ANNEX - VII

AGRICULTURE AND AGRICULTURAL ECONOMY

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1. PRESENT CONDITION OF AGRICULTURE

1.1 Present Condition of Mwea Irrigation Settlement Scheme (MIS) Operation

1.1.1 Organization set-up

The Mwea Irrigation Settlement (MIS) Scheme office has following eight (8) departments as shown in Fig. VII-1.

(a) Production
(b) Research
(c) Workshop
(d) Construction Maintenance Operation
(e) Building Maintenance Construction
(f) Works
(g) Mainstores
(h) Health and Nutrition

A total of 320 staff are working in various fields under the office. The MIS staff comprises 16 senior staff, 152 junior staff and 152 subordinates.

Each section has an irrigation officer who controls the management of rice production in respective section. Each section is staffed with Head Field Assistant, Field Assistant, Head Water Guard and Water Guard.

All of the farmers in MIS are so-called "Tenants" who have settled under the Irrigation Regulation, 1977. The number of the tenant farmers is gradually increased with expansion of irrigated paddy field, and as of 1986, the tenant farmers total 3,236 as shown in Table VII-1.

The tenant farmers communicate with MIS Office and NIB Management through:

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

In the meetings of the above, major operational issues are discussed. Mwea Irrigation Settlement Committee is a general meeting and is held irregularly a year. Mwea Irrigation Settlement Sub-Committee is held once a year and his functions are the actions toward allocation of plots to new tenants, termination of tenancy, issuing of licences, etc. Members of this committee is D.C, the manager of MIS, tenant representatives who are the best farmers (one or two persons) selected from each section. Tenant Advisory Committee meets about once or twice a

year. In this meeting, the matters concerning the operations of MIS, such as (i) flooding, rotavation and cropping programme, (ii) yields, (iii) varieties to be grown and the places where are planted, etc. His members are irrigation officers, field assistants and tenant representatives who are selected by farmers themselves. Tenant Liaison Council is held in each section. His function is to inform the MIS manager on the running situations of the various sections. The members are irrigation officer and tenant representatives who are selected by farmers themselves. Tenant Meeting could be chaired by MIS manager when he feels its necessary and should be held once a year or every two years after harvesting. This meeting is the smallest meeting presided over by an irrigation officer. On this meeting, they discuss about the yield, introduced crops in next year, etc.

In 1984, the tenant farmers established the Mwea Amalgamated Rice Growers Co-operative Society Ltd., for acceleration of their co-operative movement.

1.1.2 Operational regulation

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

(1) Regulations for MIS Office

a. MIS office supplies following services to the tenant farmers

- to rotavate the rice field for tenant farmers by tractors,
- to provide the tenant farmers with farm inputs such as fertilizer and insecticide.

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

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

(2) Regulations for tenant farmers

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

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

c. Tenant farmers maintain at all times for his holding and all field feeders and drainage channels to satisfactory.

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

1.1.3 Farming practices

(1) Farming practices

Farming practices are conducted according to the cropping programme prepared by MIS office (See Fig. VII-2).

a. Land Preparation

During 1957-1960, the field was dry - ploughed using oxen-drawn mouldboard plough, followed by flooding and levelled in wet by dragging a fineless levelling board several times over the field.

In 1960, 6 tractors were first introduced to MIS, and thereafter, mechanical rotavation has been carried out with about 30 tractors. The fields are given a pre-rotavation flooding of about 10 cm of water and rotavated within three days of the flooding. Pre-rotavation flooding for longer periods is likely to result in bogging down of tractors.

The rotavation depth is approximately 15 cm. After rotavation, paddy fields have been kept flooded with a layer of water approximately 10 cm in depth.

Generally, the rotavation begins in March and it continues through to August. In each Section the farmers are organized into four rotavation groups. Group I rotavates first in beginning of March and group IV rotavates last (July/August). The farmers rotate through the groups with time. Sowing in the nurseries is done according to the rotavation groups and this begins in mid-July with almost weekly intervals between the groups. Transplanting is usually done four weeks later (25 to 28 days). The farmers in Group I plant first and farmers in Group IV plant last. The pre-planting flooding periods for the various groups vary as follows:

Group I	:	160-95 days
Group II	:	100-55 days
Group III	:	65-40 days
Group IV	:	4-30 days

b. Nursery Preparation

Each tenant farmer seeds their own nursery to cater for his holding paddy field. The nursery measures about one-sixteenth of the holding. The nursery is usually prepared manually. The seeds are broadcasted at the rate of 18 kg/per each quarter of the nursery, a total of 72 kg of seeds per four (4) acre holding. Nitrogen (total 25 kg N of Salphate of Ammonium) is also broadcasted at the sowing time in each holding's nursery.

After sowing the water level in the nursery is increased gradually following the growth of the seedlings up to a depth of about 5 cm.

c. Transplanting

It has been recommended that transplanting be made at a spacing of 10 cm x 10 cm with one seedling per hill. Transplanting is usually done during the school holidays in August, and with hired labour transplanting a holding (4 acres) takes 4-5 days. For a man and his wife only, it takes them up to 5 days to complete transplanting one acre.

d. Fertilizer Application

Nitrogen is applied before transplanting by broadcasting, in the form of sulphate of ammonia at the rate of one bag of 50 kg per acre (26 kg N/ha). Triple superphosphate is also applied before transplanting at the rate of one bag of 50 kg per acre (57.5 kg P_2O_5/ha).

Top dressing with nitrogen is recommended at 42 days after transplanting to sindano, while 37 days to Basmati. Thus the total amount of nitrogen applied per crop is 52 kg N/ha.

No potassium response has been realized at MIS and, therefore, its application is not recommended.

e. Field Maintenance

After transplanting, the water level in fields is increased as required, and it normally does not exceed 10 cm in depth. The water stands in the fields throughout the growing period.

Besides the water control in the fields, other operations such as bird scaring, top dressing and weeding are conducted from time to time when required. Minor cases of damage by insect such as leaf minor, stem borer, leaf eating caterpillars are occasionally noticed and effectively controlled by spraying Sumithion or Furadan.

f. Pre-harvesting Drainage

After transplanting, the water level is maintained up to the ripening stage of the rice plant. Before harvesting the fields are drained and dried out for three to four weeks.

g. Harvesting

If the average moisture contents of paddy grains in whole plot is less than 22 percent, field officer permits the farmers to harvest the rice.

After cutting, threshing by beating, wind-winnowing and bagging are carried out in the harvested fields before the bags of paddy are collected and transported to the reception centre. Casual labour is usually employed for harvesting.

After harvesting it has been recommended that the paddy straw be evenly spread over the fields and then be burned. Not all the farmers follow this instruction.

1.1.4 Rice production

Since MIS started rice production in 1957, rice production increased about 2.3 times from 10,887 tons (1960/61) to 26,408 tons (1985/86) with expansion of the paddy fields as shown in Table VII-3. Unit yield per ha, however, has been decreasing gradually from 6.0 tons level in early 1970's to 5.0 tons level in early 1980's. Table VII-4 shows rice production records in each section for the period from 1974/75 to 1985/86. In most of years, only short rains crop of paddy (Aug./Sept.- Dec./Jan.) was grown. In general, unit yield considerably fluctuates year by year in every section as shown in Fig.VII-3. There is a tendency towards decrease in the unit yield in all sections except Karaba Section where unit yield largely fluctuates depending upon the availability of irrigation water.

Using rice production records in each unit for the period from 1974/75 to 1983/84, yield patterns map was prepared as shown in Fig.VII-4. Large variation in unit yield between units is observed on the map.

Large variation in unit yield is also observed between tenant farmers as seen from Table VII-5. In 1984/85, about 14% of farmers

harvested only less than 15 bags per acre (2.8 tons/ha); on the other, about 16% of the farmers got more than 35 bags/acre (6.5 tons/ha).

Reasons for the large variations in unit yield have not been clearly identified yet.

1.1.5 Farm economy of tenant farmers

Table VII-6 shows crop budget for two major varieties, Sindano and Basmati at an average level of production in the years 1982/83-1985/86. Sindano is more profitable than Basmati at the present level of government price, KShs.3.00/kg for Sindano and KShs.4.00/kg for Basmati. High rate of increase in farm input costs has worsened the profitability of rice cultivation. This tendency is more clearly observed in Fig. VII-5 in which yearly changes in income level are shown for the period from 1976/77 to 1985/86. Actual income in 1985/86 corresponds to only 30 % of that in 1976/77. Table VII-7 shows yearly distribution of farmers in different income classes. Large variation in income level between the farmers is recognized. In 1984/85, about 50% of farmers received more than KShs.10,000 as net income; on the other, about 12% of the farmers gained less than KShs.3,000. Number of low income class farmers who receive less than KShs.3,000 per annum is gradually increasing.

In order to obtain the data on the present condition of farm management, farm economic survey was carried out with good cooperation of the irrigation officers from MIS. A total of 51 farmers were interviewed, using the questionnaire prepared by JICA Study Team. The farmers were selected at random over the Mwea Irrigation Settlement Scheme area:

Section	Nos. of farmers
Tebere	10
Mwea	10
Thiba	10
Wamumu	10
Karaba	11
Total	51

The interview with the farmers were made by MIS staff during the period of February 3 - 14, 1987. Answers from 51 farmers were carefully analyzed by JICA Study Team at the Project Office, Nairobi.

Findings from farm economic survey are given as follows:

(1) Average family size is 9.5 persons as shown in Table VII-8.

(2) Average farm size is 2.8 ha in total, in which rice field is 2.1 ha including extra field of 0.5 ha and upland field is 0.7 ha (see in Table VII-9).

(3) Farm budgets of average farmer who has no extra field based on the result of farm economic survey are estimated as shown in Table VII-10. As shown in this table, annual net incomes of average farmer are KShs.1,300.

(4) Improvement points under present running-in of rice cultivation are summarized as irrigation water supply, prevention of pests and diseases, and supply of high yield varieties. Particularly, the farmers are strongly anxious to introduce high yield varieties as shown in Fig. VII-6.

(5) The farmers in this area are anxious to increase their farm incomes by all manner of means including introduction of double cropping system (see Fig. VII-6).

1.1.6 Processing and marketing of rice

Paddy is transported by lorries to each Reception Centre within three to five days after bagging at field. The paddy is dried on the concrete floor of the reception centres in each respective section, to a constant moisture content 14%, re-bagged to a standard weight of 75kg bags and stored until milling. Basically, re-bagged paddy could be shipped to Mwea Rice Mills on the following day after drying. The general layout of the existing reception centres is given in Fig. VII-7. The paddy is milled at the Mwea Rice Mills Ltd., which is located within MIS area. The post-harvest process is shown in Fig. VII-8. The milled rice is marketed under sole responsibility of the National Cereal and Produce Board (NCPB).

The payment to the tenant farmers is made through banking section of the Mwea Amalgamated Rice Growers Co-operative Society Ltd., (established in 1984), while non-members are paid through their respective bank accounts at the commercial banks. The paddy bags sent to Mwea Rice Mills Ltd. are stored at the warehouses within the rice mill compound which are managed by NCPB. The stored paddy is gradually milled by full use of 2 rice mill machines with 5 ton/hr capacity and another two with 2 ton/hr capacity.

The total capacity of Mwea Rice Mill is around 28,000 to 32,000 tons per annum under 2-shift operation. The average milling rate is reported to be 62% on an average with production of 5% broken rice. The broken rice is marketed at KShs.1.5/kg, and the bran is sold at KShs.0.8/kg. Milled rice is shipped to the depot of NCPB at Sagana and later sold to the consumers, through another depot of NCPB. The present controlled

price as of February 1987 is KShs.7.30/kg for Sindano and KShs.9.05/kg for Basmati.

1.1.7 Result of rice yield survey

(1) Method of rice yield survey

The paddy yield survey was conducted at representative paddy fields in order to obtain the data on paddy yield components; i.e., number of hills per m^2, number of panicles per hill, number of grains per panicle, percentage of ripened grains and weight of 1000 ripened grains. The survey was carried out during the period from 3rd to 13th of February in both sections of Tebere and Karaba. In other sections, paddy was already harvested at that time. The yield survey was made on 30 plots of paddy fields in total; 25 plots in Tebere section and 5 plots in Karaba section. A paddy sample was taken from each plot. Sampled varieties are as follows:

Section	Variety	Nos. of Samples
Tebere	Sindano	11
	IR2035	14
Karaba	BW192	5
Total		30

About 60-200 hills were harvested at random from each sampling site. The average number of panicle per hill for the sampling hills was calculated and about 20 hills were taken, as the representative hills, from the hills which have the nearest number of panicles per hill to the average value. The panicles of selected 20 samples were then separately cut off and only the panicles of each sample hill were weighted, and the average weight was computed. Out of 20 sample bundles of panicles, 3 samples which have the nearest weight to the average, were selected for analysis in the office.

In the office, Nairobi, the survey samples were analyzed in accordance with the method described in "Rice Cultivation for the Million[/1]", and the following yield components were determined:

(1) number of hills per m^2
(2) number of panicles per hill
(3) number of grains per panicle
(4) percentage (%) of ripened grains
(5) 1000 grain weight

At first, the representative panicles taken from the sampling site were threshed by hand and all the rachis-branches were removed. The grains thus obtained were dried for 7 days under the shade. The dried grains were then put into a salt solution with 1.06 specific gravity and stirred for 1 min. By this operation, the grains are well divided into two groups, i.e., a floating group and a sunken group. All the sunken grains can be taken as fully ripened grains and all the floating grains as non-ripened grains.

The floating grains were scooped out with net spoon and dried and counted. The sunken grains were also counted after taking them out of the salt solution by transferring the solution to another vessel by using a sieve and washing them well with water. Then, the number of grains per panicle was calculated by dividing the total number of grains, which is the sum of the number of floating grains and that of sunken grains, by the total number of panicles of the representative hills.

The percentage of ripened grains is easily calculated by dividing the number of sunken grains by total number of grains.

It is considered that all the sunken grains represent the actual yield. The sunken grains were well dried upto the moisture content of 14% under the sun. The dried grains were then accurately weighted. The 1,000 grains weight was calculated by dividing the weight of dried grains by the total number of sunken grains. The grain yield of rice is the product of these yield components. The unit yield is expressed by the following equation:

Unit Yield (ton/ha)
= Number of hills per m^2
x Number of panicles per hill
x Number of grains per panicle
x Percentage of ripened grains
x 1,000 grains weight
÷ 1,000 (conversion to one grain weight)
x 10,000 (conversion to yield per ha)
÷ 1,000,000 (conversion to metric ton in weight)

The result of paddy yield survey and analysis carried out are given in Table VII-11.

The grain yield of rice can be increased through improvement of defects involved in each yield component. In order to find the defects of the present rice yield, the relation between unit yield and each of yield component was examined. (See Fig. VII-9) There is a clear correlation between unit yield and number of grains per m^2 (nos. of hills per m^2 x nos. of panicles per hill x nos. of grains per panicle). While, there is no correlation between unit yield and other yield components. The most

important factor for increase of rice yield in the Study Area is the number of grains per m^2.

In the number of grains per m^2 is positively correlated with the unit yield as shown in Fig. VII-9.

The most decisive factor is the number of grains per panicle, which is generally determined during the period of 25 days before flowering. This period is included in the stage of panicle formation which is sensitive to low temperature. The effect of low temperature on rice yield should be considered on formulation of proposed cropping pattern (see Section 2.3 and Fig. VII-13).

The another yield component, the number of panicles per hill is determined in early stages of plant growth, generally before maximum tiller number stage, and the measures to increase the number of panicles per m^2 are:

(1) to raise the healthy seedlings,
(2) to apply basal fertilizers before transplanting,
(3) to transplant in shallow depth,
(4) to suppress the non-bearing and late-emerging tillers, and
(5) to make the rice plant head at the optimum time when good weather lasts for 15 days before heading and 20 days after heading.

The problem is how the number of grains per m^2 can be increased without lowering the percentage of ripened grains. Reduction of emerging non-productive tillers is the key to solve this problem. The generation of non-productive tillers can be minimized by drying practices and proper fertilization, considering stages of plant growth.

1.1.8 Field research and trials for future development

(1) Double cropping trials

A trial on double cropping (two crops of rice a year) was started at the Mwea Irrigation Research Station in 1975 under the Operational Research and Training Project of NIB. In 1976/77 a total area of 56 ha (138 acres) was double-cropped at Thiba Section. Although the results of experiments on double cropping of rice at the research station showed good indication of success, the first double cropping trial of commercial scale ended in total failure and the idea was abandoned.

In 1979/80, the idea of double cropping was re-introduced to the Mwea Scheme, following the directive from the Government. The trials were made at Tebere Section with a total area of 536 ha (1,326 acres) in

1979/80 and also at Mwea Section of 546 ha (1,359 acres) in 1980/81. The results were not promising and the trials were discontinued.

In 1985/86, a large scale trial of double cropping was attempted after a series of discussions among authorities concerned. About 40% of the total paddy field or 2,480 ha (6,026 acres) were put under the trial. The results were far below the expected level of production and later all of the persons involved in the trials gave up the further attempt of double cropping.

The cropping patterns of double cropping trials in the years of 1979/80, 1980/89 and 1985/86 are illustrated on Fig. VII-10, VII-11 and VII-12. The results of these trials are summarized in Table VII-12.

Possible explanations for poor performance of double cropping, given by the authorities concerned, are:

a. bogging-down problems of tractors resulting from disappearance of hard layer in the subsoils which is caused by continuous flooding for double cropping.

b. shorter wet fallow period after rotavation which may reduce the good effects of long wet fallow on paddy yield.

c. cool and cloudy climate during the period from June to August which affects normal ripening of rice.

d. harvesting and drying difficulties under wet weather which are likely to be involved in long rains crop or rice.

e. increase in crop damages caused by propagation of insects and diseases resulting from continuous cropping, and

f. shortage of irrigation water, especially in Thiba part of the Scheme, during low water period.

Small scale trials of double cropping which have been continued at the Mwea Irrigation Research Station, shows better results of long rains rice as seen from Table VII-13. The experiment results indicate that long rains rice will depend on availability of cold tolerant, early matured and disease resistant varieties. Such varieties have not been made available for release.

(2) Crop rotation trials in paddy fields

In January 1984, His Excellency The President Moi directed, during his visit to the Scheme, that after hearing the difficulties of double

cropping of rice, other early maturing crops should be tried in the paddy field soon after the harvesting of short rains rice was completed.

A trial was started immediately after the presidential directive and several crops such as sunflower, cowpeas and green grams were put under the trial. About 10 acres of irrigated paddy fields were used. For this trial, a committee comprising Ministry of Agriculture, NIB, Research Station and Provincial Administration was organized and all of the members worked jointly to implement the Presidential directive without delay.

The trial ended with some technical problems and was discontinued.

(3) Development of red soils

In 1978/79, about 32 ha (80 acres) of Red Soils at Tebere Section were allocated to 40 tenant farmers for cultivation of various crops such as beans, maize and cotton under rainfed condition. A dairy cattle feedlot and piggery were also constructed in 1978/79 for the purpose of establishing a semi-zero grazing system to be supported by rice by-products.

The rainfed cropping of various crops was repeatedly tried. Based on the past experimental results, rainfed crops of maize and local beans are selected as promising ones and are kept under further examination. Irrigated crops of French beans, dudhi and chillies have recently been tried with 2 ha of sprinkler irrigation at Tebere Section.

Some farmers of Tebere Section grow horticultural crops such as tomatoes, French beans and onions in red soil area nearby the existing canals, under irrigated condition. Such irrigated farming on the red soils is quite successful; however the Area under cultivation is limited at present. Rice is not cultivated in the red soils area because of excessive seepage losses.

1.2 Present Condition of Mutithi Extension Area

1.2.1 Socio-economic survey

The land in Mutithi extension area is privately owned. Most of the lands have not been utilized for agricultural purposes, remoting from public services and infrastructure such as electricity and domestic water supplies, roads and agricultural institutions and facilities. There are no irrigation facilities. Most of the land holders are staying outside of the Area. It implies that irrigation development of the Area will require not only irrigation/drainage facilities but also other all ancillary facilities which will help the farmers (the land holders) to settle in the Area.

The development strategy to be applied should be best suited to the Area and acceptable to both NIB and the land holders. Such strategy should be possibly determined only through the studies on the present land tenure conditions and the land holders' intentions to the irrigation development.

Considering above mentioned, the socio-economic survey was conducted for 213 farmers in order to grasp the following points:

i) farmers' economic activities
ii) present situations of land tenure conditions
iii) informations on land holder's intention to irrigation development, particularly on their attitude to the NIB's development concept

(1) Method of Socio-economic survey

a. The survey

The survey was curried out during the period from 1st to 31st of August, 1987 by a team of the local consultant assigned by NIB and JICA.

b. Study design

Aspects investigated in the interview with the sample of farmers included land tenure and holding, family structure and composition, attitudes and perceptions of farmers toward irrigation farming, cropping and livestock management patterns, farm income and farmers' intentions toward irrigation development by NIB through the questionnaire (see Data Book).

c. Sampling design

The Multi-stage sampling technique was applied in sample selection. Subsequently, Mutithi extension area was divided into four clusters or transects. The team had ten enumerators. These enumerators were assigned in groups of twos to each cluster. In total, 213 farmers were interviewed and constituted a representative sample of the Study Area. The overall sampling fraction achieved was in the ratio of 1:7 land holdings. The sampled farms were about 14 percent of all the land holdings in the Area and had approximately 21 percent of the total population of the Mutithi extension area.

1.2.2 Demography

The Mutithi extension area is located next to the existing MIS Scheme area. The Area falls under Mutithi Location, Mwea Division of Kirinyaga District. The Area represents about 27% of the Mutithi Location whose area is 187 km^2, falling within the following six (6) sub-locations:

(1) Mutithi/Chumbiri
(2) Mwerua/Rukanga
(3) Mwerua/Kabirini
(4) Mutithi/Kabirini
(5) Mwerua/Kagio
(6) Kiirie/Sagana

The population of Mutithi Location according to the 1979 census was 22,200. At an assumption of growth rate of 3.9%, the projected population of this location is about 30,100 people as of 1987, which gives a current density of 161 people per km^2. Total population living in the Area is around 5,100 as of 1979, or 960 households with an average family size of 5.3 persons per household.

The land in the Mutithi area in many other part of the Central Province is privately owned. It is freehold obtained from the Trust Land in accordance with the Land Adjudication Act 284 and Land Consolidation Act Cap.283. In particular, the Mutithi area contrasts sharply with the adjacent MIS Scheme area where the former Trust Land is least to the tenant farmers by the Government through NIB.

The present JICA study identified there are about 1,580 land holders who own various sizes and shapes of the land in the Area. In the black cotton soils, about 1,060 of land holders are identified and 520 land holders in the red soils area. However, about 60% of the land holders on the black cotton soils area are absent, while in the red soils areas almost fully occupied by the land owners or their relatives. There seems to be a steady population growth in the red soils areas. The rate of population growth however on the black cotton soils area is very low.

1.2.3 Land tenure and holding

There are three (3) categories of land tenure in Kenya:

(1) Government Land
(2) Trust Land
(3) Private Land

The government land means all land in the country which is neither trust land nor private land. The trust land means all land in special areas which for the time being are vested in County Councils of the District where the land is situated. Private land means any land for

which a free title has been granted directly by the Government or one in which a freehold title has been granted by the Government under the Land Consolidation Act or the Land Adjudication Act. Therefore, a piece of land for which certificate of ownership has been granted or such claim of ownership has not been disallowed is private land (Legal Notice 589/1960). In land transaction, the "competent authority" means; the Minister of Lands for the government land, the County Council for the trust land and the owner of the land for the private land.

In early 1950's when land demarcation in the Central Province was taking place, the demarcation of the Mutithi extension area was intentionally left out with the hope that the Area would be irrigated for rice cultivation like the adjacent MIS Scheme which was constructed in early 1950's. However, the Mutithi area was not included in the Scheme due to lack of water.

The County Council decided therefore demarcate all the reserved land and issued them out accordingly on clan basis. The demarcation in the Mutithi area took place between 1968 and 1972.

The recent socio-economic survey revealed that as of 1987, about 67% of the land owners in the Mutithi area obtained their land from clan, and about 24% by purchase and the rests have the inherited land from their fathers. This means land transaction in the Area is not significant since the demarcation took place.

The land holders in the Mutithi area are classified by size of land holding as follows:

Land Size (ha)	No. of Land Holders	Percentage
Less than 1	98	6
1 - 3	865	55
3 - 5	404	25
5 - 7	108	7
7 - 9	54	3
More than 9	50	3
Total	1,579	100

1.2.4 Present landuse

The black cotton soils is treeless plains with grass in areas which have not been cultivated. In the southern side some scattered trees are to be found on red soils patches. It is a dryland scrub vegetation composed of acacia species such as *Acacia polyacanthia*. Other common vegetation which has been scavenged for firewood are *Erithrina abyssinica* and several species of *Combretum*.

The majority of the land owners living in the Mutithi area are full-time farmers. The farmers in red soils area use their land intensively for cultivation of maize and beans; on the other, those in the black cotton soils area use their land mostly for cattle grazing. Normal cropping on the black cotton soils areas is very limited due to difficulties of crop cultivation under rainfed condition which are resulted from the nature of the soils. The black cotton soils are usually flooded during the rainy season and become very hard with deep cracks on the ground surface during the dry season. These natures of the soils give the farmers a lot of difficulties for normal cropping.

Crop yield is generally very low, as indicated that an average unit yield of maize is about 1.1 tons/ha.

1.2.5 Present farm economy

It is estimated that the farmers with land holding around 3 ha earn an average of about KShs.500 per annum from the sales of their produce, while the other farmers in 3-7 ha group earn around double the amount. Especially, from the results of socio-economic survey, the average farm size is 3.2 ha. Breakdown of farm budget is given in Table VII-10. This farm income level is very low as compared to that of the MIS farmers who earn an average of KShs.10,000 per annum from the irrigated rice cultivation. With a very few exceptions, most of the Mutithi farmers are engaged in subsistence farming which limits them to a poor standard of living.

1.2.6 Land holder's intention to irrigation development

The land in the Mutithi area is privately owned. The land tenure condition is quite different from that of the existing MIS area, and the Government regulation (Irrigation Regulation 1977 - Legal Notice No.68) which has been applied to MIS, may not be applicable to the Mutithi area.

The development strategy to be applied to the Mutithi area should be best suited to nature of the Area and acceptable to both NIB and the land holders. JICA Study Team considered that such strategy would be possibly determined only through the study on the land holder's intentions to the irrigation proposal to be prepared by NIB. After full discussion on this

idea with NIB, JICA Study Team decided to employ a local consultant to carry out the questionnaire survey for this purpose, and made a contract with UNICONSULT LTD. (hereinafter referred to as "the consultant"). The consultant prepared the questionnaire on the basis of the NIB's idea for irrigation development in the Mutithi extension area which is given as follows:

NIB' DEVELOPMENT CONCEPT

1) Farmers to form Company or Co-operative Organization incorporating all farmers who are interested in irrigation development within the Mutithi area. This body corporate to secure the necessary commitments from the members and to be responsible for dealing with NIB in all land issues in the Area. Legal machinery for this arrangement will need to be fully explored and applied.

