a single storey building with two patios. The patios facilitate cross ventilation and ensure indirect sunlight while the location of the building in the east-west direction will further protect the interior from direct sunlight. Fixed louvres will be provided on the south facade to prevent exposure to sunlight from the south and windows on the west side will be minimized. Training and research rooms will be located in the north side. An exhibition space will be provided at the entrance hall and an outdoor terrace adjacent to the exhibition space will connect the same to the patios.

The following rooms and spaces will be designed:

Administration
- Offices for accountant and general affairs
- Office for manager
- Meeting room
- Secretary room

Research
- Research room for agronomy
- Research room for soil and plant nutrition
- Research room for plant pathology
- Research room for entomology
- Research room for breeding
- Processing room
- Temperature control room
- Library and data room
- Sample room
- Offices for technical cooperation experts
- Secretary room

Training
- Classroom

Others
- Entrance/Exhibition
- Storages
- Electrical room
- Telephone room
- Rest rooms

(2) Horticultural Facilities

Horticultural facilities will be provided for research and training purposes subject to the following practices of grafting and nursery operation. This area will be enclosed by a chain link net fence.

Seeds for stocks will be sown in a seedbed which has been filled with sand. After three or four months of germination, the seedlings for stocks will be taken up one by one from the seedbed and transplanted into a pot with soil and fertilizers. After transplanting, it will be transferred to a shady area to strike roots and then, shifted to the stockyard for hardening.

Once the stock seedlings have grown to an appropriate size for grafting, quality scions will be grafted to the same. Grafted seedlings will be located in a greenhouse with appropriate moisture content and shade for success of grafting operations.

After three or four months of grafting, the seedlings in the greenhouse will be transferred to a shadehouse for domestication before transplanting in the experimental farm or farmers field.

The layout of nursery facilities will be arranged considering the work process as above mentioned, i.e. soil preparation, transplanting of rootstock, cultivation under shade and stockyard hardening, grafting, greenhouse and shadehouse.

Facilities:

- Storage area for transplanting materials
- Seedbed
- Nursery workshop
- Root stockyard with shadehouse
- Greenhouse
- Shadehouse

The main facilities will be the following three structures.

1) Nursery workshop

The nursery workshop will be divided into the following sections:

- Preparation workshop (transplanting)
- Offices (nursery, training and propagation)

- Grafting workshop
- Cold room (5 - 10°C) for storage of scions
- Spray space
- Storage
- Restrooms

2) Greenhouse

A greenhouse of about 200m^2 will be designed. Motor driven ridge windows, side windows, and forced fans as well as movable roof curtains to control sunlight will be provided beneath the roof glass in the same. Watering facilities for moisture control, pad and fan type air conditioner and benches for pots will also be provided.

3) Shadehouse

A shadehouse with a total of about 1,850m^2 will be provided for care of grafted seedlings prior to grafting and delivery to farmers or transplanting in the experimental farm. Sloped paving with drainage and benches for pots will be provided to facilitate workability.

In addition a farm building as a supporting facility for the experimental farm will be provided adjacent to the nursery facilities. The farm building will be divided into the following rooms:

- Garage for farm machinery
- Office room
- Storage for chemicals
- Storage for fertilizers
- Storage for equipment
- Repair shop

No siding will be provided for the garage while a chain link net fence wall with door will be provided in the equipment storage and repair shop.

(3) Hostel

The hostel consists of a bedroom section with 12 bedrooms for a total 24 trainees, and a dining section.

The bedroom section includes toilets with showers, laundry, a small office room and lobby space. The dining room and kitchen of the dining section will be designed to provide meals for 24

trainees including breakfast, lunch and supper. Serving lunch for researchers and administrative staff would also be possible, however, the capacity of the kitchen and dining room capacity will be designed with a limit of up to 24 persons at one time.

The following rooms and spaces will be designed;

Bedrooms
- Twelve bedrooms to be furnished with bunk beds
- Rest rooms with showers
- Laundry
- Small office
- Entrance and lobby

Dining
- Dining room for 24 persons
- Kitchen (kitchen sink, gas stoves, oven, cooking table, pan rack, refrigerator, food storage)

(4) Access Road

An access road from the existing Kandara Road to the main building will be constructed.

