(9) post-harvest process and marketing of the farm produce.

The proposed organization set-up of the O&M office is shown in Fig. 7.2.1. The proposed O&M office will consist of a head office and 8 branch offices. The office will have two divisions; administrative division and technical division. The administrative division will have four (4) departments such as personnel, procurement and store keeping, account, and marketing. The technical division will have three (3) departments; namely, production, operation and maintenance, and machinery and equipment.

The branch offices will take responsibility for day-to-day operations in their responsible areas under the instructions given by the head office. The branch offices will be established at the Thiba dam and seven (7) reception centers including two new centers in the Mutithi area.

7.2.2 Water management

The success of irrigation project depends fully upon the proper water management which assures the distribution of the irrigation water in a timely and efficient manner as to meet the crop water requirements.

The MIS Scheme is however facing to the following constraints and problems in water management:

(1) shortage of irrigation water and deterioration of the existing irrigation and drainage facilities,

(2) insufficient budget,

(3) insufficient number of qualified staff for proper operation and maintenance of the facilities,

(4) lack of operation rule for irrigation facilities,

(5) lack of water user's associations for effective water management at on-farm level and poor cooperation between farmers and MIS staff in charge of water management,

(6) insufficient number of O&M equipment for repair and maintenance of the infrastructural facilities, and

(7) lack of efficient communication system such as telephone, wireless system and walkie-talkie.

The proposed water management system mentioned in Section 5.2 of Chapter V is conceived particularly from the engineering point of view, with a view to solving these constraints and problems. The proposed system, furthermore, will have to be supported from institutional aspects.

The water management for the Project will broadly divided into two (2) aspects; one is the operation and maintenance of the major irrigation facilities including the Thiba dam, headworks and link canals and headraces, and the other is the water management in the irrigation service areas.

The proposed Project will intake the irrigation water from different sources; namely, the Nyamindi, Thiba and Ruamuthambi rivers and all these water sources will be fully utilized by diversion in combination with the operation of the Thiba dam. Integrated water intake control will be indispensable for overall water management. For this, a branch office will be newly required at the Thiba dam which is linked by telephone with the head office where precise instructions for gate operation will be given.

The head office will also be linked with other branch offices at the reception centers where rainfall gauges will be equipped. The instruction for gate operations will be prepared at the head office through calculation by computer on the basis of the reports on the river discharges and rainfall from the branch offices.

In the irrigation areas, supply of the right amount of irrigation water at the right time will have to be ensured. Accordingly, it is important for the farmers to keep the planting time schedule beforehand, because the delay in planting time will give the great influence on the irrigation schedule. Therefore, close communication and coordination between sections in charge of irrigation and farm operations will be indispensable for proper water management.

The major irrigation facilities such as the Thiba dam, headworks, link canals and headraces, main and secondary canals, and farm roads will be put under the control of the head office. The water management of on-farm facilities in each Irrigation Unit will be under the responsibility of the farmers. For effective water management at the Unit level, the farmers will be allowed to organize the water user's associations.

The proposed institutional set-up for water management is shown in Figure on page 95 in Section 5.2 of Chapter V.

7.3 Farmers Cooperatives

At present, NIB provides the tenant farmers obligatorily with all necessary support services such as irrigation water supplies, rotavation (land preparation), rice research, extension services, credit and farm input supplies.

The relationship between NIB and the tenants seems to be somewhat outdated, in relation to the modern development policy of the Kenyan Government towards the rural areas and it gives also little motivation to the development of independent and competent farmers. Although the tenants rarely are being dismissed, still the general fear for this seems to exist and the farmers do not consider the paddy fields as their land, with negative consequences for the operation and maintenance.

Although in the MIS Scheme area some cooperatives exist, most of the farming activities are executed by NIB at a high cost and high managerial requirement. It might be beneficial to NIB as well as the tenant farmers to look into the present regulations on the act of NIB and the cooperatives.

The present system could be gradually transferred to a system in which the farmers cooperatives would take part in decision-making and execution of farming activities, while NIB gets the role of an extension organization and/or responsible body for operation and maintenance of the Project facilities. The payment for the NIB services could be made by the farmers at cost basis, while the paddy-price to the farmers could be set in relation with their payments as well as the cost of inputs and reasonable profits.

As mentioned in Section 2.6 of Chapter II, most of the NIB Schemes are facing to the financial problems mainly due to higher production costs and lower productivity under the present system resulting in unfavourable imbalance in Scheme account.

Considering all these, it is recommended that NIB scrutinize, in close coordination with other agencies, the future institutional arrangement required for successful achievement of the development objectives. In particular, attention should be given to the future relationship between NIB

and the farmers' cooperatives. The farmers' involvement in collective farming operations as well as water management at the Unit level might be required for improvement of the current financial problems.

CHAPTER VIII PROJECT EVALUATION

8.1 General

The preliminary economic evaluations were carried out for six (6) alternative development options as a part of the Project optimization process discussed in Chapter IV. The height of the Thiba dam has been fixed at 35.0 m, corresponding to a reservoir capacity of 18 MCM, as the optimum size of the dam which also made optimum use of the available water resources.

The results from the initial evaluations which revealed several economically feasible options, led to selection of the proposed development for an area of 9,560 ha, enabling a cropping intensity of 200%. The development area comprises 6,660 ha of the existing MIS Scheme area and 2,900 ha of the Mutithi extension area. In this Chapter, overall Project evaluation is discussed in detail for this selected particular case.

The Project evaluation has been made through an assessment of Project feasibility in view of economic, financial and socio-economic aspects. The economic feasibility is evaluated by calculating the internal rate of return (IRR) and the net present value (NPV) at the discount rate of 10%. Sensitivity analyses have also been made in order to elucidate the economic viability of the Project against the changes in the benefits, build-up period, construction periods and the Project costs.

Financial evaluation has been carried out by analyzing the effect of the Project on a typical farm holding 1.6 ha of rice field and also by preparing the repayment schedule for the anticipated loan.

The socio-economic impacts from the implementation of the Project have also been briefly studied.

8.2 Economic Evaluation

8.2.1 Basic assumptions

The economic evaluation has been made on the following basic assumptions:

(1) The construction period will be eight (8) years including the period of detailed design and preparatory works.

(2) The economic useful life of the Project will be 50 years after implementation.

(3) All prices are expressed in constant mid-1987 prices.

(4) The exchange rate of US$1.00 = KShs.16.5 = ¥150 as of mid-1987 is used throughout.

(5) Only irrigation benefits are counted in the economic evaluation, and any benefits to be derived from the fishery, hydropower generation, water release for downstream areas, etc., are not taken into account.

8.2.2 Evaluation of economic factors

For evaluation of economic prices and costs, the following criteria have been used:

(1) Standard conversion factor (SCF)

In order to evaluate the Project costs and benefits with respect to world market prices, a SCF of 0.86 has been applied to the prices of non-traded goods and services. This figure is calculated on the basis of the export and import statistics for the years 1982 -1986 given in the "Annual Trade Yearbook" published by the Custom & Excise Department of the Custom House.

(2) Transfer payment

From the viewpoint of the international economy, the transfer payments such as contract tax, duty, subsidy and interest are considered as a domestic monetary movement without direct production. These transfer payments are, therefore, excluded from the Project costs as far as the economic analysis is concerned.

(3) Economic prices for agricultural outputs and inputs

The economic prices of farm products such as paddy and vegetables and of farm inputs such as fertilizers and agro-chemicals have been estimated on the basis of the projected international market prices forecasted for the year of 1995 by

IBRD in the long term range in 1987 constant US dollar. The domestic components are adjusted by SCF of 0.86.

(4) Economic opportunity cost of farm labour

At present, most of the farm labour requirement are generally met by family labour. Seasonal labourers required for transplanting and harvesting are mainly hired from neighours at the rate of KShs.20 per man-day. In the MIS Scheme area, there is an abundant labour supply compared with its requirement. The estimated labour force in the MIS Scheme area is 10,938 adult-man equivalent. The present labour requirement for farm operations is, on the other, estimated to be 7,766 adult-man equivalent in total, which corresponds to about 70% of the total available labour force. Family labour is therefore shadow-priced at 70% of the present common labour rate as the surplus labour is considered underemployed. The adjusted conversion factor for family labour is therefore taken as 0.611 (0.71 x SCF), being wage rate of KShs.12.2/man-day.

(5) Economic opportunity cost of common construction labour

During the rainy season, which is the period of peak demand for farm labour, the construction activities would slow down and labour would be less required. During the dry season, the Project would require more construction labour and such non-farm employment would be an attractive alternative for most of the local labourers because of scarce farm work. This suggests that the economic opportunity cost of the construction labour may correspond to that of the hired farm labour.

The observations of the construction works in the vicinity of the Project area shows, however, local labourers require at least a 50% premium to be attracted to the construction work since it is harder than farming works. This has been reflected in the financial wage rate that is an average of KShs.50/man-day, but should not in determination of the corresponding economic opportunity cost. The economic opportunity cost of the common construction labour may be assumed to equal that of the hired farm labour of KShs.20/man-day. Related to the average financial wage rate of KShs.50/man-day, it would give a conversion factor of (20/50) x SCF = 0.344.

(6) Construction conversion factor (CCF)

The individual financial costs for major Project components are split into four (4) categories of transfer payment, construction labour, non-traded costs and traded cost, for each

of which an economic/financial conversion factor is applied. The construction conversion factor (CCF) that is the weighted average of the above component, is calculated as 0.84 for the dam and 0.80 for the irrigation works, as shown in Table 8.2.1.

8.2.3 Economic benefits

The irrigation benefits are primarily derived from the increased crop production attributable to a stable irrigation water supplies. These benefits are estimated as the difference of the annual net crop production values under with and without Project conditions.

The net crop production value is defined as the difference between the gross production value and crop production cost. The net production values under future with and without Project conditions are summarized as follows (for details, see Section 5.1):

(Unit: KShs. million)

Description	Without Project	With Project	Increment
1. Gross production value			
(a) MIS	83.5	325.8	242.3
(b) Mutithi	1.7	144.2	142.5
(c) Total	85.2	470.0	384.8
2. Total production cost			
(a) MIS	29.0	79.7	50.7
(b) Mutithi	1.0	35.5	34.5
(c) Total	30.0	115.2	85.2
3. Net production value			
(a) MIS	54.5	246.1	191.6
(b) Mutithi	0.7	108.7	108.0
(c) Total	55.2	354.8	299.6

It is assumed that the irrigation benefit will initially accrue from up-grading of the existing MIS Scheme in 5th year by 50% of the incremental benefits under single cropping and it will increase up to 100% of the benefit in 10th year. After completion of the dam construction, the incremental benefits will accrue from double cropping. The double cropping benefits will gradually increase during the build-up period of 6 years after completion of the dam from 50% in 7th year to 100% in 12th year, as shown in Table 8.2.2.

8.2.4 Economic cost

(1) Capital cost

The Project cost broadly comprises (1) cost for preparatory works, (2) construction cost for Project facilities including contractor's overhead, profits and contract tax, (3) cost for land acquisition, compensation and resettlement, (4) administrative expenses, (5) procurement cost of agricultural machinery and O/M equipment, (6) expenses for engineering services, (7) physical contingencies and (8) price contingencies. All these costs are estimated on a financial basis as given in Table 6.6.1.

The financial costs are converted into the economic costs by applying the CCF for each of major components (see Table 8.2.1):

(Unit: KShs.x10^6)

	Components	Total	Foreign Currency	Local Currency
(1)	Dam & Reservoir	331.9	235.0	96.9
(2)	Irrigation Works	305.3	175.3	130.0
(3)	Farm Machinery	81.2	73.8	7.4
(4)	O&M Equipment	65.6	56.8	8.8
(5)	Farm Building	26.9	13.7	13.2
(6)	Land Acquisition	1.9	-	1.9
(7)	Administration	24.4	-	24.4
(8)	Engineering Services	81.1	48.6	32.5
(9)	Physical Contingencies	91.8	60.2	31.6
(10)	Price Contingencies	217.0	95.3	121.7
	Total	1,227.1	758.7	468.4

(2) Annual operation and maintenance costs

The annual O&M costs estimated in Section 6.6 of Chapter VI include the depreciation cost of O&M equipment and gates. In the economic evaluation, however, the depreciation is taken as the replacement cost. The depreciation cost of agricultural machinery estimated in the crop production costs is also taken as the replacement cost in the economic evaluation. The O&M cost after exclusion of the said depreciation cost is then converted into the economic cost using the respective CCF for each item:

(Unit: KShs.x10^5)

Cost Components	Financial Cost	CCF	Economic Cost
(1) Salaries & Wages	14.0	0.67	9.4
(2) Office Expenses	0.4	0.77	0.3
(3) O&M for Project Facilities			
(a) Dam and reservoir	2.5	0.84	2.1
(b) Irrigation works	19.5	0.80	15.6
Total	36.4		27.4

(3) Replacement cost

The replacement costs estimated in in Section 6.6 of Chapter VI comprise (1) O&M equipment in every 10 years, (2) agricultural machinery in every 5 years , (3) farm buildings in every 20 years and (4) gates and attachments in every 25 years after Project implementation. These costs are converted into the economic cost applying a CCF of 0.99 for imported goods and SCF of 0.86 for farm buildings.

(Unit: KShs.x10^6)

Description	Useful Life (year)	Financial Cost	CCF	Economic Cost
(1) Agricultural machinery	5	81.2	0.99	80.4
(2) O & M equipment	10	65.6	0.99	64.9
(3) Farm buildings	20	26.9	0.86	23.1
(4) Gates & others	25	27.2	0.86	23.3

8.2.5 Internal rate of return (IRR)

The economic rate of return is calculated on the basis of the flows of economic benefits and costs mentioned above (see Table 8.2.3). The calculated result is:

IRR = 18.4%

8.2.6 Net present value (NPV)

The net present value at the discount rate of 10% is also calculated on the same assumptions mentioned above:

NPV = KShs.682 million

8.2.7 Sensitivity analysis

In order to evaluate the soundness of the Project against the possible changes in future economic conditions, sensitivity analysis is made for the following cases:

Case-1: 10% Project cost increase due to unforeseen geological and topographical conditions and unexpected increase of material cost

Case-2: 10% Project benefit decrease due to unexpected decrease in forecasted price of farm product and crop yield

Case-3: Two year overrun of the build-up period due to unexpected inefficiency in O&M management and agricultural extension services

Case-4: Two year overrun of construction period due to unexpected and unforeseen reasons

The effects of these changes in IRR and NPV (discount rate: 10%) are summarized as shown below:

Case	IRR (%)	NPV (KShs. million)
Case-1	17.0	598
Case-2	16.8	530
Case-3	17.6	626
Case-4	16.8	530

8.2.8 Result of economic evaluation

From the above results, the Project could be justified economically with IRR of 18.4% and NPV of KShs.682 million at the discount rate of 10%. The sensitivity analysis indicates that the economic feasibility of the Project is rather insensitive to the possible changes.

8.3 Financial Analysis

8.3.1 Financial cost

The financial cost estimated on the basis of the current prices as of mid 1987, is as follows:

(Unit:KShs.x10^6)

Foreign Currency	Local Currency	Total
758.7	468.4	1,227.1

In this estimate, the price contingencies of 7% per annum for local currency portion and 3% for foreign currency portion are included.

8.3.2 Farm budget analysis and payment capacity

In order to evaluate the Project from the farmer's viewpoint, the farm budget analyses are made under future with and without the Project conditions as described in Section 5.1 of Chapter V.

The payment capacity is recognized as the ability of the Project-benefited farmers to bear the expenses required for operation and maintenance of the Project facilities as well as for repayment of capital cost. The payment capacity is defined to be the difference of net disposable reserves under future with and without the Project conditions, which the farmers can actually earn from the Project after all the farm expenses and living costs are deducted from the gross farm income.

The payment capacity under the Project at the full operation stage is estimated as follows:

(Unit: KShs.)

Description	Farm Size (ha)	Disposable Reserve		Payment Capacity	
		With Project	Without Project	Per Farmer	Per ha
(1) MIS	1.8	47,600	2,800	44,800	24,900
(2) Mutithi	3.2	76,200	500	75,700	23,700

The increased net disposable reserve would offer the better living conditions and welfare to the farmers and also the incentives for farm re-investment and further development, and the substantial payment capacity would make the farmers to make some payment for irrigation water.

8.3.3 Anticipated project revenue

The irrigation water charges which should cover the annual O&M expenses for the Project facilities and a part of the capital cost, would be collected from the Project-benefited farmers. The amount of irrigation water charge should be decided by the Government of Kenya, considering the payment capacity of the farmers and annual costs for operation and maintenance as well as the repayment for the capital cost. It should be noted that the payment capacity of the farmers would largely depend upon the prices of rice which is politically determined by the Government. The payment capacity of the farmers mentioned above is estimated on the basis of the present prices as of mid 1987.

8.3.4 Repayment of project cost

It is assumed that the initial investment required for the Project implementation will be arranged under the following conditions:

(1) For foreign currency portion, the capital is financed by bilateral or international organization with an interest of 3.0% per annum for a repayment period of 30 years including 10 year grace period.

(2) For local currency portion, the capital is arranged by the Government budget allocation with no repayment.

Based on the above conditions, the repayment schedule for the foreign currency portion is prepared as shown in Table 8.3.1.

8.3.5 Result of financial evaluation

The Project will bring about a great improvement in farm budget, and give an incentives for further improvement of the irrigated land to the farmers. The farmers who will receive a large economic return, will spend their increased income for various purposes and the economic activities will thereby enhanced. Increased tax revenue will also be expected from such

future economic circumstances. The Project could be justified from the farmer's viewpoint.

During the repayment period of 30 years for foreign loan, the annual average amount of the Government budget requirement for covering the loan repayment, loan interest, replacement cost and O&M costs is about KShs.98.1 million. This amount corresponds to KShs.10,300 per ha per annum, or about 40% of the above-mentioned payment capacity per ha per annum. Most of the budget requirement for loan repayment and O&M expenses would be covered by the expected Project revenue in terms of water charge. The Project could be also justified from the financial viewpoint.

8.4 Socio-Economic Impacts

In addition to the direct benefits counted in the economic evaluation, various secondary and intangible benefits and/or favourable socio-economic impacts are expected from the implementation of the Project. Major socio-economic impacts are described hereunder:

(1) Increase of employment opportunity

Employment opportunity to the local people will be increased by the implementation of the Project, and a favourable impacts to the regional economy will be expected through the increased monetary movement. The employee will gain more experience, technical know-how, skillfulness in various working fields. These accumulations of working techniques would be applied to the future development in the region.