2) Farmers to accept adjustment of their boundaries to facilitate suitable irrigation layout and must further accept some reductions in parcel sizes necessitated by construction of irrigation network i.e. canals, drains, roads, reception centres etc.

3) Farmers to accept to surrender their titles to the Farmer's Organization which will in turn surrender same to the National Irrigation Board. The Board will in turn charge these titles for a period of 30 years after which the titles will be surrendered back to the Farmer's Organization. The titles may be discharged earlier if the Farmer's Organization is able to repay proportionate development costs to NIB.

4) The Farmer's Organization to handle all land cases within the developed area through a committee. This committee would also be responsible for valuation of houses and land, with advice of NIB and Government experts, whenever a land transaction takes place. The committee would also be involved in disciplinary cases such as when a farmer fails to comply with Irrigation Area Rules accepted between NIB and Farmer's Organization.

5) NIB will only develop the irrigation and road works and other communal facilities such as reception centres, offices, etc. The individual farmers will be expected to put up their own houses in the Areas surveyed and marked out for the purpose without any assistance from NIB. Modest compensation may be possible where permanent houses may have to be moved to allow for construction of irrigation/road network.

6) Once the land is developed, relation between the NIB and each farmer would be direct as the Mwea Irrigation Settlement Scheme and Advisory Committee would continue to form the necessary forum for interactions and communication between the farmers and NIB.

The consultant executed the questionnaire survey in the field for a period of one month in August 1987. The consultant interviewed 213 land holders living in the Mutithi area and 20 absent holders who are living outsides the Area. The consultant also interviewed local administrative officers and opinion leaders with primary ties with the community in the Mutithi area. The results of the questionnaire survey show that most of

the Mutithi farmers, the local administration and leaders are highly in favour of the proposed irrigation development. The farmers especially in the black cotton soils area are very much keen to join an irrigation Scheme since their land is highly underutilized as a result of factors beyond the control of any individual farmers.

The results of the questionnaire survey are summarized as follows:

	NIB Concept No.	Agreed (%)	Comment (%)
1.	Farmers to form a cooperative incorporating all farmers who are interested in irrigation development	98	2
2.	Farmer to accept changes in boundary and sizes of land holdings due to irrigation infrastructures	78	22
3.	Establishment of farmer's committee to deal with land transactions and valuations	92	8
4.	To mortgage land as security for development costs	80	20
5.	Farmers would build their own houses in the Area marked by NIB	77	23
6.	Relation between farmers and NIB would be direct as is the case with MIS Scheme	85	15

Those who made comments on the proposed irrigation development concept according to the consultant' view, seem to mistrust the real intention of NIB mainly because of recent delay in payment to the MIS farmers which has resulted from the financial problems of NCPB. This negative image of NIB might explain their comments which are mainly geared to the fear of the farmers in losing land. These farmers could be convinced through patient discussions under strong support of the cooperative who acts as a buffer between NIB and the farmers.

The absent land holders who live outsides are generally recognized as those who have either inherited or purchased their pieces of land. They have similar views to resident farmers. In particular, all of them have no objection to the proposed irrigation development; about half of them readily expressed their willingness to negotiate the transfer of the ownership of the land to NIB if fairly compensated and another half of them to join the irrigation farming in accordance with the NIB proposal.

The local administrative officers and opinion leaders are wholly in support of the proposed irrigation development.

2. AGRICULTURAL DEVELOPMENT PLAN

2.1 Assessment of Land Resources

The potential maximum area for irrigation development in the Study Area is estimated to be 9,560 ha as shown below:

(1)	Mwea Irrigation Settlement Scheme Area		
	a. existing irrigated paddy area	:	5,860 ha
	b. rain-fed red soils	:	800 ha
(2)	Mutithi Extension Area		
	a. uncultivated black cotton soils	:	2,470 ha
	b. rain-fed red soils	:	430 ha
	Total	:	9,560 ha

The potential maximum area of 9,560 ha is determined through the present study on soils and topography on the basis of the detailed topographic maps scaled 1/5,000:

(1) The irrigated rice field of MIS is determined to be 5,860 ha which is a total of the maximum area planted in each Unit in the past 10 years. This area almost corresponds to 85 % of a gross area (6,900 ha) measured on 1/5,000 topographic maps. The black cotton soils left un-utilized as irrigated paddy, are all not suitable for new irrigation development due to unfavourable soil and topographic conditions. These soils are presently used for cattle grazing and considered better to be left as they are.

(2) The horticultural crop field of 800 ha in MIS area is determined, excluding poor soil areas, high-elevated lands where gravity irrigation is difficult, residential areas, and small scattered irrigable lands which are not economically feasible for irrigation development.

In the MIS Scheme, rice is grown generally once a year. Total area under rice cultivation is 5,860 ha. Land preparation for rice cultivation is generally started in March and ended in July. The land preparation is made by tractors under sole responsibility of the Scheme Management. After land preparation, the paddy fields are flooded until transplanting will start. The nursery is prepared individually by the farmers and seedlings are transplanted manually in August and September. Rice is generally harvested in December and January.

The farmers of MIS Scheme grow maize and beans mainly for home consumption in the vacant uplands with permission of the Scheme Management during the period from March to September. The estimated area under

cultivation of these crops is about 1,500 ha. Unit yields of these crops are generally low due to rainfed cultivation without use of farm inputs. Irrigated cultivation of horticultural crops is very limited in the Area.

In the Mutithi extension area, about 40% of the total area or about 1,600 ha of the land are cultivated for maize and beans. The inhabitants usually stay in the upland area and utilize the red soils for maize cultivation under rainfed condition. Crop yield seems to be very low.

The present cropping pattern is illustrated on Fig. VII-2.

2.2 Change in Land Use

The present land use in the above irrigable area will be changed by the implementation of the Project as follows:

(Unit: ha)

Land Use	Without Project	With Project
MIS Area		
1. Rice		
Short Rains Rice	5,860	5,860
Long Rains Rice	0	5,860
2. Upland Crops		
Maize	600	0
Beans	200	0
French beans	0	800
Onions	0	400
Tomatoes	0	400
Mutithi Area		
1. Rice		
Short Rains Rice	0	2,470
Long Rains Rice	0	2,470
2. Upland Crops		
Maize	430	0
Beans	0	0
French beans	0	430
Onions	0	215
Tomatoes	0	215

Rice cultivation is suited to the black cotton soils and horticultural crops to the brownish red soils. In the black cotton soils area, single cropping of rice has been practiced under irrigated condition in MIS area and those in the Mutithi area are mostly used for cattle grazing. The brownish red soils are more intensively cropped at present for cultivation of maize and various beans.

After implementation of the Project, the land will be double-cropped under full irrigation with a cropping intensity of 200%. In the black cotton soils area, double cropping of rice will be practiced. The brownish red soils will be cropped with highly marketable vegetables such as French beans, tomatoes and onions.

The upland where the farmers now grow maize and beans for their home consumption (1,230 ha) will be converted to the horticultural crops field and the present production of maize and beans on these land (1,250 tons of maize and 1,000 tons of beans) will be lost annually; however, the irrigated farmers will surely be compensated with the increased farm income from the cultivation of horticultural crops on these land.

2.3 Proposed Cropping Pattern

The following basic principles, which govern the selection of crops and cropping patterns under the Project, are conceived:

(1) The crops and cropping pattern must create maximum benefits for the farmers as well as the nation as a whole,

(2) The crops and cropping pattern must make optimum use of water to be supplied by the Project,

(3) The crops and cropping pattern should be practicable with the limited number of available family labour, and

(4) The crops and cropping pattern must conform with the present social traditions and be acceptable to the farmers.

Considering the principles mentioned above, "rice" and "horticultural crops" such as tomatoes, onions and French beans are selected as major crops in the framework of the future cropping pattern.

Rice is the most profitable crop, among other possible grown crops, under present economic situations. There is no marketing problems. Rice is still scarce in Kenya. Increase in rice production largely contributes to achievement of self-sufficiency in food which the Government of Kenya has strongly emphasized in her policy papers (see Section 2.7). The farmers in the Area have long experience for the rice cultivation under irrigated condition and are likely to realize the maximum benefits from irrigated rice cultivation.

Tomatoes, onions and French beans have relatively large market outlets and significantly profitable among other horticultural crops (see Table VII-14). These crops are tentatively selected from various crops presently marketed in large quantity to Nairobi (see Section 2.7). It is

reported that these crops will generally show large irrigation benefits resulting from increase in unit yield as well as improvement in quality of the products.

The proposed cropping pattern is shown in Fig. VII-13. Rice is grown in the black cotton soils area, and horticultural crops are grown in the red soils area. All the irrigable lands will be doubled-cropped with cropping intensity of 200%.

(1) Proposed cropping pattern for rice

In the proposed cropping pattern, long rains crop of rice is transplanted in March/April and harvested in June/July, and short rains December/January. The early maturing varieties with a total growth period of 110-120 days will be used for long rains crop and the present varieties and/or improved varieties such as BW196, IR54, IR1561, IR2793 with the growth period of 150-160 days will be for short rains crop. For long rains crop, suitable varieties are not available at present. Prior to actual operations, selection of suitable varieties will be inevitable for successful introduction of double cropping. Early maturing varieties of Basmati strain will be preferable for long rains crop due to its high marketability.

In preparing the proposed cropping pattern for rice, the following has been considered:

a. low temperature in July/August and December/January

The booting stage, particularly meiosis stage, of rice growth is very sensitive to low temperature so that cropping calendar be adjusted to avoid such critical stage from the low temperature periods.

b. high precipitation and wet condition in April/May and October/November

In case of harvesting in these rainy seasons, various difficulties in harvesting and drying as well as large post-harvest losses are expected, and therefore, harvesting seasons should be planned in other periods.

c. necessity of vacant period that no rice is observed

Vacant period of at least one (1) month will be required for maintenance and repair of irrigation facilities and also to prevent rice plant from damages caused by building-up of insects and diseases.

The proposed cropping pattern for rice meets all the conditions mentioned above.

In particular, the proposed pattern for rice is formulated, with a view to minimizing the paddy yield reduction caused by low temperature in July-August, through the present study on relationship between reduction in paddy yield and low temperature (The study flow is illustrated on Fig. VII-14). For this study, the yield reduction against low temperature in five (5) consecutive days is considered, because reduction in paddy yield is likely to occur when low temperature continues for more than six (6) days, and in the MIS area, the low temperature less than 20°C seldom continues for more than six (6) days.

First of all, using the daily mean temperature records at the Embu-Mwea meteorological station for the period of nine (9) years from 1978 to 1986, the low temperature year with five (5) year return period is determined to be 1986 through probability analysis on annual accumulated daily mean temperature (See Fig. VII-15). Secondly, using the actual daily mean temperature records for the year of 1986, moving average values of the daily mean temperature for five (5) consecutive days are calculated, and the lowest moving average values in each 10 day period are selected, as being the five (5) consecutive day low temperature with 1/5 probability on a 10 day basis (See Table VII-20). Thirdly, the yield reduction rates at different periods of plant growth against the five (5) consecutive day low temperature with 1/5 probability are estimated, as shown in Fig. VII-16, on the basis of the "guideline for estimation of yield reduction against low temperature" published by the Ministry of Agriculture, Forestry and Fisheries of Japan (Fig. VII-17, to be referred).

The relationship between reduction in unit yield and low temperature in the proposed cropping pattern is summarized in Fig. VII-18 (for short rains crop) and Fig. VII-19 (for long rains crop).

The study results show that an estimated yield reduction rate of rice sowed in March is about 11% of the potential unit yield without any damages, while that sowed in May more than 50% (see Fig. VII-16). Serious reduction in unit yield is caused by low temperature less than 20°C at the booting stage. There is no clear difference in crop yield reduction against low temperature between short rains crop and long rains crop (see Fig. VII-18 and VII-19).

The following facts are identified through this study:

a. The paddy planted earlier shows better yield, as generally experienced in MIS area (Fig. VII-16, to be referred).

b. Early start in planting (probably in February) gives better results; however, it will increase the peak water requirement for irrigation. On the contrary, late start in planting results in enormous loss of harvest due to high sterility caused by low temperature in July-August.

c. Planting/harvesting in a shorter period gives better production. On the contrary, it will increase peak water requirement and number of machinery for rotavation. The proposed planting/harvesting period of 60 days might be optimum in an economical sense.

The proposed cropping pattern for rice is optimum among other possible patterns, considering all the factors mentioned above.

(2) Proposed cropping pattern for horticultural crops

The proposed cropping pattern for horticultural crops is prepared on the basis of the following considerations:

a. To minimize the crop water requirement

The periods of peak water requirement for horticultural crops should not be overlapped with that for rice, and

b. To market the products during the period of high marketing prices in Nairobi

Tomatoes and beans are high priced in dry season of February/March, on the other, the price of onions is almost constant throughout the year (see Fig. VII-20).

The proposed cropping pattern for horticultural crops meets all these requirements and conditions mentioned above.

2.4 Proposed Farming Practices

After the Project is realized, the present farming practices will be gradually changed under introduction of double cropping system:

(1) Rice cultivation

a. Land preparation

In order to complete the rotavation within 60 days before transplanting, the tractors will have to be increased in number. The required number of tractor will be 126 in total which will comprise 112 units of 60 PS class four wheel driven type tractor with wide floating type tyre and cage wheel, and 14 units of 60 PS class crawler type tractor. The wheel type tractors will be used mostly for ordinary rotavation and sometimes for chisel ploughing in the cases that no irrigation water is available in time and the soils will have to be ploughed under the dried conditions in order to keep the planting time schedule. The crawler tractors will be used for rotavation of the land with soft foundation where the ordinary tractors are bogged down.

The paddy field will be pre-flooded with about 12 cm of water before rotavation. Prolonged period of pre-rotavation flooding is likely to result in bogging-down of the tractors. About three (3) days after flooding will be the best timing for rotavation. The present system of grouping the farmers for rotavation is reasonable and realistic because early planting group will certainly get better yield. Therefore, the present rotational grouping system will not be changed even after the Project is realized.

b. Nursery preparation

The farmers will prepare their own nurseries within their paddy plots. The nursery measures about 1/20 of each holding. The nursery beds will be prepared manually. The seeds will be broadcasted on the beds at the rate of 45 kg/ha (namely, 45 kg per nursery required for one ha of main field to be transplanted). The required amount of fertilizer for nursery will be 6 kg N per nursery for one ha of main field to be transplanted. Prior to the seeding, seeds should be selected by a solution of 1.13 specific gravity and further be treated with seed disinfectants like Benrate-T or Homai.

c. Transplanting

For transplanting, the recommendable number of seedings will be 3-4 per hill, and planting density of 20-30 hills per m^2 will be recommendable under the conditions that the improved varieties

be introduced. The presently recommended density of 100 hills per m^2 (10 cm x 10 cm) is derived from low tillering ability of Basmati and Sindano.

d. Fertilizer application

Ammonium Sulphate of about 150 kg/ha and Triple Superphosphate of 125 kg/ha will be applied as the basal fertilizers at the time of about five (5) days before transplanting. Top dressing will be carried out 2-3 times; about 15 days after transplanting, at the young panicle formation stage and at the full heading stage. The amount of fertilizer for top dressing will be 20-30 kg N/ha in a form of Ammonium Sulphate. It is recommended that compound fertilizers containing Nitrogen and Phosphorus be tested in future in order to save the costs of transportation and storing as well as labour cost for application.

e. Field maintenance

Insect and disease control should be carried out at the proper time without delay. Recommendable chemicals will be Sumithion, Diazinon, Furadan,etc. for insect control, and Kasumin, Kitazin, etc. for disease control. Weeding will be made manually several times according to the condition of weed growth. Use of herbicides for weed control will not be recommended.

The water level in the paddy field will be maintained at 7.5 cm in depth after transplanting. There are critical periods in the life of the rice plant against the shortage of irrigation water,i.e.,just after transplanting, panicle initiation stage, reduction division stage and flowering stage. Irrigation water will have to be maintained in the field at these stages of plant growth. Proper water management, considering the plant growth stage, will be desired.

f. Post-harvest drainage

Before harvesting, the paddy field will be drained and dried out for about 3 weeks as the MIS Scheme does at present.

g. Harvesting

Harvesting will be made manually by sickle. Threshing, winnowing and bagging will also be carried out manually in the

harvested field. In future, however, the mechanical harvesting and threshing by means of engine-driven harvester and treadle thresher will have to be considered.

(2) Cultivation of horticultural crops

Modern cultivation techniques such as introduction of high yield varieties, reasonable fertilizer application and control of insects and diseases as well as proper supply of irrigation water should be introduced into the Area.

As far as irrigation method is concerned, furrow irrigation method will be applied for all the crops.

In case of tomatoes, irrigation water will be applied through furrows at an interval of every 7 - 14 days. Enough water must be applied at each irrigation time to thoroughly moisten the soil in the root zone. It is desirable to have the soils well watered before ripening begins so that subsequent irrigation can be kept to the minimum.

For onions, irrigation water should not be applied too frequently in the early stages, as seedings are likely to rot off in the seed-beds. Excess water to young transplants causes rank growth, thick necks and poor bulbing.

French beans have the critical growth period towards water stress from flowering to ripening, while the crop is sensitive to over irrigation.

2.5 Anticipated Crop Yield and Production

The rice yield in MIS has been fluctuate year by year as shown in Table VII-4. Although the Scheme is widely regarded as being the most successful irrigation rice project in Kenya, its performance has now begun to deteriorate with decreasing production level (see Fig. VII-21). The main contributory factor is lack of adequate maintenance and rehabilitation with respect to all aspects of Scheme operation and maintenance. The situation is likely to get worse with disastrous consequences unless corrective measures are urgently taken. Besides, the present yield of horticultural crops from the result of farm economic survey is low compared with the level in Central Province and Kirinyaga District.

After completion of the Project, the yield of crops will be stabilized and increased through supply of irrigation water, improvement

of farming practices and water management and further expansion of agricultural supporting services.

The anticipated crop yields are estimated as follows:

(Unit: ton/ha)

Crops	Present	Without	With
Long rains rice	-	-	6.0
Short rains rice	4.5	3.5	6.0
Maize	1.1	1.3	-
Beans	5.0	5.0	-
Tomatoes	-	-	15.0
Onions	-	-	10.0
French beans	-	-	10.0

Generally rice yield depends on soil condition, climatological environment, degree of irrigation water supplies, and farm management practices. The soils of the Project area is generally suitable for rice cultivation due to their general characteristics of heavy texture and slow permeability. Although the soils are poor in plant nutrients, the deficits will be possibly supplemented by application of fertilizers. The adequate amounts of fertilizers are calculated and included in the proposed farming practices. It is also assumed that sufficient irrigation water will be supplied to the paddy fields under the Project. Consequently, the climatological environment and farm management practices directly affect the future paddy yield under the Project, as the uncontrollable factors.

Rice yield can be formulated as:

$$\text{Yield (ton/ha)} = \text{nos. of grain per } m^2 \times \text{1,000 grains weight (gr)} \times \text{percentage of ripened grains (\%)} \times 10^{-5}$$

According to the yield survey mentioned in Section 1.1.7, among other yield components "the number of grains per m^2" is recognized as the decisive factor which causes low paddy yield.

It is generally conceived that the factor "the number of grain per m^2" is positively correlated with daily solar radiation and negatively with the daily mean temperature during the 25 day period before flowering. The International Rice Research Institute (IRRI), Philippines, made a series of rice experiments in this respects and reported the following empirical

formula for estimation of "potential maximum number of grain per m^2" using climatic data:

$$N = S(278 - 7.07t)$$

where, N: potential maximum number of grains per m^2

S: average daily solar radiation during 25 days before flowering (cal/cm^2)

t: average daily temperature during 25 days before flowering (°C)

Using 20g for 1,000 grain weight and 80% per percentage of ripened grains (the estimation of the results of rice yield survey and irrigation research' station for Basmati in MIS), the rice yield could be estimated as:

$$Y(ton/ha) = S(278 - 7.07t) \times 20 \times 0.8 \times 10^{-5}$$

Applying the actual records for solar radiation and temperature in MIS, the potential paddy yields are estimated at 7.7 tons per ha for long rains rice and short rains rice (for details, see Table VII-20).

The actual rice yields are, however, generally affected by another uncontrollable factor, or "farm management practices". This factor includes water management, farming operations, farm inputs supplies, post-harvest operations, extension services and other agricultural activities to support the proper irrigation farming. The efficiency of all these activities is assumed to be about 80% as a whole.

The anticipated yield is therefore set at 80% of the estimated potential yield, i.e., 6.0 tons per ha both for long and short rains rices.

As for the anticipated yield of rice under without project condition, constraints such as prolongment of cultivation period caused by delay of rotavation and irrigation periods, unawareness of modern rice, etc. will be downward as shown in on the basis of the result of Fig. VII-3. In 1995, the rice yield will be lowered up to the level of 3.5 ton/ha.

Besides, as for the yield of horticultural crops, under without project condition, the yield of maize will increase up to the level of Kirinyaga District, while about the yield of beans it is estimated that its yield will not almost increase. Under "with project" condition, the yield of horticultural crops is estimated as mentioned above on the basis of the statistical data of Kirinyaga District and actual results of horticultural production in Kibirigwi Irrigation Project, Kirinyaga District.

The crop production will increase gradually during the build-up period of 5 years after completion of the construction works. The incremental crop production at the full development stage is estimated:

(Unit: tons)

Crops	Without Project	With Project
MIS Area		
1. Rice		
Short Rains Rice	20,500	35,200
Long Rains Rice	0	35,200
2. Horticultural Crops		
French beans	0	8,000
Onions	0	4,000
Tomatoes	0	6,000
3. Upland Crops		
Maize	800	0
Beans	1,000	0
Mutithi Area		
1. Rice		
Short Rains Rice	0	14,300
Long Rains Rice	0	14,300
2. Horticultural Crops		
French beans	0	4,300
Onions	0	2,100
Tomatoes	0	3,200
3. Upland Crops		
Maize	600	0

2.6 Farm Inputs and Labour Requirement

Farm inputs and labour requirement per hectare for proposed farming practices are shown in Table VII-26 and VII-27.

The total requirement of farm inputs and incremental amount in the project area is calculated as shown in Table VII-21 and summarized as follows:

	Unit	MIS	Mutithi	Total
Without project				
Seed	ton	320	10	330
Fertilizer	ton	2,330	50	2,380
Agro-chemicals	ton	20	0	20
	lit	12,300	430	12,730
With project				
Seed	ton	560	240	800
Fertilizer	ton	6,970	3,030	10,000
Agro-chemicals	ton	40	20	60
	lit	25,000	10,700	35,700
Incremental amount				
Seed	ton	240	230	470
Fertilizer	ton	4,640	2,980	7,620
Agro-chemicals	ton	20	20	40
	lit	12,700	10,270	22,970

The proposed farming will be basically practiced by family labour except land preparation and plant protection carried out by NIB. The labour balance in the project area is also studied under the conditions given in Table VII-22. The result of the labour balance is shown in Fig. VII-22. According to this table, the family labour can cover the labour requirements throughout the year.

2.7 Marketing and Price Prospect

2.7.1 Marketing for rice

The "Scheduled" crops such as rice are marketed under sole responsibility of the National Cereals and Produce Board (NCPB). The total marketed output of milled rice that is sold to NCPB, is around 24,000 tons per annum. About 98% of the total output are produced in the existing NIB irrigation Schemes. The rest (2%) is produced in small rainfed paddy fields privately owned.

In recent years, the country has imported a remarkable quantity of milled rice to meet the ever growing demand for rice. The quantity of imported milled rice is rapidly increasing. It amounted to 44,800 tons in 1983 and 96,200 tons in 1984. Total availability of milled rice to the nation, including the imported, during the period of 1965-1984 is given below:

Year	Marketed Output (tons)	Imports (tons)	Total (tons)	Price Capita Consumption (kg)
1965-70	11,400	1,600	13,000	1.3
1971-75	21,100	2,700	23,800	1.9
1976-80	25,200	2,300	27,500	2.0
1981	27,300	4,600	31,900	2.0
1982	25,600	11,900	37,500	2.1
1983	24,200	44,800	69,000	3.7
1984	24,000	96,200	120,200	6.1

Source: (1) Development Plan 1984-88
(2) Statistical Abstract 1985

It is clear that rice consumption has not kept pace with population growth. There is a tendency of the nation to move to rice as a basic food because of the considerable lower energy costs involved in preparing rice compared with traditional crops such as maize. The Ministry of Agriculture predicts that this trend is almost certain to continue and even accelerate as population increases and the energy costs continue to escalate.

During the 1970's, the population grew at an annual rate of 3.4%. The recent estimate given by the Central Bureau of Statistics suggests that the population in the year of 2000 will be 38 million compared with 20 million in 1985. The assumption that demand for rice is directly related to population increase, suggests that the demand for rice in the year of 2000 will be in the order of 154,000 tons per annum even under minimum per capita consumption level of 4.0 kg per year in 1982-84 (see Fig. VII-23).

Per Capita Consumption (kg/year)	Total Demand for Milled Rice in the Year 2000
2.0	76,000
2.5	95,000
3.0	114,000
3.5	133,000
4.0	154,000

The existing NIB Schemes will not be able to meet this increased demand, if their performance during the last decade is considered. The deficit in rice currently stands at some 58,000 tons (per capita consumption of 4.0 kg/annum is assumed). If the present level of rice production continues, the deficit is likely to reach some 130,000 tons by the year 2000.

The present economic situations of Kenya is unlikely to spend much foreign exchange to make up for the deficit in rice demand from the import of rice. Emphasis on imports of cereals has been placed upon other crops such as maize. This situation will continue and imports will never satisfy the increased demand for rice.

Under such situations, it is expected that NIB will be able to increase their rice production through every possible effort on expansion of irrigated paddy fields, improvement of present unit yield and introduction of double cropping system (two crops of rice a year).

The Mwea Irrigation Development Project is expected to improve the expected supply-demand imbalance of rice and also to contribute towards the achievement of the Government's goal of self-sufficiency in foods.

2.7.2 Marketing for horticultural crops

Fig. VII-22, VII-23 and VII-24 show the trend between demand and supply of proposed horticultural crops toward Nairobi market. The results are summarized as following table.

Demand and Supply at Nairobi Market/1

	Potential Required Supply/2 (ton)	Future in the Project (ton)	Production Area (%)/3
Tomatoes	70,000	9,200	13
Onions	12,600	6,200	49
French beans	19,500	12,300	63

Note: /1: See Fig. VII-24, VII-25 and VII-26.
/3: Proportion of the production in the Project area toward required supply to Nairobi.
/2: Considering the future demand in rural area and future export amount.

The "Scheduled" crops such as rice are marketed under sole responsibility of the National Cereals and Produce Board (NCPB). There will be no marketing problem for rice, because it is "scheduled crop" and furthermore the Kenya's latent demand for rice is large enough compared to the anticipated production of 100,000 tons in the Project area as mentioned in Chapter II (See Fig. VII-22, ANNEX-VII).