5.2.3 Construction and Materials

(1) Codes and Standards

In principle local construction practices and local materials will be incorporated into the plan whenever possible, and the following Kenyean construction specifications will be applied:

- General Specification for Building Works, 1976
- Concrete Specification for Building, 1974
- Structural Steelwork Specification, 1973
- Standard Specification for Metric Sized Concrete Blocks for Building, 1972

(2) Materials

The following materials as they will be imported from Japan or other countries may not comply with the above specifications or British Standards:

- Steel products such as structural steel, grating, checkered steel plate, etc.
- Ceramic, mosaic and glazed tiles
- Acoustic ceiling tiles and metal suspended ceiling system
- Metal fittings

- Hardware
- Sanitary equipment
- Steel pipes
- Any local materials which may present difficulties in quality, color, size, quantity and delivery
- Any materials which may not be replaced after construction

(3) Finishing

The guidelines of exterior and interior finishings are as follows:

1) Main building

Exterior
Roof: Roof tile
Wall: Stone
Fittings: Aluminum doors/steel doors/steel window frames/fixed louver

Interior
Floor: Terrazzo tile/mortar trowel finish
Base: Terrazzo tile/paint on mortar finish
Wall: Paint on plaster
Ceiling: Acoustic ceiling tile/paint on asbestos board
Fittings: Wooden doors

2) Nursery workshop

Exterior
Roof: Corrugated asbestos cement sheet
Wall: Paint on mortar finished concrete block/ chain link net fence
Fittings: Steel doors/steel window frames

Interior
Floor: Terrazzo tile/mortar trowel finish
Base: Terrazzo tile/paint on mortar finish
Wall: Paint on plaster
Ceiling: Paint on asbestos board (offices/storage)
Fittings: Steel doors/wooden doors

3) Farm building

Exterior
Roof: Corrugated asbestos cement sheet
Wall: Paint on mortar finished concrete block/ chain link net fence

Interior
Floor: Mortar trowel finish/Terrazzo tile
Base: Paint on mortar finish/Terrazzo tile
Wall: Paint on plaster

Ceiling: Paint on asbestos board (office and storage area for chemicals /fertilizers only)
Fittings: Steel doors/angle doors with chain link net

4) Hostel

Bedroom section exterior

Roof: Roof tile
Wall: Paint on mortar finished concrete block
Fittings: Steel door/steel window frames

Bedroom section interior

Floor: Terrazzo tile/wooden floor (bedrooms only)
Base: Terrazzo tile/paint on wooden base (bedrooms only)
Wall: Paint on plaster/paint on asbestos cement sheet (bedrooms only)
Ceiling: Paint on asbestos cement sheet
Fittings: Wooden doors

Dining section exterior

Roof: Roof tile
Wall: Paint on mortar finished concrete block
Fittings: Steel doors/steel window frames

Dining section interior

Floor: Terrazzo tile/ceramic tile (kitchen)
Base: Terrazzo tile
Wall: Paint on plaster/ceramic tile (kitchen)
Ceiling: Exposed/paint or asbestos cement sheet (kitchen)

5) Pump station (Thika River side)

Exterior

Roof: Corrugated asbestos cement sheet
Wall: Paint on concrete blocks
Fittings: Steel doors/steel window frames

Interior

Floor: Mortar trowel finish
Base: Paint on mortar finish
Wall: Paint on plaster

5.2.4 Structure

(1) Codes and Standards

Structural calculations will be based on the following local codes and standards and/or the standards of the Architectural Institute of Japan (AIJ Standard):

- Code of Practice for the Design & Construction of Buildings & Other Structures in Relation to Earthquakes, 1973
- BS CP3, Wind Loads

- BS CP110, The Structural Use of Concrete
- BS 449, The Use of Structural Steel in Building
- Standard Specifications for Metric Sized Blocks for Building

(2) Design Criteria

1) Live load

Unit: kg/m^2

Category of Live Load	Floor & Beam	Frame & Foundation
Office, etc.	300	180
RC roof	100	100
Wooden roof structure	30	30

2) Seismic load

According to local codes, the Project site is located in seismic zone VI. In the said area, no seismic design is required for reinforced concrete or steel frame structures.