Irrigation will improve the present low land productivity and increase crop production in the Project area. The increased crop production will accelerate further development of agro-industries and marketing activities in the surrounding areas. It will also increase the employment opportunity.

(2) Foreign exchange saving

After completion of the Project, significant increase in rice production is expected. The marketable production would be about 100,000 tons of paddy. The increased production would largely reduce the import of rice and consequently contribute to the foreign exchange saving equivalent to around KShs.404 million per annum.

(3) Demonstration effects

The Mwea Irrigation Development Project has been given a leading role of pioneering the rice irrigation projects in Kenya. The successful implementation of the Project certainly leads to easier realization of other projects because of technical knowledge and skills to be accumulated through the Project implementation. With the completion of the Project, the farmers in the potential areas for irrigation development, as well as those in the Project area, will become familiar with double cropping of rice under modern irrigation practices and their incentives for irrigation practices will be much enhanced. In the succeeding projects, therefore, the build-up period will be possibly shortened.

(4) Increase of land value

The economic value of the land will surely increase with the Project implementation, particularly in the Mutithi extension area. It means that the value of land assets as a mortgage will become higher and the land owners will have the larger monetary power when they will expand their business. It will also accelerate the economic activities in the region. During a certain period after completion of the Project, land transactions in the Project area will have to be controlled by the Government in order to achieve the social justice in the present system of land transactions.

(5) Improvement of local transportation

The local transportation will be much improved by the construction of the operation and maintenance roads along the irrigation canals as well as the link canals and headrace. The expanded road system will not only enhance the economic activities but also contribute to inter-regional accessibility and communication.

(6) Mitigation of flood damages

The downstream area in the Thiba part is sometimes flooded in the rainy season. Although the proposed plan does not include the flood control in its purpose, operation of the reservoir will have incidental effects on flood control through reduction in flood frequency and peak discharge.

(7) Improvement of farm product

The quality of rice will be much improved through sufficient irrigation water supplies which enable the crop damages to minimize and assure the full and uniform maturing of rice. Such improved quality would increase the marketability of the product.

(8) Improvement of rural water supplies

The rehabilitation of the existing canal system will improve the situation of water shortage through year-round supply of the fresh water in sufficient quantity from the irrigation canals. New construction of irrigation canals in the Mutithi area will provide the farmers with easy access to domestic water.

(9) Potential uses of the reservoir

After creation of the reservoir, the fish production will become possible. It will provide the local people with new business opportunity. The rapid increase of rural population around the Project area will cause a significant increase in the use of reservoir for recreational purposes like fishing and boating. Provision should be made to obtain the maximum recreational benefits from the completed reservoir.

CHAPTER IX RECOMMENDATIONS

(1) Early Implementation of the Project

The Mwea Irrigation Development Project is verified herewith to be technically sound, and economically and financially feasible. It is highly recommended that the necessary arrangement for early implementation of the Project be taken as soon as possible.

The performance in the existing MIS Scheme has now begun to deteriorate with decreasing production level. The situation is likely to get worse with disastrous consequences unless corrective measures are urgently taken. With such pressing needs for rehabilitation works, the Project is rather urgently required.

(2) Establishment of Pilot Farm

Following the Government food policy, the Project is formulated under the basic concept that the Area be doubled cropped per year. The introduction of double cropping has necessitated the establishment of a pilot farm in the Project area to make demonstration and trials possible before implementation.

(3) Stagewise Implementation of the Project

It is recommended that the Project be implemented in two stage of:

Phase-I : Establishment of a Pilot Farm (50 ha) and Rehabilitation of existing MIS Scheme (6,660 ha), and

Phase-II : Dam construction and development of Mutithi extension area (2,900 ha),

because Phase-I should be urgently required for improvement of the decreasing rice production level in MIS; on the other, Phase-II would require, before its implementation, a lot of preparatory works such as environmental study for dam construction, compensation for prospective reservoir area and land tenure problem in the Mutithi area.

The Project components to be implemented under Phase-I and Phase-II would be as follows:

Phase-I: Establishment of a Pilot Farm (50 ha) and Rehabilitation of existing MIS Scheme (6,660 ha)

(1) Establishment of a Pilot farm (50 ha) and operation running-in,

(2) Construction of a link canal system from new Nyamindi headworks to the existing Thiba headworks,

(3) Rehabilitation of the existing irrigation and drainage system covering 5,860 ha as well as land reclamation and construction of a new irrigation and drainage system for uncultivated red soils area of 800 ha,

(4) Provision of farm machinery and O&M equipment, and

(5) Improvement of farm buildings and reception centres.

Phase-II: Dam construction and development of Mutithi extension area

(1) Construction of new dam (storage capacity: 18 MCM) at upstream of the Thiba river,

(2) Construction of link canal from the existing Thiba headworks to the Mutithi extension area,

(3) Construction of new headworks on the Ruamuthambi river and headrace therefrom,

(4) Land reclamation and construction of a new irrigation and drainage system covering 2,900 ha,

(5) Provision of farm machinery and O&M equipment for Mutithi area, and

(6) Construction of required farm buildings and reception centres.

It is strongly recommended, considering the pressing needs for rehabilitation of the existing MIS, that at least Phase-I of the Project be implemented as early as possible and also that necessary actions be taken for preparatory works required for continuous implementation of Phase-II.

(4) Further Study on Resettlement and Rural Community Development in the Mutithi Extension Area

The Mutithi extension area is remoted from the public services and infrastructures such as electricity and domestic supplies, roads and agricultural institutions and facilities. Villages are not well developed, particularly in the black cotton soils area, no single village is observed. Such present condition implies that irrigation development of the Area will require not only irrigation/drainage facilities but also other ancillary facilities which will help the farmers (land holders) to settle in the Area. These may include electricity and rural water supplies, health facilities for sanitary protection, and educational facilities.

In order to realize the Project smoothly, such rural community development will be required. The studies on these facilities are, however, not included in the "Scope of Work for the Feasibility Study". These will have to be made, in close coordination with other agencies concerned, during the detailed design stage of the Project.

(5) Environmental Study for Dam Construction

Dam construction coupled with irrigation development is generally considered influential in altering the environmental resources. Environmental study is, therefore, required before implementation will take place. Such study generally comprises manifold items of environmental impacts evaluation on physical resources, ecological resources, human use values, and quality of life values as mentioned in Section 5.3 of Chapter V. In particular, the compensation problem for prospective reservoir area covering about 140 ha will have to be urgently solved.

The impacts on environmental resources and compensation problem will have to be carefully studied during the stage of detailed design of the Project.

(6) Improvement of Rice Mill

The total annual processing capacity of the Mwea Rice Mill is around 30,000 tons under normal operation. It could be increased up to about 60,000 tons in 2-shift operation. However, it would not meet, even under 2-shift operation, the future rice production of about 100,000 tons. It is therefore

recommended that an additional rice mill be installed in future when the existing Mwea Rice Mill will have the difficulties to process the paddy harvested in the Project area.

(7) Encouragement of Cooperative Movement

At present, NIB provides the tenant farmers obligatorily with all necessary services. The relationship between NIB and the tenants seems to be somewhat outdated, in relation to recent government policy towards development of rural areas which intends to bring up the independent and competent farmers. The present system seems to give little motivation to development of such farmers, with negative consequences for the operation and maintenance.

The present system could be gradually transferred to a system in which the farmers cooperatives would take part in decision-making and execution of farming activities, while NIB gets the role of an extension organization and/or responsible body for operation and maintenance of the Project facilities.

As mentioned in Section 2.6 of Chapter II, most of the NIB Schemes are facing to the financial problems mainly due to higher production costs and lower productivity under the present system resulting in unfavourable imbalance in Scheme account. Such situation seems to be partly attributable to the present regulations that forces NIB to execute almost all activities for the tenants at a high cost and high managerial requirement.

Considering all these, it is recommended that NIB scrutinize, in close coordination with other agencies concerned, the future institutional arrangement required for successful achievement of the development objectives. In particular, attention should be paid to the future relationship between NIB and the farmers' cooperatives.

(8) Increase in Paddy Price

Higher rate of increase in farm input costs compared to the government price increase for paddy has worsen the profitability of rice cultivation. This tendency is clearly observed in Fig.3.9.5 in which yearly changes in income level are shown for the period from 1976/77 to 1985/86. The net income of the Mwea rice farmer at 1977 constant price has dropped from about KShs.9,600 to KShs.2,600 on an average during the said period.

The average net income in 1985/86 corresponds to only 30% of that in 1976/77. The drastic decrease in net farm income seems to affect the farmers' motivation to improve their rice production and might reflect the present situation that rice production is declining in the existing MIS.

It is desired that the NIB service charges be paid by the farmers at cost basis, while the paddy-price to the farmers be set in relation to their payments as well as the costs of inputs and reasonable profits.

(9) Technical assistance

It is recommended that the technical assistance be considered during the period of initial stage of the Project for (1) initial operation of the pilot farm and (2) introduction of the new water management system.

The proposed pilot farm will have the following objectives:

(1) selection of rice varieties suitable for long rains crop and demonstration of double cropping to the farmers,

(2) field trials on farm machinery and equipment,

(3) field trials and demonstration of irrigated horticultural crops on the red soils,

(4) field trials on irrigation practices and water management at on-farm level both for rice and horticultural crops, and

(5) seed multiplication

The technical assistance in the field of rice breeding and farm machinery will enable NIB to operate the pilot farm smoothly and effectively.

After completion of Phase-I of the Project, the Nyamindi river will be connected with the Thiba river through construction of new Nyamindi headworks and Link canal-I, and the Thiba part of MIS will benefit by the increased irrigation water from the Nyamindi river. Under such conditions, systematic operations of the irrigation facilities will be indispensable

for ensuring the expected benefits. Technical assistance for introduction of the new water management system is therefore needed.

The experts required for the technical assistance will be as follows:

(a) Rice breeder
(b) Water management specialist
(c) Mechanical engineer

The experts will be based at the project site and carry out their duties in conjunction with the Kenya counterpart staff. During the period of the technical assistance programme both local and overseas training for the Kenyan project staff will be required.

TABLES

Table 2.1.1 Population and Population Growth Rate (1969-2000)

	Population					Population Growth Rate (%)		
	1969	1979	1986	1989	2000	1969 - 1979	1979 - 1989	1989 - 2000
KENYA 1. Declining Fertility Declining Mortality	10,942,705	15,327,061	21,021,253	23,513,198	34,792,475	3.4	3.2	3.6
2. Constant Fertility Declining Mortality	10,942,705	15,327,061	21,211,976	24,008,756	38,409,072	3.4	4.6	4.4
3. Constant Fertility Constant Mortality	10,942,705	15,327,061	21,163,249	23,882,549	37,504,536	3.4	4.5	4.2
Central Province	1,675,647	2,345,833	3,160,342	3,550,270	(5,582,211) *	3.4	4.2	4.2
Kirinyaga District	216,998	291,421	386,800	431,722	(664,616)*	3.0	4.0	4.0
Mwea Division	58,262	81,054	(101,736)*	(112,144)*	(160,281)*	3.3	3.3	3.3

Sources (1) Kenya Population Census, 1969, Ministry of Finance and Economic Planning
(2) Kenya Population Census, 1979, Ministry of Finance and Economic Planning
(3) Population Projections for KENYA 1980 - 2000, Central Bureau of Statistics

Note : * Estimated by JICA Study Team because of no data available

Table 2.1.2 Population Census 1979

Province	District	Population	Land Area (km^2)	Density
NAIROBI:	-	827,775	684	1,210
CENTRAL:	Kiambu	606,290	2,448	280
	Kirinyaga	291,431	1,437	202
	Muranga	648,333	2,476	261
	Nyandarua	233,302	3,528	66
	Nyeri	486,477	3,284	148
	Sub-Total/Ave.	2,345,833	13,173	178
EASTERN	Embu	263,173	2,714	96
	Isiolo	43,478	25,605	1
	Kitui	464,283	29,388	15
	Machakos	1,022,522	14,178	72
	Marsabit	96,216	73,952	1
	Meru	830,179	9,922	83
	Sub-Total/Ave.	2,719,851	155,759	17
COAST:	Kilifi	430,986	12,414	34
	Kwale	288,363	8,257	34
	Lamu	42,299	6,506	6
	Mombasa	341,148	210	1,622
	Taita Taveta	147,597	16,959	8
	Tana River	92,410	38,694	2
	Sub-Total/Ave.	1,342,803	83,040	16
NORTH EASTERN:	Garissa	128,867	43,931	2
	Mandera	105,601	26,470	3
	Wajir	139,319	56,501	2
	Sub-Total/Ave.	373,787	126,902	2
NYANZA:	Kisii	869,512	2,196	395
	Kisumu	482,327	2,093	230
	Siaya	474,516	2,522	188
	South Nyanza	817,601	5,714	143
	Sub-Total/Ave.	2,643,956	12,525	211
RIFT VALLEY:	Baringo	203,792	9,885	20
	Elegeyo Markwet	148,868	2,279	65
	Kajiado	149,005	19,605	7
	Kericho	633,348	3,931	161
	Laikipia	134,534	9,718	13
	Nakuru	522,709	5,769	90
	Nandi	299,319	2,745	109
	Narok	210,306	16,115	13
	Samburu	76,908	17,521	4
	Trans-Nzoia	259,503	2,078	124
	Turkana	142,702	61,768	2
	Uasin Gishu	300,766	3,378	89
	West Pokot	158,652	9,090	1
	Sub-Total/Ave.	3,240,412	163,882	19
WESTERN:	Bungoma	503,935	3,074	163
	Busia	297,841	1,626	183
	Kakamega	1,030,887	3,495	294
	Sub-Total/Ave.	1,832,663	8,195	223
	TOTAL	15,327,080	564,160	27

Source: Statistical Abstract 1986, CBS

Table 2.1.3 Real Growth Rates of GDP

(Unit: % in real terms)

Period/Year	Growth rate		Year	Growth Rate
1964 - 69	Average 5.8)		1980	3.3
1970	6.8)		1981	5.3
71	7.0)		1982	3.4
72	6.8)		1983	4.2
73	4.3)		1984	2.9
74	1.1)	Average 5.1	1985	4.5
75	4.1)			
76	2.4)			
77	8.8)			
78	6.6)			
79	3.3)			

Source: (1) Economic Survey 1980 (1970-79)
(2) Economic Survey 1983 (1980-82)
(3) Economic Survey 1986 (1983-85)
(4) Figure for 1964-69 calculated from the figure for 1964-72 in (2)

Table 2 1.4 Gross Domestic Product (GDP) by Industrial Origin at Current Prices

(Unit: K£ million)

Item	1983	1984	1985	1986	Percentage
A. Traditional Economy	197	227	293	318	6.6
B. Monetary Economy					
Agriculture	1,067	1,122	1,241	1,400	29.0
Manufacturing	415	470	528	587	12.1
Electricity/water	47	52	57	64	1.3
Construction	138	132	162	187	3.9
Trade, etc.	577	659	770	939	19.4
Finance & others	395	443	517	581	12.0
Government	475	522	619	757	15.7
Total	3,114	3,400	3,894	4,515	93.4
C. Total GDP	3,311	3,627	4,187	4,833	100.0
D. GDP per capita (K£)	176.6	186.2	206.9	229.9	-

Source: Economic Survey 1987, CBS

Table 2.1.5 Capital Formation (at Current Prices)

(Unit: K£ million)

Item	1983	1984	1985	1986	Percentage
A. Traditional Economy	66	78	99	108	8.9
B. Monetary Economy					
Agriculture	54	59	76	93	7.7
Manufacturing	117	32	107	174	14.4
Electricity/water	57	37	29	36	3.0
Construction	59	68	46	65	5.4
Trade, etc.	137	175	184	318	26.2
Finance & others	125	135	177	184	15.1
Government	102	153	192	234	19.3
C. Total	717	737	910	1,212	100.0

Note: Agriculture includes forestry and fishing.
Manufacturing includes mining and gunning.
Trade, etc. includes restaurants, hotels, transport, storage and communications.