The horticultural crops are marketed through the free channels. The selected crops such as tomatoes onions and French beans have relatively large marketing outlets particularly in Nairobi. The domestic demand for

these crops will surely increase with the population growth in cities and increase in income level.

The assumption that demand for these crops is directly related to population growth, suggests that even under the present level of per capita consumption, the additional demand for these crops in Nairobi will amount to 70,000 tons of tomatoes, 13,000 tons of onions and 20,000 tons of French beans per annum by the year of 2000. The anticipated marketable production of these crops from the Project area will be, on the other, 9,200 tons of tomatoes, 6,200 tons of onions and 12,300 tons of French beans. This indicates that considering the limited possibility of additional production in other areas due to very limited availability of irrigated land, the Project will have enough market outlets for these horticultural crops (See Fig. VII-23, VII-24 and VII-25).

2.7.3 Price prospects for rice and horticultural crops

Economic prices of rice/paddy at the farm gate are estimated, on the basis of the projected international market prices forecasted by IBRD for the year of 1995 in 1985 constant US dollars and further taking into account the costs for transpiration, processing and others, to be KShs.3,670 per ton, as shown in Table VII-25, VII-26 and VII-27.

Financial prices of rice/paddy at the mill gate is fixed by the Government as of mid-1987 to be:

Paddy		
Basmati	:	KShs.4,000/ton
Others	:	KShs.3,000/ton
Milled rice		
Basmati	:	KShs.9,050/ton
Others	:	KShs.7,300/ton

The financial farm gate prices of horticultural crops are estimated on the basis of the projected prices for the year of 1995 using available data on wholesale prices at Nairobi from 1981 to 1986 and further costs for transportation and others as well as sales margins (See Table VII-28 and VII-29).

The economic prices are obtained by multiplying the estimated financial prices by the standard conversion factor of 0.86 (See Table VII-31 and VII-32). The estimated prices are summarized as follows (See Table VII-23, ANNEX-VII):

Financial Prices

Tomatoes	:	KShs.3,400/ton
Onions	:	KShs.4,500/ton
French beans	:	KShs.3,700/ton

Economic prices

Tomatoes	:	KShs.2,900/ton
Onions	:	KShs.3,900/ton
French beans	:	KShs.3,200/ton

2.8 Farm Budget

From the farmer's viewpoint, the financial evaluation in "with project" and "without project" conditions is made for the average farmers as classified in Table VII-10.

Calculations for both income and outgo in 1995 are made on the basis of following assumptions:

(1) The proposed potential irrigation area in MIS is utilized as an arable land at present, while in Mutithi extension area, almost of all is potential arable land except a part of arable land where maize has been cultivated. Under such condition, significant changes in agricultural production will not be expected unless new water resources are exploited. With this viewpoint, agricultural economy under future condition without the project is considered the same with that under present condition.

(2) Crop yield under future without project and with project conditions is estimated as follows:

(Unit: ton/ha)

	Without Project	With Project
MIS		
Long rains rice	-	6.0
Short rains rice	3.5	6.0
Maize	1.3	-
Beans	5.0	-
Tomatoes	-	15.0
Onions	-	10.0
French beans	-	10.0
Mutithi		
Long rains rice	-	6.0
Short rains rice	-	6.0
Maize	1.3	-
Tomatoes	-	15.0
Onions	-	10.0
French beans	-	10.0

(3) The financial prices of agricultural products in 1987 are estimated as follows:

(Unit: KShs./ton)

Rice	3,500
Maize	2,000
Beans	3,700
Tomatoes	3,400
Onions	4,500
French Beans	3,700

Note: For detail, see Table VII-23.

Financial price of each crop is calculated by multiplying growth rate, or 15% of consumer price index on the basis of wholesale price at Nairobi market in 1985 except rice and maize.

Besides as for rice, the price is average price between 4 KShs./kg of Basmati and 3 KShs./kg of Sindano as of 1987, while for maize 2.00 kShs./kg. The prices of rice and maize are the controlled price determined by NCPB.

(4) Financial crop production costs under without and with project conditions are estimated are estimated as follows:

(Unit: KShs./ha)

Crop	Without Project	With Project
Long rains	-	3,700
Short rains	2,900	3,700
Maize	1,100	-
Beans	1,500	-
Tomatoes	-	6,300
Onions	-	9,200
French beans	-	6,300

Note: For detail, see Table VII-26 and VII-27.

(5) According to the result of farm economic survey, the average farmers in MIS cultivate 1.8 ha of farmland of which rice field is 1.6 ha and upland field 0.2 ha. The average family size is 9.5 persons per household.

Besides, the average farmers in Mutithi extension area cultivate 3.2 ha of farmland of which rice field is 2.7 ha and upland field 0.5 ha, based on the result of socio-economic survey. The average family size is 6.6 persons per household.

The results of the analysis are summarized as follows (for details, see Table VII-28).

I. MIS (Unit: KShs.1,000)

	Without Project	With Project
Planted Area		
Rice	1.6	1.6
Horticultural crops	0.2	0.2
Total	1.8	1.8
Gross Income		
Farm income	21.8	84.2
Others	1.5	-
Total (A)	23.3	84.2
Out-go		
Farm expenses	4.9	14.6
Living expenses	15.5	22.5
Total (B)	20.4	37.1
Net Reserve (A - B)	2.9	47.1

II. Mutithi extension area (Unit: KShs.1,000)

	Without Project/1	With Project
Planted Area		
Rice	-	2.7
Horticultural crops	1.0	0.5
Total	1.0	3.2
Gross Income		
Farm income	2.6	160.7
Others	6.2	-
Total (A)	8.8	160.7
Out-go		
Farm expenses	1.1	27.9
Living expenses	7.2	22.5
Total (B)	8.3	50.4
Net Reserve (A - B)	0.5	110.3

Note) /1: Out of total farm land (3.2 ha), planted area is 1.0 ha and potential arable land in black cotton soils is 2.2 ha.

Based on the above tables, implementation of the Scheme is expected to result in a significant increase in farm income. Thus, the balance (or capacity to pay) will be increased remarkably.

2.9 Gross and Net Crop Production Values under the Proposed Project

Net incremental benefit of the Project is defined as the difference between the net production value "with" the Project and the net production value "without" the Project. The net production value is defined as the difference between the gross production value and the production cost as shown in Table VII-29 and VII-30.

Table VII-31 shows the net incremental benefits at the full development stage in both "with project" and "without project" conditions. The following table shows the summary of net incremental benefit of the Project.

(Unit: KShs.million)

	Without Project	With Project	Incremental Benefit
I. MIS			
Long rains rice	-	101.4	101.4
Short rains rice	50.9	101.4	50.5
Maize	1.0	-	-1.0
Beans	2.6	-	-2.6
Tomatoes	-	13.3	13.3
Onions	-	10.6	10.6
French beans	-	19.4	19.4
Sub-total (I)	54.5	246.1	191.6
II. Mutithi			
Long rains rice	-	42.7	42.7
Short rains rice	-	42.7	42.7
Maize	0.7	-	-0.7
Beans	-	-	-
Tomatoes	-	7.2	7.2
Onions	-	5.7	5.7
French beans	-	10.4	10.4
Sub-total (II)	0.7	108.7	108.0
III. Total (I + II)			
Long rains rice	-	144.1	144.1
Short rains rice	50.9	144.1	93.2
Maize	1.7	-	-1.7
Beans	2.6	-	-2.6
Tomatoes	-	20.5	20.5
Onions	-	16.3	16.3
French beans	-	29.8	29.8
Total	55.2	354.8	299.6

2.10 Rehabilitation and Improvement of Farming Facilities

2.10.1 Farm buildings and reception centre

(1) MIS Scheme area

The existing five (5) reception centres of MIS would be improved and expanded to the scale that would be able to accommodate the increased production of double cropping of rice and horticultural crops. A centralized machine centre would be also required for effective operation and maintenance of increased number of the farm machinery and equipment. The proposed site for the machine centre should be located near the existing MIS Headquarters.

The following farm buildings are included in the proposed works (for details see Table VII-32):

Reception Centres

a. Expansion of concrete floor
b. Construction of warehouse for fertilizer and agro-chemicals
c. Construction of short-term storage for collecting/shipping of horticultural crops

Machine Centre

a. offices for controlling all the machinery including O/M equipment
b. workshop
c. fuel tanks
d. garages

(2) Mutithi extensions area

The Mutithi extension area of 2,900 ha would have almost same irrigation layout as the existing MIS and be divided into two (2) sections, or Kibiriri and Rukanga (tentative named).

Reception Centres

a. Office
b. Weighing facilities
c. Concrete floor for drying grains
d. Short term storage house for dried paddy
e. Warehouse for fertilizer and agro-chemicals
f. Temporary garage for farm machinery and equipment

Machine centre

Machine centre would be centralized and located near the existing MIS headquarters. Accordingly, machinery centre will not be established in Mutithi extension area. The centralized machine centre in MIS would be shared with the Mutithi extension area.

2.10.2 Rice processings facilities

In future, under with project condition, irrigable rice field of 8,330 ha will be developed (MIS: 5,860 ha, Mutithi: 2,470 ha) and the paddy production will attain about 100,000 tons per annum under double cropping system with cropping intensity of 200%.

The paddy sold to NCPB is processed on the commercial basis by the existing two (2) large millers who hold license from NCPB.

One is the Mwea Rice Mill (MRM) and the other is the United Millers Ltd. located at Kisumu in the Western Province. All of paddy harvested in MIS has been processed at MRM.

Presently, MRM operates its milling machines for six (6) days a week, or 50 weeks a year excluding two (2) weeks in June and December. The operation hours are eight (8) hours a day for normal season and 16 hours in 2-shift operation for peak season. The present milling capacity during the normal season is 112 tons/day, and for the peak season, 224 tons/day. It corresponds to annual milling capacity of 33,600 tons under normal operation and 67,200 tons in 2-shift operation throughout the year.

The present processing capacity of MRM will not meet the future rice production of about 100,000 tons. However, if considered 3-shift operation throughout the year, the milling capacity of MRM would be 336 tons/day or 100,800 tons/year and MRM would be able to process the future paddy production of 100,000 tons.

The 3-shift operation throughout the year is not realistic under the present socio-economic circumstances in the Area. It is therefore, recommended that an additional rice mill be established in future when the existing MRM will have the difficulties to process the paddy harvest from the Project area.

2.10.3 Farm machinery

The proposed system of farm machinery operation will be mostly conformed to the present one; namely, MIS headquarters will own all of farm machinery and carry out the mechanical cultivation for the farmers. In the Mutithi extension area, same service system will be applied. The proposed farm machinery is considered for rice cultivation, not for upland cultivation. For effective utilization of tractors, the trailers for

transportation of farm inputs and harvests and large sprayers for effective operation of plant protection work. The proposed number of farm machinery is shown in Table VII-33. The proposed general specifications of farm machinery are as follows:

Wheel Tractor	:	60 PS class (for operation under swampy condition)	
Crawler Tractor	:	60 PS class	
Rotavator	:	Width;	200 cm
Chisel Plow	:	Width;	150 cm
Trailer	:	Load capacity;	2.0 ton
Sprayer	:	Tank volume;	500-1,000 lit

2.10.4 O/M equipment

Adequate number and kind of heavy equipment, light vehicles and workshop equipment will be one of the pre-requisites for proper operations and maintenance of the Project.

The proposed O/M equipment is listed in Table VII-34.

3. AGRICULTURAL SUPPORT SYSTEM

As for extension services, MIS's staff, field assistant, have responsibility concerned with extension of rice cultivation technology.

Besides, for upland crops, it has been operated through the staff of Ministry of Agriculture. Extension services are primarily supervised in the field, at both the provincial and district levels. Frontline extension work is undertaken by Junior Technical Assistants and Technical Assistants.

There are currently about 5,100 frontline staff in whole country, giving a ratio of one extension worker to every 450 smallholder farmers. This ratio compares favorably to ratio in most developing countries.

At the provincial level the Ministry of Agriculture is represented by an Assistant Director of Agriculture (ADA) who is usually referred to as Provincial Director of Agriculture (PDA). He is assisted by a team of specialists. At District level the MOA is represented by a Senior Agricultural Officer and a team of specialists. This line is continued up to the locational level where the Locational Extension Officer comes into direct contact with the farmers.

Agricultural credit in Kenya is supported by four main sources: Cereals and Sugar Finance Corporation, foreign donors, selling of promissory notes,and mobilization of savings. There are five channels through which these funds are transmitted to farmer, i.e. Agricultural Finance Corporation (AFC), Co-operative Bank of Kenya (CBK), parastatal organizations, and commercial banks and companies. The main agencies involved in lending are AFC and CBK. The farmers are applicable advance credit for purchase of livestock, equipment, machinery, even for land.

In MIS, Mwea Amalgamated Rice Growers Cooperative Society Ltd., which has operated from 1984, has responsibility for the credit services toward tenant farmers.

The main objectives of the Society is to help members (tenant farmers) to save and borrow. Together with this, it operates trading activities like sales of store for resale, sales of fuel and transportation. This Society has loan services, such as transplanting/ levelling loan, weeding loan and harvesting loan. Members can withdraw anytime for loans mentioned above.

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Table VII-1 Number of Tenant Farmers in Mwea Irrigation Settlement Scheme (1975 - 1986)

Year	Tebere	Mwea	Thiba	Wamumu	Karaba	Scheme Total
1975	624	590	631	560	563	2,973
1976	624	589	631	560	568	2,972
1977	625	590	631	559	626	3,031
1978	625	590	631	560	627	3,033
1979	635	591	631	665	627	3,149
1980	635	591	631	665	627	3,150
1981	635	591	631	666	627	3,150
1982	635	591	631	666	627	3,150
1983	636	591	631	666	627	3,151
1984	649	611	660	667	646	3,233
1985	653	612	660	666	645	3,236
1986	653	612	660	666	645	3,236

Source : NIB Mwea Irrigation Settlement Annual Reports (1974/75 - 1985/86)

Table VII-2 Field Performance of Tractor Operation in Mwea Irrigation Settlememnt Scheme (1960/61-1985/86)

Year	Tractors (Nos)	Area Rotavated (ha)	Working Days (Days)	Work Efficiency (ha/tractor/day)
1960/61	6	637	N.A.	N.A.
1961/62	11	2,005	85	2.14
1962/63	11	1,976	80	2.25
1963/64	11	2.227	113	1.79
1964/65	13	2,169	130	1.28
1965/66	15	2,486	140	1.18
1966/67	18	2,837	98	1.61
1967/68	18	3,170	122	1.44
1968/69	18	3,440	125	1.53
1969/70	19	3,788	132	1.51
1970/71	23	4,310	136	1.38
1971/72	24	4,794	141	1.42
1972/73	26	4,819	126	1.47
1973/74	30	5,512	119	1,54
1974/75	30	5,429	125	1.45
1975/76	30	5,607	123	1.52
1976/77	30	5,614	122	1.53
1977/78	30	5,652	120	1.56
1978/79	30	5,765	167	1.15
1979/80	30	5,761	157	1.22
1980/81	30	5,774	123	1.56
1981/82	30	5,763	134	1.43
1982/83	24	5,764	156	1.54
1983/84	26	5,829	147	1.53
1984/85	24	5,825	156	1.56
1985/86	26	5,829	166	1.35

Source : NIB Mwea Irrigation Settlement Annual Reports (1981/82 - 1985/86)

Table VII-3 Summary of Crop Station in Mwea Irrigation Settlement Scheme (1960/61-1985/86)

Year	Planted Area (ha)	Production (tons)	Unit Yield (ton/ha)
1960/61	2,007	10,887	5.42
1961/62	2,013	11,599	5.76
1962/63	2,009	12,155	6.05
1963/64	2,208	12,010	5.44
1964/65	2,242	11,374	5.07
1965/66	2,593	14,455	5.57
1966/67	2,830	13,854	4.90
1967/68	3,129	17,370	5.55
1968/69	3,412	17,467	5.12
1969/70	3,788	23,018	6.08
1970/71	3,906	24,760	6.34
1971/72	4,660	27,938	5.99
1972/73	4,734	31,221	6.60
1973/74	5,534	30,819	5.57
1974/75	5,379	28,423	5.29
1975/76	5,609	32,060	5.72
1976/77	5,616	35,960	6.41
1977/78	5,648	30,657	5.43
1978/79	5,767	29,046	5.04
1979/80	6,301	29,202	4.63
1980/81	6,312	32,248	5.11
1981/82	5,782	29,848	5.16
1982/83	5,784	28,751	4.97
1983/84	5,820	29,336	5.04
1984/85	5,837	27,553	4.72
1985/86	5,829	26,408	4.53

Source : NIB Mwea Irrigation Settlement Annual Reports (1981/82 - 1985/86

Table VII-4 Rice Production Statistics in Mwea Irrigation Settlement Scheme (1974/75-1985/86)

Year	Tebere Section			Mwea Section			Thiba Section		
	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)
1974/75	1,253	4,687	3.7	1,204	6,922	5.7	1,135	7,155	6.3
1975/76	1,269	8,017	6.3	1,209	5,303	4.4	1,139	6,964	6.1
1976/77	1,254	8,884	7.1	1,209	8,038	6.6	1,139	7,176	6.3
1977/78	1,261	7,728	6.1	1,217	5,472	4.5	1,141	5,485	4.8
1978/79	1,278	7,609	6.0	1,217	7,093	5.8	1,139	4,871	4.3
1979/80	1,277	5,215	4.1	1,216	6,629	5.5	1,139	6,351	5.6
	536*	1,373*	2.6*	-	-	-	-	-	-
1980/81	1,280	6,920	5.4	1,213	4,609	3.8	1,134	5,312	4.7
	-	-	-	546*	1,206*	2.2*	-	-	-
1981/82	1,284	7,242	5.6	1,217	6,406	5.3	1,142	5,151	4.5
1982/83	1,281	7,118	5.6	1,217	7,967	6.5	1,143	4,438	3.9
1983/84	1,282	6,631	5.2	1,218	5,042	4.1	1,142	6,197	5.4
1984/85	1,288	6,461	5.0	1,218	5,970	4.9	1,144	4,399	3.8
1985/86	1,286	6,425	5.0	1,218	4,423	3.6	1,141	4,989	4.4
Ave.	1,274	6,911	5.4	1,214	6,156	5.1	1,140	5,791	5.0

Year	Wamumu Section			Karaoa Section			Scheme Total		
	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)	Planted Area (ha)	Total Production (tons)	Unit Yield (ton/ha)
1974/75	937	5,337	5.7	850	4,322	5.1	5,379	28,423	5.3
1975/76	970	5,572	5.7	1,022	6,203	6.1	5,609	32,060	5.7
1976/77	980	4,701	4.8	1,034	7,161	6.9	5,616	35,960	6.4
1977/78	981	6,280	6.4	1,033	5,692	5.5	5,648	30,657	5.4
1978/79	1,099	4,167	3.8	1,034	5,306	5.1	5,767	29,046	5.0
1979/80	1,099	5,577	5.1	1,034	4,057	3.9	5,765	27,829	4.8
	-	-	-	-	-	-	536*	1,373*	2.6*
1980/81	1,100	6,251	5.7	1,038	7,959	7.7	5,766	31,042	5.4
	-	-	-	-	-	-	546*	1,206*	2.2*
1981/82	1,100	4,736	4.3	1,039	6,313	6.1	5,782	29,848	5.2
1982/83	1,104	5,456	4.9	1,039	3,772	3.6	5,784	28,751	5.0
1983/84	1,112	4,160	3.7	1,066	7,306	6.9	5,820	29,336	5.0
1984/85	1,119	7,653	6.8	1,068	3,070	2.9	5,837	27,553	4.7
1985/86	1,117	4,209	3.8	1,068	6,361	6.0	5,829	26,408	4.5
Ave.	1,060	5,342	5.1	1,027	5,627	5.5	5,717	29,743	5.2

Note : * Second crop of paddy
Source: NIB Mwea Irrigation Settlement Annual Reports (1974/75 - 1985/86)

Table VII-5 Relative Distribution of Farmers Falling in Various Yield Classes (1975/76-1985/86)

(Unit : %)

Yield Class (bags/acre)	Yield Class (ton/ha)	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
0-10	0-1.9	-	-	1.0	-	4.7	0.8	0.9	1.3	0.9	4.7	12.5
10-15	1.9-2.8	0.4	0.1	4.9	4.0	13.6	4.3	2.5	6.9	4.3	9.3	31.0
15-20	2.8-3.7	4.0	1.3	22.4	13.0	23.1	10.3	9.6	19.3	15.8	17.3	30.0
20-25	3.7-4.6	17.3	8.5	32.6	25.8	18.3	21.9	25.9	26.0	25.2	22.7	14.2
25-30	4.6-5.6	25.1	18.5	18.4	24.5	18.0	23.0	25.7	19.3	20.4	17.6	6.6
30-35	5.6-6.5	25.1	23.9	11.8	20.8	14.2	14.2	18.7	12.1	13.4	12.3	3.5
35-40	6.5-7.4	19.5	28.2	6.5	8.2	5.7	10.2	8.9	8.1	9.4	7.4	1.6
40(+)	7.4(+)	8.5	19.0	2.3	2.9	1.7	14.7	8.0	6.2	10.6	8.7	0.7
Average Yield (ton/ha)		5.7	6.4	5.4	5.0	4.8	5.4	5.2	5.0	5.0	4.7	4.5

Source : NIB Mwea Irrigation Settlement Annual Report 1985/86

Table VII-6 Crop Budget Per Acre in Mwea Irrigation Settlement Scheme (1982/83-1985/86)

Description	Unit	Variety : Sindano				Variety : Basmati			
		1982/83	1983/84	1984/85	1985/86	1982/83	1983/84	1984/85	1985/86
1. Gross Return									
Average Unit Yield	Bags/acre	30.8	31.1	30.2	26.3	20.3	22.4	18.2	21.7
Unit Price of Rice	KShs./kg	2.35	2.70	2.70	2.90	2.80	3.25	3.25	3.75
	KShs./bag	176.25	202.50	202.50	217.50	210.00	243.75	243.75	281.25
Gross Return	KShs/acre	5,428.50	6,297.75	6,115.50	5,720.25	4,263.00	5,460.00	4,436.25	6,103.13
2. Deduction per Acre									
Service charge	KShs./acre	1,943.00	1,943.00	2,223.00	2,223.00	1,943.00	1,943.00	2,223.00	2,223.00
Fertilizers									
Sulphate of Ammonia	KShs./acre	111.75	125.75	154.10	176.50	111.75	124.75	154.10	176.50
T.S.P.	KShs./acre	182.50	182.50	182.90	227.95	182.50	179.60	182.90	227.95
Urea	KShs/acre	-	-	102.60	-	-	-	102.60	-
Field Boards	KShs./acre	2.80	2.80	3.50	8.40	2.80	2.80	3.50	8.40
Gates	KShs./acre	41.00	41.00	50.00	58.00	41.00	41.00	50.00	58.00
Seeds	KShs./acre	45.10	49.25	60.30	70.30	58.25	68.20	70.60	87.40
Sprays	KShs./acre	21.85	53.25	62.95	186.95	21.85	53.25	62.95	186.95
Handling Charges	(KShs./bag)	(4.65)	(4.65)	(5.80)	(7.00)	(4.65)	(4.65)	(5.80)	(7.00)
	KShs./acre	143.22	144.62	175.16	184.10	94.40	104.16	105.56	151.90
K.W.F. Loan	KShs./acre	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Total	KShs./acre	2,511.22	2,562.17	3,034.51	3,155.20	2,475.53	2,536.76	2,975.21	3,140.10
3. Net Return (1) - (2)	KShs./acre	2,917.28	3,735.58	3,080.99	2,565.05	1,787.45	2,923.23	1,461.04	2,963.03
4. Net Return per 4 Acres Holding Farmer	KShs./Farmer	11,669.00	14,942.00	12,324.00	10,260.00	7,150.00	11,693.00	5,844.00	11,852.12

Source : Unpublished Data from NIB

Table VII-7 Relative Distribution of Various Income Classes

(Unit:%)

Income Classes (KSh.1000)	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
0 ~ 1	-	0.4	0.9	1.3	1.9	2.6	4.7	3.0	5.1	41.0
1 ~ 2	-	0.2	0.6	1.8	2.4	1.7	2.7	1.4	3.0	13.6
2 ~ 3	0.4	0.8	1.6	3.1	2.5	2.0	3.9	2.0	3.6	10.6
3 ~ 4	0.1	0.8	3.4	5.3	4.7	3.3	5.0	2.6	4.3	5.6
4 ~ 5	1.0	2.1	5.5	8.3	6.3	4.7	5.8	3.8	4.7	4.7
5 ~ 6	2.6	3.6	10.2	12.3	7.8	5.4	6.5	4.6	5.0	4.5
6 ~ 7	7.5	6.9	15.0	14.9	9.8	6.7	7.3	4.8	5.3	3.9
7 ~ 8	15.8	10.4	17.7	15.2	11.2	8.5	8.8	5.7	5.9	3.0
8 ~ 9	20.5	16.2	17.6	13.6	13.0	9.9	8.0	6.0	5.5	3.1
9 ~ 10	24.1	17.9	14.4	10.4	10.6	12.1	9.6	9.2	6.7	2.0
10 (+)	28.0	40.7	13.1	13.6	28.3	45.6	38.9	56.9	50.9	8.0
Average Income (KSh.)	8,638	9,714	8,996	8,763	8,861	11,087	11,348	13,853	12,776	9,017

Note : Farmers are classified according to the amounts of net payment against total number of paddy bags they delivered.

Source: NIB Mwea Irrigation Settlement Annual Report 1985/86

Table VII-8 Average Farm Size

(Unit: ha)

Paddy		Upland Field		
		Maize	Beans	Total
Tebere	2.3	0.3	0.4	0.7
Mwea	2.4	0.5	0.3	0.8
Thiba	1.8	0.5	0.4	0.9
Wamumu	2.1	0.3	0.2	0.5
Karaba	1.8	0.5	0.3	0.8
Average	2.1	0.4	0.3	0.7

Table VII-9 Average Family Size by Sex and Age in MIS

Section	Less than 15		16-19		20-39		40-59		More than 60		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Tebere	1.4	1.1	0.4	0.4	1.3	2.3	0.8	1.0	0.3	-	9.0
Mwea	1.9	1.1	0.7	0.8	2.6	2.7	0.8	1.2	0.5	0.4	12.7
Thiba	1.7	2.3	0.4	0.4	1.0	1.4	0.9	0.4	0.1	-	8.6
Wamumu	1.5	2.5	0.7	0.5	1.0	0.9	0.6	0.7	0.2	0.1	8.7
Karaba	1.4	2.5	0.4	0.4	1.1	1.4	0.6	0.4	0.1	-	8.3
Average	1.6	1.9	0.5	0.5	1.5	1.8	0.7	0.7	0.2	0.1	9.5

Source: Farm economic survey in MIS

Table VII-10 Farm Budget of Average Farmer under Present Condition

	MIS	Mutithi
Average Far Size (ha)		
Rice field	1.6	-
Upland field	0.2 /1	1.0
Uncultivated land	-	2.2
Total	1.8	3.2
		(Unit: KShs.1,000)
I. Gross Income		
i) Farm Income		
Rice	25.2	-
Maize	0.2	2.2
Beans	1.9	-
Sub-total	27.3	2.2
ii) Non-Farm Income	1.5	6.6
Total (I)	28.8	8.8
II. Gross Out-go		
i) Farming Expenses/2		
Rice	4.6	-
Maize	0.1	1.1
Beans	0.2	-
Sub-total	4.9	1.1
ii) Living Expenses	15.5	7.2
Total (II)	20.4	8.3
III. Net Reserve (I - II)	8.4	0.5

Note: Data was estimated from results of farm economic survey in MIS and socio-economic survey in Mutithi extension area.