For load bearing structures in the same (hard ground), the following horizontal force is to be applied for buildings with the usage classification A or B;

$F = CW$

F : total horizontal force
C : coefficient, C = 0.018
W : total building weight

For load bearing structures with usage classification C or D, no seismic design is required for structures of 3 storeys or less.

3) Wind load

Basic Wind Speed : 28 m/sec.

$F = C_f q A_e$

F : total horizontal force
Cf : force coefficient
q : dynamic pressure of wind
q = 50 kg/m^2 (28m/sec)
Ae : effective frontal area

4) Soil bearing capacity

Twenty t/m^2 of design soil bearing capacity at 1m below the ground level will be applied for the structural design of the Project.

5) Design strength

Reinforced concrete

Class 20 205kg/cm^2 at 28 day

Reinforcement

Specified characteristic strength
SD 30 (JIS G 3112)
ft = 2,000kg/cm^2
or BS4461 fy = 425N/mm^2 (43kg/mm^2) over 16mm dia
fy = 460N/mm^2 (47kg/mm^2) up to 16mm dia

Structural steel

SS 41 (JIS G3101) F = 2.4
Allowable tensile strength ft = 1.6 t/cm^2
or Grade 43 (BS 4)
Allowable tensile strength pbt=165 N/mm^2 (1.7 t/cm^2)

Concrete blocks

-For one story load bearing structure
Grade B
Minimum average compressive strength:
3.5 N/mm^2 (36kg/cm^2)
Lowest individual block strength:
2.8N/mm^2 (29kg/cm^2)

-For non-load bearing structure
Grade C
Minimum average compressive strength:
2.5N/mm^2 (26kg/cm^2)

6) Expansion joint

Expansion joints will be provided at not more than 30m intervals for reinforced concrete structures and 60m intervals for masonry structures.

(3) Materials for Structural Use

In principle, the following structural materials will be used:

- Cement-BS12, Ordinary Portland Cement
- Reinforcement-JIS G3112, SD 30 or BS4461, Cold Twisted Steel Reinforcement
- Structural Steel-JIS G 3101, SS41 or BS 4, Grade 43

(4) Structural Plan

1) Frame

Reinforced concrete frame structure with masonry walls or load bearing masonry structure will be applied. Prefabricated aluminum structure will be imported for greenhouse.

2) Foundation

All foundations for major columns and equipment will be reinforced concrete.

3) Slab on grade

Welded wire fabric reinforced concrete on heavy duty poly-ethylene sheets will be used.

4) Partition walls

Concrete block walls will be used as partitions.

5) Roof structure

Wooden frame or truss structures will be used.

5.2.5 Plumbing

(1) General

This clause covers the plumbing system for the main building, hostel and nursery workshop.

(2) Water Supply System

Domestic water from an elevated water tank will be supplied by a gravity feed system to the main building, hostel and nursery workshop (Fig. V-1).

(3) Sewage System

Sewage from toilets and waste water from lavatories will be led to a septic tank and leaching field (french drain). Waste water from the kitchen will be led to the septic tank via a grease trap. Waste water containing oil from the repair shop and car washing area will be led to the septic tank via an oil intercepter; and chemical water from the laboratory will be led to the same after chemical treatment.

Storm water from buildings and paved area, and irrigated water from greenhouse and shadehouse will be led to a pond in the lowland area (Fig. V-2).

(4) Materials

The following materials will be used:

- Faucets	Chrome plated
- Gate valves (Pressure 5 kg/cm^2)	
50mm dia or below	Brass
65mm dia or above	Cast-iron
- Pipes	
Supply	Galvanized steel pipe
Waste	Polyvinyl-chloride
Air vent	Polyvinyl-chloride
- Sanitary fixtures	
Water closet	Vitreous china
Urinal	"
Lavatory	"
Janitor sink	"
Accessory	Chrome plated

5.2.6 Electrical

(1) Codes and Standards

Electrical planning will comply with the following codes and standards:

- British Standards
- Japanese Industrial Standards (JIS)
- Standards of the Japanese Electrotechnical Committee (JEC)
- The Standards of Japan Electrical Manufacturers Association (JEMA)
- Technical Instructions - MOW Electrical Dept.