Source: Economic Survey 1987, CBS

Table 2.1.6 External Trade (1983-1986)

(1) Balance of Trade

(Unit: K£ million)

Item	1983	1984	1985	1986*
1. Export	652	777	811	987
2. Import	906	1,097	1,196	1,338
3. Balance of Trade	-254	-320	-385	-351

(2) Major Export Items

(Unit: K£ million)

Item	1983	1984	1985	1986*	Share (%)
1. Coffee, Unroasted	160.1	203.7	230.7	388.5	40.6
2. Tea	123.4	189.5	191.7	172.8	18.0
3. Petroleum Products	123.8	131.6	116.5	99.0	10.3
4. Cement	21.8	17.5	15.4	13.4	1.4
5. Pinapples, canned	20.9	25.9	24.4	24.2	2.5
6. Beans	13.8	2.5	0.6	6.7	0.7
7. Sisal	12.1	12.6	14.4	10.9	1.1
8. Others	157.2	171.5	191.4	242.5	25.4
Total	633.1	754.8	785.1	958.0	100.0

(3) Major Import Items

(Unit: K£ million)

Item	1983	1984	1985	1986*	Share (%)
1. Crude Petroleum	275.2	292.4	344.1	207.8	15.5
2. Industrial Machinery	137.2	173.6	164.6	236.9	17.7
3. Iron and Steel	48.4	63.0	64.8	64.4	4.8
4. Motor Vehicles	32.3	55.1	63.8	88.0	6.6
5. Fertilizer	25.1	13.9	52.0	50.0	3.7
6. Pharmaceuticals	19.6	20.0	23.3	32.7	2.4
7. Paper and Paper Products	12.0	11.8	9.4	15.7	1.2
8. Others	355.8	467.4	474.0	642.6	48.1
Total	905.6	1,097.2	1,196.0	1,337.9	100.0

Note: * Provisional

Source: Economic Survey 1987, CBS

Table 2.1.7 Balance of Payments

(Unit: K£ million)

Item	1983	1984	1985
A. Total Current Account	-89.0	-146.6	-169.3
a. Visible Trade Balance	-313.3	-373.4	-445.4
b. Invisible Trade Balance	224.3	227.0	276.1
B. Capital Movements	158.6	183.9	86.3
a. Private Long-term	62.0	77.0	79.9
b. Government Long-term	57.3	71.5	9.2
c. Government Corporations	14.7	-1.3	-7.9
d. Short-term	24.6	36.7	5.1
C. Monetary Movements	-70.6	-39.0	86.3
a. Transactions with I.M.F.	63.9	16.6	100.0
b. Other Charges in Assets and Liabilities	-134.5	-55.6	-13.7
D. Errors and Omissions	-1.4	-1.7	-2.9

Source: Economic Survey 1987, CBS

Table 2.1.8 Central Government Revenue

(Unit: K£ million)

Item	1983/84	1984/85	1985/86	1986/87*
A. Direct Taxation	251.8	301.0	358.7	400.0
B. Indirect Taxation				
a. Sales Tax	253.7	273.6	302.2	419.2
b. Import Duties	183.5	165.1	210.4	240.5
c. Excise Duties	79.4	78.8	89.0	100.9
d. Others	44.0	67.5	103.5	134.0
Sub-total	560.6	585.0	705.1	894.6
C. Other Revenue	111.2	133.6	122.6	182.9
Total	923.6	1,019.6	1,186.4	1,477.5

Note: * Provisional
Source: Economic Survey 1987, CBS

Table 2.1.9 Central Government Expenditure

(Unit: K£ million)

Item	1983/84	1984/85	1985/86	1986/87*
A. General Public Administration	161.4	212.7	227.5	341.6
B. Defence	140.0	112.2	127.3	168.4
C. Education	220.1	259.8	332.8	404.5
D. Health	73.3	82.7	92.7	119.3
E. Economic Services				
a. Agriculture	93.8	140.8	147.7	240.0
b. Other Services	220.6	263.4	217.7	285.5
F. Others	345.5	463.1	506.1	574.9
Total	1,254.7	1,534.7	1,651.8	2,134.2

Note: * Provisional
Source: Economic Survey 1987, CBS

Table 2.2.1 Agricultural Population

Year	Population			Economically Active Population		
	Total	Agriculture	Per Cent	Total	Agriculture	Per Cent
1970	11,290	9,577	84.8	4,950	4,199	84.8
1975	13,703	11,362	82.9	5,890	4,883	82.9
1980	16,766	13,582	81.0	7,072	5,729	81.0
1985	20,600	16,242	78.8	8,389	6,614	78.8

Source: Production Year Book 1985, FAO

Table 2.2.2 Land Use

Item	Area (1,000 ha)	Per Cent (%)
Land Area	56,925	100.0
Arable Land	1,850	3.2
Land under Permanent Crops	485	0.9
Land under Permanent Meadows and Pasture	3,750	6.6
Forest and Woodland	3,740	6.6
Other Land	47,100	82.7
Water Area	1,340	-
Total Area	58,265	-

Source: Production Year Book 1985, FAO

Table 2.2.3 Categories of Agricultural Land

(Unit: 1,000 ha)

Province	High Potential	Percent %	Medium Potential	Percent %	Low Potential	Percent %	Total	Percent %	All Other Land	Total Land Area
Coast	373	5.5	796	11.7	5,663	82.8	6,832	100.0	1,472	8,304
North-Eastern	-	-	-	-	12,690	100.0	12,690	100.0	-	12,690
Eastern	503	3.6	2,189	15.5	11,453	80.9	14,145	100.0	1,431	15,576
Central	909	94.2	15	1.6	41	4.2	965	100.0	353	1,318
Nairobi	16	29.6	-	-	38	70.4	54	100.0	14	68
Rife Valley	3,025	19.7	123	0.8	12,220	79.5	15,368	100.0	1,515	16,883
Nyanza	1,218	97.3	34	2.7	-	-	1,252	100.0	-	1,252
Western	741	100.0	-	-	-	-	741	100.0	82	823
Total	6,785	13.0	3,157	6.1	42,105	80.9	52,047	100.0	4,867	56,914

Note: The three categories are defined as follows:

High Potential : Annual Rainfall of 857.5 mm or more
(over 980 mm in Coast Province)

Medium Potential : Annual Rainfall of 735 mm - 857.5 mm
(735 mm - 980 mm coast province and 612.5 mm - 857.5 mm in Eastern Province)

Low Potential : Annual Rainfall of 735 mm or less
(Under 612.5 mm in Eastern Province)

Source: Statistical Abstruct 1986, C.B.S.

Table 2.2.4 Production of Main Crops

Crops		1969-71 Average	1974-76 Average	1979-81 Average	1983	1984	1985
Maize	Area Harvested (1,000 ha)	1,383	1,513	1,273	1,236	1,200	1,400
	Unit Yield (ton/ha)	1.49	1.62	1.35	1.76	1.19	1.89
	Production (1,000 ton)	2,060	2,450	1,714	2,178	1,422	2,650
Weat	Area Harvested (1,000 ha)	133	110	106	120	110	120
	Unit Yield (ton/ha)	1.68	1.61	2.01	2.09	1.31	2.08
	Production (1,000 ton)	223	177	212	251	144	250
Rice/Paddy	Area Harvested (1,000 ha)	6	7	8	9	9	9
	Unit Yield (ton/ha)	4.75	5.32	4.65	4.08	3.49	3.89
	Production (1,000 ton)	27	35	39	36	31	35
Sugar Cane	Area Harvested (1,000 ha)	26	33	38	35	40	39
	Unit Yield (ton/ha)	62.88	63.23	111.69	110.96	105.43	101.54
	Production (1,000 ton)	1,645	2,097	4,211	3,846	4,171	3,960
Coffee Green	Area Harvested (1,000 ha)	85	106	113	137	150	150
	Unit Yield (ton/ha)	0.67	0.68	0.78	0.64	0.74	0.87
	Production (1,000 ton)	57	72	88	87	111	130
Tea	Area Harvested (1,000 ha)	30	49	65	79	80	90
	Unit Yield (ton/ha)	1.25	1.63	1.44	1.51	1.45	1.63
	Production (1,000 ton)	38	57	93	119	116	147
Sisal	Area Harvested (1,000 ha)	52	47	44	39	38	38
	Unit Yield (ton/ha)	0.89	1.16	0.95	1.28	1.35	1.32
	Production (1,000 ton)	46	55	42	50	51	50

Source: Production Year Book 1981, 1984, 1985, FAO

Table . 2.5 Recorded Marketed Production at Current Prices

(Unit: K£ milion)

Item	1982	1983	1984	1985	1986*
Cereals	59.7	81.4	71.4	91.0	107.2
Maize	30.8	49.0	49.1	54.6	66.5
Wheat	22.0	26.9	17.8	26.3	32.9
Others	6.9	5.5	4.5	10.1	7.8
Temporary Industrial Crops	53.9	51.2	58.5	65.9	92.7
Sugar Cane	29.4	34.3	41.0	46.8	52.8
Pyrethrum	14.8	5.0	1.9	2.9	4.5
Others	9.7	11.9	15.6	16.2	35.4
Other Temporary Crops	10.7	12.0	9.5	17.3	27.8
Permanent Crops	232.9	316.6	551.8	459.4	550.8
Coffee	122.9	166.3	227.7	191.9	288.3
Tea	93.2	130.3	301.1	247.6	242.3
Sisal	12.6	15.5	17.3	15.0	15.4
Others	4.2	4.5	5.7	4.9	4.8
Total Crops	357.2	461.2	691.2	633.6	778.5
Livestock & Products	91.7	94.3	97.6	122.3	159.8
Cattle and Calves	52.3	51.8	59.0	70.4	84.3
Daily Products	28.5	32.8	25.8	36.3	56.5
Others	10.9	9.7	12.8	15.6	19.0
Total	448.9	555.5	788.8	755.9	938.3

Note : * Provisional

Source : Economic Survey 1987, CBS

Table 2.2.6 Intensity of Agricultural Land Use by Province

Province	Land Area	Agricultural Land	Land Under Forest	Land Available For Agriculture	Land Cropped	Intensity of Agricultural Land Use (%)
	(1)	(2)	(3)	(4)=(2)-(3)	(5)	(6)=(5)/(4)x100
1. Nairobi	648	-	-	-	-	-
2. Central	13,173	7,727	1,672	6,055	5,636	93.1
3. Eastern	155,760	11,535	1,892	9,643	6,586	68.3
4. Coast	83,040	18,198	1,226	16,972	2,549	15.0
5. North Eastern	126,902	-	-	-	-	-
6. Nyanza	12,526	11,252	191	11,061	5,012	45.3
7. Rift Valley	171,108	31,159	6,150	25,009	5,335	21.3
8. Western	8,223	6,636	428	6,208	3,645	58.7
Total	571,308	86,507	11,559	74,948	28,763	38.4

Source: Sessional Paper No. 4 of 1981, on National Food Policy.

Table 2.2.7 Consumption Projection

Item	Consumption per Capita (kg)	Consumption in 1983/85 (1,000 ton)	Consumption In 1980 (1,000 ton)	Consumption in 1995 (1,000 ton)	Consumption in 2000 (1,000 ton)
Maize	120.0	2,443.8	2,984.6	3,662.6	4,500.6
Wheat Flour	11.5	234.2	286.0	351.0	431.3
Rice	4.0/1	81.5/1	100.1/1	123.8/1	153.6/1
Millet/Sorghum	21.6	439.9	537.2	659.3	810.1
Beans	12.0	244.4	298.5	366.3	450.1
Potatoes	27.4	558.0	681.5	836.3	1,027.6
Sugar	17.9	364.5	445.2	546.3	671.3
Beef	9.0	183.3	223.8	274.7	337.5
Milk	52.4	1,067.1	1,303.3	1,599.4	1,965.3

Note : Consumption = Consumption per Capita x Projected Population
/1 = Estimated Data during the period from 1990-2000 by JICA Study Team

Source : Development Plan 1979-1983.
Population Projection for Kenya 1980-2000, CBS 1983.

Table 2.6.1 Current Features of NIB Scheme Operations

Description	Unit	Mwea	Ahero	West Kano	Bunyala	Perkerra	Tana (Hola)	Total/Ave.
1. Cropped area under irrigation	ha	5,830	1,070	670	210	100	830	8,710
a. Rice	ha	5,830	1,070	450	210	-	-	7,560
b. Sugar cane	ha	-	-	220	-	-	-	220
c. Cotton	ha	-	-	-	-	-	830	830
d. Vegetables	ha	-	-	-	-	100	-	100
2. Nos. of plot holders	Nos.	3,236	519	553	131	342	603	5,384
3. Crop production								
a. Rice	ton	29,200	3,300	2,300	1,300	-	-	36,100
b. Sugar cane	ton	-	-	5,500	-	-	-	5,500
c. Cotton	ton	-	-	-	-	-	1,560	1,560
d. Vegetables	ton	-	-	-	-	1,190	-	1,190
4. Unit yields of crops per ha								
a. Rice	ton/ha	5.0	3.1	5.1	6.1	-	-	4.8
b. Sugar cane	ton/ha	-	-	25.0	-	-	-	25.0
c. Cotton	ton/ha	-	-	-	-	-	1.9	1.9
d. Vegetables	ton/ha	-	-	-	-	11.9	-	11.9
5. Gross values of crops	KShs.1,000	84,270	8,970	7,610	3,490	3,740	6,680	114,760
a. per ha	KShs./ha	14,450	8,380	11,360	16,620	37,400	8,050	13,180
b. per plot holder	KShs./holder	26,040	17,280	13,760	26,640	10,940	11,080	21,320
6. NIB service charge & Other deductions	KShs.1,000	40,320	6,480	3,680	1,630	2,080	4,310	58,500
a. per ha	KShs./ha	6,920	6,060	5,490	7,760	20,800	5,190	6,720
b. per plot holder	KShs./ha	12,460	12,490	6,650	12,440	6,080	7,150	10,870
7. Payment to plot holders (5-6)	KShs.1,000	43,950	3,390	3,390	1,860	1,660	2,370	57,160
a. per ha	KShs./ha	7,530	2,320	5,870	8,860	16,600	2,860	6,460
b. per plot holder	KShs./holder	13,580	4,790	7,110	14,200	4,860	3,930	10,450

Source: NIB Annual Report 1983/84

Table 2.6.2 Income and Expenditure Account for NIB Schemes in the Year 1985/86

(Unit: KShs.1,000)

Description	Head Office	NIB Scheme					
		Mwea	Ahero	West Kano	Bunyala	Perkerra	Tana (Hola)
1. INCOME							
(1) Service Charge	6,227	31,087	4,223	932	760	875	3,082
(2) Government Grant & Others	-	-1,545	-90	-62	27	73	-244
Total	6,227	29,542	4,133	870	787	948	2,838
2. EXPENDITURE							
(1) Staff Cost	6,001	8,397	2,762	3,182	604	1,551	2,562
(2) Office Expenses	3,925	1,219	574	311	137	405	750
(3) O/M Expenses							
a. Buildings & Canals Maintenance	196	1,994	298	114	199	1,374	829
b. Diesel, Petrol & Oil	332	4,847	1,051	1,017	549	957	1,658
c. Repair & Renewal of:							
(i) Plant & Machinery	-	812	1,679	1,165	353	182	2,065
(ii) Motor Vehicle	292	1,340	520	407	28	250	752
(iii) Tractor & Equipment	-	7,843	1,215	1,119	440	511	1,116
Sub-total	820	16,836	4,763	3,822	1,569	3,274	6,420
(4) Interest on Loan & Others	13	38	11	10	2	11	13
(5) Depreciation on Fixed Assets	375	1,579	537	645	108	108	275
Total	1,134	28,069	8,647	7,970	2,420	5,349	10,020
3. EXCESS OF INCOME OVER EXPENDITURE	-4,907	1,473	-4,514	-7,100	-1,633	-4,401	-7,182

Table 2.6.3 Income and Expenditure Account of Mwea Irrigation Scheme (1976/77 - 1985/86)

(Unit: KShs.1,000)

Description	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86
1. INCOME										
(1) Service Charge	6,655	6,349	5,508	6,622	7,496	24,489	29,396	38,426	32,651	31,087
(2) Government Grant & Others	4,284	4,049	4,905	6,601	964	428	-4,427	3,819	3,864	-1,545
Total	10,939	10,938	10,413	13,223	8,460	24,917	24,969	42,245	38,515	29,542
2. EXPENDITURE										
(1) Staff Cost	3,865	4,412	4,715	5,023	6,064	6,950	5,215	6,160	6,666	8,397
(2) Office Expenses	389	343	1,010	650	1,067	1,131	807	1,023	1,536	1,219
(3) O/M Expenses										
a. Buildings & Canals Maintenance	751	1,761	776	1,823	1,645	1,598	882	1,010	809	1,994
b. Diesel, Petrol & Oil	879	914	949	1,604	2,259	2,134	2,661	2,347	3,593	4,847
c. Repair & Renewal of:										
(i) Plant & Machinery	296	253	362	489	694	1,040	576	1,078	661	812
(ii) Motor Vehicle	257	316	347	486	779	851	516	953	936	1,340
(iii) Tractor & Equipment	463	616	783	1,018	1,413	1,779	1,132	1,193	4,465	7,843
Sub-total	2,664	3,860	3,214	5,420	6,790	7,402	5,767	6,581	10,464	16,836
(4) Interest on Loan & Others	3,502	1,081	485	704	1,544	3,124	1,726	174	324	38
(5) Depreciation on Fixed Assets	519	702	989	1,426	1,532	1,910	1,596	1,207	1,066	1,579
Total	10,939	10,398	10,413	13,223	16,997	20,517	15,111	15,145	20,056	28,069
3. EXCESS OF INCOME OVER EXPENDITURE	0	0	0	0	-8,537	4,400	9,858	27,100	18,459	1,473

Source: (1) NIB Annual Reports (1976/77 - 1983/84)
(2) NIB Account Reports (1984/85 - 1895/86)

Table 3.3.1 Monthly Meteorological Record

Station: Embu-Mwea Meterological Station Lat. 0° 41 ' S Long. 37° 20' E
Station number: 9037112 Alt. 1158 m For the year 1978 - 1986 (Average)

Month	Temperature (°C)			Relative humidity (%)			Evaporation (mm/day)		Mean Wind Speed (km/day)	Sunshine Hours (hrs/day)	Radiation (cal/ cm2/day)	Rainfall	
	Max.	Min.	Mean	Max.	Min.	Mean	Piche	Pan (class A)				Depth (mm)	No. of Days (day)
Jan.	29.4	14.9	22.2	66	40	53	-	7.1	134	9.2	645	21	2
Feb.	31.0	15.6	23.2	61	33	47	-	8.2	145	9.4	675	12	1
Mar.	31.6	17.2	23.7	68	35	52	-	8.2	154	8.4	639	94	5
Apr.	28.9	18.3	23.4	76	48	62	-	5.7	124	7.0	587	281	13
May	27.3	17.8	22.7	76	53	65	-	5.2	111	6.5	561	137	7
Jun.	25.8	16.5	21.2	76	51	64	-	4.7	94	5.4	491	12	1
Jul.	25.2	15.8	20.4	76	49	63	-	4.5	112	4.3	441	6	1
Aug.	26.1	16.0	20.9	74	45	60	-	5.1	139	4.6	471	7	2
Sep.	28.4	16.8	22.7	69	36	53	-	7.0	177	6.5	589	17	1
Oct.	29.4	17.5	23.4	71	40	56	-	6.6	143	7.2	602	142	7
Nov.	27.6	17.0	22.4	77	54	66	-	5.1	118	6.9	573	147	10
Dec.	27.6	15.9	21.5	72	51	62	-	5.6	126	7.3	600	50	3
Total	338.3	199.3	267.7	862	535	703	-	73.0	1,577	82.7	6,874	926	53
Average	28.2	16.6	22.3	72	45	59	-	6.1	131	6.9	573	77	4

Note: Number of rainy days is counted for daily rainfall more than 5mm.