/1: Minimum size of rice field in each farmer is 1.6 ha while upland field of each farmer is estimated to around 0.2 ha considering the project area in where rice field is 5,860 ha and upland field is 800 ha.

/2: Excluding family labour

Table VII-11 Result of Rice Yield Survey

Sampling Plot	Variety	Nos. of Hills per m^2 (1)	Nos. of Panicles per Hill (2)	Nos. of Spicklets per Panicle (3)	Percentage of Ripened Grains (%) (4)	1,000 Grain Weight (g) (5)	Unit Yield (ton/ha) (6)=[(1)x(2)x(3)x(4)x(5)]/10^7
T5	Sindano	40.7	5.1	79	89.6	27.2	4.0
		37.0	5.4	72	86.9	26.1	3.3
		45.7	5.6	74	84.1	24.9	3.9
		34.3	6.5	91	85.0	26.2	4.5
		22.0	6.8	81	88.0	26.8	2.9
		39.3	5.6	92	91.1	26.2	4.8
		28.0	7.8	77	80.6	27.2	3.7
		40.7	6.2	101	83.5	24.3	5.2
		27.3	7.7	103	83.3	25.5	4.6
		29.3	5.6	101	81.5	25.8	3.5
T7	IR2035	36.3	10.1	101	76.5	24.6	6.9
		45.3	7.4	87	80.0	26.6	6.2
		58.7	7.1	78	77.8	26.6	6.7
		46.7	7.1	84	76.0	24.4	5.2
		52.0	8.2	80	70.4	25.8	6.2
T11	Sindano	46.0	8.5	91	74.5	28.0	7.5
		23.7	9.1	100	86.6	27.4	5.1
		24.7	11.6	104	84.1	26.9	6.7
		29.3	10.7	91	79.6	26.0	5.9
		30.3	10.7	114	82.8	25.4	5.2
T21	IR2035	27.3	8.1	91	91.5	25.8	4.7
T22		37.3	12.8	86	86.1	28.6	10.1
T23		28.3	10.7	71	90.4	26.8	5.2
T25		63.3	6.3	76	82.0	25.4	6.4
		41.0	8.9	81	81.1	27.0	6.5
Karaba	BW192	74.2	7.2	58	85.9	29.9	8.0
		38.0	6.1	68	92.4	29.6	4.3
		45.3	8.5	61	90.7	30.3	6.4
		24.0	15.5	72	84.5	29.8	6.7
		50.3	9.6	100	87.3	28.8	12.1

Table VII-12 Results of Double Cropping Trials in Mwea Irrigation Settlement Scheme

Description	1979/80		1980/81		1985/86	
	S.R.	L.R.	S.R.	L.R.	S.R.	L.R.
1. Area planted	536 ha (1,326 acres)	536 ha (1,326 acres)	546 ha (1,359 acres)	546 ha (1,359 acres)	2,480 ha (6,026 acres)	2,480 ha (6,026 acres)
2. Locations planted	Tebere Section		Mwea Section		Whole Scheme	
3. Variety Used	Sindano	Basmati	Basmati	Sindano	Sindano	Basmati/BG90-2
4. Cropping Calendar						
Rotavation	Mar. - May	Nov./Dec.	February	Sept./Oct.	Feb. - Apr.	Oct. - Dec.
Transplanting	July	January	April	Nov./Dec.	May/June	Dec. - Feb.
Harvesting	November	May	August	Mar./Apr.	Sept./Oct.	May - July
5. Total Production	2,798 tons (37,301 bags)	1,373 tons (18,313 bags)	1,206 tons (16,083 bags)	1,804 tons (24,054 bags)	6,773 tons (90,306 bags)	8,258 tons (110,105 bags)
6. Unit Yield	5.2 tons/ha (28.1 bags/acre)	2.6 tons/ha (13.8 bags/acre)	2.2 tons/ha (11.8 bags/acre)	3.3 tons/ha (17.7 bags/acre)	2.7 tons/ha (15.0 bags/acre)	3.3 tons/ha (18.1 bags/acre)
7. Observations :	a. Harvesting interrupted by short rains in November	a. Bogging down of tractors b. Scarce labour for transplanting c. Serious damages and delay in harvesting caused by wet weather in Apr./May d. Serious damages by quelea birds	a. 28 tractors used for rotavation b. Scarce labour for transplanting and harvesting c. increase of pests (leaf-minor and army worm) but controlled by spraying DDT25ML d. Cool weather in May/June resulting in high percentage of unripened grains e. Serious damages by quelea birds	a. Severe shortage of irrigation water in Sept./Oct. b. Break-down of tractors and shortage of spare parts resulting in delayed operations c. Serious damages of seedlings by pests (leaf minors and leaf rollers resulting in delayed transplanting and damages by rains in April d. Serious damages by wild ducks in Dec.	c. Adverse effects of cool weather on grain formation in August b. high incidence of pests c. Serious damages by quelea birds and wild duck	a. Prolonged land preparation owing to frequent bogging down of tractors resulting in transplanting of overgrown seedlings b. Shorter wet fallow period c. Increase in crop damages caused by pests and diseases (stem-rot) d. Shortage of irrigation water in Feb./Mar. e. Serious damages by rains in harvesting period of May/June.

Source : (1) NIB Mwea Irrigation Settlement Annual Reports 1979/80, 1980/81, 1985/86
(2) Report on 1985/86 Double Cropping in Mwea Irrigation Settlement, Oct. 1986

Table VII-13 Results of Double Cropping Trials at Mwea Irrigation Reseach Station (1975-1985)

(Unit : tons/ha)

Variety/ Year	Sindano/Fallow		Sindano		Basmati		IR579-48-1-3		IR1561-228-3-3	
	L.R.	S.R.	L.R.	S.R.	L.R.	S.R.	L.R.	S.R.	L.R.	S.R.
1975	-	6.4	6.9	7.9	5.6	7.1	7.2	9.2	-	-
1976	-	6.9	-	6.7	-	5.3	-	7.5	-	-
1977	-	5.9	6.0	6.4	5.3	4.9	6.9	7.0	-	-
1978	-	5.9	5.1	5.8	3.9	4.9	5.1	6.2	-	-
1979	-	7.1	3.4	6.2	3.3	5.6	4.2	6.5	-	-
1980	-	-	5.0	-	3.8	-	4.3	-	-	-
1981	-	3.6	-	3.1	-	3.7	-	4.5	-	-
1982	-	-	-	6.5	-	5.2	-	6.5	-	-
1983	-	-	5.9	4.2	5.1	3.9	6.4	4.5	-	4.7
1984	-	-	3.5	3.9	4.1	3.8	4.3	3.2	3.7	3.6
1985	-	-	3.3	-	3.8	-	3.7	-	3.8	-
Average	-	6.0	4.9	5.6	4.4	5.0	5.3	6.1	3.8	4.2

L.R. : Long Rains Period

S.R. : Short Rains Period

Source: NIB, Operational Research and Training Project Technical Report No.30, 1986

Table VII-14 Profitability per Ha of Major Horticultural Crops

(Unit: KShs.1,000)

Crops	G.P.V.*	P.C.**	N.P.V.***
Tomatoes	51	14	37
Egg Plant	17	11	6
Cucumber	12	10	2
Chillies	12	11	1
Capsicum	12	10	2
Cabbage	11	9	2
Lettuce	11	9	2
Carrot	10	8	2
Onions	45	17	28
Welsh Onion	10	6	4
Potato	14	13	1
Sweet Potato	18	11	7
Cauliflower	11	9	2
French Beans	37	11	26
Rice	18	6	12

Remarks: *: G.P.V. = Gross Production Value
**: P.C. = Production Cost including Labour Cost
***: Net Production Value

Note: All figures are estimated by JICA Study Team on the basis of following sources:

1) Farm economic survey
2) Data on wholesale price of agro-products in municipal wholesale market, MOA (1981-1986)
3) Farm budget of rice and onion in 1985/86, NIB
4) Agricultural costs and prices 1985, Farm Management Handbook Vol1.111B, MOALD
5) Natural condition and farm management information
6) Supplemental survey during 2nd stage.

Table VII-15 Proposed Farming Practices for Long Rains Rice and Short Rains Rice

1. Management of Nursery		
Amount of seed	:	45 kg/ha
Area of nursery bed	:	500 m^2/ha
2. Planting		
Planting method	:	Transplanting
Planting density	:	20-30 hills/m^2
3. Application of Fertilizer		
Nursery bed	:	6 kg of SA/bed
Rice field	:	400 kg of SA 125 kg of TSP
Time in Rice Field		
125 kg of TSP 150 kg of SA	:	Basic dressing before transplanting
50 kg of SA	:	First top dressing at 15 days after transplanting
200 kg of SA	:	Second top dressing after late panicle formation stage
4. Weeding	:	at 30th and 60th days after transplanting
5. Application of Agro-chemicals	:	1.5 kg of Carbofuran/ha 1.0 lit of Sumithion/ha
6. Water Control		
- Transplanting to rooting stage	:	Deep water depth
- Most tillering stage	:	Shallow water depth with intermitted irrigation
- Neck-node differenciation stage upto panicle formation stage	:	Midseason drainage
- Panicle formation stage upto heading	:	Shallow water depth
- Full ripening stage to harvesting stage	:	Water drained
7. Harvesting	:	By sickle

Table VII-16 Proposed Farming Practices for Tomato

1. Management of Nursery		
Amount of seed	:	1 kg/ha
Area of nursery bed	:	200 m^2/ha
2. Planting		
Planting method	:	Transplanting
Planting density	:	1.5-2 m between rows 300-500 m in row
3. Application of Fertilizer		
- 1st application	:	150 kg of CAN 125 kg of TSP 35 kg of SOP
- 2nd application	:	150 kg of CAN 125 kg of TSP 35 kg of SOP
4. Weeding	:	around 30th and 60th days after transplanting
5. Application of Agro-chemicals		
Insecticide	:	Trichlorphon 2 kg/ha Penthion 1 lit/ha
Fungicide	:	Propineb 2.5 kg/ha

6. Water Control

- Furrow irrigation with an interval of every 7-14 days
- Enough watering to thoroughly moisten the soils in the root zone
- On repening stage, subsequent irrigation should be kept to the minimum.

7. Harvesting	:	By hand

Table VII-17 Proposed Farming Practices for Onion

1. Management of Nursery		
Amount of seed	:	5 kg/ha
Area of nursery bed	:	200 m^2/ha
2. Planting		
Planting method	:	Transplanting
Planting density	:	200-300 mm between rows 50-80 mm in row
3. Application of Fertilizer		
- 1st application	:	50 kg of CAN/ha 50 kg of TSP/ha 25 kg of SOP/ha
- 2nd application	:	50 kg of CAN/ha 50 kg of TSP/ha 25 kg of SOP/ha
4. Weeding	:	at 10th, 30th, 50th, 70th after transplanting
5. Application of Agro-chemicals	:	
- Insecticide	:	Trichlorphon 1 kg/ha Fenthion 1 lit/ha

6. Water Control

- Excess water to young transplants causes rank growth, thick necks and poor bulbing
- In the early stage, it should not be applied too frequently

7. Harvesting	:	By hand

Table VII-18 Proposed Farming Practices for French Bean

1. Planting		
Planting method	:	Direct sowing
Planting density	:	50-70 cm between rows 20-30 cm in row
2. Application of Fertilizer		
- 1st application	:	150 kg of CAN 100 kg of TSP 40 kg of SOP
- 2nd application	:	150 kg of CAN 100 kg of TSP 40 kg of SOP
3. Weeding	:	at 30th and 60th days after sowing
4. Application of Agro-chemicals	:	1.0 kg of Trichlonphon/ha 1.0 lit of Fenthion/ha 1.0 kg of Propinef/ha
5. Water Control		
- Furrow irrigation with an interval of every one week		
- The critical growth period towards water stress in the period from frowering to ripening		
6. Harvesting	:	By hand

Table VII-19 Low Temperature on a 10-day Basis in 1986

(Unit: °C)

	1st 10 Days	2nd 10 Days	3rd 10 Days
January	20.8	21.3	22.1
February	23.3	23.3	22.8
March	23.3	22.5	22.7
April	22.9	21.9	22.5
May	22.1	21.9	21.4
June	20.6	18.6	18.5
July	19.1	19.0	18.5
August	19.8	19.5	19.7
September	20.3	20.1	22.1
October	23.1	23.2	22.6
November	22.7	21.0	20.8
December	20.9	20.9	20.9

Source: Dayly mean temperature at the Embu - Mwea Meteorological Station (1978-1986)

Note : This low temperature is a minimum temperature in moving averages for five (5) days during each 10 days.

Table VII-20 Effects of Low Temperature on Maximum Potential Yield in Proposed Cropping Pattern

Conditions	Maximum Potential Yield/1 (ton/ha)	Damage of Low Temperature/2 (%)	Actual Potential Yield (ton/ha)
I. Long Rains Rice	10.9	29	7.7
II. Short Rains Rice	10.9	29	7.7

Note: /1: Maximum potential yield was estimated from following formula:

$Y = S(278 - 7.07\ t) \times g \times P \times 10^{-5}$

where, Y: Maximum potential yield

S: Average daily solar radiation for 25 days before following

t: Average daily temperature for 25 days before floweing

g: Gram of 1,000-grains weight: 20 g

P: Percentage of ripened grain (80%)

/2: Damages were estimated considering minimum temperature for each 10-days according to Fig. VII-17 (See Fig. VII-16).

/3: Actual Potential Yield = Max. Potential Yield (ton/ha) x Damage of Low Temperature (%)

Source: 1. Proceedings of the Symposium on Climate and Rice, IRRI

2. Agrometeorology of the Rice Crop, IRRI

3. Meteorological data (temperature/solar radiation) from Emu-Mwea Meteorological Station at Thiba Reception Centre (1978, 5 - 1986, 11)

Table VII-21 Incremental Farm Inputs in the Project Area

Crop	Without Project				With Project				Incremental Input			
	Seed (ton)	Fertilizer (ton)	Agro-Chemicals (ton)	(lit)	Seed (ton)	Fertilizer (ton)	Agro-Chemicals (ton)	(lit)	Seed (ton)	Fertilizer (ton)	Agro-Chemicals (ton)	(lit)
MIS												
(1) Long Rains Rice	0	0	0	0	263,700	3,077	18	11,720	263,700	3,077	18	11,720
(2) Short Rains Rice	264	2,198	18	11,720	263,700	3,077	18	11,720	263,436	879	0	0
(3) Maize	15	75	0	600	0	0	0	0	-15	-75	0	-600
(4) Beans	40	58	0	0	0	0	0	0	-40	-58	0	0
(5) Tomato	0	0	0	0	200	248	2	400	200	248	2	400
(6) Onion	0	0	0	0	2,000	100	3	400	2,000	100	3	400
(7) French Bean	0	0	0	0	32,000	464	3	800	32,000	464	3	800
Sub-Total	319	2,331	18	12,320	561,600	6,965	44	25,040	561,281	4,635	26	12,720
Mutithi												
(1) Long Rains Rice	0	0	0	0	111,150	1,297	7	4,940	111,150	1,297	7	4,940
(2) Short Rains Rice	0	0	0	0	111,150	1,297	7	4,940	111,150	1,297	7	4,940
(3) Maize	10,750	54	0	430	0	0	0	0	-10,750	-54	0	-430
(4) Beans	0	0	0	0	0	0	0	0	0	0	0	0
(5) Tomato	0	0	0	0	108	133	1	215	108	133	1	215
(6) Onion	0	0	0	0	1,075	54	2	215	1,075	54	2	215
(7) French Bean	0	0	0	0	17,200	249	2	430	17,200	249	2	430
Sub-Total	10,750	54	0	430	240,683	3,030	19	10,740	229,933	2,976	19	10,310
Total	11,069	2,384	18	12,750	802,283	9,995	63	35,780	791,214	7,611	45	23,030
	(11,070)	(2,380)	(20)	(12,750)	(802,280)	(9,990)	(60)	(35,780)	(791,210)	(7,610)	(50)	(23,030)

Table VII-22 Available Labour Force for Farming Practices

	Item	Man-day
1	Avalage Family Size	9.50
2	Labour Force for Household	1.50
3	Potential Labour Force for Farming Practices	8.00
4	Actual Labour Force for Farming Practices (equivalent to Adult Farmer)	3.47
5	Labour Force for Off-farm Income	0.09
6	Actual Available Labour Force for Farming Prac	3.38
7	Actual Available Labour Force in Whole Area	10,938

Note:Each Man-day is estimated as follows:

1 Avalage Family Size

age	Male	Female	total
less than 15	1.60	1.90	3.50
16 to 19	0.50	0.50	1.00
20 to 39	1.50	1.80	3.30
40 to 59	0.70	0.70	1.40
more than 60	0.20	0.10	0.30
total	4.50	5.00	9.50

2 Labour Force for Household

age	Male	Female	total
less than 15	-	-	-
16 to 19	-	-	-
20 to 39	-	1.50	1.50
40 to 59	-	-	-
more than 60	-	-	-
total	-	1.50	1.50

3 Potential Labour Force for Farming Practices

age	Male	Female	total
less than 15	1.60	1.90	3.50
16 to 19	0.50	0.50	1.00
20 to 39	1.50	0.30	1.80
40 to 59	0.70	0.70	1.40
more than 60	0.20	0.10	0.30
total	4.50	3.50	8.00

4 Conversion Factor to Adult Equivalent

age	Male	Female
less than 15	0.3	0.3
16 to 19	0.5	0.5
20 to 39	1.0	0.7
40 to 59	0.3	0.0
more than 60	0.0	0.0

5 Depending on Farm Economic Survey

6 Actual Available Labour Force for Farming Practice=3.47-0.09

7 Actual Available Labour Force in Whole Area=3.38x3,236
(Nos. of farm household is 3,236.)

Table VII-23 Financial and Economic Prices for Agricultural Outputs and Inputs

(Unit: KShs./Unit)

Outputs and Inputs	Unit	Financial (1987)	Economic /1 (1995)
Outputs			
- Rice (Import Parity)	ton	3,500	3,800 /2
- Maize (Import Parity)	ton	2,000	3,100 /3
- Beans	ton	3,700	3,200 /4
- Tomatoes	ton	3,400	2,900 /4
- Onions	ton	4,500	3,900 /4
- French Beans	ton	3,700	3,200 /4
Inputs			
(1) Seed			
- Rice	kg	5.4	4.6 /4
- Maize	kg	9.7	8.3 /4
- Beans	kg	23.0	19.8 /4
- Tomatoes	kg	1,007.3	866.3 /4
- Onions	kg	1,099.2	945.3 /4
- French Beans	kg	42.0	36.1 /4
(2) Fertilizer			
- CAN	kg	4.3	3.0 /5
- TSP	kg	3.1	2.2 /5
- SOP	kg	6.8	4.8 /5
- Sulfate of Ammonia	kg	3.1	2.2 /5
- 20-10-10	kg	5.5	3.9 /5
(3) Agro-chemicals			
- Propineb	kg	182.4	127.7 /5
- Trichlorphon	kg	151.8	106.3 /5
- Fenthion	l	225.4	157.8 /5
- Carbofuran	kg	70.7	49.5 /5
- Sumithion	l	117.3	82.1 /5
(4) Agro-materials			
- Container			
for Tomatoes	ha	1,500.0	1,500.0
for Onions	ha	750.0	750.0
for French Beans	ha	1,000.0	1,000.0
- Field Board	ha	22.0	22.0
- Gate	ha	144.0	144.0
(5) Labour			
Family Labour	Man-day	-	14 /6
(6) Machinery			
Rotavation	hr	120.0	120.0

Note: /1: 1987 constant price.
/2: For breakdown, see Table VII-26.
/3: For breakdown, see Table VII-27.
/4: Using Standard Conversion Factor of 0.86.
/5: Fertilizer and agro-chemicals are exempted the taxes. Handling cost is 30% of financial price.
/6: Using shadow wage rate of 0.7.

Table VII-24 Economic Price Structure of Rice

	Items	Unit	Constant 1987 Price
1.	World Price (F.O.B. Bangkok) in 1995/1	US$/ton	265.8
2.	Freight and insurance (Bangkok to Mombasa)	US$/ton	+80
3.	Value C.I.F. Mombasa	US$/ton	345.8
	(US$1 = KShs.16.5)	KShs./ton	5,706
4.	Port handling charge, bagging and weighing, and transport	KShs./ton	+958
5.	Value at Mwea warehouse	KShs./ton	6,664
6.	Transport (warehouse to mill gate) including handling charge	KShs./ton	-4
7.	Value in term of husked paddy/2	KShs./ton	4,329
8.	Value of bran	KShs./ton	+144
9.	Milling charge	KShs./ton	-210
10.	NCPB charge/3	KShs./ton	-420
11.	Transport (NCPB buying centre to farm gate)	KShs./ton	-58
12.	Farm gate price of paddy	KShs./ton	3,785 (=3,800)

Note: /1: 1987 Based on the IBRD Commodity Price Projection, September, 1987. The IBRD estimated price given in 1985 constant US$ has been adjusted by a factor of 1.254 (MUV) to allow for price escalation between 1985 and 1987.

/2: Milling rate: 65%.

/3: Consisting of insecticide cost, overhead cost of NCPB and loss at depot.

Table VII-25 Economic Price Structure of Maize

	Items	Unit	Constant 1987 Price
1.	World Price (FOB US$ Gulf) in 1995/1	US$/ton	119.1
2.	Freight and insurance	US$/ton	+37
3.	Value C.I.F. *Mombasa*	US$/ton	156.1
	(US$1 = KShs.16.5)	KShs./ton	2,576
4.	Port handling charge, bagging and weighing and transport	KShs./ton	+981
5.	Value at Mwea warehouse (= Wholesale price)	KShs./ton	3,557
6.	NCPB charge	KShs./ton	-420
7.	Transport (NCPB buying centre to farm gate)	KShs./ton	-58
8.	Farm gate price	KShs./ton	3,079 (≒3,100)

Note: /1: Based on the IBRD Commodity Price Projection, 1987. The IBRD estimated price given in 1985 constant US$ has been adjusted by a factor of 1.254 (MUV) to allow for price escalation between 1985 and 1987.

Table VII-26 Financial Production Cost Under Without Project Condition (1/3)

Item		Unit	Short Rains Rice Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed		kg	5.4	45	243
2 Fertilizer	: S.A(21%N)	kg	3.1	250	775
	: TSP(46%P2O5)	kg	3.1	125	388
3 Agro-chemicals	: Carbofuran	kg	70.7	3	212
	: Sumithion	lit	117.3	2	235
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	: Others	l.s.	0	0	0
	Sub-total(A)				2,018
(B)Labour Requirement					
1 Nursery Preparation		M-D	0	5	0
2 Soil Preparation		M-D	0	10	0
3 Transplanting		M-D	0	40	0
4 Appl.of Fertilizer		M-D	0	8	0
5 Protecting		M-D	0	5	0
6 Weeding		M-D	0	25	0
7 Water Management		M-D	0	15	0
8 Harvesting/Drying		M-D	0	45	0
9 Threshing/Transporting		M-D	0	17	0
	Sub-total (B)			170	0
(C)Land Preparation	: Rotavation	hr	110	4	440
	: Handling	l.s.	323	1	323
	Sub-total (C)				763
(D)Miscellaneous Cost	(5% of (A)+(B)+(C))				139
(E)Total Production Cost					2,920 (=2,900)

Table VII-26 Financial Production Cost Under Without Project Condition (2/3)

Item		unit	Unit Price (ksh/unit)	Maize Quantity (unit/ha)	Maize Value (ksh/ha)
(A)Farm Input					
1 Seed	: Hybrid Maize	kg	9.7	25	243
2 Feilizer	: 20 -20 -10	kg	5.5	125	688
3 Agro-chemical	: Sumithion	lit	117.3	1	117
	Sub-total(A)				1,047
(B)Labour Requirement					
1 Soil Preparation		M-D	0	30	0
2 Seeding		M-D	0	15	0
3 Appl.of Fertilizer		M-D	0	3	0
4 Protecting		M-D	0	2	0
5 Weeding		M-D	0	30	0
6 Harvesting		M-D	0	15	0
7 Transporting		M-D	0	25	0
	Sub-total(B)			120	0
(C)Land Preparation	: Rotavation	hr			0
	: Handling	l.s.			0
	Sub-total(C)				0
(D)Miscellaneous cost	(5% of (A)+(B))				52
(E)Total Production Cost					1,100

Table VII-26 Financial Production Cost Under Without Project Condition (3/3)

Item		unit	Unit Price (ksh/unit)	Beans Quantity (unit/ha)	Beans Value (ksh/ha)
(A)Farm Input					
1 Seed	: Hybrid Bean	kg	23	200	398
2 Feilizer	: CAN(26%N)	kg	4.3	150	555
	: TSP(46%P2O5)	kg	3.1	100	270
	: SOP(61%K2O)	kg	3.1	40	216
	Sub-total(A)				1,439
(B)Labour Requirement					
1 Soil Preparation		M-D	0	30	0
2 Seeding		M-D	0	15	0
3 Appl.of Fertilizer		M-D	0	6	0
4 Protecting		M-D	0	0	0
5 Weeding		M-D	0	30	0
6 Harvesting		M-D	0	36	0
7 Transporting		M-D	0	10	0
	Sub-total(B)			127	0
(C)Land Preparation	: Rotavation	hr		0	0
	: Handling	l.s.		0	0
	Sub-total(C)				0
(D)Miscellaneous cost	(5% of (A)+(B))				72
(E)Total Production Cost					1,511 (=1,500)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-27 Financial Production Cost Under With Project Condition (1/5)

			Long Rains Rice(L.R.R.)		
			Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed	: L.R.R	kg	5.4	45	243
2 Fertilizer	: SA(21%N)	kg	3.1	400	1,240
	: TSP(46%P2O5)	kg	3.1	125	388
3 Agro-chemical	: Carbofuran	kg	70.7	3	212
	: Sumithion	lit	117.3	2	235
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	Sub total(A)				2,483
(B)Labour Requirement					
1 Nursery		M-D	0	5	0
2 Soil Preparation		M-D	0	10	0
3 Taransplanting		M-D	0	40	0
4 Appl.of Fertilizer		M-D	0	11	0
5 Protecting		M-D	0	3	0
6 Weeding		M-D	0	25	0
7 Water Management		M-D	0	20	0
8 Harvesting/Drying		M-D	0	56	0
9 Threshing/Transporting		M-D	0	23	0
	Sub total(B)			193	0
(C)Machinery and handling					
	: Rotavation	hr	120	4	480
	: Handling	l.s.	554	1	554
	Sub total(C)				1,034
(D)Miscellaneous cost (5% of (A)+(B)+(C))					176
(E)Total Production Cost					3,693 (=3,700)