(2) Basic Guidelines

Electrical planning will be made with the ojectives below. The planning will also take into consideration the problems involved in conservation of energy and electric power and architectural design guidelines based on fundamental concepts of construction as follows:

- A comfortable and safe living environment for the users of the facility
- Rationalization of electric installation functions which are required for facility operation
- Simplification of facility maintenance and control
- Economy in construction and maintenance and control costs

(3) Design Criteria

1) General

This criteria covers electrical planning and works for the main building, hostel, nursery facilities and farm building.

2) Power and substation system

An open type power receiver will be installed outside of the main building by the Kenya Power and Lighting Co. Ltd. A breaker panel will be installed in the electrical room located in the main building (Fig. V-3).

3) Main feeders and power wiring system

Main feeders system

Electric power is supplied from the distribution board to the motor control, lighting panel and equipment. The system will be divided according to the operating conditions of the facility.

- Power supply system: 3ø, 4W, 415V/240V, 50 Hz

Electrical wiring system

Electric power will be supplied via a power panel to the equipment, room ventilating systems and plumbing systems.

4) Lighting and receptacle outlet system

This facility will be illuminated sufficiently for working and to create a comfortable environment. Illumination will mainly consist of fluorescent lamps to minimize power consumption. Lobbies, etc. will be illuminated to harmonize with the architectural design.

- Electric system: 1ø, 2W, 240V, 50Hz
- Wiring system: A conduit system will be applied
- Switch system: To conserve energy, lights in each room will be turned on and off using individual switches. In corridors, 3-way switches will be used so that lamps can be turned on and off at several entrances and exits. Outdoor lights will be turned on and off by means of automatic switches.

The illumination of major rooms will be as follows:

300 lux:	Office, general affairs, manager's room, meeting room, classroom, library, kitchen & dining room
200 lux:	Workshop
100 lux:	Lobby, washrooms, storage & hostel bedrooms
50 lux:	Corridor

One receptacle will be installed about every $20m^2$ except for exclusive receptacles.

5.2.7 Telephone System

(1) General

Extension telephones will be installed in the main building, hostel and nursery workshop. Piping for public telephones will be installed in the lobby of the main building and hostel.

(2) Telephone Wiring and Piping System

A main distribution frame (MDF), terminal board and private branch exchange (PMBX) will be installed in the telephone room of the main building. Extension telephones will be installed where necessary, such as in office rooms, etc. Also empty piping will be set up to install public telephones (Fig. V-4).

Telephone system: 4 outside lines/24 extensions
Outside calls will be switched to internal extensions and visa versa a via switching set operated by a telephone operator.

5.2.8 Fire Protection System

(1) Portable Fire Extinguishers

Powder fire extinguishers will be provided in the main building and hostel, and foam fire extinguishers will be provided in the nursery workshop and farm building.

5.3 Experimental Farm Planning

5.3.1 General

An experimental farm of 3.65ha in gross will be created in the proposed Project area in order to reflect the results of research activities in the laboratory and to perform field experiments. This farm will be composed of a trial field and scion garden, 3.05 and 0.6ha respectively.

Main activities in the trial field will be as follows:

- comparison test among quality varieties
- yield and quality test
- soil and fertilizer test
- plant protection on disease and insects
- grafting and physiological affinity between scion and stock
- effects of irrigation
- inter-cultivation test

Besides these activities the experimental farm will be attached to a scion garden for supplying quality scions for grafting of breeding and propagation of quality seedlings.

For the purpose of these activities, a water supply system for irrigation in the experimental farm will be provided. Furthermore, a small farm building will be required for farm management and custody of farming materials and repair works of equipments.

5.3.2 Basic Plan for Experimental Farm

On the basis of the purpose of the experimental farm, location, dimension and function of the same is as stated below.

(1) Proposed Experimental Farm

The experimental farm will be located in the northwest section of the Project area. The total area, the majority of which is presently used for farmland, is 3.05ha with a length of 400m from northwest to southeast and a width varying from 50-100m. The land slopes in a south-north direction and would be divided into experimantal farm blocks approximately 50m in width from east to west with an average area of 0.25-0.45ha. Approximately 0.60ha in the northeast portion is presently uncultivated field. This area will be used for field experiments.