Table 3.6.1 Soil Physical and Chemical Analysis (1/2)

Point No.	Horizon	Area (Section)	Mapping* Unit	pH (Water)	pH (KCl)	Conductivity (m mho/cm)	Carbon (%)	Available P (ppm)	Nitrogen (%)
3	U	Mutithi	PBVP1	7.65	6.05	0.98	2.17	77	0.07
4	U	Mutithi	PBVP1	7.25	5.50	0.98	4.51	75	0.10
5	U	Mutithi	PBNV	6.30	4.25	0.52	2.56	80	0.08
6	U	Mutithi	SBNV	6.45	4.90	0.47	4.92	120	0.17
7	U	Mutithi	PBNV	6.45	5.20	1.13	4.64	112	0.14
8	U	Mutithi	PBVP1	7.15	5.45	0.94	6.05	106	0.07
12	U	Wamumu	PBVP1	7.55	6.15	0.84	3.82	110	0.08
13	U	Mwea	PBVP1	6.35	4.95	0.80	7.17	32	0.08
15	U	Tebere	SBNV	6.45	5.50	0.84	5.06	156	0.09
16	U	Tebere	PBNV	6.45	5.05	0.70	5.88	198	0.06
17	U	Mwea	PBVP1	6.55	5.20	0.58	8.08	69	0.12
18	U	Mwea	PBNV	6.50	4.80	0.49	8.92	57	0.13
19	U	Mutithi	PBNV	7.20	5.50	0.41	8.57	159	0.11
19	L	Mutithi	PBNV	6.95	5.80	0.31	8.00	87	0.09
20	U	Mutithi	SBNV	6.85	5.75	0.49	8.74	44	0.13
20	L	Mutithi	SBNV	7.25	5.60	0.59	7.35	19	0.06
24	U	Mutithi	PBVP1	7.70	6.35	0.48	7.43	35	0.07
25	U	Mutithi	PBVP1	7.85	6.10	0.60	8.57	60	0.06
25	L	Mutithi	PBVP1	8.40	6.50	0.81	6.39	14	0.03
26	U	Mutithi	PBNV	7.00	5.45	0.23	3.10	73	0.09
28	U	Mutithi	PBVP1	7.40	5.95	0.49	7.70	61	0.13
30	U	Mutithi	PBVP1	7.45	5.65	0.44	6.76	40	0.06
31	U	Mutithi	PBVP1	6.85	5.95	0.38	6.54	40	0.05
37	U	Tebere	PBNV	6.95	5.30	0.17	7.74	93	0.13

Table 3.6.1 Soil Physical and Chemical Analysis (2/2)

Point No.	Horizon	Area (Section)	Mapping* Unit	Exchangeable Cations meq/100 g					Texture USDA			
				Mg	Na	K	Ca	CEC	Sand 2-0.05mm	Silt 0.05-0.002mm	Clay 0.002mm-	Classification
3	U	Mutithi	PBVP1	32.6	2.0	0.1	53.2	78.5	3.1	11.7	85.2	C
4	U	Mutithi	PBVP1	13.9	0.8	0.1	37.5	65.4	7.8	16.9	75.3	C
5	U	Mutithi	PBNV	1.6	0.8	0.1	0.6	25.2	11.6	54.0	34.4	SiCL
6	U	Mutithi	SBNV	4.8	1.0	0.6	1.5	29.3	5.9	36.8	57.3	C
7	U	Mutithi	PBNV	4.8	0.4	2.1	11.2	38.7	57.2	19.0	23.8	SCL
8	U	Mutithi	PBVP1	39.4	3.1	0.1	32.5	85.0	6.2	26.0	67.8	C
12	U	Wamumu	PBVP1	20.9	1.9	1.3	48.7	73.9	8.2	27.1	64.7	C
13	U	Mwea	PBVP1	34.0	2.1	0.1	28.7	81.1	8.3	39.7	52.0	C
15	U	Tebere	SBNV	4.8	2.4	1.7	4.5	34.5	10.2	47.7	42.1	SiC
16	U	Tebere	PBNV	6.2	0.9	2.4	9.7	37.8	24.0	24.0	52.0	C
17	U	Mwea	PBVP1	13.4	0.7	0.6	16.8	81.5	7.5	37.2	55.3	C
18	U	Mwea	PBNV	9.8	0.6	0.3	10.0	65.4	11.4	62.7	25.9	SiL
19	U	Mutithi	PBNV	7.9	0.3	3.4	4.1	51.5	12.8	61.6	25.6	SiL
19	L	Mutithi	PBNV	6.7	0.4	1.0	3.2	48.7	13.1	73.9	13.0	SiL
20	U	Mutithi	SBNV	7.8	0.4	1.8	3.5	52.8	3.2	30.8	66.0	C
20	L	Mutithi	SBNV	7.0	0.5	0.2	0.5	46.3	9.2	56.2	34.6	SiCL
24	U	Mutithi	PBVP1	24.1	1.5	0.1	29.4	85.0	9.7	55.2	35.1	SiCL
25	U	Mutithi	PBVP1	20.1	2.1	0.2	26.3	109.6	7.2	16.4	76.4	C
25	L	Mutithi	PBVP1	25.6	3.4	0.3	20.9	85.9	6.7	29.3	64.0	C
26	U	Mutithi	PBNV	8.7	0.4	2.1	4.1	44.1	11.3	50.8	37.9	SiCL
28	U	Mutithi	PBVP1	20.1	1.5	0.5	40.1	124.6	9.8	47.4	42.8	SiC
30	U	Mutithi	PBVP1	22.6	1.4	0.5	25.7	132.0	7.4	40.5	52.1	SiC
31	U	Mutithi	PBVP1	22.3	3.6	0.3	23.3	109.6	5.2	21.3	73.5	C
37	U	Tebere	PBNV	6.0	0.4	1.6	3.1	57.0	13.3	63.9	22.8	SiL

Remarks: * Mapping Unit: PBVP1: pell Vertisols (deep phase), PBNV: verto-eutric Nitosols (brownish coloured phase), SBNV: vert-eutric Nitosols (red coloured phase)

Table 3.8.1 Net Area under Rice Cultivation in Each Unit

(Unit: ha)

Tebere		Mwea		Thiba		Wamumu		Karaba	
T2	22	M1	80	H1	73	W1	130	K1	208
T5	117	M2	41	H2	92	W2	195	K2	165
T6	57	M3	53	H3	108	W3	173	K3	132
T7	110	M4	132	H4	90	W4	132	K4	145
T8	159	M5	75	H5	156	W5	163	K5	148
T11	129	M6	64	H6	111	W6	206	K6	111
T13	71	M7	49	H7	83	W7	121	K7	131
T15	34	M8	25	H8	96			K8	30
T16	77	M9	51	H18	115				
T17	23	M10	33	H19	111				
T18	59	M11	48	H20	115				
T19	105	M12(A)	29						
T20	115	M12(B)	48						
T21	79	M13	68						
T22	74	M14	106						
T23	46	M15	47						
T25	23	M16	132						
		M17	139						
Total:	1,300		1,220		1,150		1,120		1,070

Source: NIB

Table 3.8.2 Existing Related Irrigation Structures

(Unit: No.)

No.	Name of Structure	NMI	NBI-I	NBI-II	NBI-III	TMI	TBI-I	TBI-II	TBI-III	TBI-IV	Total
1.	Parshal flume	1	-	-	-	1	-	1	1	-	4
2.	Culvert	1	3	4	1	3	4	7	7	17	47
3.	Bridge	4	-	-	-	3	-	1	-	2	10
4.	Turnout or offtake	6	8	9	3	14	6	6	11	9	72
5.	Chute	1	-	1	-	-	-	-	-	-	2
6.	Concrete flume	1	-	-	-	-	-	-	-	-	1
7.	Drop	15	16	15	11	32	5	13	21	28	156
8.	Check	1	9	5	3	8	-	3	1	1	31
9.	Washing step	-	2	-	1	-	-	1	-	2	6
10.	Spillway	-	-	1	1	-	-	1	-	-	3
11.	Concrete lining	-	-	-	-	1	-	-	-	-	1
12.	Cross drain	-	-	-	-	1	-	-	-	-	1
13.	Horse shoe weir	-	-	-	-	1	-	-	6	8	15
14.	Stone masonary lining	-	-	-	-	-	-	-	-	1	1
15.	Cipolletti weir	-	-	1	-	-	-	-	-	-	1
	Total	30	38	36	20	64	15	33	47	68	351

Table 3.8.3 Existing Related Drainage Structures

(Unit: No.)

No.	Name of Structure	NMD-I	NMD-II	NMD-III	TMD-I	TBD-I-1	TMD-II	TMD-III	TMD-IV	KMD	Total
1.	Culvert	3	3	1	3	1	5	3	3	4	26
2.	Drop	2	-	-	-	2	1	-	-	-	5
3.	Check	-	-	-	-	-	1	-	-	-	1
4.	Drainage inlet	-	-	-	4	7	-	-	-	5	16
5.	Aqueduct	-	-	-	-	-	-	1	-	1	2
	Total	5	3	1	7	10	7	4	3	10	50

Table 3.9.1 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 3.9.2 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	21.95	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	2,475.55	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 3.9.3 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 3.9.4 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 3.9.5 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. Dogging 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.	a. 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 3.9.6 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	5.8	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 4.3.1 Calculation of Irrigable Areas by Drought Discharges in 1980

MONTH	DAY	(UNIT IRR. REQ.) (P)	(H)	(EXIST. NYAMINDI HEADWORKS) (A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(EXIST. THIBA HEADWORKS) (A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(NEW RWAMUTHAMBI HEADWORKS) (A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	Σ(F)	Σ(G)	Σ(H)
JAN	1 - 10	0.40	1.21	3.02	2.70	1.34	0.00	1.36	1,180	570	1,750	4.96	4.06	1.97	0.00	2.09	4,680	230	4,910	1.76	1.44	1.38	0.00	0.06	2,470	400	2,870	8,330	1,200	9,530
	11 - 20	0.13	1.32	2.46	2.14	0.89	0.00	1.25	1,180	570	1,750	4.44	3.54	0.85	0.00	2.69	4,680	230	4,910	1.36	1.04	0.88	0.00	0.16	2,470	430	2,900	8,330	1,230	9,560
	21 - 31	0.00	1.37	2.61	2.29	0.76	0.00	1.53	1,180	570	1,750	4.75	3.85	0.31	0.00	3.54	4,680	230	4,910	1.57	1.24	0.57	0.00	0.67	2,470	430	2,900	8,330	1,230	9,560
FEB	1 - 10	0.00	1.39	3.26	2.94	1.79	0.00	1.15	1,180	570	1,750	4.57	3.67	0.32	0.00	3.35	4,680	230	4,910	1.40	1.12	0.60	0.00	0.52	2,470	430	2,900	8,330	1,230	9,560
	11 - 20	0.22	1.13	2.66	2.34	0.89	0.00	1.45	1,180	570	1,750	3.66	2.76	1.17	0.00	1.59	4,680	230	4,910	1.15	0.83	1.03	0.20	0.00	2,470	260	2,730	8,330	1,060	9,390
	21 - 29	0.45	0.84	1.99	1.67	1.22	0.00	0.45	1,180	570	1,750	4.24	3.34	2.95	0.00	0.39	4,680	230	4,910	1.00	0.72	1.98	1.26	0.00	1,190	0	1,190	7,050	800	7,850
MAR	1 - 10	0.90	0.39	3.17	2.85	1.23	0.00	1.62	1,180	570	1,750	5.72	4.82	3.92	0.00	0.90	4,680	230	4,910	0.97	0.69	2.39	1.70	0.00	760	0	760	6,620	800	7,420
	11 - 20	1.42	0.94	2.63	2.31	1.91	0.00	0.40	1,180	570	1,750	5.56	4.66	6.15	1.49	0.00	3,720	0	3,720	0.88	0.60	3.74	3.14	0.00	430	0	430	5,330	570	5,900
	21 - 31	1.44	0.75	2.23	1.91	2.02	0.11	0.00	1,180	410	1,590	5.39	4.49	6.27	1.82	0.00	3,530	0	3,530	0.66	0.38	2.06	1.78	0.00	400	0	400	5,110	410	5,520
APR	1 - 10	1.01	0.97	3.26	2.94	1.51	0.00	1.43	1,180	570	1,750	5.52	4.62	4.44	0.00	0.18	4,680	230	4,910	1.15	0.87	2.74	1.87	0.00	840	0	840	6,700	800	7,500
	11 - 20	0.81	0.62	5.21	4.89	1.26	0.00	3.63	1,180	570	1,750	5.73	4.83	3.56	0.00	1.27	4,680	230	4,910	1.36	1.08	2.27	1.19	0.00	1,330	0	1,330	7,190	800	7,990
	21 - 30	0.96	0.87	6.52	6.20	1.53	0.00	4.67	1,180	570	1,750	7.19	6.29	4.25	0.00	2.04	4,680	230	4,910	2.14	1.86	2.72	0.85	0.00	1,310	0	1,310	7,170	800	7,970
MAY	1 - 10	4.01	0.47	15.87	15.55	4.27	0.00	11.28	1,180	570	1,750	7.27	6.37	6.12	0.00	4.12	4,680	230	4,910	2.95	2.67	0.23	0.00	2.44	2,470	430	2,900	8,330	1,230	9,560
	11 - 20	0.60	0.71	13.73	13.41	1.06	0.00	12.35	1,180	570	1,750	12.84	11.94	2.71	0.00	9.23	4,680	230	4,910	2.73	2.45	1.79	0.00	0.66	2,470	430	2,900	8,330	1,230	9,560
	21 - 31	0.57	0.40	7.16	6.84	0.91	0.00	5.93	1,180	570	1,750	11.53	10.63	2.53	0.00	8.10	4,680	230	4,910	1.95	1.67	1.41	0.00	0.26	2,470	430	2,900	8,330	1,230	9,560
JUN	1 - 10	0.61	0.84	5.99	5.67	1.65	0.00	4.02	1,180	570	1,750	9.16	8.26	2.73	0.00	5.53	4,680	230	4,910	1.53	1.25	1.78	0.53	0.00	2,040	0	2,040	7,900	800	8,700
	11 - 20	0.45	0.72	4.03	3.71	0.91	0.00	2.80	1,180	570	1,750	7.94	7.04	2.07	0.00	4.97	4,680	230	4,910	1.25	0.97	1.42	0.45	0.00	2,150	0	2,150	8,010	800	8,810
	21 - 30	0.28	0.78	3.31	2.99	0.76	0.00	2.23	1,180	570	1,750	6.98	6.08	1.37	0.00	4.71	4,680	230	4,910	1.14	0.86	1.03	0.17	0.00	2,470	210	2,680	8,330	1,010	9,340
JUL	1 - 10	0.09	0.79	3.03	2.71	0.55	0.00	2.16	1,180	570	1,750	4.83	3.93	0.56	0.00	3.37	4,680	230	4,910	1.35	1.07	0.56	0.00	0.51	2,470	430	2,900	8,330	1,230	9,560
	11 - 20	0.15	0.81	2.99	2.67	0.63	0.00	2.04	1,180	570	1,750	6.16	5.26	0.82	0.00	4.44	4,680	230	4,910	1.22	0.94	0.72	0.00	0.22	2,470	430	2,900	8,330	1,230	9,560
	21 - 31	0.46	0.82	2.84	2.52	0.98	0.00	1.54	1,180	570	1,750	5.85	4.95	2.14	0.00	2.81	4,680	230	4,910	1.14	0.86	1.49	0.63	0.00	1,860	0	1,860	7,720	800	8,520
AUG	1 - 10	0.70	0.64	3.02	2.70	1.15	0.00	1.55	1,180	570	1,750	7.12	6.22	3.12	0.00	3.10	4,680	230	4,910	1.68	1.40	2.00	0.60	0.00	2,000	0	2,000	7,860	800	8,660
	11 - 20	0.99	0.64	10.27	9.95	1.47	0.00	8.48	1,180	570	1,750	7.77	6.87	3.34	0.00	3.53	4,680	230	4,910	2.55	2.27	2.72	0.45	0.00	2,290	0	2,290	8,150	800	8,950
	21 - 31	1.24	0.57	5.16	4.84	1.71	0.00	3.13	1,180	570	1,750	7.64	6.74	5.39	0.00	1.35	4,680	230	4,910	1.84	1.56	3.31	1.75	0.00	1,250	0	1,250	7,110	800	7,910
SEP	1 - 10	1.72	0.50	3.61	3.29	2.21	0.00	1.08	1,180	570	1,750	7.03	6.13	7.41	1.28	0.00	4,000	0	4,000	1.55	1.27	4.46	3.19	0.00	730	0	730	5,910	570	6,480
	11 - 20	1.74	0.55	3.54	3.22	2.26	0.00	0.96	1,180	570	1,750	6.37	5.47	7.50	2.03	0.00	3,580	0	3,580	1.20	0.92	4.53	3.62	0.00	520	0	520	5,280	570	5,850
	21 - 30	1.50	0.69	4.43	4.11	2.27	0.00	1.84	1,180	570	1,750	5.59	4.69	6.90	2.21	0.00	3,400	0	3,400	1.27	0.99	4.29	3.30	0.00	620	0	620	5,200	570	5,770
OCT	1 - 10	1.34	1.05	9.08	8.76	2.10	0.00	6.66	1,180	570	1,750	4.84	3.94	5.90	1.96	0.00	3,380	0	3,380	1.12	0.84	3.76	2.92	0.00	620	0	620	5,180	570	5,750
	11 - 20	1.37	1.13	3.93	3.61	2.07	0.00	1.54	1,180	570	1,750	4.94	4.04	5.44	1.40	0.00	3,520	0	3,520	1.01	0.73	3.63	2.90	0.00	570	0	570	5,270	570	5,840
	21 - 31	0.49	0.74	6.28	5.96	0.98	0.00	4.98	1,180	570	1,750	6.62	5.72	2.25	0.00	3.47	4,680	230	4,910	2.32	2.04	1.54	0.00	0.50	2,470	430	2,900	8,330	1,230	9,560
NOV	1 - 10	0.00	0.64	7.62	7.30	0.36	0.00	6.94	1,180	570	1,750	9.07	8.17	4.15	0.00	4.02	4,680	230	4,910	3.22	2.94	0.28	0.00	2.66	2,470	430	2,900	8,330	1,230	9,560
	11 - 20	0.52	0.56	10.27	9.95	0.90	0.00	9.05	1,180	570	1,750	12.15	11.25	2.33	0.00	8.92	4,680	230	4,910	4.98	4.70	1.53	0.00	3.17	2,470	430	2,900	8,330	1,230	9,560
	21 - 30	0.49	0.53	9.35	9.03	0.85	0.00	8.18	1,180	570	1,750	12.61	11.71	2.20	0.00	9.51	4,680	230	4,910	3.03	2.75	1.44	0.00	1.31	2,470	430	2,900	8,330	1,230	9,560
DEC	1 - 10	0.83	0.50	5.74	5.42	1.24	0.00	4.18	1,180	570	1,750	9.02	8.12	3.72	0.00	4.40	4,680	230	4,910	2.57	2.29	2.31	0.02	0.00	2,470	370	2,840	8,330	1,170	9,500
	11 - 20	0.79	0.81	5.02	4.70	1.35	0.00	3.35	1,180	570	1,750	7.90	7.00	3.54	0.00	3.46	4,680	230	4,910	2.61	2.33	2.30	0.00	0.03	2,470	430	2,900	8,330	1,230	9,560
	21 - 31	0.57	0.92	4.27	3.95	1.16	0.00	2.79	1,180	570	1,750	8.01	7.11	2.63	0.00	4.48	4,680	230	4,910	2.24	1.96	1.80	0.04	0.00	2,470	380	2,850	8,330	1,180	9,510
	TOTAL	25.45	27.05	191.04	179.52	44.39	0.11	135.26	-	-	-	253.09	226.49	114.31	12.43	124.40	-	-	-	61.70	53.62	74.84	34.15	12.83	-	-	-	-	-	-

Remarks

1. Unit: (P), (H) = (l/sec/ha),
   (A), (B), (C), (D), (E) = (m³/sec),
   (F), (G), (H) = (ha).

2. (P)=Rice,
   (H)=Horticultural Crops,
   (A)=Drought Discharge at the Headworks,
   (B)=Available Drought Discharge at the Headworks = (A)-Total Water Rights-Maintenance Flow,
   (C)=Diversion Requirement of The Potential Maximum Area,
   (D)=Deficit of Irrigation Water=(C)-(B)>0,
   (E)Surplus of Available Drought Discharge=(B)-(C)>0,
   (F)=Irrigable Area of Rice Including Re-use Area,
   (G)=Irrigable Area of Horticultural Crops,
   (H)=Total Irrigable Area =(F) + (G).