Table VII-27 Financial Production Cost Under With Project Condition (2/5)

			Short Rains Rice(S.R.R)		
			Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed	: S.R.R	kg	5.4	45	243
2 Fertilizer	: SA(21%N)	kg	3.1	400	1,240
	: TSP(46%P2O5)	kg	3.1	125	388
3 Agro-chemical	: Carbofuran	kg	70.7	3	212
	: Sumithion	lit	117.3	2	235
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	Sub total(A)				2,483
(B)Labour Requirement					
1 Nursery		M-D	0	5	0
2 Soil Preparation		M-D	0	10	0
3 Taransplanting		M-D	0	40	0
4 Appl.of Fertilizer		M-D	0	11	0
5 Protecting		M-D	0	3	0
6 Weeding		M-D	0	25	0
7 Water Management		M-D	0	20	0
8 Harvesting/Drying		M-D	0	56	0
9 Threshing/Transporting		M-D	0	23	0
	Sub total(B)			193	0
(C)Machinery and handling					
	: Rotavation	hr	120	4	480
	: Handling	l.s.	554	1	554
	Sub total(C)				1,034
(D)Miscellaneous cost (5% of (A)+(B)+(C))					176
(E)Total Production Cost					3,693 (=3,700)

Table VII-27 Financial Production Cost Under With Project Condition (3/5)

Item		Unit	Unit Price (ksh/unit)	Tomato Quantity (unit/ha)	Tomato Value (ksh/ha)
(A) Farm Input					
1 Seed	: Hybrid Tomato	kg	1007.3	1	504
2 Fertilizer	: CAN(26%N)	kg	4.3	300	1,290
	: TSP(46%P2O5)	kg	3.1	250	775
	: SOP(61%K2O)	kg	6.8	70	476
3 Agro-chemical	: Propineb	kg	182.4	2.5	456
	: Trichlorphon	kg	151.8	2	304
	: Fenthion	lit	225.4	1	225
4 Agro-materials	: Container	l.s.	750	2	1,500
	: Other material	l.s.	500	1	500
	Sub-total(A)				6,030
(B)Labour Requirement					
1 Nursery		M-D	0	10	0
2 Soil Preparation		M-D	0	30	0
3 Taransplanting		M-D	0	80	0
4 Appl.of Fertilizer		M-D	0	10	0
5 Protecting		M-D	0	30	0
6 Weeding		M-D	0	40	0
7 Water Management		M-D	0	30	0
8 Harvesting		M-D	0	120	0
9 Transporting		M-D	0	40	0
	Sub-total(B)			380	0
(C)Machinery and Handling					
	: Rotavation	hr		0	0
	: Handling	l.s.		0	0
	Sub-total(C)			0	0
(D)Miscellaneous Cost (5% of (A)+(B)+(C))					301
(E)Total Production Cost					6,331 (=6,300)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-27 Financial Production Cost Under With Project Condition (4/5)

Item		Unit	Unit Price (ksh/unit)	Onion Quantity (unit/ha)	Onion Value (ksh/ha)
(A) Farm Input					
	: Hybrid Onion	kg	1099.2	5	5,496
2 Fertilizer	: CAN(26%N)	kg	4.3	100	430
	: TSP(46%P2O5)	kg	3.1	100	310
	: SOP(61%K2O)	kg	6.8	50	340
3 Agro-chemical	: Propineb	kg	182.4	6	1,094
	: Trichlorphon	kg	151.8	1	152
	: Fenthion	lit	225.4	1	225
4 Agro-materials	: Container	l.s.	750	1	750
	Sub-total(A)				8,798
(B)Labour Requirement					
1 Nursery		M-D	0	10	0
2 Soil Preparation		M-D	0	30	0
3 Taransplanting/Seeding		M-D	0	80	0
4 Appl.of Fertilizer		M-D	0	10	0
5 Protecting		M-D	0	30	0
6 Weeding		M-D	0	40	0
7 Water Management		M-D	0	30	0
8 Harvesting		M-D	0	120	0
9 Transporting		M-D	0	40	0
	Sub-total(B)			380	0
(C)Machinery and Handling					
	: Rotavation	hr		0	0
	: Handling	l.s.		0	0
	Sub-total(C)			0	0
(D)Miscellaneous Cost (5% of (A)+(B)+(C))					440
(E)Total Production Cost					9,237 (=9,200)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-27 Financial Production Cost Under With Project Condition (5/5)

			French Bean		
		Unit	Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed	:	kg	42	40	1,680
2 Fertilizer	: CAN(26%N)	kg	4.3	300	1,290
	TSP(46%P2O5)	kg	3.1	200	620
	: SOP(61%k2O)	kg	6.8	80	544
3 Agro-chemicals	: Trichlorphon	kg	151.8	1	152
	: Fenthion	lit	225.4	1	225
	: Propineb	kg	182.4	2.5	456
4 Other materials	: Container	l.s.			1,000
	Sub-total(A)				5,967
(B)Labour Requirement					
1 Soil Preparation		M-D	0	30	0
2 Seeding		M-D	0	20	0
3 Appl.of Fertilizer		M-D	0	10	0
4 Protecting		M-D	0	6	0
5 Weeding		M-D	0	40	0
6 Water Management		M-D	0	30	0
7 Harvesting		M-D	0	60	0
8 Transporting		M-D	0	20	0
	Sub-total (B)			216	0
(C)Land Preparation	: Rotavation	hr			0
	: Handling	acre			0
	Sub-total(C)				0
(D)Miscellaneous Cost	(5% of (A) + (B) +(C))				298
(E)Total Production Cost					6,266 (=6,300)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-28 Farm Budget Analysis

	MIS		Mutithi	
	Without	With	Without	With
Average Far Size				
Rice field	1.6	1.6	-	2.7
Upland field	0.2	0.2	1.0	0.5
Potential arable land	-	-	2.2	-
Total	1.8	1.8	3.2	3.2
			(Unit:	KShs.1,000)
I. Gross Income				
i) Farm Income				
Rice	19.6	67.2	-	113.4
Maize	0.3	-	2.6	-
Beans	1.9	-	-	-
Tomatoes	-	5.1	-	15.3
Onions	-	4.5	-	13.5
French beans	-	7.4	-	18.5
Sub-total	21.8	84.2	2.6	160.7
ii) Non-Farm Income	1.5	-	6.2	-
Total (I)	23.3	84.2	8.8	160.7
II.Gross Out-go				
i) Farming Expenses/1				
Rice	4.6	11.8	-	20.0
Maize	0.1	-	1.1	-
Beans	0.2	-	-	-
Tomatoes	-	0.6	-	1.9
Onions	-	0.9	-	2.8
French beans	-	1.3	-	3.2
Sub-total	4.9	14.6	1.1	27.9
ii) Living Expenses	15.5	22.5/2	7.2	22.5/2
Total (II)	20.4	37.1	8.3	50.4
III. Net Reserve (I - II)	2.9	47.1	0.5	110.3
(Kshs./ha)	(1.6)	(26.2)	(0.2)	(34.5)

Note: Data was estimated from results of farm economic survey in MIS and socio-economic survey in Mutithi extension area.

/1: Excluding family labour

/2: Including the expenses for home consumption of food

Table VII-29 Economic Production Cost Under Without Project Condition (1/3)

Item		Unit	Short Rains Rice Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed		kg	4.6	45	207
2 Fertilizer	: S.A(21%N)	kg	2.2	250	550
	: TSP(46%P2O5)	kg	2.2	125	275
3 Agro-chemicals	: Carbofuran	kg	49.5	3	149
	: Sumithion	lit	82.1	2	164
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	: Others	l.s.	0	0	0
	Sub-total(A)				1,511
(B)Labour Requirement					
1 Nursery Preparation		M-D	12.2	5	61
2 Soil Preparation		M-D	12.2	10	122
3 Transplanting		M-D	12.2	40	488
4 Appl.of Fertilizer		M-D	12.2	8	98
5 Protecting		M-D	12.2	5	61
6 Weeding		M-D	12.2	25	305
7 Water Management		M-D	12.2	15	183
8 Harvesting/Drying		M-D	12.2	45	549
9 Threshing/Transporting		M-D	12.2	17	207
	Sub-total (B)			170	2,074
(C)Land Preparation	: Rotavation	hr	110	4	440
	: Handling	l.s.	323	1	323
	Sub-total (C)				763
(D)Miscellaneous Cost	(5% of (A)+(B)+(C))				217
(E)Total Production Cost					4,565 (=4,600)

Table VII-29 Economic Production Cost Under Without Project Condition (2/3)

Item		unit	Unit Price (ksh/unit)	Maize Quantity (unit/ha)	Maize Value (ksh/ha)
(A)Farm Input					
1 Seed	: Hybrid Maize	kg	8.3	25	208
2 Feilizer	: 20 -20 -10	kg	3.9	125	488
3 Agro-chemical	: Sumithion	lit	82.1	1	82
	Sub-total(A)				777
(B)Labour Requirement					
1 Soil Preparation		M-D	12.2	30	366
2 Seeding		M-D	12.2	15	183
3 Appl.of Fertilizer		M-D	12.2	3	37
4 Protecting		M-D	12.2	2	24
5 Weeding		M-D	12.2	30	366
6 Harvesting		M-D	12.2	15	183
7 Transporting		M-D	12.2	25	305
	Sub-total(B)			120	1,464
(C)Land Preparation	: Rotavation	hr			0
	: Handling	l.s.			0
	Sub-total(C)				0
(D)Miscellaneous cost	(5% of (A)+(B))				112
(E)Total Production Cost					2,353 (=2,400)

Table VII-29 Economic Production Cost Under Without Project Condition (3/3)

Item		unit	Unit Price (ksh/unit)	Beans Quantity (unit/ha)	Beans Value (ksh/ha)
(A) Farm Input					
1 Seed	: Hybrid Bean	kg	19.8	200	398
2 Feilizer	: CAN(26%N)	kg	3	150	555
	: TSP(46%P2O5)	kg	2.2	100	270
	: SOP(61%K2O)	kg	4.8	40	216
	Sub-total(A)				1,439
(B) Labour Requirement					
1 Soil Preparation		M-D	12.2	30	366
2 Seeding		M-D	12.2	15	183
3 Appl.of Fertilizer		M-D	12.2	6	84
4 Protecting		M-D	12.2	0	0
5 Weeding		M-D	12.2	30	366
6 Harvesting		M-D	12.2	36	504
7 Transporting		M-D	12.2	10	140
	Sub-total(B)			127	1,643
(C) Land Preparation	: Rotavation	hr			0
	: Handling	l.s.			0
	Sub-total(C)				0
(D) Miscellaneous cost	(5% of (A)+(B))				154
(E) Total Production Cost					3,236 (=3,200)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-30 Economic Production Cost Under With Project Condition (1/5)

			Long Rains Rice(L.R.R.)		
			Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed	: L.R.R	kg	4.6	45	207
2 Fertilizer	: SA(21%N)	kg	2.2	400	880
	: TSP(46%P2O5)	kg	2.2	125	275
3 Agro-chemical	: Carbofuran	kg	49.5	3	149
	: Sumithion	lit	82.1	2	164
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	Sub total(A)				1,841
(B)Labour Requirement					
1 Nursery		M-D	12.2	5	61
2 Soil Preparation		M-D	12.2	10	122
3 Taransplanting		M-D	12.2	40	488
4 Appl.of Fertilizer		M-D	12.2	11	134
5 Protecting		M-D	12.2	3	37
6 Weeding		M-D	12.2	25	305
7 Water Management		M-D	12.2	20	244
8 Harvesting/Drying		M-D	12.2	56	683
9 Threshing/Transporting		M-D	12.2	23	281
	Sub total(B)			193	2,355
(C)Machinery and handling					
	: Rotavation	hr	120	4	480
	: Handling	l.s.	554	1	554
	Sub total(C)				1,034
(D)Miscellaneous cost (5% of (A)+(B)+(C))					261
(E)Total Production Cost					5,491 (=5,500)

Table VII-30 Economic Production Cost Under With Project Condition (2/5)

			Short Rains Rice(S.R.R)		
			Unit Price (ksh/unit)	Quantity (unit/ha)	Value (ksh/ha)
(A)Farm Input					
1 Seed	: S.R.R	kg	4.6	45	207
2 Fertilizer	: SA(21%N)	kg	2.2	400	880
	: TSP(46%P2O5)	kg	2.2	125	275
3 Agro-chemical	: Carbofuran	kg	49.5	3	149
	: Sumithion	lit	82.1	2	164
4 Other materials	: Field Board	l.s.	22	1	22
	: Gates	l.s.	144	1	144
	Sub total(A)				1,841
(B)Labour Requirement					
1 Nursery		M-D	12.2	5	61
2 Soil Preparation		M-D	12.2	10	122
3 Taransplanting		M-D	12.2	40	488
4 Appl.of Fertilizer		M-D	12.2	11	134
5 Protecting		M-D	12.2	3	37
6 Weeding		M-D	12.2	25	305
7 Water Management		M-D	12.2	20	244
8 Harvesting/Drying		M-D	12.2	56	683
9 Threshing/Transporting		M-D	12.2	23	281
	Sub total(B)			193	2,355
(C)Machinery and handling					
	: Rotavation	hr	120	4	480
	: Handling	l.s.	554	1	554
	Sub total(C)				1,034
(D)Miscellaneous cost (5% of (A)+(B)+(C))					261
(E)Total Production Cost					5,491 (=5,500)

Table VII-30 Economic Production Cost Under With Project Condition (3/5)

Item		Unit	Unit Price (ksh/unit)	Tomato Quantity (unit/ha)	Tomato Value (ksh/ha)
(A) Farm Input					
1 Seed	: Hybrid Tomato	kg	866.3	1	433
2 Fertilizer	: CAN(26%N)	kg	3	300	900
	: TSP(46%P2O5)	kg	2.2	250	550
	: SOP(61%K2O)	kg	4.8	70	336
3 Agro-chemical	: Propineb	kg	127.7	2.5	319
	: Trichlorphon	kg	106.3	2	213
	: Fenthion	lit	157.8	1	158
4 Agro-materials	: Container	l.s.	750	2	1,500
	. Other material	l.s.	500	1	500
	Sub-total(A)				4,909
(B)Labour Requirement					
1 Nursery		M-D	12.2	10	366
2 Soil Preparation		M-D	12.2	30	122
3 Taransplanting		M-D	12.2	80	976
4 Appl.of Fertilizer		M-D	12.2	10	122
5 Protecting		M-D	12.2	30	366
6 Weeding		M-D	12.2	40	488
7 Water Management		M-D	12.2	30	366
8 Harvesting		M-D	12.2	120	1,464
9 Transporting		M-D	12.2	40	488
	Sub-total(B)			380	4,758
(C)Machinery and Handling					
	: Rotavation	hr		0	0
	: Handling	l.s.		0	0
	Sub-total(C)			0	0
(D)Miscellaneous Cost	(5% of (A)+(B)+(C))				483
(E)Total Production Cost					10,150 (=10,200)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-30 Economic Production Cost Under With Project Condition (4/5)

Item		Unit	Unit Price (ksh/unit)	Onion Quantity (unit/ha)	Onion Value (ksh/ha)
(A) Farm Input					
	: Hybrid Onion	kg	945.3	5	4,727
2 Fertilizer	: CAN(26%N)	kg	3	100	300
	: TSP(46%P2O5)	kg	2.2	100	220
	: SOP(61%K2O)	kg	4.8	50	240
3 Agro-chemical	: Propineb	kg	127.7	6	766
	: Trichlorphon	kg	106.3	1	106
	: Fenthion	lit	157.8	1	158
4 Agro-materials	: Container	l.s.	750	1	750
	Sub-total(A)				7,267
(B)Labour Requirement					
1 Nursery		M-D	12.2	10	366
2 Soil Preparation		M-D	12.2	30	122
3 Taransplanting/Seeding		M-D	12.2	80	976
4 Appl.of Fertilizer		M-D	12.2	10	122
5 Protecting		M-D	12.2	30	366
6 Weeding		M-D	12.2	40	488
7 Water Management		M-D	12.2	30	366
8 Harvesting		M-D	12.2	120	1,464
9 Transporting		M-D	12.2	40	488
	Sub-total(B)			380	4,758
(C)Machinery and Handling					
	: Rotavation	hr		0	0
	: Handling	l.s.		0	0
	Sub-total(C)			0	0
(D)Miscellaneous Cost (5% of (A)+(B)+(C))					601
(E)Total Production Cost					12,626 (=12,600)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-30 Economic Production Cost Under With Project Condition (5/5)

		Unit	Unit Price (ksh/unit)	French Bean Quantity (unit/ha)	French Bean Value (ksh/ha)
(A)Farm Input					
1 Seed	:	kg	36.1	40	1,444
2 Fertilizer	: CAN(26%N)	kg	3	300	900
	TSP(46%P2O5)	kg	2.2	200	440
	: SOP(61%k2O)	kg	4.8	80	384
3 Agro-chemicals	: Trichlorphon	kg	106.3	1	106
	: Fenthion	lit	157.8	1	158
	: Propineb	kg	127.7	2.5	319
4 Other materials	: Container	l.s.			1,000
	Sub-total(A)				4,751
(B)Labour Requirement					
1 Soil Preparation		M-D	12.2	30	366
2 Seeding		M-D	12.2	20	244
3 Appl.of Fertilizer		M-D	12.2	10	122
4 Protecting		M-D	12.2	6	73
5 Weeding		M-D	12.2	40	488
6 Water Management		M-D	12.2	30	366
7 Harvesting		M-D	12.2	60	732
8 Transporting		M-D	12.2	20	244
	Sub-total (B)			216	2,635
(C)Land Preparation	: Rotavation	hr			0
	: Handling	acre			0
	Sub-total(C)				0
(D)Miscellaneous Cost	(5% of (A) + (B) +(C))				369
(E)Total Production Cost					7,756 (=7,800)

Note; CAN : Calucium Ammonium Nitrate
SOP : Sulfate of Potash

Table VII-31 Irrigation Benefit Estimate at the Full Development Stage

Crop	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (KShs./ton)	Gross Production Value (Million kshs.)	Unit Production Cost (KShs./ha)	Total Production Cost (KShs.Million)	Net Production Value (KShs.Million)
I Without Project								
1) MIS								
1 Rice field								
Short Rains Rice	5,860	3.5	20,510	3,800	77.9	4,600	27.0	50.9
2 Upland field								
Maize	600	1.3	780	3,100	2.4	2,400	1.4	1.0
Beans	200	5.0	1,000	3,200	3.2	3,200	0.6	2.6
2) Mutithi								
Upland field								
Maize	430	1.3	559	3,100	1.7	2,400	1.0	0.7
Total					85.2		30.0	55.2
II With Project								
1) MIS								
1 Rice field								
Long Rains Rice	5,860	6.0	35,160	3,800	133.6	5,500	32.2	101.4
Short Rains Rice	5,860	6.0	35,160	3,800	133.6	5,500	32.2	101.4
2 Upland field								
French Beans	800	10.0	8,000	3,200	25.6	7,800	6.2	19.4
Onion	400	10.0	4,000	3,900	15.6	12,600	5.0	10.6
Tomatoes	400	15.0	6,000	2,900	17.4	10,200	4.1	13.3
2) Mutithi								
1 Rice field								
Long Rains Rice	2,470	6.0	14,820	3,800	56.3	5,500	13.6	42.7
Short Rains Rice	2,470	6.0	14,820	3,800	56.3	5,500	13.6	42.7
2 Upland field								
French Beans	430	10.0	4,300	3,200	13.8	7,800	3.4	10.4
Onion	215	10.0	2,150	3,900	8.4	12,600	2.7	5.7
Tomatoes	215	15.0	3,225	2,900	9.4	10,200	2.2	7.2
Total					470.0		115.2	354.8
III Incremental Benefit (With Project - Without Project)								299.6

Table VII-32 Extension of Existing Reception Centre in MIS and Construction of New Reception Centre in Mutithi Extension Area

(Unit: m^2)

Item	Required Area
I. Reception Centre in MIS	
a. Drying floor	9,800
b. Warehouse /1	5,500
c. Collection/shipping space	4,000
d. Office	1,000
(Sub-Total)	(20,300)
II. Machine Centre	
a. Garage	9,600
b. Workshop	3,200
c. Parking area /2	19,800
d. Stores for spair parts	600
e. Office	200
(Sub-total)	(33,400)
III. Reception Centre in Mutithi Extension Area	
a. Drying floor	14,800
b. Warehouse /1	2,400
c. Collection/shipping space /3	2,200
d. Storing space /4	4,400
e. Office	900
(Sub-total)	(24,700)
IV. Total (I + II + III)	78,400

Note: /1: Warehouse for storing of fertilizer and agro-chemicals
/2: Including the space for washing the car
/3: For horticultural crops
/4: Space for storing of small farming implements

Table VII-33 Proposed Numbers of Agricultural Machinery Introduced to the Project Area

Item	Required Number
1. 4-wheel drive tractor (60ps) /1	
MIS	53
Mutithi	33
Total	86
2. Crawler tractor (60ps)	
MIS	10
Mutithi	4
Total	14
3. Rotavator	
MIS	59
Mutithi	35
Total	94
4. Chisel plow	
MIS	4
Mutithi	2
Total	6
5. Sprayer	
MIS	19
Mutithi	8
Total	27
6. Trailer	
MIS	32
Mutithi	13
Total	45

Note: /1: Excluding existing 26 tractors

Table VII-34 Required Numbers for Operation & Maintenance Equipment, Instrument & Tools

Item	Specification	Unit	Required Numbers			
			M I S	Mutithi	D a m	Total
Backhoe shovel	0.3 m^3	nos.	3	2		5
Backhoe shovel	0.6 m^3	"	1	1	1	3
Bulldozer	11 t	"	1	1	1	3
Wheel loader	1.0 m^3	"	1	1		2
Motor grader	3.7 m	"	2	1	1	4
Road roller	5 t	"	1	1	1	3
Vibrating plate	3 ps	"	2	1		3
Concrete mixer	0.12 m^3	"	2	1		3
Submargible pump	50 mm	"	2	1	2	5
Portable generator	3 kVA	"		1	1	2
Long wheel base lorry	12 t	"	2			2
Fuel tanker	8 t	"	1			1
Truck	5 t	"	1	1		2
Dump truck	8 t	"	2	1	1	4
Dump truck	3 t	"	1	1		2
Cargo truck	6 t	"	5	2		7
Cargo truck with 3t crane	3 t	"	5	2		7
Pick up truck	1 t	"	5	2		7
Workshop service vehicle	1.5 t	"	1		1	2
Jeep		"	6	2		8
Station wagon	1500 cc	"	5	2	4	11
Motor cycle	100 cc	"	15	6	4	25
Spare parts & tools		L.S	1	1	1	3
Telecommunication system						
Base station		nos.	1			1
Field station		"	5	2	4	11
Personal computer		"	1			1
Meteorological equipment		L.S	1	1	1	3
Motor boat	50 cc	nos.			1	1
Boom		"			1	1
Survey Instruments		L.S			1	1
Control panel for monitoring equipment		nos.			1	1
Flood alarm system		L.S			1	1