(2) Scion Garden

The proposed scion garden area, located to the northwest of the Project site, covers 0.6ha with 60m from east to west and 100m from north to south. The land slopes gently in the south-north direction and is presently used as cultivated farm field. Under the Project the said area will be further subdiveded into 2 sections of 0.3ha each. This area will supply selected quality scions for grafting.

(3) Existing Macadamia Trial Farm

The existing macadamia trial farm occupies 3.4ha of a long narrow strip of land along the western edge of the Project area, 400m from north to south with a width varying from 50m-100m. The said area is to be utilized as a sample garden and/or supplemental scion garden because quality macadamia trees are planted in the area at present.

However, this area is not included in the Project area, but a water pipe for irrigation will be extended thereto.

(4) Supporting Buildings

Pump station

Electrical equipment to control the pump will be installed in a pump station while the pump itself will be located closer to the Thika River.

Farm building

A farm management building will be constructed at the site of the nursery facilities.

5.3.3 Water Requirement

The total unit water requirement for the design of intake facilities was determined at 20ℓ/sec in consideration of evapotranspiration, crop coefficient, and irrigation efficiency in the area, and supply for domestic water.

The summary of water requirement is shown below and procedure for determination of the water requirement is discussed in APPENDIX V.

WATER REQUIREMENT

Section	m^3/day	Water Requirement (ℓ/s)
Domestic Water for Buildings	29.0	1.6
Nursery Facilities	35.0	1.8
Scion Garden	60.0	2.8
Proposed Experimental Farm	229.0	10.6
Existing Macadamia Farm	62.4	3.2
Total	415.4	20.0

5.3.4 Water Supply Plan

(1) Water Supply Facilities

Domestic water and irrigation water for the various sections of the buildings, experimental farm and nursery facilities will be pumped up from the Thika River and conveyed to the site via a pipe. The proposed layout diagram of water supply facilities are broadly divided into 5 sections (Fig. V-5) namely:

- River intake facilities (fixed weir)
- Intake pump and introduction pipe
- Settling pond
- Distribution pump
- Water pipe

1) River intake facilities (fixed weir)

As water depth during drought periods can fall as low as 20cm, direct intake from the river is presently impossible. For this reason, a fixed weir will be constructed across the river approximately 20m downstream from the intake site to raise the water level and thus provide a stable intake level. The riverbed of proposed construction site has a suitable bedrock foundation extending across the entire river width.

2) Intake pump and introduction pipe

In order to lift water from the Thika River to the site, a submerged vertical motor pump is proposed, and controls for operation of the pump will be installed seperately in an operation cubicle to be set up near the settling tank.

In order to avoid possible damage or obstruction by floating debris, the intake pump will not be placed directly in the river. Instead, an intake tank will be constructed on the left bank. The intake tank will be of reinforced concrete, and the intake pump will be installed inside the same tank. Water will then be conveyed up the slope via an introduction pipe (castiron) laid along the ground surface of the bank to a settling pond.

3) Settling pond

As water from the Thika River contains a fair amount of sediment, direct use of the same for irrigation will result in clogging of water pipes as well as having adverse effects upon plant growth. Accordingly, a settling pond will be installed for desilting and purification of water.

4) Distribution pump

Purified surface water will be discharged through a hole in the wall of the settling pond and will pass through a drain into the suction tank where it will be temporarily stored.

Water will be pumped from the suction tank through a pipe to an acrylic distribution tank. The foundation for the same will be concrete while the structure will be composed of steel framing.

5) Water pipe

The proposed alignment of the water pipe is two main pipes, one of which extends 500m from north to south to irrigate the fields and the other 860m from west to east also to irrigate the area, covering a total length of 1,360m. From these main pipes, water will subsequently be directed into a series of branch pipes and distributed manually wherever necessary via hoses attached to upright pipes. The latter main pipe will be extended and connected to the reservoir tank for domestic water. Basic design of water supply facilities is discussed in APPENDIX VI.

(2) Irrigation Plan

1) Scion garden

The farm will be divided into 2 sections, each with its own main pipe running through the center. From these main pipes, branch pipes will extend with upright pipes and hoses attached where necessary for manual irrigation.

2) Proposed experimental farm

The main pipe will be embedded along the existing road at the northwest edge of the area. Branch pipes will extend from the same to supply irrigation water where required via hoses attached to upright pipes. Field crops will be irrigated by manually operated hoses.