3. Figures through (A) to (E) are rounded off to two decimal places.

   Figures of (F) and (G) are omitted below the first digit.

Table 4.5.1 Water Balance Calculation (1/3)

(Total Diversion Requirement for Water Balance Calculation (Alternative: T-1)

MONTH	DAY	(UNIT IRRI.REQ) (A)	(UNIT IRRI.REQ) (B)	(MIS(NYAMINDI)) (A) 1,160-60 =1,120ha	(MIS(NYAMINDI)) (B) 570ha	(MIS(NYAMINDI)) Subtotal	(MIS(THIBA)) (A) 4,680-440 =4,240ha	(MIS(THIBA)) (B) 230ha	(MIS(THIBA)) Subtotal	(MUTITHI) (A) 2,470ha	(MUTITHI) (B) 430ha	(MUTITHI) Subtotal	Total
JAN	1 - 10	0.40	1.21	0.45	0.69	1.14	1.70	0.28	1.97	0.99	0.52	1.51	4.62
	11 - 20	0.13	1.30	0.15	0.74	0.89	0.55	0.30	0.85	0.32	0.56	0.88	2.62
	21 - 31	0.00	1.33	0.00	0.76	0.76	0.00	0.31	0.31	0.00	0.57	0.57	1.64
FEB	1 - 10	0.00	1.39	0.00	0.79	0.79	0.00	0.32	0.32	0.00	0.60	0.60	1.71
	11 - 20	0.22	1.13	0.25	0.64	0.89	0.93	0.26	1.19	0.54	0.49	1.03	3.11
	21 - 29	0.65	0.86	0.73	0.49	1.22	2.76	0.20	2.95	1.61	0.37	1.98	6.15
MAR	1 - 10	0.90	0.39	1.01	0.22	1.23	3.82	0.09	3.91	2.22	0.17	2.39	7.53
	11 - 20	1.42	0.56	1.59	0.32	1.91	6.02	0.13	6.15	3.51	0.24	3.75	11.81
	21 - 31	1.44	0.71	1.61	0.40	2.02	6.11	0.16	6.27	3.56	0.31	3.86	12.15
APR	1 - 10	1.01	0.67	1.13	0.38	1.51	4.28	0.15	4.44	2.49	0.29	2.78	8.73
	11 - 20	0.81	0.62	0.91	0.35	1.26	3.43	0.14	3.58	2.00	0.27	2.27	7.10
	21 - 30	0.96	0.80	1.08	0.46	1.53	4.07	0.18	4.25	2.37	0.34	2.72	8.50
MAY	1 - 10	0.01	0.45	0.01	0.26	0.27	0.04	0.10	0.15	0.02	0.19	0.22	0.63
	11 - 20	0.60	0.71	0.67	0.40	1.08	2.54	0.16	2.71	1.48	0.31	1.79	5.57
	21 - 31	0.57	0.48	0.64	0.27	0.91	2.42	0.11	2.53	1.41	0.21	1.61	5.05
JUN	1 - 10	0.61	0.64	0.68	0.36	1.05	2.59	0.15	2.73	1.51	0.28	1.78	5.56
	11 - 20	0.45	0.72	0.50	0.41	0.91	1.91	0.17	2.07	1.11	0.31	1.42	4.41
	21 - 30	0.28	0.78	0.31	0.44	0.76	1.19	0.18	1.37	0.69	0.34	1.03	3.16
JUL	1 - 10	0.09	0.79	0.10	0.45	0.55	0.36	0.18	0.56	0.22	0.34	0.56	1.68
	11 - 20	0.15	0.81	0.17	0.46	0.63	0.64	0.19	0.82	0.37	0.35	0.72	2.17
	21 - 31	0.46	0.82	0.52	0.47	0.98	1.95	0.19	2.14	1.14	0.35	1.49	4.61
AUG	1 - 10	0.70	0.64	0.78	0.36	1.15	2.97	0.15	3.12	1.73	0.28	2.00	6.27
	11 - 20	0.99	0.64	1.11	0.36	1.47	4.20	0.15	4.34	2.45	0.28	2.72	8.54
	21 - 31	1.24	0.57	1.39	0.32	1.71	5.26	0.13	5.39	3.06	0.25	3.31	10.41
SEP	1 - 10	1.72	0.50	1.93	0.29	2.21	7.29	0.12	7.41	4.25	0.22	4.46	14.08
	11 - 20	1.74	0.55	1.95	0.31	2.26	7.38	0.13	7.50	4.30	0.24	4.53	14.30
	21 - 30	1.58	0.68	1.77	0.50	2.27	6.70	0.20	6.90	3.90	0.28	4.28	13.45
OCT	1 - 10	1.34	1.05	1.50	0.60	2.10	5.68	0.24	5.92	3.31	0.45	3.76	11.78
	11 - 20	1.27	1.13	1.42	0.64	2.07	5.38	0.26	5.64	3.14	0.49	3.62	11.33
	21 - 31	0.49	0.76	0.55	0.43	0.98	2.08	0.17	2.25	1.21	0.33	1.54	4.77
NOV	1 - 10	0.00	0.64	0.00	0.36	0.36	0.00	0.15	0.15	0.00	0.28	0.28	0.79
	11 - 20	0.52	0.56	0.58	0.32	0.90	2.20	0.13	2.33	1.28	0.24	1.53	4.76
	21 - 30	0.49	0.53	0.55	0.30	0.85	2.08	0.12	2.20	1.21	0.23	1.44	4.49
DEC	1 - 10	0.85	0.50	0.95	0.29	1.24	3.60	0.12	3.72	2.10	0.22	2.31	7.27
	11 - 20	0.79	0.81	0.88	0.46	1.35	3.35	0.19	3.54	1.95	0.35	2.30	7.19
	21 - 31	0.57	0.92	0.64	0.52	1.16	2.42	0.21	2.63	1.41	0.40	1.80	5.59
	TOTAL	25.45	27.85	28.50	15.87	44.38	107.91	6.41	114.32	62.86	11.98	74.84	233.53

REMARKS

1. UNIT: UNIT IRRI. REQ. (l/sec/ha)
   OTHERS (m³/sec)

2. (A)=Rice
   (B)=Horticultural Crops

3. Above figures are rounded off to two decimal places.

Table 4.5.1 Water Balance Calculation (2/3)

(Water Balance Calculation of Headworks (Alternative: T-1)

(UNIT: m³/sec)

MONTH	DAY	(NYAMINDI HEADWORKS) (A)	(B)	(C)	(D)	(E)	(THIBA HEADWORKS) (A)	(B)	(C)	(D)	(E)	(RUAMUTHAMBI HEADWORKS) (A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
JAN	1 - 10	2.81	2.49	1.14	0.00	1.35	4.96	4.06	1.97	0.00	2.09	1.76	1.48	1.51	0.03	0.00	0.03	3.44	0.00	2.09
	11 - 20	2.45	2.13	0.89	0.00	1.24	4.44	3.54	0.85	0.00	2.69	1.32	1.04	0.88	0.00	0.16	0.00	4.09	0.00	2.69
	21 - 31	2.60	2.28	0.76	0.00	1.52	4.75	3.85	0.31	0.00	3.54	1.52	1.24	0.57	0.00	0.67	0.00	5.74	0.00	3.54
FEB	1 - 10	3.24	2.92	0.79	0.00	2.13	4.57	3.67	0.32	0.00	3.35	1.40	1.12	0.60	0.00	0.52	0.00	6.00	0.00	3.35
	11 - 20	2.65	2.33	0.89	0.00	1.44	3.68	2.78	1.19	0.00	1.59	1.11	0.83	1.03	0.20	0.00	0.20	3.03	0.00	1.59
	21 - 29	1.98	1.66	1.22	0.00	0.44	4.24	3.34	2.95	0.00	0.39	1.00	0.72	1.98	1.26	0.00	1.26	0.83	0.43	0.00
MAR	1 - 10	3.15	2.83	1.23	0.00	1.60	5.72	4.82	3.91	0.00	0.91	0.97	0.69	2.39	1.70	0.00	1.70	2.51	0.00	0.82
	11 - 20	2.62	2.30	1.91	0.00	0.39	5.56	4.66	6.15	1.49	0.00	0.88	0.60	3.75	3.14	0.00	4.63	0.39	4.24	0.00
	21 - 31	2.22	1.90	2.02	0.12	0.00	5.35	4.45	6.27	1.82	0.00	0.86	0.58	3.86	3.28	0.00	5.10	0.00	5.10	0.00
APR	1 - 10	3.28	2.96	1.51	0.00	1.45	5.52	4.62	4.44	0.00	0.18	1.15	0.87	2.78	1.92	0.00	1.92	1.63	0.28	0.00
	11 - 20	5.18	4.86	1.26	0.00	3.60	5.75	4.85	3.58	0.00	1.27	1.36	1.08	2.27	1.19	0.00	1.19	4.87	0.00	1.27
	21 - 30	8.48	8.16	1.53	0.00	6.63	7.19	6.29	4.25	0.00	2.04	2.14	1.86	2.72	0.85	0.00	0.85	8.66	0.00	2.04
MAY	1 - 10	15.79	15.47	0.27	0.00	15.20	7.17	6.27	0.15	0.00	6.12	2.95	2.67	0.22	0.00	2.46	0.00	23.78	0.00	6.12
	11 - 20	13.88	13.56	1.08	0.00	12.48	12.84	11.94	2.71	0.00	9.23	2.73	2.45	1.79	0.00	0.66	0.00	22.38	0.00	9.23
	21 - 31	7.12	6.80	0.91	0.00	5.89	11.53	10.63	2.53	0.00	8.10	1.95	1.67	1.61	0.00	0.06	0.00	14.05	0.00	8.10
JUN	1 - 10	5.36	5.04	1.05	0.00	3.99	9.16	8.26	2.73	0.00	5.53	1.53	1.25	1.78	0.53	0.00	0.53	9.52	0.00	5.53
	11 - 20	4.01	3.69	0.91	0.00	2.78	7.94	7.04	2.07	0.00	4.97	1.25	0.97	1.42	0.45	0.00	0.45	7.74	0.00	4.97
	21 - 30	3.29	2.97	0.76	0.00	2.21	6.98	6.08	1.37	0.00	4.71	1.14	0.86	1.03	0.17	0.00	0.17	6.93	0.00	4.71
JUL	1 - 10	3.01	2.69	0.55	0.00	2.14	6.83	5.93	0.56	0.00	5.37	1.35	1.07	0.56	0.00	0.51	0.00	8.01	0.00	5.37
	11 - 20	2.97	2.65	0.63	0.00	2.02	6.18	5.28	0.82	0.00	4.46	1.22	0.94	0.72	0.00	0.22	0.00	6.70	0.00	4.46
	21 - 31	2.83	2.51	0.98	0.00	1.53	5.85	4.95	2.14	0.00	2.81	1.14	0.86	1.49	0.63	0.00	0.63	4.34	0.00	2.81
AUG	1 - 10	3.00	2.68	1.15	0.00	1.53	7.12	6.22	3.12	0.00	3.10	1.68	1.40	2.00	0.61	0.00	0.61	4.64	0.00	3.10
	11 - 20	10.22	9.90	1.47	0.00	8.43	7.77	6.87	4.34	0.00	2.53	2.55	2.27	2.72	0.45	0.00	0.45	10.95	0.00	2.53
	21 - 31	5.15	4.83	1.71	0.00	3.12	7.64	6.74	5.39	0.00	1.35	1.84	1.56	3.31	1.75	0.00	1.75	4.47	0.00	1.35
SEP	1 - 10	3.59	3.27	2.21	0.00	1.06	7.03	6.13	7.41	1.28	0.00	1.55	1.27	4.46	3.19	0.00	4.47	1.06	3.41	0.00
	11 - 20	3.52	3.20	2.26	0.00	0.94	6.37	5.47	7.50	2.03	0.00	1.20	0.92	4.53	3.62	0.00	5.65	0.94	4.71	0.00
	21 - 30	4.41	4.09	2.27	0.00	1.82	5.59	4.69	6.90	2.21	0.00	1.27	0.99	4.28	3.29	0.00	5.50	1.82	3.68	0.00
OCT	1 - 10	9.03	8.71	2.10	0.00	6.61	4.64	3.94	5.92	1.98	0.00	1.12	0.84	3.76	2.92	0.00	4.91	6.61	0.00	0.00
	11 - 20	3.91	3.59	2.07	0.00	1.52	4.94	4.04	5.64	1.60	0.00	1.01	0.73	3.62	2.90	0.00	4.50	1.52	2.98	0.00
	21 - 31	6.25	5.93	0.98	0.00	4.95	6.62	5.72	2.25	0.00	3.47	2.32	2.04	1.54	0.00	0.50	0.00	8.91	0.00	3.47
NOV	1 - 10	7.58	7.26	0.36	0.00	6.90	9.07	8.17	0.15	0.00	8.02	3.22	2.94	0.28	0.00	2.66	0.00	17.58	0.00	8.02
	11 - 20	10.22	9.90	0.90	0.00	9.00	12.15	11.25	2.33	0.00	8.92	4.98	4.70	1.53	0.00	3.17	0.00	21.09	0.00	8.92
	21 - 30	9.30	8.98	0.85	0.00	8.13	12.61	11.71	2.70	0.00	9.51	5.07	4.76	1.44	0.00	1.31	0.00	28.95	0.00	9.51
DEC	1 - 10	5.71	5.39	1.24	0.00	4.15	9.02	8.12	3.72	0.00	4.40	2.57	2.29	2.31	0.03	0.00	0.03	8.55	0.00	4.40
	11 - 20	4.99	4.67	1.35	0.00	3.32	7.90	7.00	3.54	0.00	3.46	2.61	2.32	2.30	0.00	0.03	0.00	6.82	0.00	3.46
	21 - 31	4.25	3.93	1.16	0.00	2.77	8.01	7.11	2.63	0.00	4.48	2.04	1.76	1.80	0.04	0.00	0.04	7.25	0.00	4.48
	TOTAL	190.05	178.53	44.38	0.12	134.27	252.59	220.49	114.31	12.42	118.60	63.70	50.62	74.84	34.15	12.93	46.57	265.79	24.84	117.93

REMARKS

1. (A)=Drought Discharge at the Headworks,
   (B)=Available Drought Discharge at the Headworks = (A) - Total Water Rights - Maintenance Flow,
   (C)=Diversion Requirement to the Headworks,
   (D)=Deficit of Irrigation Water = (C)-(B)>0,
   (E)=Surplus of Available Drought Discharge = (B)-(C)>0,
   (F)=Total Deficit of THIBA and RUAMUTHAMBI Headworks = THIBA H.(C)+RUAMUTHAMBI H.(C),
   (G)=Total Surplus of Three Headworks = Σ(E),
   (H)=Irrigation Water Requirement to THIBA Dam = (F)-(G)>0,
   (I)=Room for Available Discharge at THIBA Headworks = THIBA H. (E)-(J)>0,
   where, (J)= Supply Water from Surplus of THIBA Headworks = (F)-(K)>0,
   where, (K)=Total Surplus of NYAMINDI and RUAMUTHAMBI Headworks = NYAMINDI H. (E) + RUAMUTHAMBI H.(E).
2. Above figures are rounded off to two decimal places.