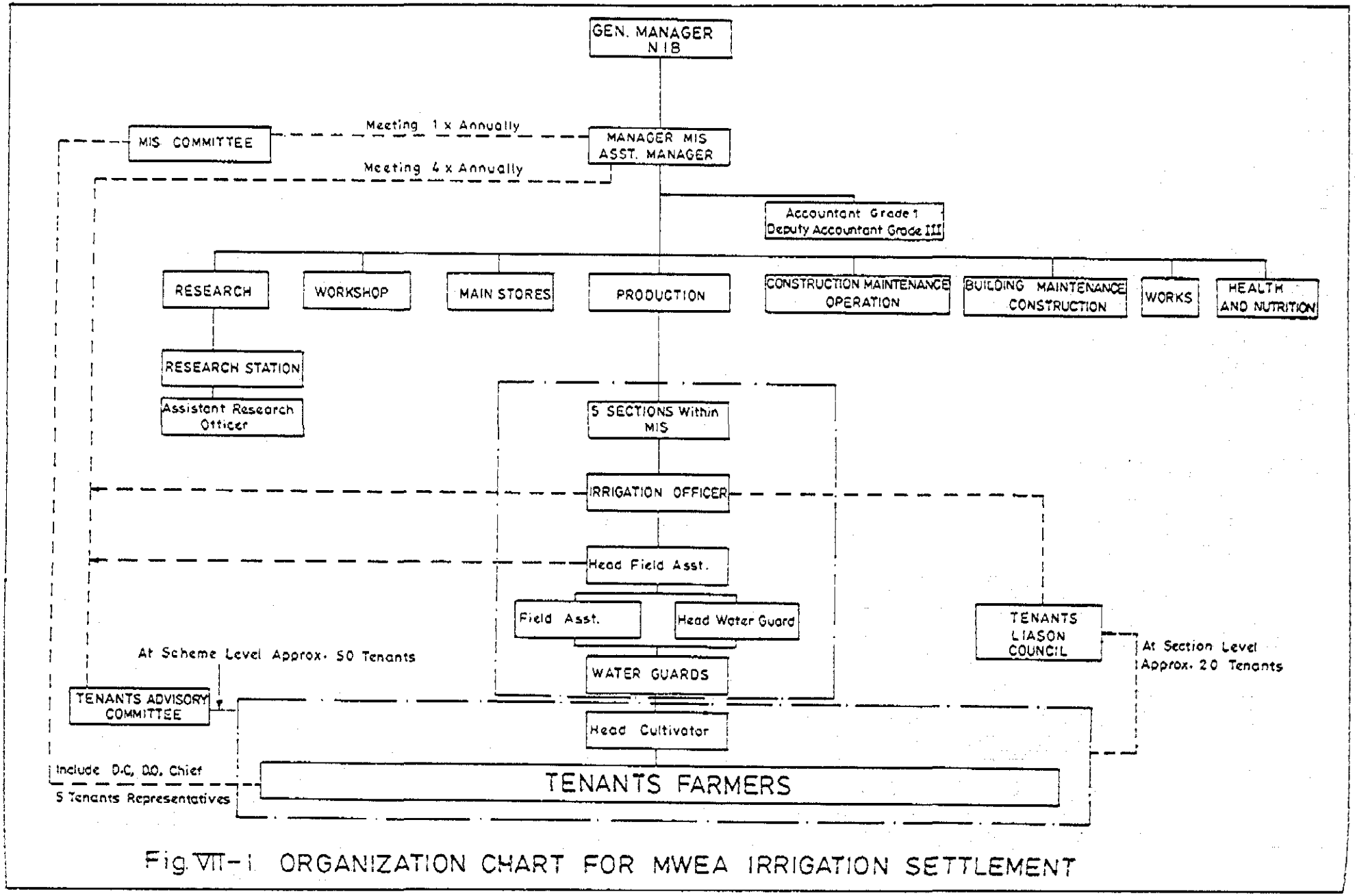


Fig. VII-1 ORGANIZATION CHART FOR MWEA IRRIGATION SETTLEMENT

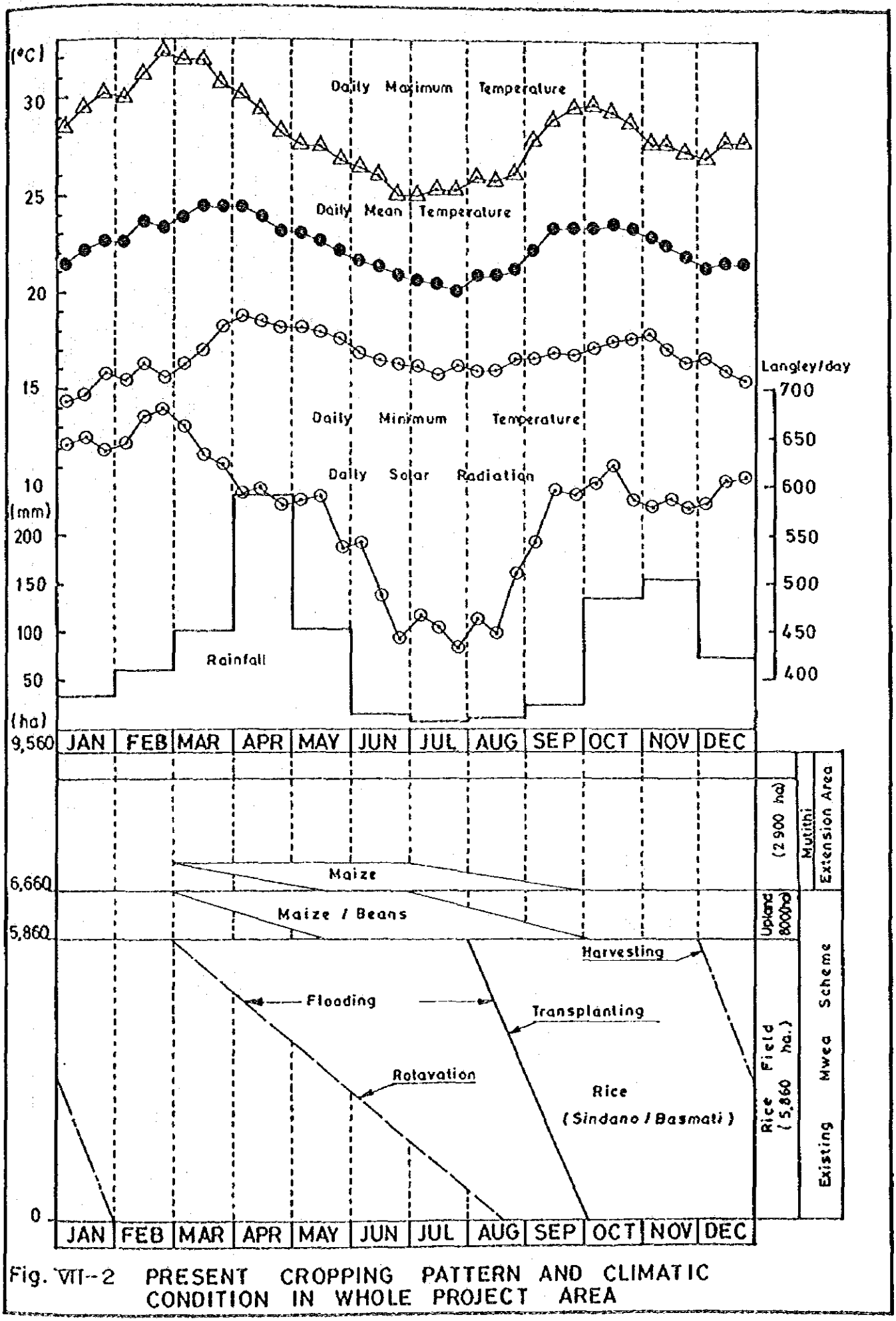


Fig. VII--2 PRESENT CROPPING PATTERN AND CLIMATIC CONDITION IN WHOLE PROJECT AREA

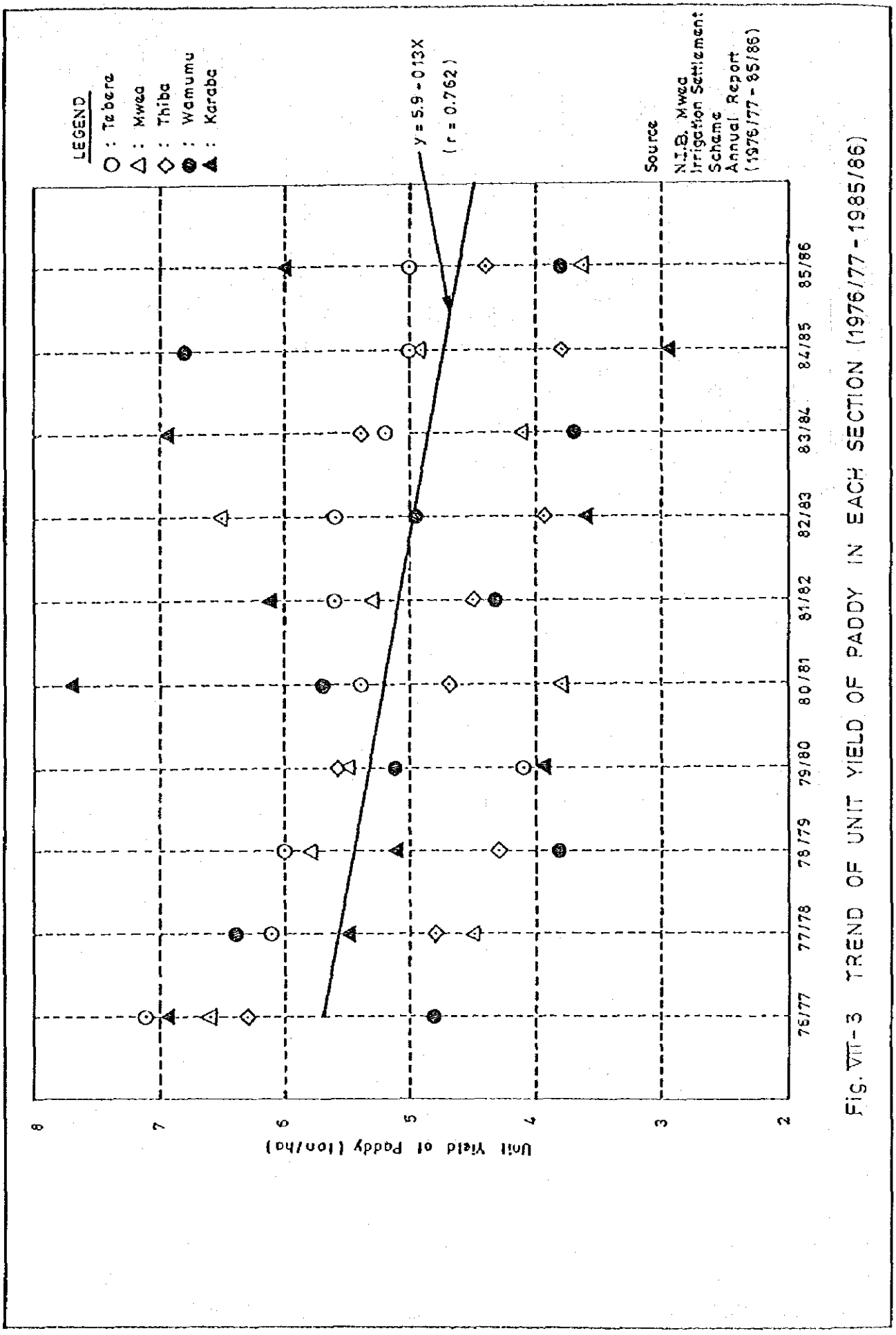


FIG. VII-3 TREND OF UNIT YIELD OF PADDY IN EACH SECTION (1976/77 - 1985/86)

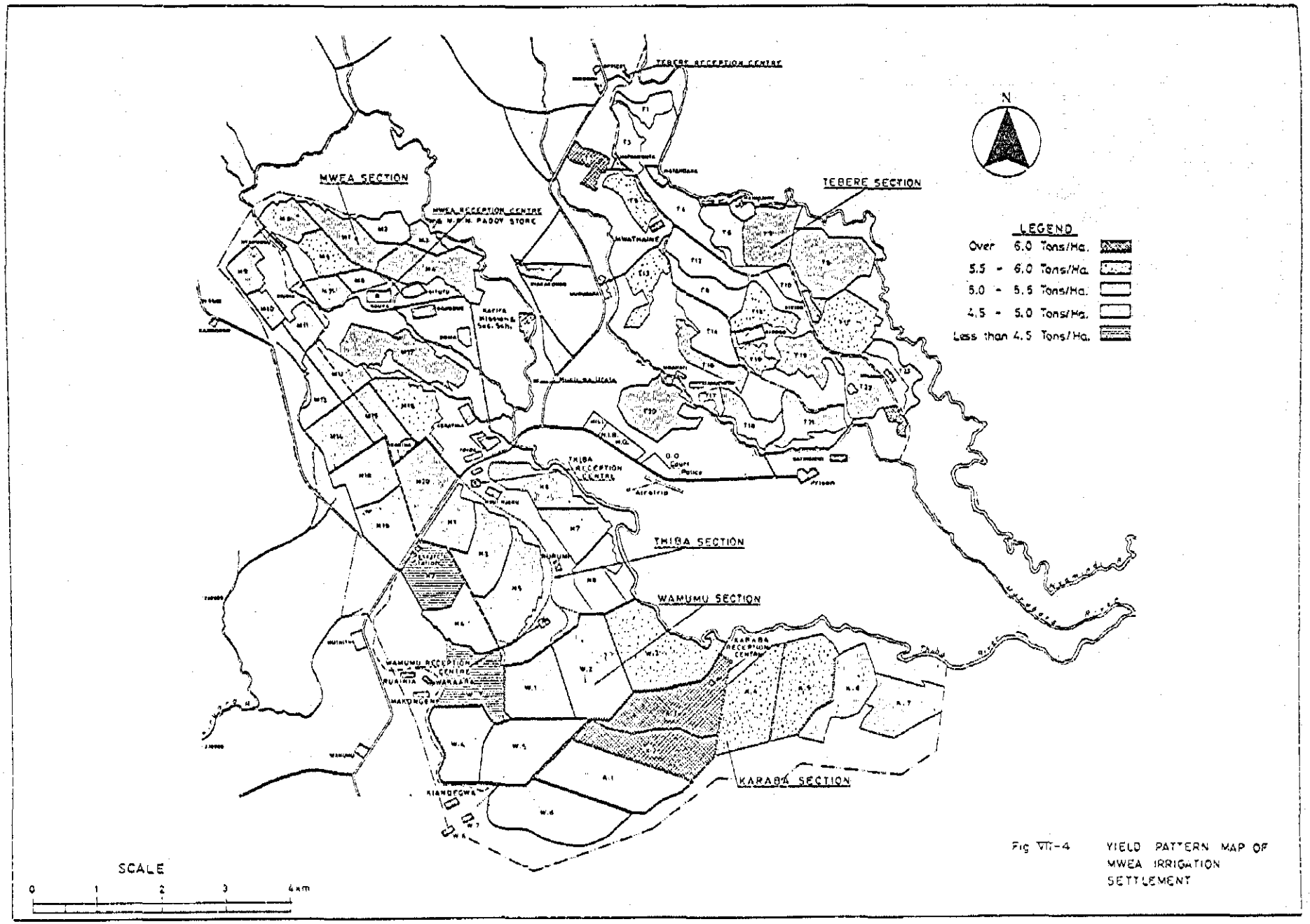


Fig VII-4 YIELD PATTERN MAP OF MWEA IRRIGATION SETTLEMENT

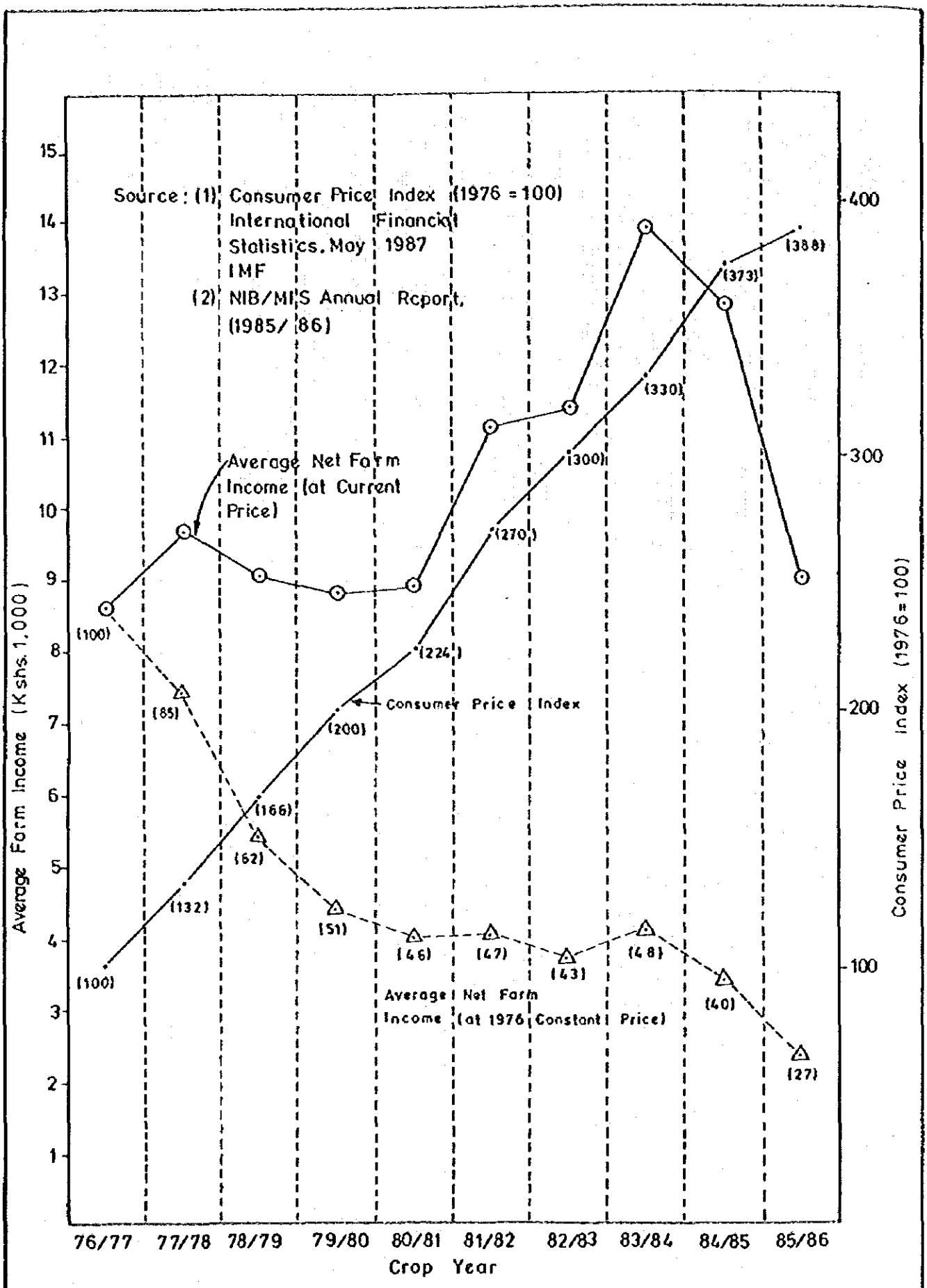
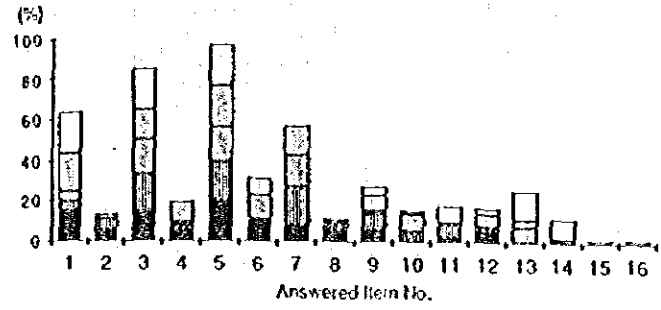


Fig. VII-5 DECLINE IN ACTUAL INCOME LEVEL AMONG MIS FARMERS

Q 1 Which item do you want to improve present farm management ?

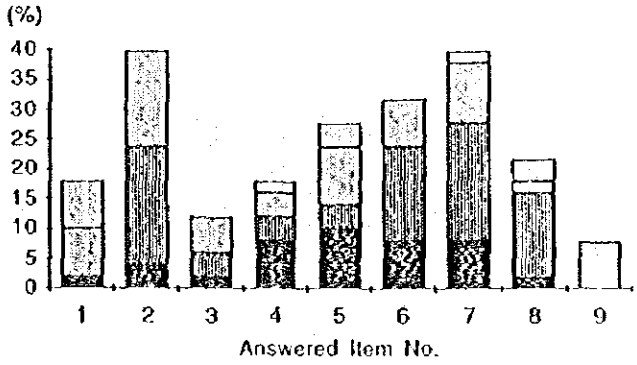
Answer
1 Irrigation water supply
2 Drainage of excess water
3 Prevention of pests and diseases
4 Supply of mechanical power services
5 High yield varieties
6 Application of more fertilizer
7 Improvement of farm road
8 Agricultural extention work
9 Improvement of irrigation and drainage facilities
10 Improvement of operation and management of water supply by NIB
11 Improvement of operation and management of water supply by farmers themselves
12 Improvement of communication for irrigation water supply
13 Improvement of marketing system
14 Agriacultural credit services
15 Double cropping of rice
16 Double cropping of rice and other crops



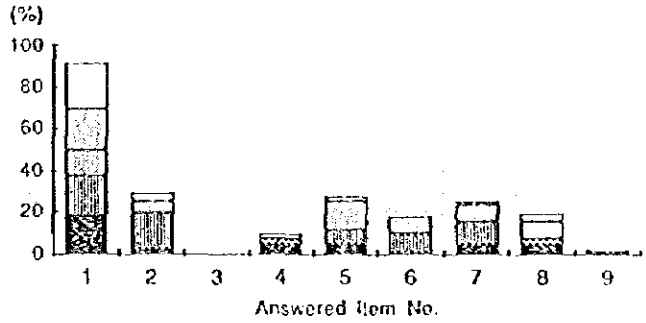
Q 2 If you can cultivate any crops in your farm plot, which kind of crops do you want to cultivate?

Answer
1 Rice
2 Maize
3 Peanut
4 Soybean
5 Cowpea
6 Sorghum
7 Tomatoes
8 Onion
9 Others

To Long Rains Season

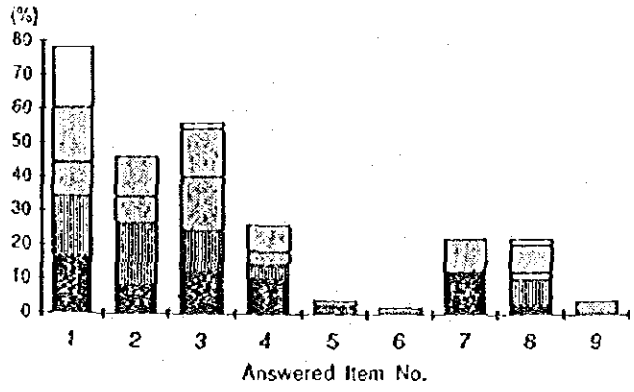


To short Rains Season



Q 3 For the Q 2, why do you want to cultivate these crops ?

Answer
1 High profitability
2 Easy farming technique
3 High marketability
4 High tolerance to pests and diseases
5 High stable market price
6 Much government subsidy
7 Recomendation from extension office
8 Soil suitability
9 Other reason



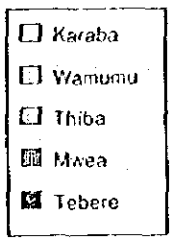


Fig.VII-6 RESULT OF FARM ECONOMIC SURVEY
(Farmer's Intention for Improvement of Present Agricultural Condition)

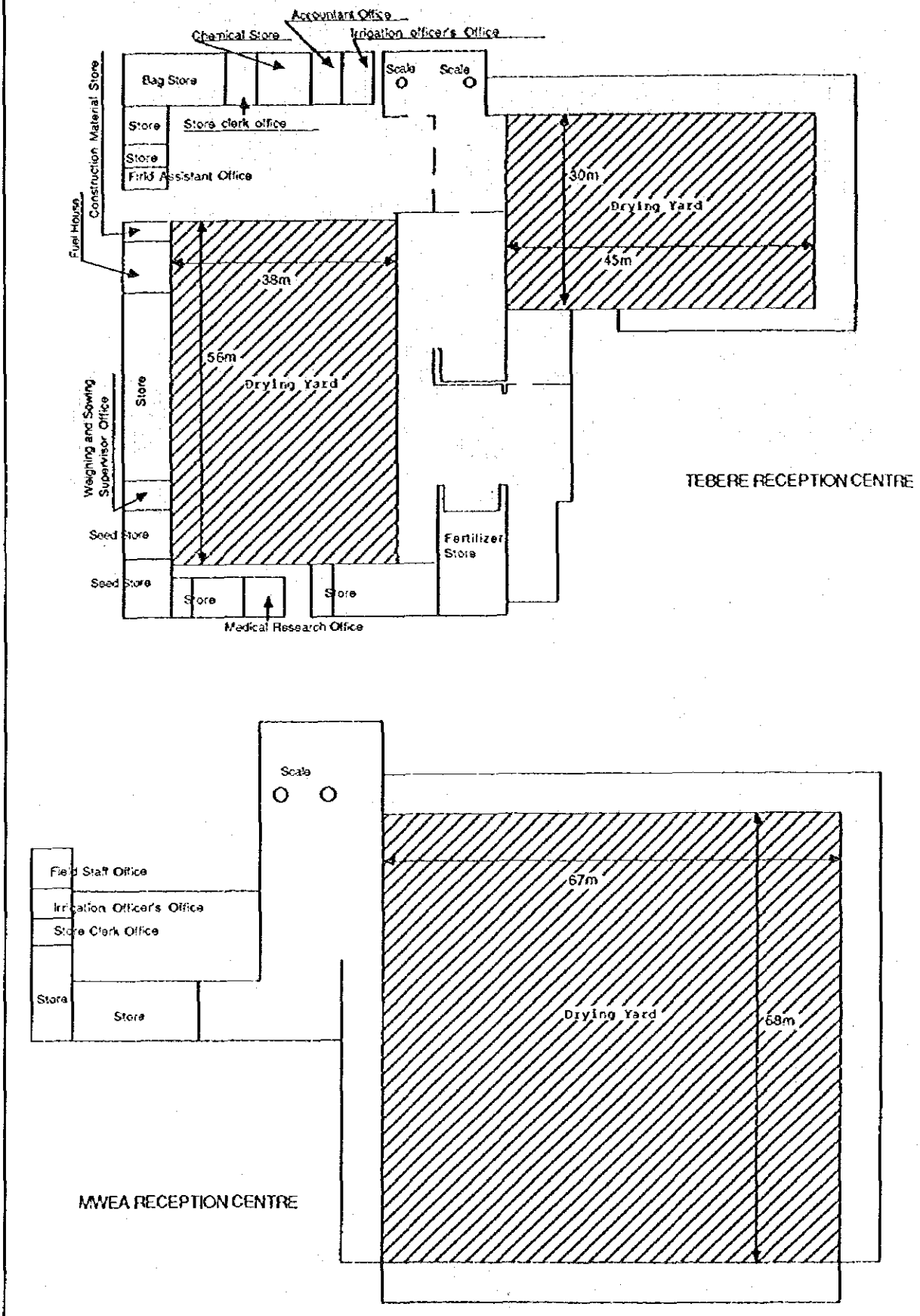
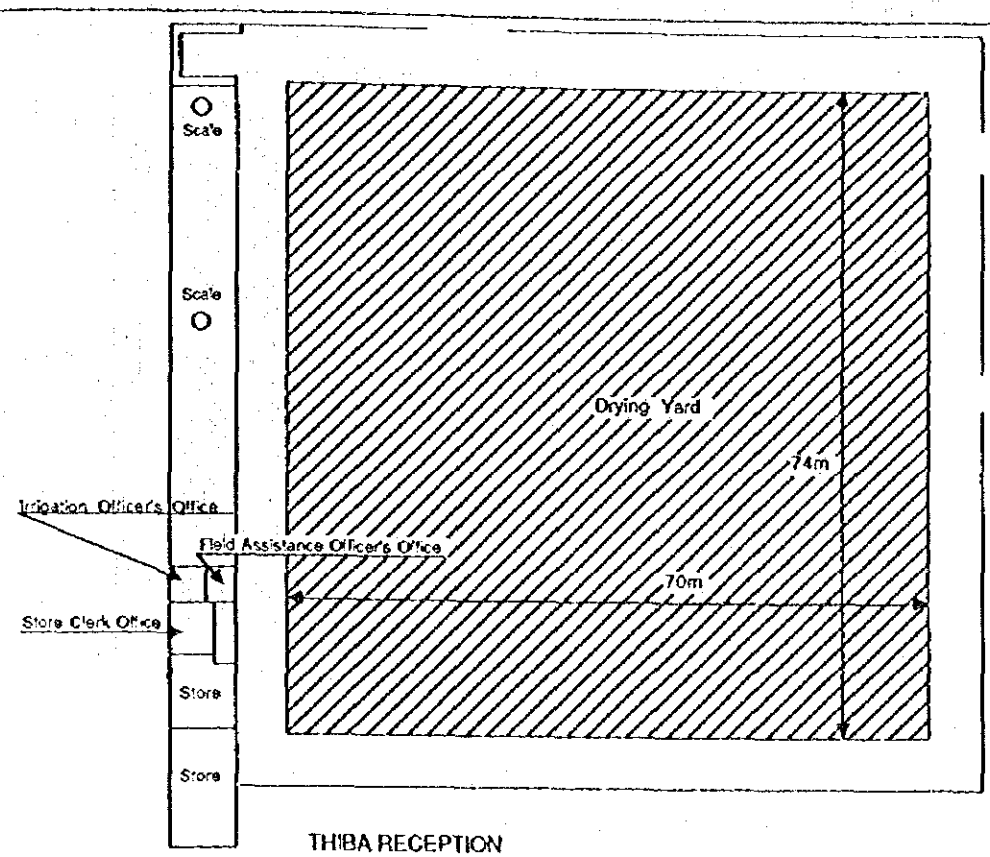
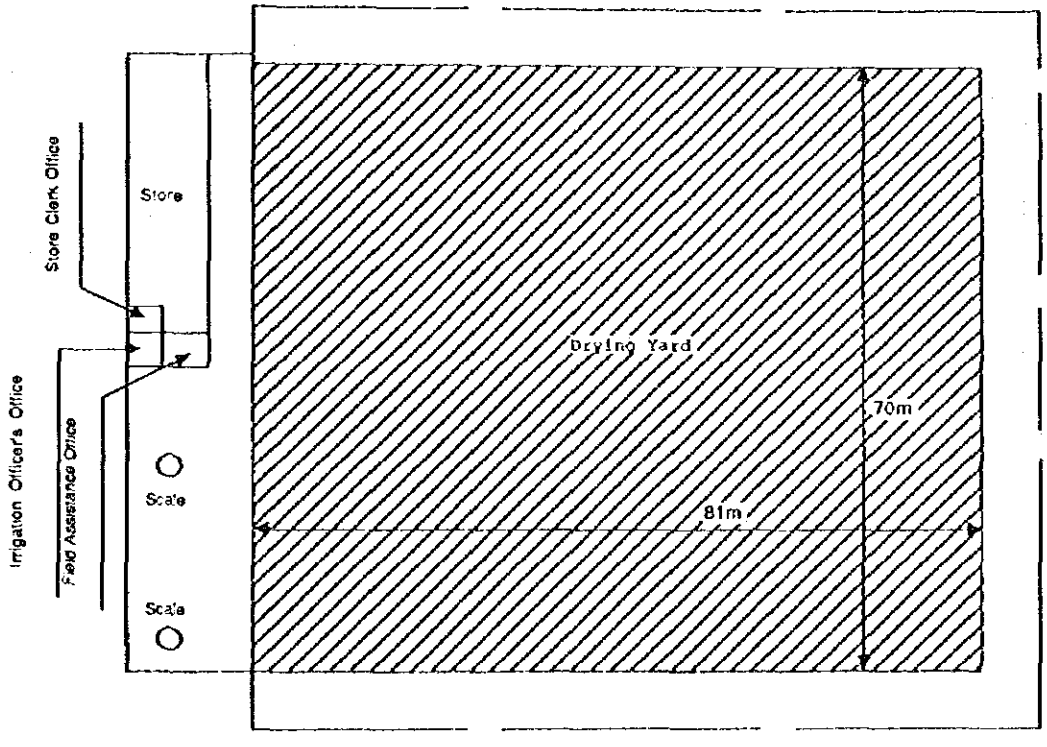