In addition to the above mentioned facilities, a record meter will be placed at the conjuntion of main branch pipes in each area to gage accumulated water flow.

3) Nursery facilities

Nursery facilities which will require irrigation water will consist of seedbed, shadehouse with stockyard, greenhouse and shedhouse for grafted seedlings. Irrigation water for the said area will be supplied by branch pipes connected to the terminus of the main pipe and distributed via manually operated hoses where required.

4) Existing macadamia trial farm

A main pipe will be embedded in the northern part of the area from which branch pipes will stem. Upright standing pipes will be attached to the latter where necessary and water will be applied directly to the roots of the trees from manually operated hoses.

(3) Domestic Water Supply Facilities

The domestic water source will be intaken from the terminus of the east-west main pipe line, and distributed to each building and facility through a water processing facility including a purifier, water tank, lift pump and elevated distribution tank.

The following buildings and facilities will be supplied with water for domestic use.

- Main building
- Nursery workshop
- Hostel

5.3.5 Drainage Plan

As there is no inflow of storm water into the Project area from outside, and the topographical incline of the area results in natural drainage from higher to lower elevations, no specific storm water drainage system has been designed except for the nursery facilities area.

5.3.6 Farm Roads

The existing unpaved road which branches off the national road to cross the northern part of the Project area from west to east can be used as a primary unpaved road. In addition, a supplementary road which branches off the above and extends along the western edge of the Project area can also be used for the same purpose. Therefore, no farm road construction or improvement has been designed. The following table presents existing conditions regarding primary roads in the Project area.

PRIMARY FARM ROADS

Primary Road	Length	Width	Conditions	Service Area	Remarks
1. West-East Road	850m	4.00	unpaved	Scion garden, trial farm, nursery	load bearing for four wheel tractors
2. North-South Road	200m	"	"	existing macadamia trial farm	"
Total	1,050m				

5.4 Machinery and Equipment

The following list of machinery and equipment required for the Project has been prepared.

Research	PH meter Plant nutrition tester Soil boring stick Soil tensiometer Moisture meter Self-registering thermometer Self-registering hygrometer Constant temperature Germinater Leaf-area planimeter Balance Analytical direct reading balance Electrical precision balance Water distilling apparatus Cylinder intake apparatus Soil sieve sets Soil tester kit Water holding capacity cylinder Microscope Wagner's pot Glassware and miscellaneous
Processing	Box type dryer Portable type manual cracker Fixed type manual cracker Prefabricated refrigerator
Grafting/Nursery	Sprayer (knapsack type) Hand spreyer Hand-cart Prefabricated regrigerator Soil mixer Tool set for grafting Trowel for transplanting Pick-up
Training	Camera & accessories Slide projector Tool set for grafting Micro-bus (20 persons) Blackboard with screen
Experimental Farm	Power tiller (8-10 HP) Trailer for power tiller 4 wheel tractor (45-50HP) Dump trailer for tractor (2 ton) Cultivator for tractor Power sprayer/duster (knapsack type) Mono-wheel cart Bush/grass cutter

Hand equipment/tools set
(Scoop, shovel, saw, hoe, sickle, pick-axe, auger, etc.)

5.5 Other Facilities

The following items will not be included in the grant aid program by the Government of Japan; however, the design criteria might be applicable.

5.5.1 Windbreak Forest

Prevailing winds in the Project area are northeasterly. Due to the shallow root depth of macadamia trees and the exposed nature of the area, possibility of wind damage is very great. For this reason, a windbreak should be planted on the northeastern edge where macadamia is grown at right angles to the wind direction. A tentative scheme might be as tabulated below.

WINDBREAKS

Location	Length (m)	Width (m)	Area (m^2)	Recommendable Type of Trees for combination
1. Experimental Farm	800	15	12,000	-Casuariua equistifolia -Prosopis iuliflora
2. Nursery	400	15	6,000	-Acacia saligua
Total	1,200	15	18,000	

5.5.2 Fences

To prevent damage to the macadamia crop by wild animals such as deer or squirrels which eat the leaves and nuts, in addition to the existing net fence, a new net fence should be erected over a distance of 800m on the northeast-side to enclose the Project site completely.