Table 4.5.1 Water Balance Calculation (3/3)

(Water Balance Calculation for Estimation of Storage Capacity (Alternative: T-1)

MONTH	DAY	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
JAN	1 - 10	1.89	1.41	0.00	2.09	0.00	0	1.41	1.89
	11 - 20	1.63	1.15	0.00	2.69	0.00	0	1.15	1.63
	21 - 31	1.78	1.30	0.00	3.54	0.00	0	1.30	1.78
FEB	1 - 10	1.70	1.22	0.00	3.35	0.00	0	1.22	1.70
	11 - 20	1.26	0.78	0.00	1.59	0.00	0	0.78	1.26
	21 - 29	1.54	0.00	0.43	0.00	0.00	-336,077	0.00	1.97
MAR	1 - 10	2.26	1.78	0.00	0.82	0.39	0	0.43	1.87
	11 - 20	2.18	0.00	4.24	0.00	0.00	-3,666,809	0.00	6.42
	21 - 31	2.09	0.00	5.10	0.00	0.00	-8,511,654	0.00	7.10
APR	1 - 10	2.16	0.00	0.28	0.00	0.00	-8,758,082	0.00	2.45
	11 - 20	2.27	1.79	0.00	1.27	1.27	-7,658,210	0.00	1.00
	21 - 30	2.98	2.50	0.00	2.04	2.04	-5,899,452	0.00	0.94
MAY	1 - 10	2.97	2.49	0.00	6.12	2.49	-3,749,917	0.00	0.48
	11 - 20	5.74	5.26	0.00	9.23	4.34	0	0.92	1.40
	21 - 31	5.10	4.62	0.00	8.10	0.00	0	4.62	5.10
JUN	1 - 10	3.94	3.46	0.00	5.53	0.00	0	3.46	3.94
	11 - 20	3.34	2.86	0.00	4.97	0.00	0	2.86	3.34
	21 - 30	2.87	2.39	0.00	4.71	0.00	0	2.39	2.87
JUL	1 - 10	2.80	2.32	0.00	5.37	0.00	0	2.32	2.80
	11 - 20	2.48	2.00	0.00	4.46	0.00	0	2.00	2.48
	21 - 31	2.32	1.84	0.00	2.81	0.00	0	1.84	2.32
AUG	1 - 10	2.94	2.46	0.00	3.10	0.00	0	2.46	2.94
	11 - 20	3.26	2.78	0.00	2.53	0.00	0	2.53	3.26
	21 - 31	3.20	2.72	0.00	1.35	0.00	0	1.35	3.20
SEP	1 - 10	2.90	0.00	3.41	0.00	0.00	-2,945,395	0.00	6.31
	11 - 20	2.58	0.00	4.71	0.00	0.00	-7,017,007	0.00	7.29
	21 - 30	2.20	0.00	3.68	0.00	0.00	-10,200,450	0.00	5.88
OCT	1 - 10	1.83	0.00	0.00	0.00	0.00	-10,200,450	0.00	1.83
	11 - 20	1.88	0.00	2.98	0.00	0.00	-12,774,080	0.00	4.86
	21 - 31	2.70	2.22	0.00	3.47	2.22	-10,665,180	0.00	0.48
NOV	1 - 10	3.90	3.42	0.00	8.02	3.42	-7,712,981	0.00	0.48
	11 - 20	5.40	4.92	0.00	8.92	4.92	-3,459,624	0.00	0.48
	21 - 30	5.63	5.15	0.00	9.51	4.00	0	1.14	1.62
DEC	1 - 10	3.87	3.39	0.00	4.40	0.00	0	3.39	3.87
	11 - 20	3.32	2.84	0.00	3.46	0.00	0	2.84	3.32
	21 - 31	3.38	2.90	0.00	4.48	0.00	0	2.90	3.38
	TOTAL	104.29	71.97	24.84	117.93	25.09	MAX.-12,774,080	43.31	104.02

REQUIRED
NET STORAGE CAPACITY

REMARKS

1. UNIT: (F) (m^3)
   Others (m^3/sec)

2. (A)=Drought Discharge at THIBA Dam Site,
   (B)=Available Drought Discharge at THIBA Dam Site =(A)-Total Water Rights-Maintenance Flow,
   (C)=Irrigation Water Requirement to THIBA Dam,
   (D)=Room for Available Discharge at THIBA Headworks,
   (E)=Actual Impounding Discharge of THIBA Dam = MIN((B), (D), (V)),
   where, (V)=Previous |(F)| ÷ 86,400 (sec) ÷ Number of days,
   (F)=Required Net Storage Capacity of THIBA Dam = Previous (F)-((C)-(E)) x 86,400(sec) x Number of Days,
   (G)=Invalid Water of Possible Impounding Discharge at THIBA Dam = MIN((B), (D)) -(E),
   (H)=THIBA River Discharge Just under the THIBA Dam = (A)-(E), when (C) = 0,
   (A)+(C), when (C) >0.

3. Above figures without (F) are rounded off to two decimal places.

Table 4.7.1 Irrigation Benefit Estimates (1/2)

Alternative Plan: T-1

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Kshs./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Kshs./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	600	1.3	780	2,900	2.3	2,776	1.7	0.6
Beans	200	6.0	1,200	3,200	3.3	3,531	0.7	3.1
II. Mutithi								
1. Horticultural Crops								
Maize	430	1.3	559	2,900	1.6	2,776	1.2	0.4
Total	-	-	-	-	81.5	-	30.7	50.9
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	800	10.0	8,000	3,200	25.6	8,144	6.5	19.1
Onion	400	10.0	4,000	3,900	15.6	13,464	5.4	10.2
Tomatoes	400	15.0	6,000	3,200	19.2	13,377	5.4	13.8
II. Mutithi								
1. Rice								
Long Rains Rice	2,412	6.0	14,928	3,600	53.4	5,598	13.9	39.6
Short Rains Rice	2,412	6.0	14,928	3,600	53.4	5,598	13.9	39.6
2. Horticultural Crops								
French Beans	430	10.0	4,300	3,200	13.8	8,144	3.5	10.3
Onion	215	10.0	2,150	3,900	8.4	13,464	2.9	5.5
Tomatoes	215	15.0	3,225	3,200	10.3	13,377	2.9	7.4
Total	-	-	-	-	457.9	-	119.8	333.1
III. Incremental Benefit (With Project - Without Project)	-	-	-	-	-	-	-	282.3

Alternative Plan: T-2

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Kshs./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Kshs./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	430	1.3	559	2,900	1.6	2,776	1.2	0.4
Beans	140	6.0	980	3,200	2.7	3,531	0.5	2.2
II. Mutithi								
1. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Total	-	-	-	-	78.3	-	28.8	49.5
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	570	10.0	5,700	3,200	18.2	8,144	4.6	13.6
Onion	285	10.0	2,850	3,900	11.1	13,464	3.8	7.3
Tomatoes	285	15.0	4,275	3,200	13.7	13,377	3.8	9.9
II. Mutithi								
1. Rice								
Long Rains Rice	1,660	6.0	9,600	3,600	35.9	5,598	9.3	26.6
Short Rains Rice	1,660	6.0	9,600	3,600	35.9	5,598	9.3	26.6
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
Total	-	-	-	-	369.0	-	96.4	271.6
III. Incremental Benefit (With Project - Without Project)								222.3

Alternative Plan: T-3

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Kshs./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Kshs./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	340	1.3	442	2,900	1.3	2,776	0.9	0.4
Beans	110	6.0	660	3,200	2.1	3,531	0.4	1.7
II. Mutithi								
1. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Total	-	-	-	-	77.2	-	28.4	48.8
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	450	10.0	4,500	3,200	14.4	8,144	3.7	10.7
Onion	225	10.0	2,250	3,900	8.8	13,464	3.0	5.8
Tomatoes	225	15.0	3,375	3,200	10.8	13,377	3.0	7.8
II. Mutithi								
1. Rice								
Long Rains Rice	2,410	6.0	14,460	3,600	52.1	5,598	13.5	38.6
Short Rains Rice	2,410	6.0	14,460	3,600	52.1	5,598	13.5	38.6
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
Total	-	-	-	-	391.4	-	102.3	289.1
III. Incremental Benefit (With Project - Without Project)								240.3

Table 4.7.1 Irrigation Benefit Estimates (2/2)

Alternative Plans: T-4

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Ksh./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Ksh./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	430	1.3	559	2,900	1.6	2,776	1.2	0.4
Beans	140	6.0	840	3,200	2.7	3,531	0.5	2.2
II. Mutithi								
1. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Total	-	-	-	-	78.1	-	28.8	49.3
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	570	10.0	5,700	3,200	18.2	8,144	4.6	13.6
Onion	285	10.0	2,850	3,900	11.1	13,464	3.8	7.3
Tomatoes	285	15.0	4,275	3,200	13.7	13,377	3.8	9.9
II. Mutithi								
1. Rice								
Long Rains Rice	1,060	6.0	6,360	3,600	22.9	5,598	5.9	17.0
Short Rains Rice	2,060	6.0	6,360	3,600	22.9	5,598	5.9	17.0
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
Total	-	-	-	-	342.0	-	89.6	252.4
III. Incremental Benefit (With Project - Without Project)								203.1

Alternative Plans: N-1

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Ksh./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Ksh./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Beans	-	6.0	-	3,200	-	3,531	-	-
II. Mutithi								
1. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Total	-	-	-	-	73.8	-	27.1	46.7
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
II. Mutithi								
1. Rice								
Long Rains Rice	2,070	6.0	12,420	3,600	44.7	5,598	11.6	33.1
Short Rains Rice	2,070	6.0	12,420	3,600	44.7	5,598	11.6	33.1
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
Total	-	-	-		342.6	-	88.6	253.8
III. Incremental Benefit (With Project - Without Project)								207.1

Alternative Plans: N-2

Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Total Production (ton)	Unit Price (Ksh./ton)	Gross Production Value (Kshs.)	Unit Production Cost (Ksh./ha)	Total Production Cost (MKshs.)	Net Production Value (MKshs.)
Without Project								
I. MIS								
1. Rice								
Short Rains Rice	5,860	3.5	20,510	3,600	73.8	4,623	27.1	46.7
2. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Beans	-	6.0	-	3,200	-	3,531	-	-
II. Mutithi								
1. Horticultural Crops								
Maize	-	1.3	-	2,900	-	2,776	-	-
Total	-	-	-	-	73.8	-	27.1	46.7
With Project								
I. MIS								
1. Rice								
Long Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
Short Rains Rice	5,860	6.0	35,160	3,600	126.6	5,598	32.8	93.8
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
II. Mutithi								
1. Rice								
Long Rains Rice	1,460	6.0	8,760	3,600	31.5	5,598	8.2	23.3
Short Rains Rice	1,460	6.0	8,760	3,600	31.5	5,598	8.2	23.3
2. Horticultural Crops								
French Beans	-	10.0	-	3,200	-	8,144	-	-
Onion	-	10.0	-	3,900	-	13,464	-	-
Tomatoes	-	15.0	-	3,200	-	13,377	-	-
Total	-	-	-		316.2	-	82.0	234.2
III. Incremental Benefit (With Project - Without Project)								187.5

Table 5.1.1 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 5.1.2 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

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 5.1.3 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	-	-	-
Tomato	-	5.1	-	15.3
Onion	-	4.5	-	13.5
French bean	-	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	20.4	37.1	-	50.4
i) Farming Expenses/1				
Rice	4.6	11.8	-	20.0
Maize	0.1	-	1.1	-
Beans	0.2	-	-	-
Tomato	-	0.6	-	1.9
Onion	-	0.9	-	2.8
French bean	-	1.3	-	3.2
Sub-total	4.9	14.6	1.1	29.9
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 5.1.4 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 (KShs.Million)	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 5.2.1 Effective Rainfall (ER) and Farm Water Requirement (FWR)

(Unit: mm)

Crops		Rice(L)		Rice(S)		Beans S(L)		Beans S(S)		Onions(L)		Tomatoes(S)	
Month	Day	ER	FWR	ER	FWR	ER	FWR	ER	FWR	ER	FWR	ER	FWR
Jan.	1-10	-	-	0	19	-	-	0	53	-	-	0	62
	11-20	-	-	0	6	-	-	0	57	-	-	0	66
	21-31	-	-	-	-	-	-	0	65	-	-	0	74
Feb.	1-10	-	-	-	-	-	-	0	63	-	-	0	69
	11-20	0	10	-	-	-	-	0	52	-	-	0	56
	21-28	0	25	-	-	-	-	0	32	-	-	0	34
Mar.	1-10	21	43	-	-	-	-	21	18	-	-	21	19
	11-20	0	67	-	-	0	12	0	16	0	10	0	15
	21-31	15	75	-	-	15	36	15	4	15	31	15	3
Apr.	1-10	29	48	-	-	14	36	-	-	19	27	-	-
	11-20	38	39	-	-	20	33	-	-	27	25	-	-
	21-30	25	45	-	-	10	41	-	-	18	35	-	-
May	1-10	90	1	-	-	30	28	-	-	53	14	-	-
	11-20	25	28	-	-	15	30	-	-	15	37	-	-
	21-31	23	30	-	-	23	13	-	-	12	37	-	-
Jun.	1-10	0	29	-	-	0	24	-	-	0	37	-	-
	11-20	0	21	-	-	0	28	-	-	0	40	-	-
	21-30	0	13	-	-	0	32	-	-	0	42	-	-
Jul.	1-10	0	4	-	-	0	34	-	-	0	40	-	-
	11-20	-	-	0	7	0	37	-	-	0	40	-	-
	21-31	-	-	0	24	0	42	-	-	0	43	-	-
Aug.	1-10	-	-	14	33	14	30	-	-	14	30	-	-
	11-20	-	-	6	47	6	31	-	-	6	30	-	-
	21-31	-	-	0	65	0	30	-	-	0	29	-	-
Seep.	1-10	-	-	0	82	0	24	-	-	0	23	-	-
	11-20	-	-	0	83	0	14	0	11	0	13	0	14
	21-30	-	-	0	75	0	4	0	33	0	4	0	41
Oct.	1-10	-	-	0	63	-	-	0	44	-	-	0	56
	11-20	-	-	0	60	-	-	0	48	-	-	0	60
	21-31	-	-	43	26	-	-	41	34	-	-	43	45
Nov.	1-10	-	-	70	0	-	-	25	30	-	-	54	31
	11-20	-	-	38	25	-	-	26	22	-	-	27	31
	21-30	-	-	39	23	-	-	14	20	-	-	12	29
Dec.	1-10	-	-	9	40	-	-	9	21	-	-	9	26
	11-20	-	-	0	37	-	-	0	35	-	-	0	41
	21-31	-	-	0	30	-	-	0	44	-	-	0	52

Table 5.2.2 Unit Diversion Water Requirement for Respective Crops

(Unit: l/s/ha)

Month	Day	Rice(L)	Rice(S)	Beans(L)	Beans(S)	Onions(L)	Tomatoes(S)
Jan.	1-10	-	0.40	-	1.12	-	1.30
	11-20	-	0.13	-	1.20	-	1.39
	21-31	-	-	-	1.24	-	1.41
Feb.	1-10	-	-	-	1.32	-	1.45
	11-20	0.22	-	-	1.09	-	1.17
	21-28	0.65	-	-	0.84	-	0.88
Mar.	1-10	0.90	-	-	0.38	-	0.39
	11-20	1.42	-	0.25	0.33	0.22	0.06
	21-31	1.44	-	0.69	0.08	0.58	-
Apr.	1-10	1.01	-	0.75	-	0.58	-
	11-20	0.81	-	0.70	-	0.53	-
	21-30	0.96	-	0.86	-	0.73	-
May	1-10	0.01	-	0.60	-	0.29	-
	11-20	0.60	-	0.64	-	0.78	-
	21-31	0.57	-	0.24	-	0.71	-
Jun.	1-10	0.61	-	0.51	-	0.77	-
	11-20	0.45	-	0.60	-	0.84	-
	21-30	0.28	-	0.68	-	0.88	-
Jul.	1-10	0.09	-	0.72	-	0.85	-
	11-20	-	0.15	0.77	-	0.85	-
	21-31	-	0.46	0.80	-	0.83	-
Aug.	1-10	-	0.70	0.64	-	0.64	-
	11-20	-	0.99	0.65	-	0.63	-
	21-31	-	1.24	0.58	-	0.55	-
Sep.	1-10	-	1.72	0.51	-	0.48	-
	11-20	-	1.74	0.30	0.23	0.27	0.29
	21-30	-	1.58	0.09	0.07	0.09	0.87
Oct.	1-10	-	1.34	-	0.93	-	1.17
	11-20	-	1.27	-	1.00	-	1.26
	21-31	-	0.49	-	0.65	-	0.86
Nov.	1-10	-	0.00	-	0.62	-	0.65
	11-20	-	0.52	-	0.46	-	0.65
	21-30	-	0.49	-	0.43	-	0.62
Dec.	1-10	-	0.85	-	0.44	-	0.55
	11-20	-	0.79	-	0.74	-	0.87
	21-31	-	0.57	-	0.84	-	0.99

Note: L: Long rains
S: Short rains

Table 5.2.3 Diversion Water Requirement (DWR)

(Unit: m^3/s)

Irrigation Part		Nyamindi			Thiba			Murithi			T-20		
Area (ha)		1185(60)	571	1756(60)	4560(444)	200	4760(444)	2470	430	2900	115	29	144
Month	Day	RDWR	HDWR	DWR	RDWR	HDWR	DWR	RDWR	HDWR	DWR	RDWR	HDWR	DWR
Jan.	1-10	0.45	0.69	1.14	1.65	0.24	1.89	0.99	0.52	1.51	0.05	0.04	0.09
	11-20	0.15	0.74	0.89	0.54	0.26	0.80	0.32	0.56	0.88	0.01	0.04	0.05
	21-31	0.00	0.76	0.76	0.00	0.27	0.27	0.00	0.57	0.57	0.00	0.04	0.04
Feb.	1-10	0.00	0.79	0.79	0.00	0.28	0.28	0.00	0.60	0.60	0.00	0.04	0.04
	11-20	0.25	0.65	0.90	0.91	0.23	1.14	0.54	0.49	1.03	0.03	0.03	0.06
	21-28	0.73	0.49	1.22	2.68	0.17	2.85	1.61	0.37	1.98	0.07	0.02	0.09
Mar.	1-10	1.01	0.22	1.23	3.70	0.08	3.78	2.22	0.17	2.39	0.10	0.01	0.11
	11-20	1.60	0.32	1.92	5.84	0.11	5.95	3.51	0.24	3.75	0.16	0.02	0.18
	21-31	1.62	0.41	2.03	5.93	0.14	6.07	3.56	0.31	3.87	0.17	0.02	0.19
Apr.	1-10	1.14	0.38	1.52	4.16	0.13	4.29	2.49	0.29	2.78	0.12	0.02	0.14
	11-20	0.91	0.35	1.26	3.33	0.12	3.45	2.00	0.27	2.27	0.09	0.02	0.11
	21-30	1.08	0.46	1.54	3.95	0.16	4.11	2.37	0.34	2.71	0.11	0.02	0.13
May	1-10	0.01	0.26	0.27	0.04	0.09	0.12	0.02	0.19	0.21	0.00	0.01	0.01
	11-20	0.68	0.41	1.09	2.47	0.14	2.61	1.48	0.31	1.79	0.07	0.02	0.09
	21-31	0.64	0.27	0.91	2.35	0.10	2.45	1.41	0.21	1.62	0.07	0.01	0.08
Jun.	1-10	0.69	0.37	1.06	2.51	0.13	2.64	1.51	0.28	1.79	0.07	0.02	0.09
	11-20	0.51	0.41	0.92	1.85	0.14	1.99	1.11	0.31	1.42	0.05	0.02	0.07
	21-30	0.32	0.45	0.77	1.15	0.16	1.31	0.69	0.34	1.03	0.03	0.02	0.05
Jul.	1-10	0.10	0.45	0.55	0.37	0.16	0.53	0.22	0.34	0.56	0.01	0.02	0.03
	11-20	0.17	0.46	0.63	0.62	0.16	0.78	0.37	0.35	0.72	0.02	0.02	0.04
	21-31	0.52	0.47	0.99	1.89	0.16	2.05	1.14	0.35	1.49	0.05	0.02	0.07
Aug.	1-10	0.79	0.37	1.16	2.88	0.13	3.01	1.73	0.28	2.01	0.08	0.02	0.10
	11-20	1.11	0.37	1.48	4.07	0.13	4.20	2.45	0.28	2.73	0.11	0.02	0.13
	21-31	1.40	0.33	1.73	5.10	0.11	5.21	3.06	0.25	3.31	0.14	0.02	0.16
Sep.	1-10	1.94	0.29	2.23	7.08	0.10	7.18	4.25	0.22	4.47	0.20	0.01	0.21
	11-20	1.96	0.31	2.27	7.16	0.11	7.27	4.30	0.24	4.54	0.20	0.02	0.22
	21-30	1.78	0.50	2.28	6.50	0.18	6.68	3.90	0.38	4.28	0.18	0.03	0.21
Oct.	1-10	1.51	0.60	2.11	5.52	0.21	5.73	3.31	0.45	3.76	0.15	0.03	0.18
	11-20	1.43	0.65	2.08	5.23	0.23	5.46	3.14	0.49	3.63	0.15	0.03	0.18
	21-31	0.55	0.43	0.98	2.02	0.15	2.17	1.21	0.33	1.54	0.06	0.02	0.08
Nov.	1-10	0.00	0.37	0.37	0.00	0.13	0.13	0.00	0.28	0.28	0.00	0.02	0.02
	11-20	0.59	0.32	0.91	2.14	0.11	2.25	1.28	0.24	1.52	0.06	0.02	0.08
	21-30	0.55	0.30	0.85	2.02	0.11	2.13	1.21	0.23	1.44	0.06	0.02	0.08
Dec.	1-10	0.96	0.29	1.25	3.50	0.10	3.60	2.10	0.22	2.32	0.10	0.01	0.11
	11-20	0.89	0.46	1.35	3.25	0.16	3.41	1.95	0.35	2.30	0.09	0.02	0.11
	21-31	0.64	0.53	1.18	2.35	0.18	2.53	1.41	0.40	1.81	0.07	0.03	0.10

Note: RDWR: Diversion water requirement for rice HDWR: Diversion water requirement for horticultural crops
Fitures in parenthesis shows irrigable area by reuse of return flow.