Fig. VII-7 GENERAL LAYOUT OF RECEPTION CENTRE(1/3)

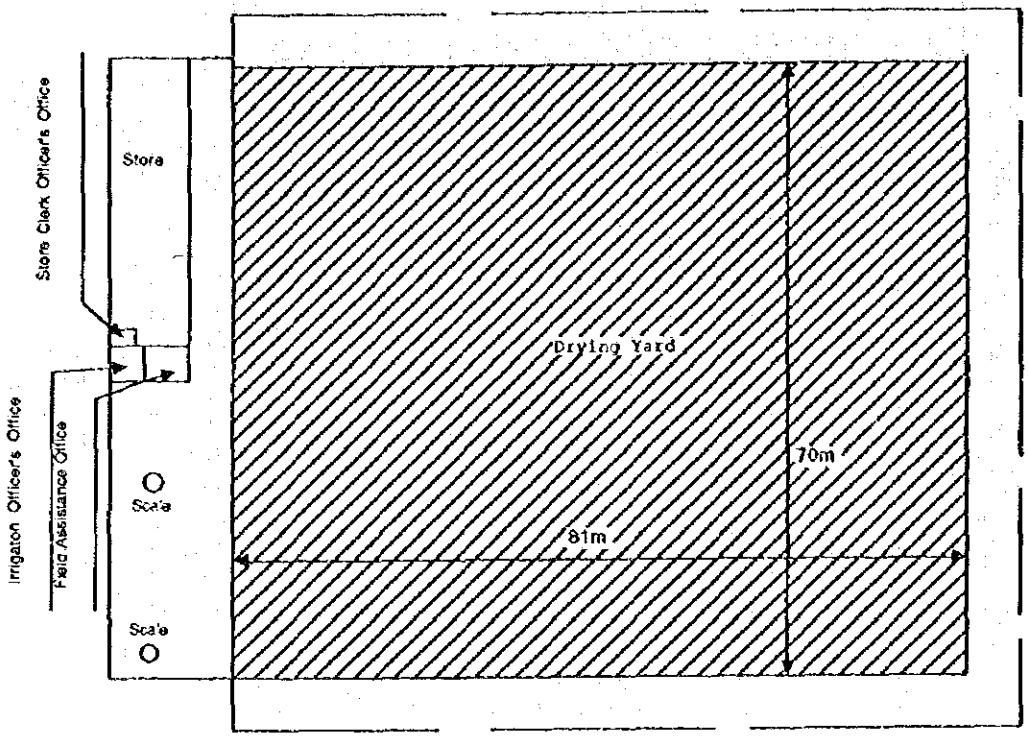


THIBA RECEPTION CENTRE



WAMUMU RECEPTION CENTRE

Fig. VII-7 GENERAL LAYOUT OF RECEPTION CENTRE(2/3)



KARABA RECEPTION CENTRE

Fig. VII-7 GENERAL LAYOUT OF RECEPTION CENTRE(3/3)

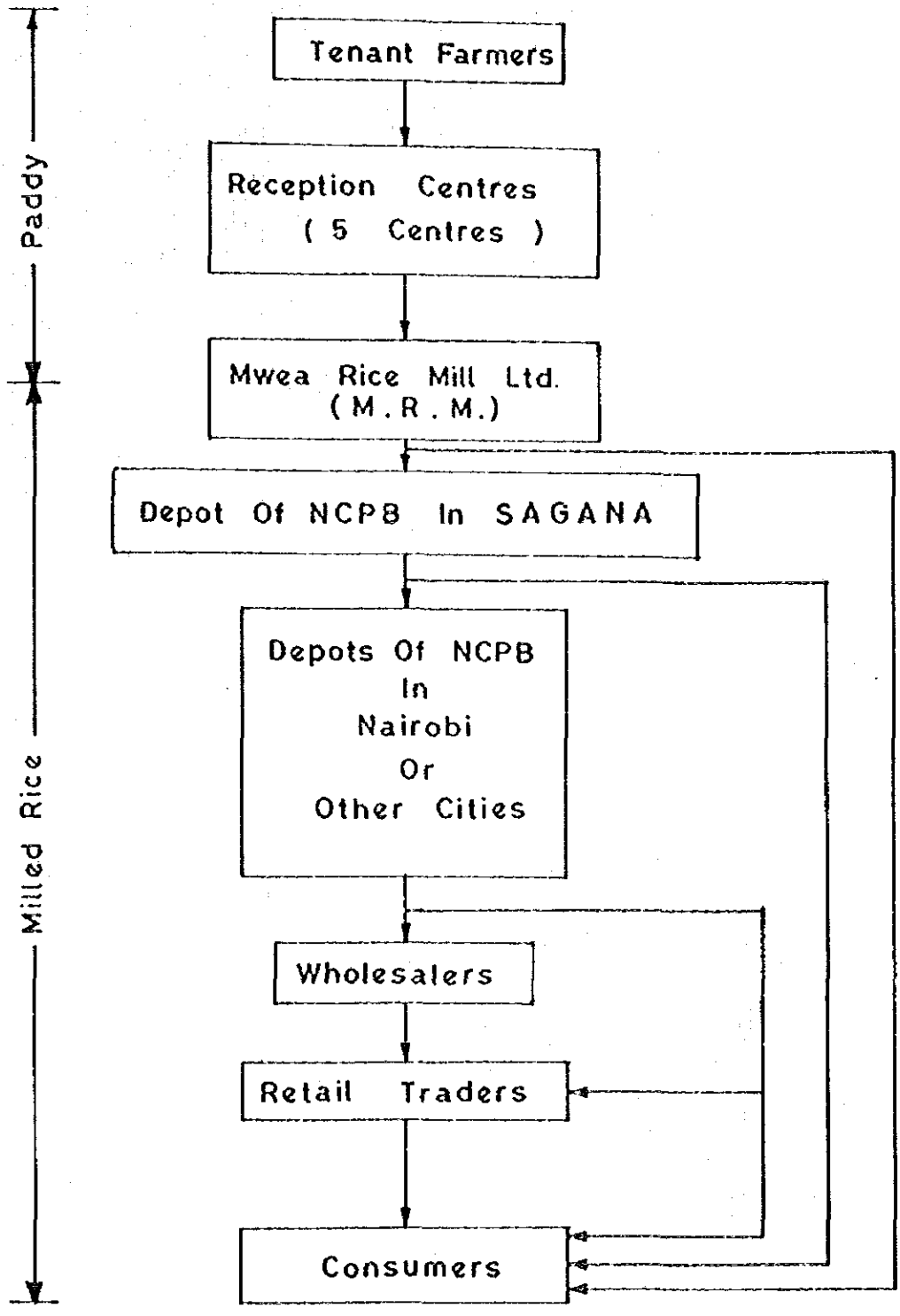
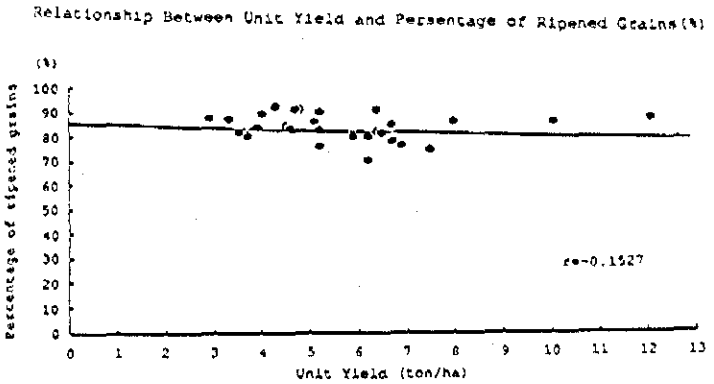
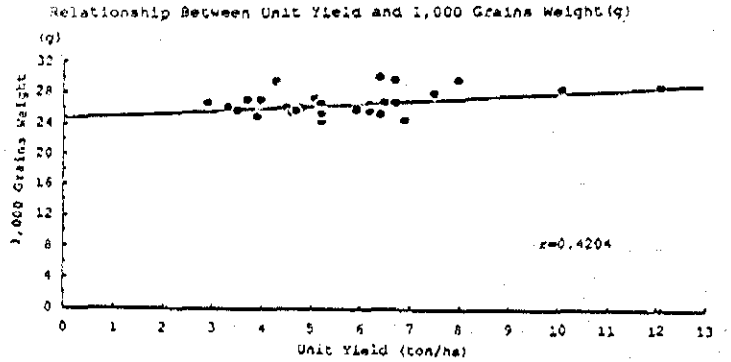
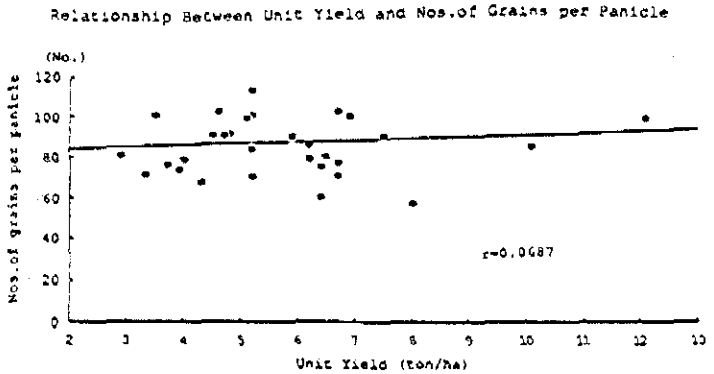
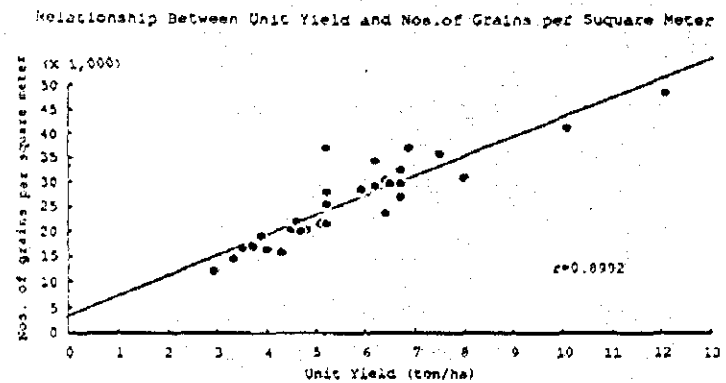


Fig. VII-8 MARKETING FLOW OF PADDY









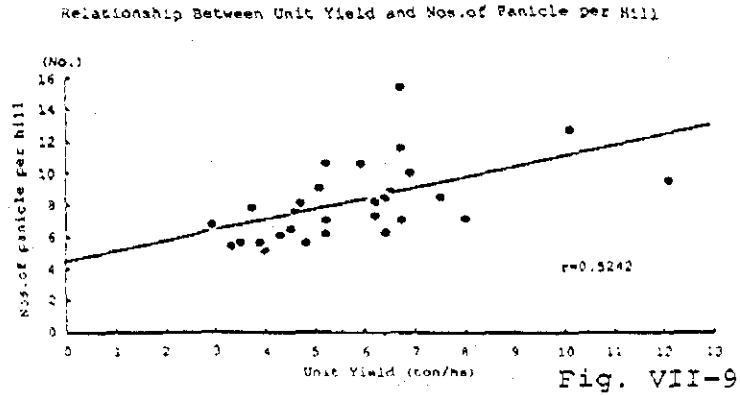
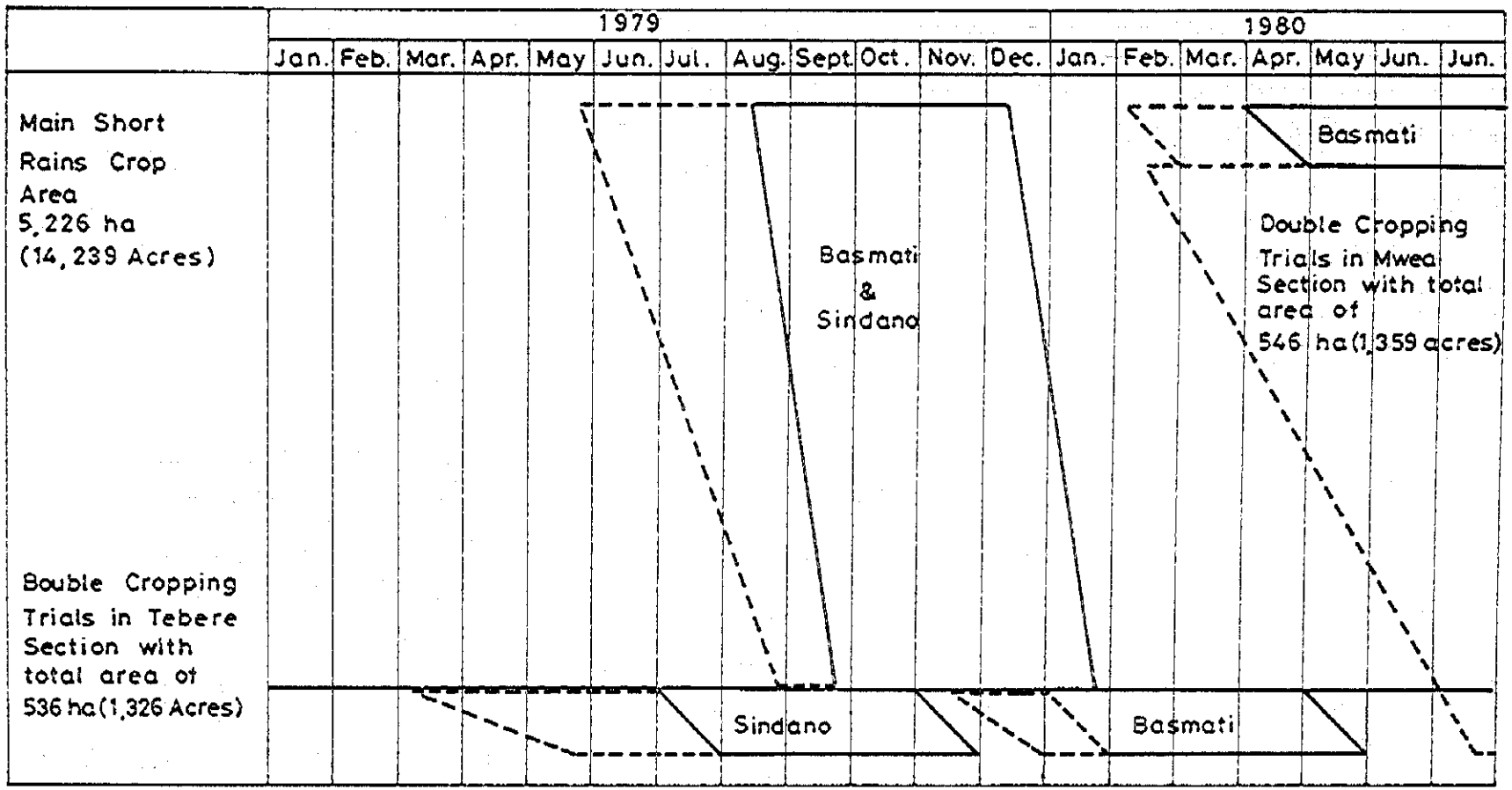
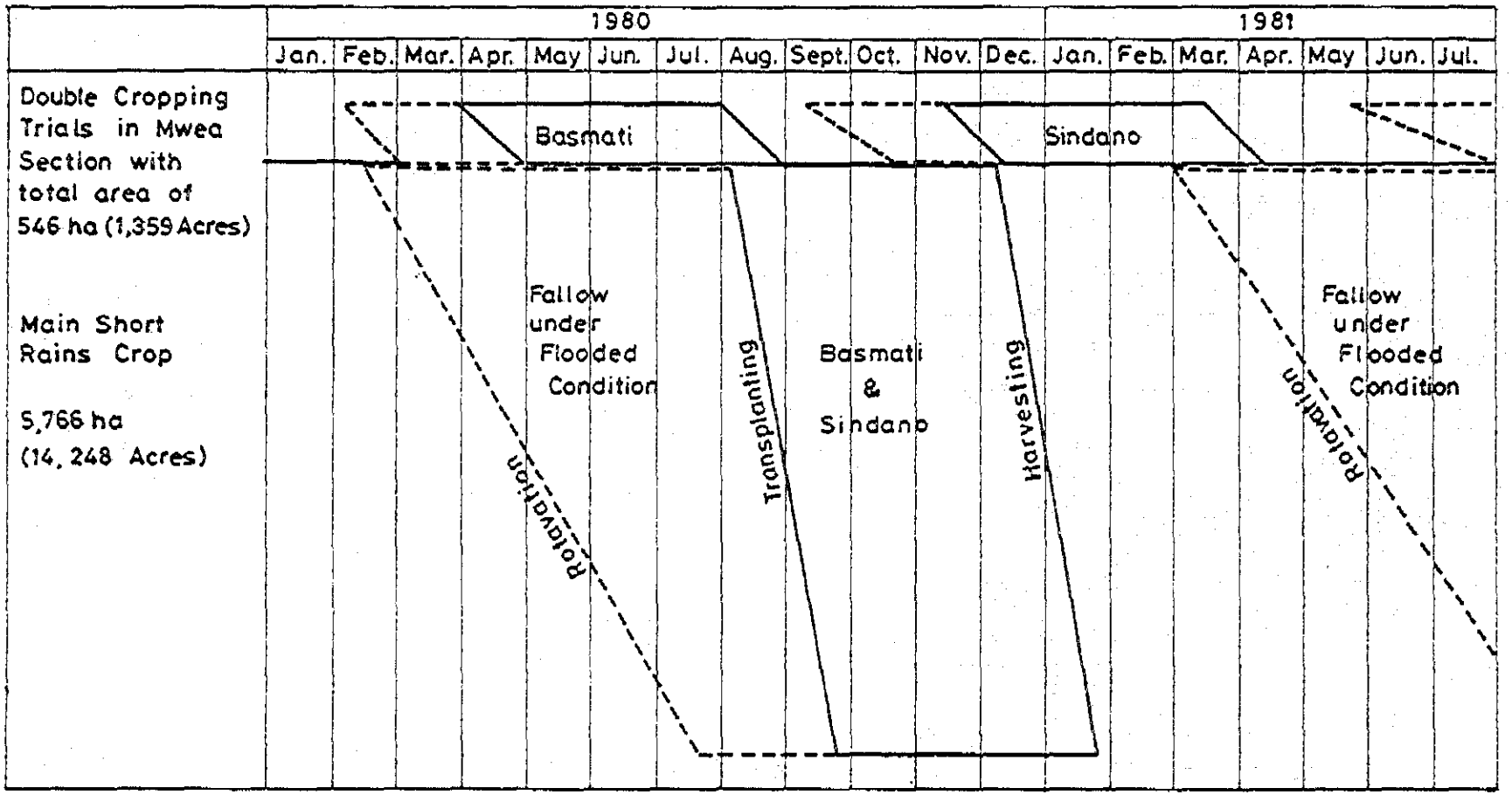


Fig. VII-9 RELATIONSHIP BETWEEN UNIT YIELD & YIELD COMPOMENTS



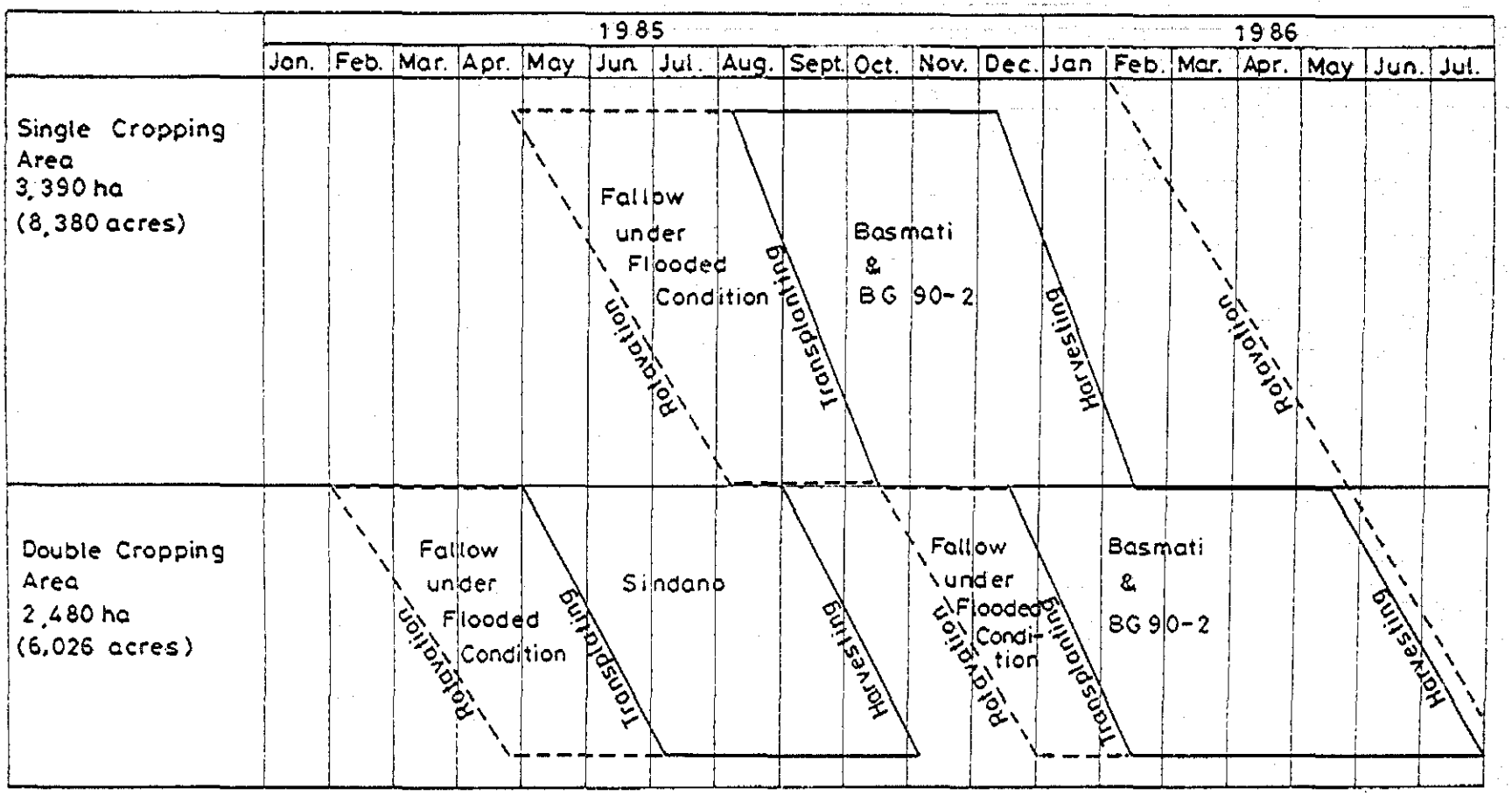
Source : Prepared by JICA Study Team on the basis of NIB Mwea Irrigation Settlement Annual Report 1979/80 and unpublished data from NIB

Fig. VII-10 CROPPING PATTERN IN 1979/80



Source : Prepared by JICA Study Team on the basis of NIB Mwea Irrigation Settlement Annual Report 1980/81 and unpublished data from NIB.

Fig. VII-11 CROPPING PATTERN IN 1980/81



Cropping Intensity : (3,390 ha + (2,480 ha. x 2) /5,850 ha) /1.5 Years (18 months)
= (8,350 ha /5,830 ha) /1.5 Years ≒ 1.0

Source : N.I.B. Mwea Irrigation Settlement Annual Report 1985/86

Fig. VII - 12 CROPPING PATTERN IN 1985/86

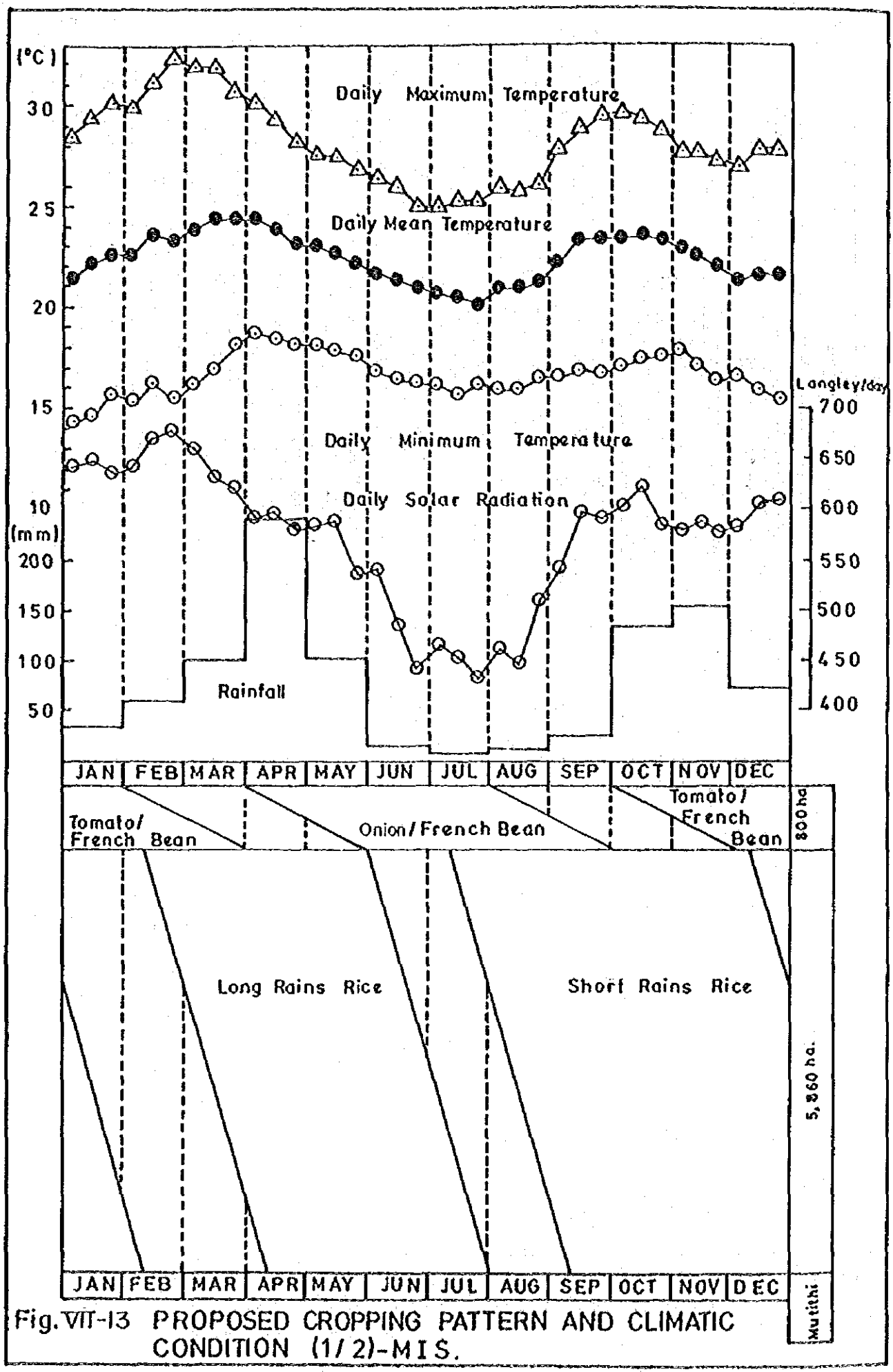


Fig. VII-13 PROPOSED CROPPING PATTERN AND CLIMATIC CONDITION (1/2)-MIS.

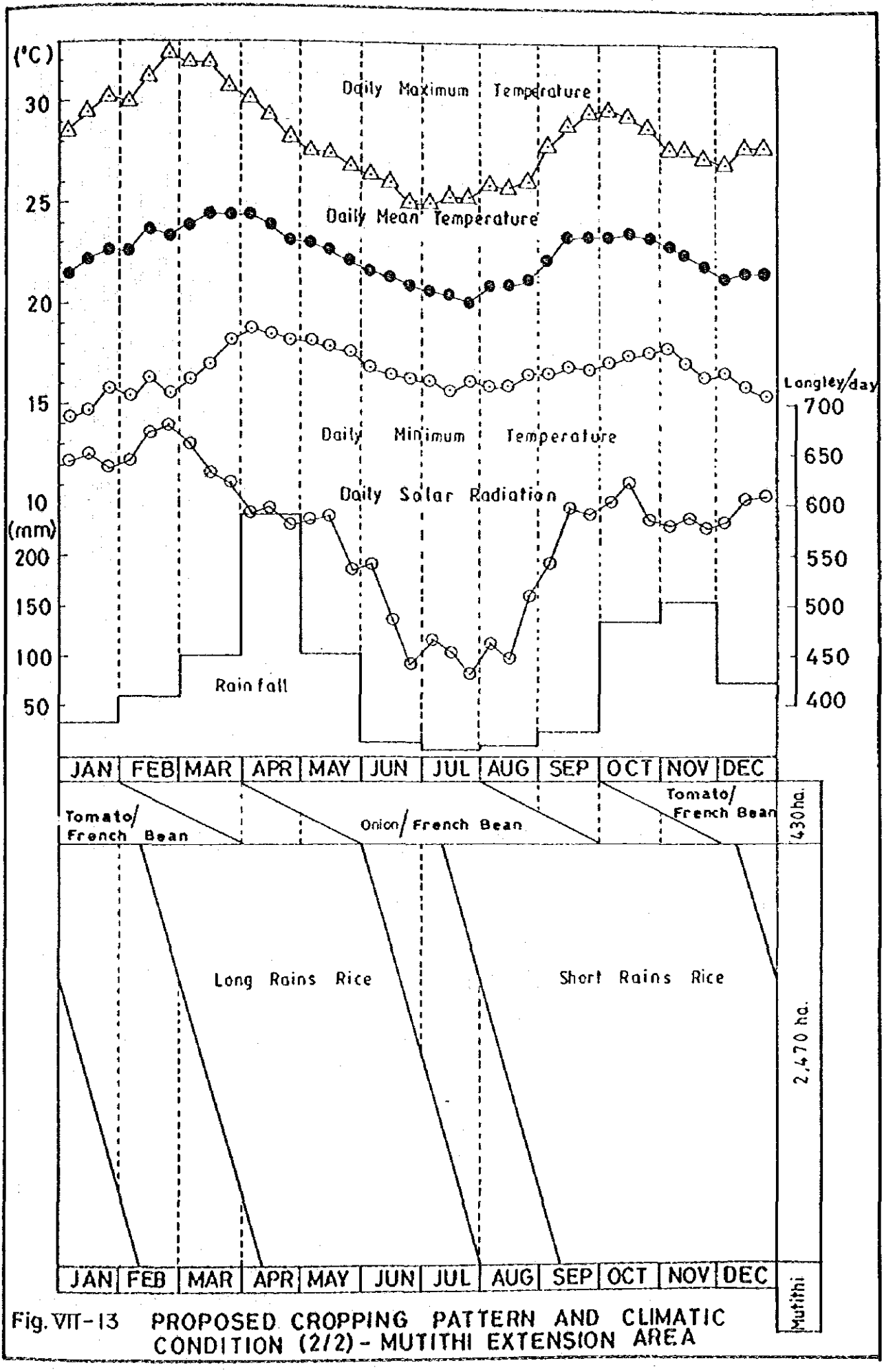
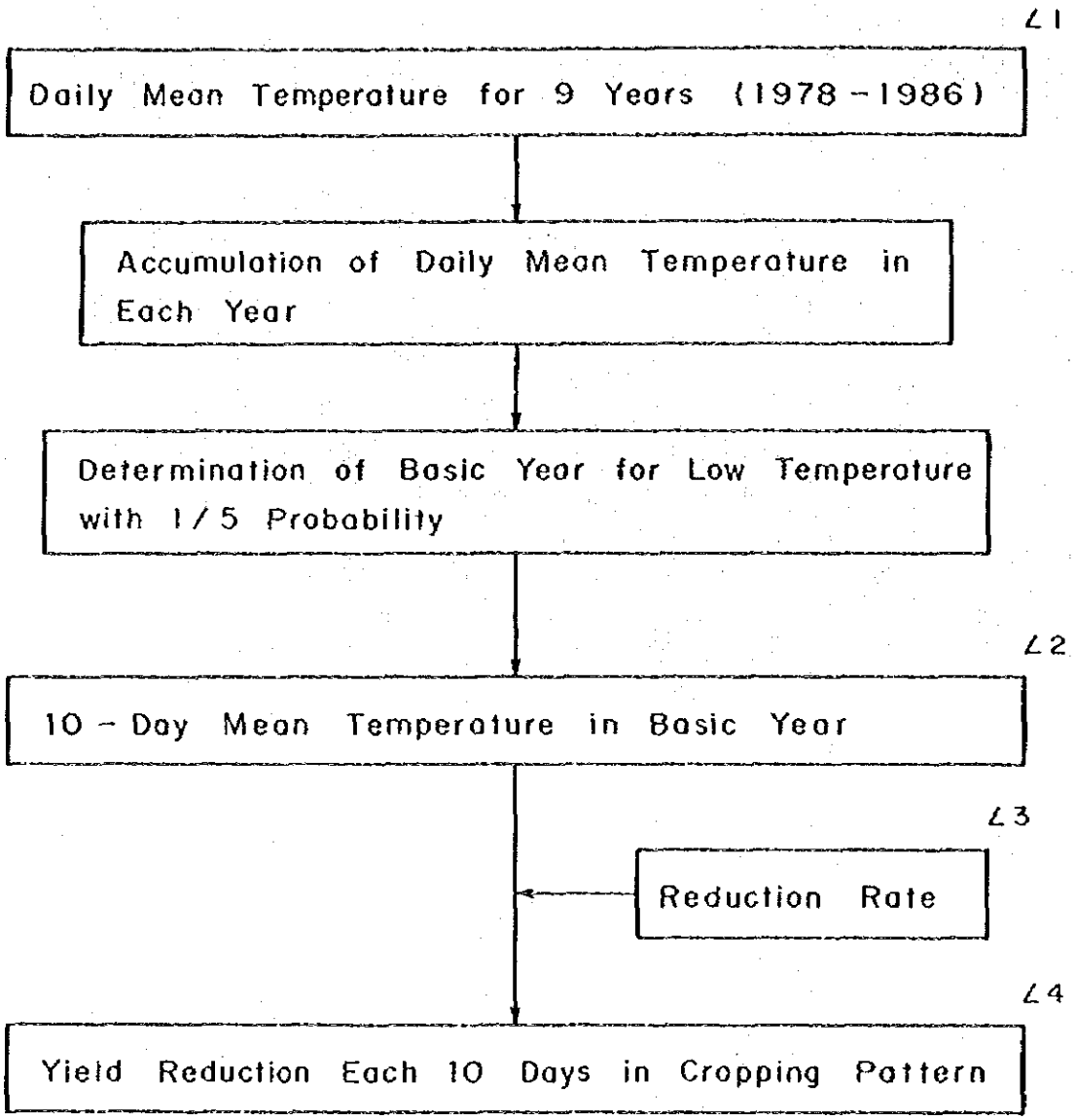


Fig. VII-13 PROPOSED CROPPING PATTERN AND CLIMATIC CONDITION (2/2) - MUTITHI EXTENSION AREA



Remarks)

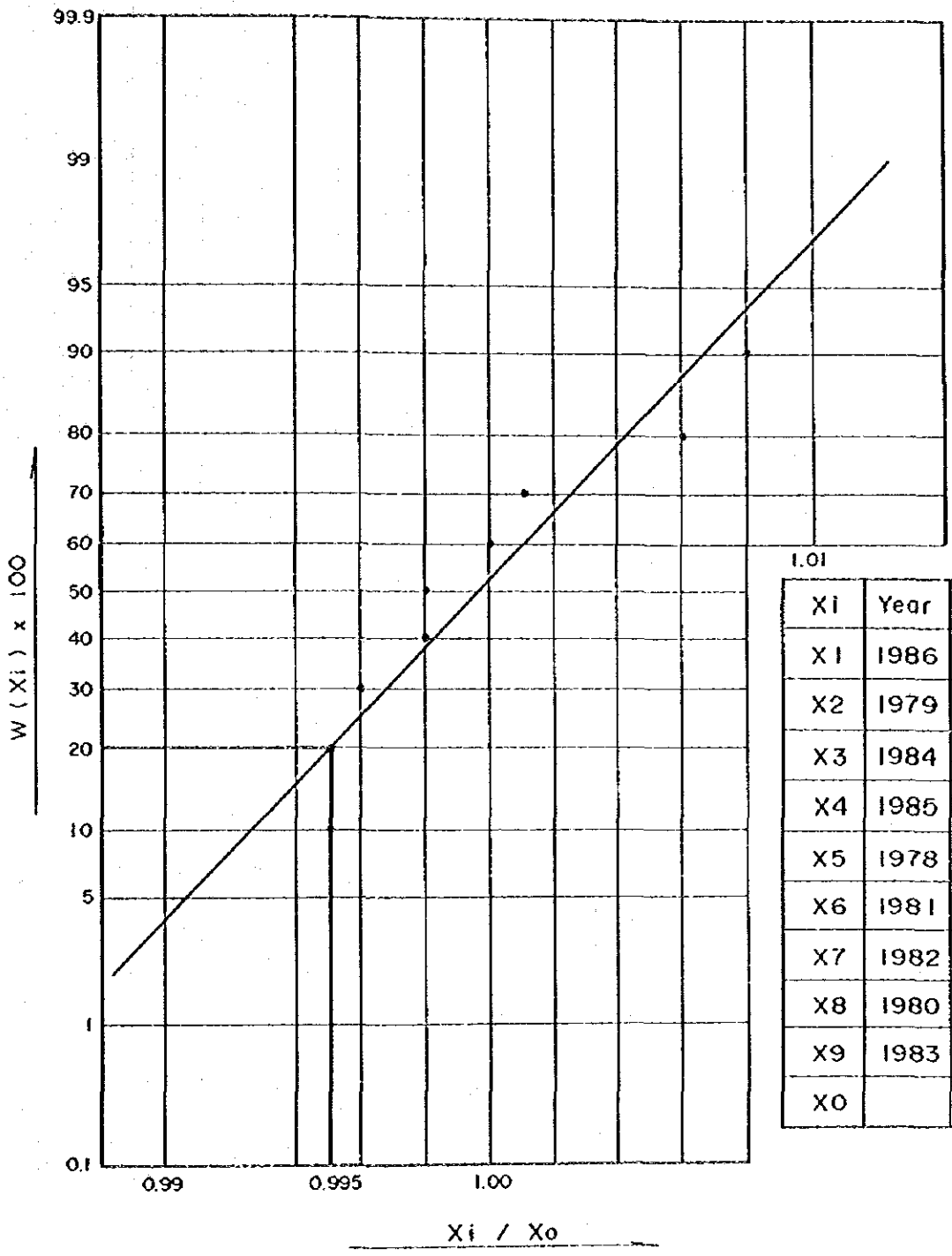
∠1 : Data from the Embu - Meteorological Station

∠2 : See Table 4.4.3

∠3 : Referred the guideline for estimation of yield reduction against low temperature as shown in Fig. 4.4.4

∠4 : See Fig. 4.4.5 and 4.4.6

Fig. VII-14 STUDY FLOM ON YIELD REDUCTION CAUSED BY LOW TEMPERATURE



Xi	Year	Temp
X1	1986	29831
X2	1979	29833
X3	1984	29849
X4	1985	29894
X5	1978	29898
X6	1981	29980
X7	1982	30007
X8	1980	30138
X9	1983	30283
X0		29968

Fig. VII-15 PROBABLE ACCUMULATION TEMPERATURE

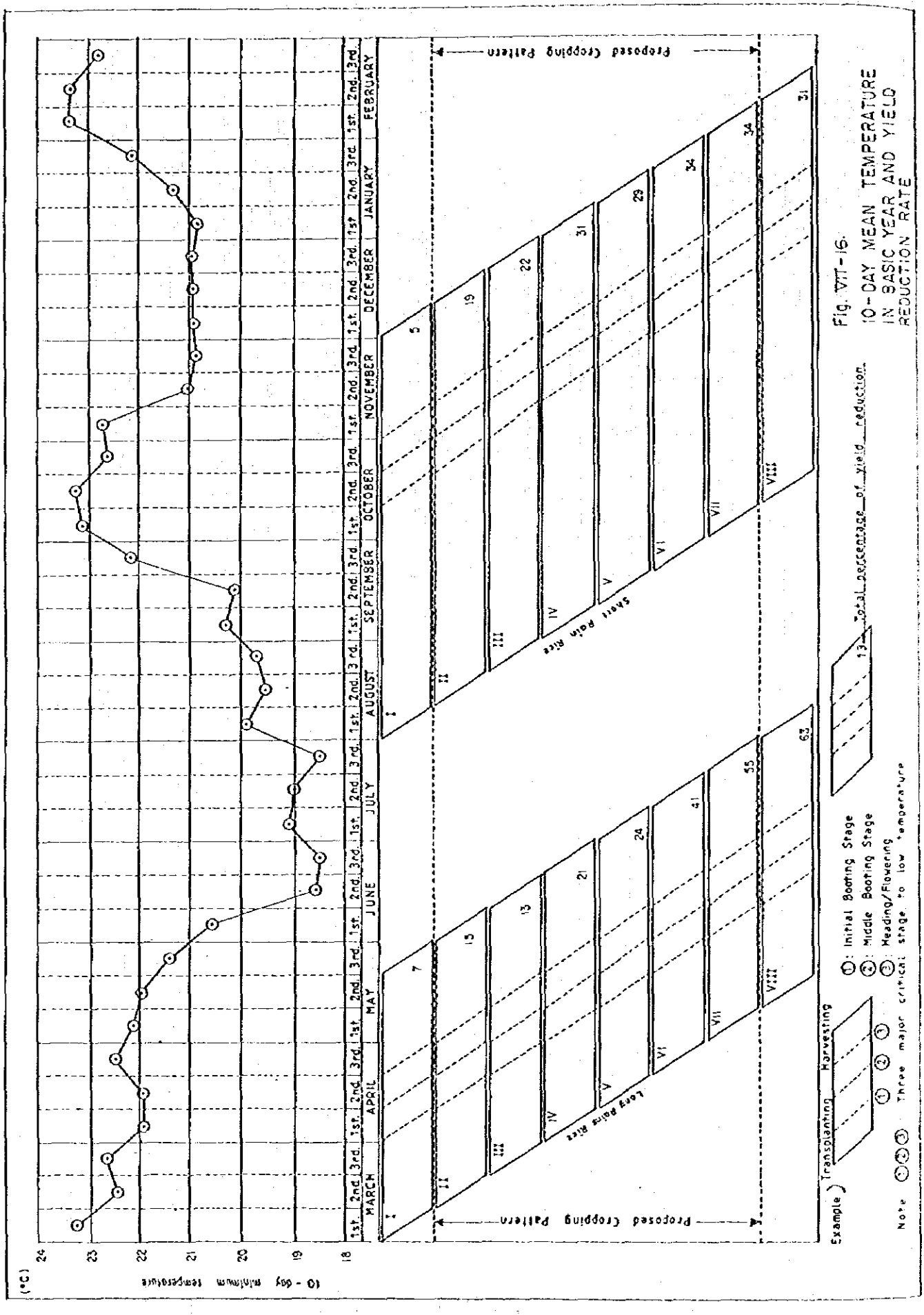
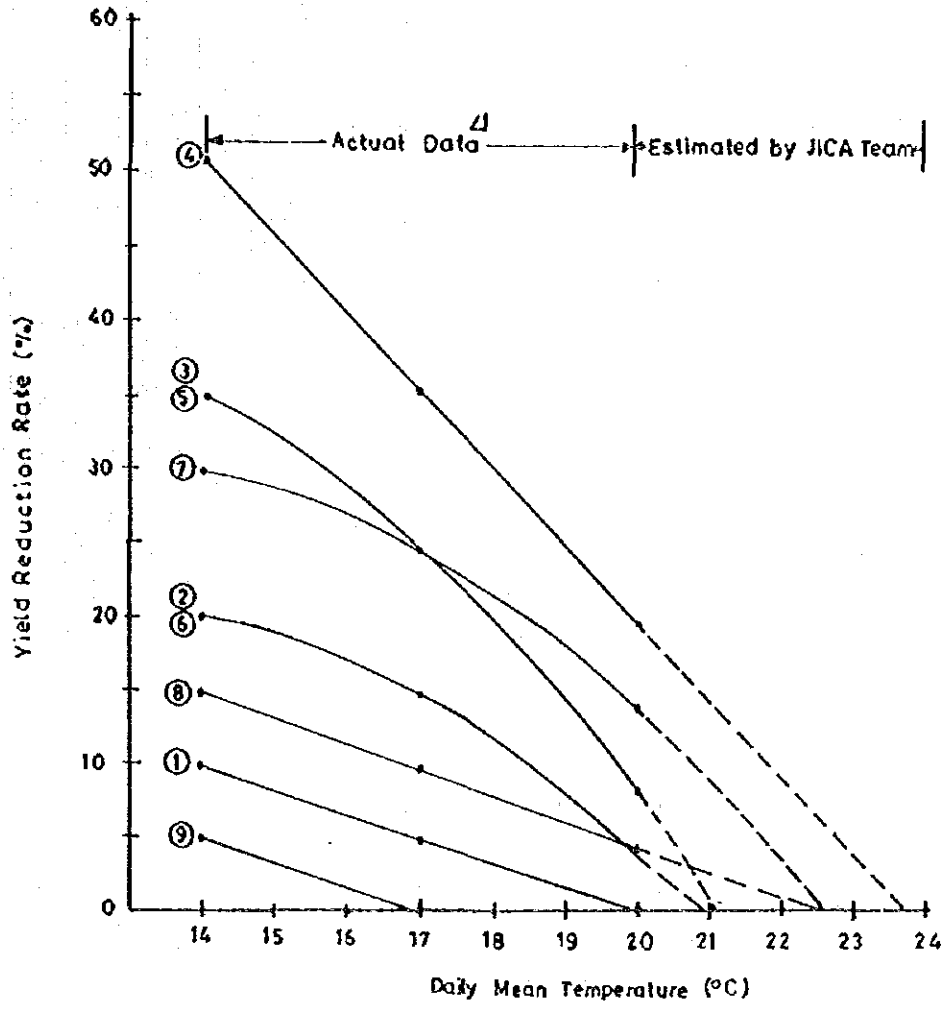


Fig. VII-16.
10-DAY MEAN TEMPERATURE
IN BASIC YEAR AND YIELD
REDUCTION RATE

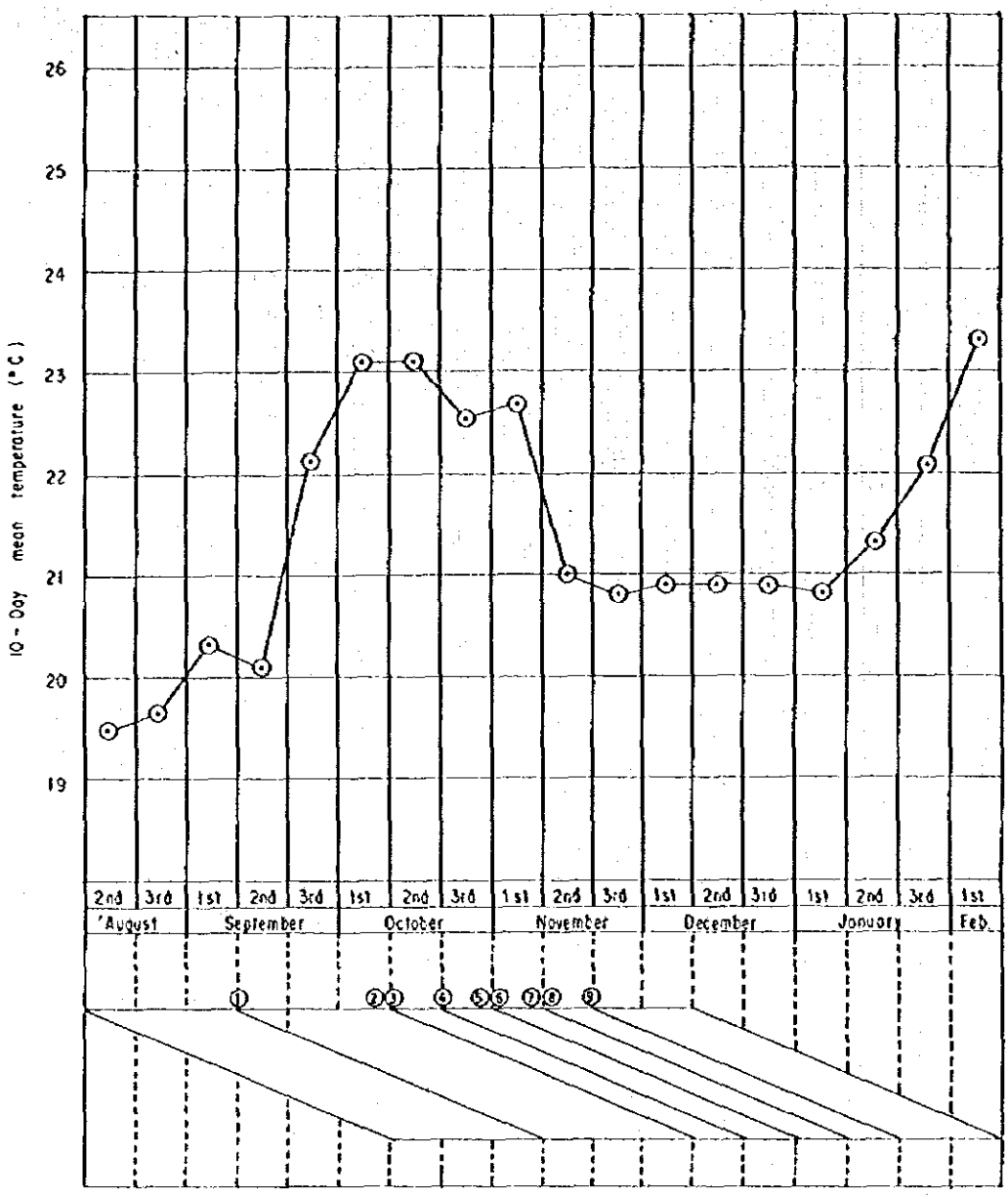


REMARKS:

① Tillering Stage
② Initial Panicle Formation Stage (30~25 days before heading)
③ Middle Panicle Formation Stage (25~15 days before heading)
④ Initial Booting Stage (15~10 days before heading)
⑤ Middle Booting Stage (10~5 days before heading)
⑥ Late Booting Stage (5~0 days before heading)
⑦ Heading / Flowering
⑧ Initial Ripening Stage (5~10 days after heading)
⑨ Middle Ripening Stage (10~25 days after heading)

Δ1: Data from guideline for estimation of yield reduction against low temperature, Japanese Ministry of Agriculture, Forestry and Fishery.

Fig. VII-17 YIELD REDUCTION AND LOW TEMPERATURE



Yield Reduction Rate Z1 (%)

																Average(%)
① Tillering stage	0	0	0	0	0	0										0
② Initial Panicle Formation stage				0	0	0	0	2	1							1
③ Middle Panicle Formation stage				0	0	0	3	4	4							2
④ Initial Booting Stage					7	6	15	15	15	15						12
⑤ Middle Booting Stage						0	3	4	4	4	4					3
⑥ Date Bootinge						0	0	2	1	1	1					1
⑦ Heading / Flowering							10	11	11	11	11	11				11
⑧ Initial Ripening Stage							3	4	3	3	3	4				3
⑨ Middle Ripening Stage								0	0	0	0	0	0			0
Yield Reduction Rate per ha through cropping pattern																29

(Note) Z1 : Yield reduction rate in each 10 days of cropping period

Z2 : Average yield reduction rate in each growing stage for 60 days of cropping period

Fig. VII-18 10 - DAY MEAN TEMPERATURE IN BASIC YEAR AND YIELD REDUCTION RATE ON SHORT RAINS RICE UNDER PROPOSED CROPPING PATTERN