Table 5.2.4 Irrigable Area by Re-use Structure

No.	Catchment Area Unit No.	Catchment Area Area (ha)	Commanded Area Unit No.	Commanded Area Area (ha)	Irrigable Area (ha)
Nyamindi Part					
1	T2	22	T5	85	6
2	T5	7	T13	71	2
3	T6	57	T7	15	14
4	T7	54	T8	28	14
5	T8	28	T8	9	7
6	T8	7	T11	20	2
7	T13	38	T13	19	10
8	T19	18	(To NBI-II)	78	5
(Sub-total)		(231)		(325)	(60)
Thiba Part					
1	M3	7	M3	2	2
2	M4	74	M4	10	10
3	M4	15	M4	18	4
4	M7	14	(To TMC)	3,943	4
5	M9,M10	27	M11	16	7
6	M12(B)	12	M12(B)	3	3
7	M15	32	(To TMC)	3,215	8
8	M9-14,H18,H19	534	(To TBI-IV)	1,688	134
9	M15,M16,H20	150	(To TBI-II)	290	38
10	H1,H3	181	(To TBI-II)	179	45
11	H2,H4	182	(To TBI-III)	497	46
12	H5	156	H8	5	5
			(To TBI-III)	172	34
13	W6, K1	414	(To TBI-IV)	564	104
(Sub-total)		(1,789)		(10,602)	(444)
Total		(2,029)		(10,932)	(504)

Table 5.2.5 Net Irrigation Area in Each Unit

(Unit: ha)

Nyamindi System				Thiba System														Mutiti System							
Tebere Section				Mwea Section				Thiba Section				Wamumu Section				Karaba Section				Kibiriri Section				Rukanda Section			
No.	P	H	T	No.	P	H	T	No.	P	H	T	No.	P	H	T	No.	P	H	T	No.	P	H	T	No.	P	H	T
T1	-	52	52	M1	80	-	80	H1	73	-	73	W1	130	-	130	K1	208	-	208	I1	14	-	14	R1	29	-	29
2	22	32	54	2	41	-	41	2	92	6	98	2	195	-	195	2	165	-	165	2	-	131	131	2	12	-	12
3	-	43	43	3	53	-	53	3	108	-	108	3	173	-	173	3	132	-	132	3	-	22	22	3	37	-	37
4	-	19	19	4	132	59	191	4	90	16	106	4	132	-	132	4	145	-	145	4	93	-	93	4	60	-	60
5	117	21	138	5	75	-	75	5	156	10	166	5	163	-	163	5	148	-	148	5	-	18	18	5	69	-	69
6	57	-	57	6	64	5	69	6	111	-	111	6	206	-	206	6	111	-	111	6	74	-	74	6	89	-	89
7	110	-	110	7	49	25	74	7	83	-	83	7	121	14	135	7	131	-	131	7	-	163	163	7	90	-	90
8	159	-	159	8	25	-	25	8	96	-	96					8	30	-	30	8	84	-	84	8	54	-	54
9	-	119	119	9	51	4	55	18	115	-	115									9	57	-	57	9	20	12	32
10	-	113	113	10	33	26	59	19	111	-	111									10	47	-	47	10	-	28	28
11	129	-	129	11	48	-	48	20	115	-	115									11	128	-	128	11	-	42	42
12	-	17	17	12A	29	-	29													12	82	-	82	12	96	-	96
13	71	20	91	12B	48	-	48													13	124	-	124	13	92	-	92
14	-	80	80	13	68	-	68													14	114	-	114	14	82	-	82
15	34	-	34	14	106	13	119													15	99	-	99	15	84	-	84
16	77	15	92	15	47	-	47													16	137	-	137	16	86	-	86
17	23	-	23	16	132	8	140													17	67	-	67	17	61	-	61
18	59	23	82	17	139	14	153																	18	82	-	82
19	105	-	105																					19	29	5	34
20	115	29	144																					20	74	9	83
21	79	-	79																					21	58	-	58
22	74	-	74																					22	86	-	86
23	46	-	46																					23	42	-	42
24	-	7	7																					24	18	-	18
25	-	10	10																								
26	23	-	23																								
	1,300	600	1,900		1,220	154	1,374		1,150	32	1,182		1,120	14	1,134		1,070	-	1,070		1,120	334	1,454		1,350	96	1,446

Note: P - Paddy area
H - Horticultural crops area
T - Total area = P + H

Table 5.2.6 Drainage Area of Each Drainage Block

(Unit: ha)

Nyamindi System																															
NMD-I				NMD-II				NMD-III				Thiba System																			
												TMD-I				TBD-I-1				TMD-II				TMD-III				TMD-IV			
No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T
1	95	66	161	1	-	5	5	1	91	158	249	1	316	25	341	1	8	-	8	1	5	-	5	1	-	20	20	1	12	121	133
				2	104	22	126					2	-	35	35	2	16	-	16	2	30	-	30	2	78	80	158	2	-	21	21
				3	-	7	7					3	124	-	124	3	133	-	133	3	33	-	33	3	34	-	34	3	-	40	40
				4	15	-	15					4	-	27	27	4	35	8	43	4	21	-	21	4	12	-	12	4	33	-	33
				5	182	-	182					5	192	-	192	5	487	1,354	1,841	5	183	229	412	5	133	47	180	5	-	37	37
				6	162	-	162					6	153	-	153													6	16	95	111
												7	-	2	2													7	-	61	61
												8	297	200	499													8	-	18	18
																												9	358	36	394
	95	66	161		463	34	497		91	158	249		1,082	289	1,371		679	1,362	2,041		272	229	501		257	147	404		419	429	848

(Unit: ha)

Thiba System								Multihi System																							
TBD-IV-1				KDM				TAMD-I				TAMD-II				KMD-I				KBD-II				KMD-II-1				KMD-III				KMD-III-1			
No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T	No.	P	S	T
1	18	64	82	1	110	24	134	1	105	22	127	1	96	-	96	1	-	3	3	1	-	23	23	1	87	-	87	1	-	4	4	1	79	-	79
				2	131	5	136	2	81	11	92	2	101	-	101	2	72	25	97	2	-	16	16	2	-	156	156	2	-	6	6	2	161	-	161
				3	125	-	125	3	-	143	143	3	97	-	97	3	-	1	1	3	109	-	109					3	-	161	161	3	-	211	211
				4	-	66	66	4	-	269	269	4	93	-	93	4	99	24	123	4	17	177	194					4	-	8	8				
				5	12	63	75	5	-	44	44	5	71	9	80	5	55	8	63									5	-	112	112				
				6	31	-	31					6	15	-	15	6	-	33	33																
				7	38	-	38					7	44	-	44	7	69	53	122																
				8	34	-	34					8	23	60	83	8	-	9	9																
				9	88	52	140					9	-	10	10	9	15	-	15																
				10	68	-	68					10	48	11	59	10	-	7	7																
				11	-	4	4					11	-	7	7	11	113	13	126																
				12	-	3	3					12	-	74	74	12	84	-	84																
				13	-	393	393					13	-	292	292	13	-	308	308																
				14	-	131	131					14	-	308	308																				
	18	64	82		637	741	1,378		186	489	675		588	771	1,359		507	484	991		126	216	342		87	156	243		-	311	311		240	211	451

Note: P - Paddy area
S - Surrounding land area
T - Total area = P+S

NMD - Nyamindi Main Drain
TMD - Thiba Main Drain
TBD - Thiba Branch Drain

TAMD - Tana Main Drain
KMD - Kiruara Main Drain
KBD - Kiruara Branch Drain

Table 6.1.1 Summary of Reservoir and Dam

Item	Thiba Dam
1. Reservoir	
Catchment area	172.6 km^2
Reservoir capacity	
Effective storage capacity	15.0 MCM
Dead storage capacity	2.6 MCM
Total storage capacity	17.6 = 18.0 MCM
Water level	
Normal water level	EL. 1,380.0 m
High water level	EL. 1,382.5 m
Dead water level	EL. 1,363.0 m
Reservoir area	
Total storage area	1.2 km^2
High water level area	1.3 km^2
2. Dam	
Type	Inclined - core zoned fill type
Height	35.0 m
Crest elevation	El. 1,385.0 m
Crest length	1,350 m
Crest width	8 m
Slopes	
Upstream	1:3.0
Downstream	1:2.3
Embankment volume	1,200,000 m^3
3. Spillway	
Main spillway	Ungated side channel type
Design discharge	560 m^3/sec
Crest length	75 m
4. River diversion	
Diversion requirement	280 m^3/sec
Diversion tunnel	550 m
Diameter	2R Horse shoe 6.3 m
Coffer dam height	7 m
5. Intake and outlet works	
Intake capacity (draw down)	25 m^3/sec
Intake structure	Drop inlet
Outlet pipe diameter	2.0 m

Table 6.2.1 General Feature of Irrigation Canals

Canal Name	Canal Length (m)	Design Discharge (m^3/sec)	Base Width (m)	Water Depth (m)	Canal Height (m)
Nyamindi System					
NMI	4,480	2.28-1.95	5.50-2.00	0.69-0.56	0.80-0.90
NBI-I	6,400	0.99-0.04	2.00-0.30	0.72-0.14	0.90-0.30
NBI-II	5,600	1.01-0.05	1.00-0.30	0.81-0.12	1.00-0.30
NBI-III	3,550	0.24-0.04	0.60-0.30	0.32-0.15	0.50-0.30
Thiba System					
TMI	8,850	6.35-4.06	6.50-4.00	1.31-1.10	1.50-1.40
TBI-I	3,460	0.92-0.33	2.00-1.50	0.70-0.50	0.90-0.70
TBI-II	4,900	0.48-0.16	1.50-1.00	0.69-0.30	0.90-0.50
TBI-III	5,800	1.56-0.30	2.00-1.50	1.08-0.36	1.30-0.60
TBI-IV	15,870	2.73-0.28	3.50-1.50	1.23-0.40	1.40-0.60
Mutithi System					
MMI	1,100	4.46-1.53	2.00-1.10	1.53-0.91	1.70-1.10
MBI-I	4,110	0.44-0.13	0.70-0.30	0.53-0.17	0.70-0.40
MBI-II	7,460	0.77-0.09	0.90-0.70	0.90-0.23	0.90-0.40
MBI-III	9,110	1.72-0.17	1.20-0.40	1.19-0.34	1.40-0.50
MBI-IV	8,130	1.53-0.25	1.10-0.40	1.10-0.38	1.30-0.60
MBI-V	3,110	0.35-0.12	0.70-0.40	0.67-0.33	0.90-0.40

Table 6.2.2 Related Structures in Irrigation Canals (1/2)

- Nyamindi and Thiba System -

Structure Name	NMI			NBI-I			NBI-II			NBI-III			TMI			TBI-I			TBI-II			TBI-III			TBI-IV			TOTAL		
	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE
PF	1												1						1			1						4		
CV	1			3			2	2			1		2			3	1		6	1		3	4		12	5		32	14	
BG	4												4						1						2			11		
TO	4	2	1	6	2	3	3	6	2	2	1	1	12	1		6		1	6			6	5		8	1	1	53	18	9
CH		1					1														1			1				1	1	2
CF		1				1																						1	1	1
DR		15	5	15	1	3	14	1	2	11		1	26	5	10	1	4	5	1	12	1	6	15	3	6	22	10	80	75	40
CK		1	1	8	1	2	5		6	3		1	7		2				2	1	2	1		3	1	2		27	5	17
WS				1	1					1					3			1		1	2					2	3	2	4	9
SP							1				1				1				1									2	1	1
CL																														
CD																														
HS													1									5	1		6			12	1	
SM																									1			1		
CW						1	1					1						1			1			1			1			6
Sub-total:	10	20	7	33	5	10	27	9	10	17	3	4	53	6	16	10	5	8	18	15	7	22	25	8	36	32	15	226	120	85
Total:		37			48			46			24			75			23			41			55			83			431	

Note: EX - Existing structures unnecessary for rehabilitation
RE - Existing structures to be rehabilitated
NE - New structures to be constructed

PF - Parshall flume
CV - Culvert
BG - Bridge
TO - Turnout or offtake
CH - Chute
CF - Concrete flume
DR - Drop
CK - Check
WS - Washing step
SP - Spillway
CL - Concrete lining
CD - Cross drain
HS - Horse shoe weir
SM - Stone masonry
CW - Cipolletti weir

Table 6.2.2 Related Structures in Irrigation Canals (2/2)

- Mutithi System -

Structure Name	MMI	MBI-I	MBI-II	MBI-III	MBI-IV	MBI-V	Total
DR	3	15	19	39	30	1	107
CV			1	4	3		8
CK	2	6	8	10	9	2	37
TO	4	6	8	10	13	2	43
CW	2	1	1	2	1	1	8
WS		1	4	3	5	1	14
CD			2	1	1	1	5
CH				1	2		3
Total:	11	29	43	70	64	8	225

Note: DR - Drop
CV - Culvert
CK - Check
TO - Turnout or offtake
CW - Cipolletti weir
WS - Washing step
CD - Cross drain
CH - Chute

Table 6.2.3 General Feature of Drainage Canals

Canal Name	Canal Length (m)	Design Discharge (m^3/sec)	Base Width (m)	Water Depth (m)	Canal Height (m)
Nyamindi System					
NMD-I	1,230	1.92	1.5	0.85	1.10
NMD-II	4,020	6.07-2.01	2.5-1.5	1.38-0.76	1.5-1.00
NMD-III	600	3.01	2.0	0.96	1.20
Thiba System					
TMD-I	5,580	40.90-3.45	10.00-1.50	2.83-1.33	3.20-1.60
TBD-I-1	2,300	24.77-5.65	15.00-3.00	1.41-1.36	1.70-1.60
TMD-II	2,100	5.99-2.12	2.50-1.50	1.50-0.84	1.80-1.00
TMD-III	2,970	4.80-2.13	2.00-1.50	1.00-0.82	1.30-1.10
TMD-IV	4,560	11.18-4.15	3.00-1.50	1.35-0.69	1.60-1.20
TMD-IV-1	1,140	1.0	1.0	0.42	0.70
KMD	8,300	16.58-1.62	10.00-2.00	1.48-0.60	1.70-0.80
Mutithi System					
TAMD-I	6,390	8.22-0.55	2.40-0.60	2.36-0.45	2.60-0.70
TAMD-II	7,800	16.38-8.36	2.60-2.00	2.56-1.82	2.90-2.00
KMD-I	4,320	11.68-3.82	8.00-4.00	1.21-0.75	1.50-1.00
KMD-II	4,200	7.08-2.39	6.50-2.00	0.93-0.78	1.10-1.00
KBD-II-1	1,800	2.94-1.93	3.00-2.50	0.52-0.41	0.70-0.60
KMD-III	3,400	25.59-16.58	3.30-2.60	3.23-2.59	3.60-2.90
KBD-III-1	3,600	5.40-2.62	1.50-1.20	1.49-1.02	1.80-1.30

Table 6.2.4 Related Structures in Drainage Canals (1/2)

- Nyamindi and Thiba System -

Structure Name	NMD-I			NMD-II			NMD-III			TMD-I			TBD-I-1			TMD-II			TMD-III			TMD-IV			KMD			TOTAL		
	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE	EX	RE	NE
CV		3		2	1		1				3	2		1			5		2	1	2	2	1	2	2	2	1	9	17	7
DR	2		2			21			3			9		1	1		1	4			8			2			34	2	2	84
DI			2							4			4	4							1			1	2	3	3	10	7	7
DJ												1												2						3
CK																	1											1		
AD																			1						1			2	0	
Sub-total:	2	3	4	2	1	21	1		3	4	3	12	4	6	1		7	4	3	1	11	2	1	7	5	5	38	23	27	101
Total:		9			24			4			19			11			11			15			10			48			151	

Note: EX - Existing structures unnecessary for rehabilitation
RE - Existing structures to be rehabilitated
NE - New structures to be constructed

CV - Culvert
DR - Drop
DI - Drainage inlet
DJ - Drainage junction
CK - Check
AD - Aqueduct

Table 6.2.4 Related Structures in Drainage Canals (2/2)

- Mutithi System -

Structure Name	TAMD-I	TAMD-II	KMD-I	KMD-II	KMD-III	KBD II-1	KBD III-1	Total
CV	3	5	4	2	1	2	3	20
DR	17	32	16	20	16	4	11	116
DI	4	6	9	2	2	1	2	26
SY	2	2						4
DJ		3						3
Total:	26	48	29	24	19	7	16	169

Note: DR - Drop
CV - Culvert
DI - Drainage inlet
SY - Syphon
DJ - Drainage junction

Table 6.2.5 Farm Roads

Nyamindi Part		Thiba Part		Mutithi Part	
Road Name	Length(m)	Road Name	Length(m)	Road Name	Length(m)
FR-N-1	11,420	FR-T-1	21,840	FR-M-1	10,800
FR-N-2	15,440	FR-T-2	8,400	FR-M-2	1,000
FR-N-3	2,160	FR-T-3	38,780	FR-M-3	7,400
FR-N-4	1,660	FR-T-4	17,000	FR-M-4	400
FR-N-5	2,040	FR-T-5	3,640	FR-M-5	950
FR-N-6	3,000	FR-T-6	1,000	FR-M-6	950
FR-N-7	780	FR-T-7	1,32	FR-M-7	1,350
FR-N-8	460	FR-T-8	2,840	FR-M-8	22,700
FR-N-9	200	FR-T-9	3,040	FR-M-9	1,720
FR-N-10	2,900	FR-T-10	1,460	FR-M-10	620
FR-N-11	640	FR-T-11	2,600	FR-M-11	2,770
FR-N-12	300	FR-T-12	4,460	FR-M-12	3,180
		FR-T-13	2,060	FR-M-13	1,300
		FR-T-14	2,600	FR-M-14	300
		FR-T-15	1,840	FR-M-15	15,670
		FR-T-16	2,400	FR-M-16	2,300
		FR-T-17	1,580	FR-M-17	1,740
		FR-T-18	3,060	FR-M-18	2,120
		FR-T-19	2,800	FR-M-19	2,630
				FR-M-20	720
Total	41,000		122,720		80,620

Table 6.4.1 Extension of Existing Reception Center in MIS and Construction of New Reception Center 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 6.4.2 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 6.4.3 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

Table 6.6.1 Summary of the Project Cost

(Unit: KShs.x10^6)

Description	Phase I			Phase II			Total		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
1. Construction Cost	70.5	87.9	158.4	156.4	322.4	478.8	226.9	410.3	637.2
Dam Works	-	-	-	96.9	235.0	331.9	96.9	235.0	331.9
Headworks	3.8	4.8	8.6	1.3	1.4	2.7	5.1	6.2	11.3
Link Canals	13.3	31.4	44.7	6.7	13.7	20.4	20.0	45.1	65.1
Irrigation Facilities	25.1	25.5	50.6	27.6	32.1	59.7	52.7	57.6	110.3
On-Farm	28.3	26.2	54.5	23.9	40.2	64.1	52.2	66.4	118.6
2. Initial Farm Investment	17.3	86.3	103.6	12.1	58.0	70.1	29.4	144.3	173.7
O & M Equipment	4.8	31.3	36.1	4.0	25.5	29.5	8.8	56.8	65.6
Agricultural Machinery	4.7	47.0	51.7	2.7	26.8	29.5	7.4	73.8	81.2
Farm Buildings	7.8	8.0	15.8	5.4	5.7	11.1	13.2	13.7	26.9
3. Administration Cost	7.9	-	7.9	16.5	-	16.5	24.4	-	24.4
4. Engineering Cost	10.5	15.7	26.2	22.0	32.9	54.9	32.5	48.6	81.1
5. Land Acquisition	0.3	-	0.3	1.6	-	1.6	1.9	-	1.9
Sub-total:	106.5	189.9	296.4	208.6	413.3	621.9	315.1	603.2	918.3
Physical Contingency	10.7	19.0	29.7	20.9	41.2	62.1	31.6	60.2	91.8
Total:	117.2	208.9	326.1	229.5	454.5	684.0	346.7	663.4	1,010.1
Price Contingency	26.8	18.8	45.6	94.9	76.5	171.4	121.7	95.3	217.0
Grand Total:	144.0	227.7	371.7	324.4	531.0	855.4	468.4	758.7	1,227.1

Table 6.6.2 Annual Disbersement Schedule of the Project

(Unit: KShs. Million)

Description	Fiscal Year 1988		1989		1990		1991		1992		1993		Total		
	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	Total
1. Phase-I															
1 - 1 Construction Cost			24.4	41.3	2.1	4.3	44.0	42.3					70.5	87.9	158.4
Headworks			3.1	3.9	0.7	0.9							3.8	4.8	8.6
Link canals			11.9	28.0	1.4	3.4							13.3	31.4	44.7
Irrigation facilities			6.9	7.1			18.2	18.4					25.1	25.5	50.6
On-farm			2.5	2.3			25.8	23.9					28.3	26.2	54.5
1 - 2 Initial Farm Investment			7.1	37.2	7.0	17.2	3.2	31.9					17.3	86.3	103.6
O & M equipment			3.0	19.4	1.8	11.9							4.8	31.3	36.1
Agricultural machinery			1.5	15.1			3.2	31.9					4.7	47.0	51.7
Farm buildings			2.6	2.7	5.2	5.3							7.8	8.0	15.8
1 - 3 Administration Cost	1.9		2.0		2.0		2.0						7.9	0.0	7.9
1 - 4 Engineering Cost	5.3	7.9	2.1	3.1	0.5	0.8	2.6	3.9					10.5	15.7	26.2
1 - 5 Land Acquisition			0.3										0.3	0.0	0.3
Sub-total:	7.2	7.9	35.9	81.6	11.6	22.3	51.8	78.1					106.5	189.9	296.4
1 - 6 Physical Contingency	0.7	0.8	3.6	8.2	1.2	2.2	5.2	7.8					10.7	19.0	29.7
Sub-total:	7.9	8.7	39.5	89.8	12.8	24.5	57.0	85.9					117.2	208.9	326.1
1 - 7 Price Contingency	0.5	0.2	5.7	5.5	2.9	2.3	17.7	10.8					26.8	18.8	45.6
Total:	8.4	8.9	45.2	95.3	15.7	26.8	74.7	96.7					144.0	227.7	371.7
2. Phase-II															
2 - 1 Construction Cost							19.4	47.0	66.6	134.7	70.4	140.7	156.4	322.4	478.8
Dam works							19.4	47.0	38.7	94.0	38.8	94.0	96.9	235.0	331.9
Head works											1.3	1.4	1.3	1.4	2.7
Link canals									2.2	4.6	4.5	9.1	6.7	13.7	20.4
Irrigation facilities									13.8	16.0	13.8	16.1	27.6	32.1	59.7
On-farm									11.9	20.1	12.0	20.1	23.9	40.2	64.1
2 - 2 Initial Farm Investment											12.1	58.0	12.1	58.0	70.1
O & M equipment											4.0	25.5	4.0	25.5	29.5
Agricultural machinery											2.7	26.8	2.7	26.8	29.5
Farm-buildings											5.4	5.7	5.4	5.7	11.1
2 - 3 Administration Cost			2.8		2.8		2.9		4.0		4.0		16.5		16.5
2 - 4 Engineering Cost			6.3	9.4	6.4	9.4	3.1	4.7	3.1	4.7	3.1	4.7	22.0	32.9	54.9
2 - 5 Land Acquisition							1.6						1.6		1.6
Sub-total:			9.1	9.4	9.2	9.4	27.0	51.7	73.7	139.4	89.6	203.4	208.6	413.3	621.9
2 - 6 Physical Contingency			0.9	0.9	0.9	0.9	2.7	5.2	7.4	13.9	9.0	20.3	20.9	41.2	62.1
Sub-total:			10.0	10.3	10.1	10.3	29.7	56.9	81.1	153.3	98.6	223.7	229.5	454.5	684.0
2 - 7 Price Contingency			1.4	0.6	2.3	1.0	9.2	7.1	32.6	24.4	49.4	43.4	94.9	76.5	171.4
Total:			11.4	10.9	12.4	11.3	38.9	64.0	113.7	177.7	148.0	267.1	324.4	531.0	855.4
Grand Total:	8.4	8.9	56.6	106.2	28.1	38.1	113.6	160.7	113.7	177.7	148.0	267.1	468.4	758.7	1,227.1

Table 6.6.3 Annual Operation & Maintenance Cost

Item	Amount (KShs.x10^3)
1. Salaries & Wages	
1-1 Staff Salaries	13,700
1-2 Labour Wages (200 M/M @1600 Kshs.)	320
2. Office Expenses	411
3. Operation & Maintenance Cost	
3-1 Depreciation of O & M Equipment	16,400
3-2 Dam	2,468
3-3 Irrigation	19,466
Total:	52,765

Table 6.6.4 O & M Staff Salary

Item	Required Number	Annual Rate	Annual Amount (KShs.x10^3)
Managing staff	32	70	2,240
Technical & Administrative staff	174	40	6,960
Workers & Labours	225	20	4,500
Total:			13,700

Table 6.6.5 Replacement Cost

	Item	Useful Life (year)	Replacement Cost (KShs.x10^3)
1.	O & M Equipment	10	65,583
2.	Project Fcilities		27,841
(1)	Dam	25	24,433
(2)	Headworks	25	1,992
(3)	Irrigation facilities	25	708
(4)	On-Farm (stop log)	5	90

Table 8.2.1 Structure of Financial and Economic Cost (in percent)

Cost Component	Financial Cost				Economic Cost				Weighted Conversion Factor
	Local Cost			Foreign Cost	Local Cost			Foreign Cost	
	Transfer Payment	Unskilled Labour	Others		Transfer Payment	Unskilled Labour	Others		
Capital Cost									
1. Dam & Reservoir	10	6	13	71	-	2	11	71	0.84
2. Irrigation Works	9	12	21	58	-	4	18	58	0.80
3. Office & Quarters	9	15	76	-	-	5	65	-	0.70
4. Land Acquisition	-	-	100	-	-	-	86	-	0.86
5. Agricultural Machinery and O&M Equipment	-	-	10	90	-	-	9	90	0.99
6. Administration	-	-	100	-	-	-	86	-	0.86
7. Engineering Services	4	-	35	60	-	-	30	60	0.90
8. On-Farm Development	9	15	20	56	-	5	17	56	0.78
O&M Cost									
1. Salaries & Wages	10	20	70	-	-	7	60	-	0.67
2. Office Expenses	10	-	90	-	-	-	77	-	0.77
3. O&M Expenses									
a. Dam	9	5	86	-	-	2	74	-	0.76
b. Irrigation	9	10	81	-	-	3	70	-	0.73

Note: The conversion factor for the transfer payments like taxes and duties is 0, compared to 0.344 for unskilled construction labour, 0.86 for other local costs and 1.00 for foreign costs.
Last column indicates the specific economic conversion factor for each cost component.

Table 8.2.2 Cost and Benefit Stream (Original Case)

(Unit:KShs.million)

Year In Order	Year (Tentative)	Economic Cost				Agricultural Benefit
		Construction Cost	Replacement Cost	O&M Cost	Total	
1.	1988	14.9			14.9	
2.	1989	130.8			130.8	
3.	1990	51.9			51.9	
4.	1991	195.9			195.9	
5.	1992	194.4		10.6	205.0	25.3
6.	1993	277.9		12.4	290.3	30.3
7.	1994			20.0	20.0	159.9
8.	1995			22.7	22.7	189.9
9.	1996			25.5	25.5	219.9
10.	1997		51.1	26.4	77.5	249.8
11.	1998			27.4	27.4	274.7
12.	1999		29.2	27.4	56.6	299.6
13.	2000			27.4	27.4	299.6
14.	2001			27.4	27.4	299.6
15.	2002		86.8	27.4	114.2	299.6
16.	2003			27.4	27.4	299.6
17.	2004		58.4	27.4	85.8	299.6
18.	2005			27.4	27.4	299.6
19.	2006			27.4	27.4	299.6
20.	2007		51.1	27.4	78.5	299.6
21.	2008			27.4	27.4	299.6
22.	2009		29.2	27.4	56.6	299.6
23.	2010			27.4	27.4	299.6
24.	2011			27.4	27.4	299.6
25.	2012		100.4	27.4	127.8	299.6
26.	2013			27.4	27.4	299.6
27.	2014		67.9	27.4	95.3	299.6
28.	2015			27.4	27.4	299.6
29.	2016			27.4	27.4	299.6
30.	2017		52.7	27.4	80.1	299.6
31.	2018			27.4	27.4	299.6
32.	2019		50.9	27.4	78.3	299.6
33.	2020			27.4	27.4	299.6
34.	2021			27.4	27.4	299.6
35.	2022		86.8	27.4	114.2	299.6
36.	2023			27.4	27.4	299.6
37.	2024		58.4	27.4	85.8	299.6
38.	2025			27.4	27.4	299.6
39.	2026			27.4	27.4	299.6
40.	2027		51.1	27.4	78.5	299.6
41.	2028			27.4	27.4	299.6
42.	2029		29.2	27.4	56.6	299.6
43.	2030			27.4	27.4	299.6
44.	2031			27.4	27.4	299.6
45.	2032		100.4	27.4	127.8	299.6
46.	2033			27.4	27.4	299.6
47.	2034		67.9	27.4	95.3	299.6
48.	2035			27.4	27.4	299.6
49.	2036			27.4	27.4	299.6
50.	2037		51.1	27.4	78.5	299.6

I.R.R= 18.4%

Table 8.3.1 Financial Cash Flow Statement

(Unit :Kshs. million)

Year	Year in Order	Cash Outflow: Project Cost	O &M Cost	Replacement Cost	Loan Interest	Loan Repayment	Total Outflow(A)	Cash Inflow: Foreign Loan	Government Budget	Government Subsidy	Water Charge	Total Inflow(B)	Balance (B)-(A)	Accumulated Loan
1987	1	17.3	0.0	0.0	0.3	0.0	17.6	8.9	8.4	0.3	0.0	17.6	0.0	8.9
1988	2	162.8	0.0	0.0	3.5	0.0	166.3	106.2	56.6	3.5	0.0	166.3	0.0	115.1
1989	3	66.2	0.0	0.0	4.6	0.0	70.8	38.1	28.1	4.6	0.0	70.8	0.0	153.2
1990	4	274.3	0.0	0.0	9.5	0.0	283.8	160.7	113.6	9.5	0.0	283.8	0.0	313.9
1991	5	291.4	20.6	0.0	14.8	0.0	326.8	177.7	113.7	35.4	0.0	326.8	0.0	491.6
1992	6	415.1	24.0	0.0	22.8	0.0	461.9	267.1	148.0	46.8	0.0	461.9	0.0	758.7
1993	7	0.0	38.5	0.0	22.8	0.0	61.3	0.0	0.0	61.3	0.0	61.3	0.0	758.7
1994	8	0.0	43.9	0.0	22.8	0.0	66.7	0.0	0.0	66.7	0.0	66.7	0.0	758.7
1995	9	0.0	49.1	0.0	22.8	0.0	71.9	0.0	0.0	71.9	0.0	71.9	0.0	758.7
1996	10	0.0	51.0	51.7	22.8	0.0	125.5	0.0	0.0	125.5	0.0	125.5	0.0	758.7
1997	11	0.0	52.8	0.0	21.7	37.9	112.4	0.0	0.0	112.4	0.0	112.4	0.0	720.8
1998	12	0.0	52.8	29.5	20.5	37.9	140.8	0.0	0.0	140.8	0.0	140.8	0.0	682.8
1999	13	0.0	52.8	0.0	19.4	37.9	110.1	0.0	0.0	110.1	0.0	110.1	0.0	644.9
2000	14	0.0	52.8	0.0	18.3	37.9	109.0	0.0	0.0	109.0	0.0	109.0	0.0	607.0
2001	15	0.0	52.8	87.8	17.1	37.9	195.7	0.0	0.0	195.7	0.0	195.7	0.0	569.0
2002	16	0.0	52.8	0.0	16.0	37.9	106.7	0.0	0.0	106.7	0.0	106.7	0.0	531.1
2003	17	0.0	52.8	59.0	14.8	37.9	164.6	0.0	0.0	164.6	0.0	164.6	0.0	493.2
2004	18	0.0	52.8	0.0	13.7	37.9	104.4	0.0	0.0	104.4	0.0	104.4	0.0	455.2
2005	19	0.0	52.8	0.0	12.6	37.9	103.3	0.0	0.0	103.3	0.0	103.3	0.0	417.3
2006	20	0.0	52.8	51.7	11.4	37.9	153.9	0.0	0.0	153.9	0.0	153.9	0.0	379.4
2007	21	0.0	52.8	0.0	10.3	37.9	101.0	0.0	0.0	101.0	0.0	101.0	0.0	341.4
2008	22	0.0	52.8	29.5	9.2	37.9	129.4	0.0	0.0	129.4	0.0	129.4	0.0	303.5
2009	23	0.0	52.8	0.0	8.0	37.9	98.7	0.0	0.0	98.7	0.0	98.7	0.0	265.5
2010	24	0.0	52.8	0.0	6.9	37.9	97.6	0.0	0.0	97.6	0.0	97.6	0.0	227.6
2011	25	0.0	52.8	103.7	5.7	37.9	200.2	0.0	0.0	200.2	0.0	200.2	0.0	189.7
2012	26	0.0	52.8	0.0	4.6	37.9	95.3	0.0	0.0	95.3	0.0	95.3	0.0	151.7
2013	27	0.0	52.8	70.1	3.5	37.9	164.3	0.0	0.0	164.3	0.0	164.3	0.0	113.8
2014	28	0.0	52.8	0.0	2.3	37.9	93.1	0.0	0.0	93.1	0.0	93.1	0.0	75.9
2015	29	0.0	52.8	53.5	1.2	37.9	145.4	0.0	0.0	145.4	0.0	145.4	0.0	37.9
2016	30	0.0	52.8	0.0	0.1	37.9	90.8	0.0	0.0	90.8	0.0	90.8	0.0	0.0
Total		1,227.1	1,283.1	536.5	363.9	758.7	4,169.3	758.7	468.4	2,942.2	0.0	4,169.3	0.0	

Foreign Loan: Annual interest of 3.0% for repayment period of 30 years including 10-year grace period.