2.5 Land Holding System

There are three types of land ownership in Kenya, i.e. Government land, Trust land and Private land. According to information obtained through Land Adjudication Office at Kisumu and Survey of Kenya at Nairobi, land in Nyakach Division has been completely adjudicated and registered in title of private land. Besides, most of the project area is also registered as private land.

The holding sizes of agricultural land in these areas are estimated as follows:

Location	Total area (km^2)	Agricultural land 1/ (km^2)	No. of household	Agricultural land per household (ha)
North Nyakach	183	128	6,489	1.97
West Nyakach	97	72	4,025	1.79
Wang Chieng	92	67	3,291	2.04

Based on the above, the holding size of agricultural land per household in the project area is estimated at about 2.0 ha on an average.

2.6 Present Cropping Patterns

The main crops grown in the project area are cotton, maize and sorghum followed by groundnut and beans. Maize and sorghum are staple food crops, generally grown in intercropping method with several kinds of beans like cowpea, green gram, etc., and also with cotton. Cotton is cultivated as the dominant cash crop in the area. Those crops are cultivated under the rainfed condition. Wetland rice is cultivated in a very limited lowlying area where irrigation has been developed under the

Small-Scale Irrigation Project. Cultivation of fruits and vegetables is very scarce due to lack of irrigation.

The planted area by crops in Wang Chieng Location and Nyakach Division are presented in Table 2.4 and Table 2.5, and summarized below:

Crops	Wang Chieng Location *		Nyakach Division **	
	Planted area (ha)	Propor-tion (%)	Planted area (ha)	Propor-tion (%)
Maize	2,910	26	2,030	26
Sorghum	2,520	23	1,150	15
Beans	30	-	300	4
Rice	-	-	230	3
Groundnut	1,040	9	420	5
Cassava	500	4	430	6
Cotton	3,580	32	2,350	31
Others	590	6	730	10
Total	11,170	100	7,640	100

*: Average for 1981 and 1982, see Table 2.4
**: Average for 1977-1980 and 1983, see Table 2.5

Although the planted area of crops in this region fluctuates year by year according to occurrence of rainfall, about one third of the planted area in a year is occupied by maize both in Nyakach Division and Wang Chieng Location. Cotton covers also about one third of the cropped area, and sorghum covers about 15 to 20% of the cropped area. Both in Nyakach and Wang Chieng, about two thirds of the cropped area are used for food crop production.

The cultivation pattern of crops is largely affected by seasonal distribution of rainfall. The planting time and the harvesting time have rather wide range because the crops are usually planted at the onset of the rainy season; planting time delays with delay of onset of rainy season. Maize, sorghum and beans for the long rainy season are planted during February to March, and harvested during May to August. Maize and sorghum for the short rainy season are generally planted in September to October and harvested in December to January. Cotton has rather long sowing time from February to June, but in the major part of the project area, it is planted during April, and harvested mainly in October to January. Rice cropping under the Small-Scale Irrigation Project is also largely affected by the rainfall because the irrigation water is drawn from small streams of which flows depend on directly to the rainfall. Sowing of rice is done during April to July and harvested from August to January. These typical cropping patterns being prevailed and the estimated cultivation area of the main crops in the command area are summarized below:

(Unit : ha)

Crops	Cultivated area *	Crop season	
		Planting	Harvesting
1. Upland crops:			
Maize	370	Feb-Mar	May-Aug
		Sep-Oct	Dec-Jan
Sorghum	250	Feb-Mar	May-Aug
		Sep-Oct	Dec-Jan
Cotton	370	Feb-Jun	Oct-Jan
Groundnut	125	Mar-Apr	Jul-Aug
Cassava and others	125	Mar-Apr	Jul-Aug
2. Rice (Small-Scale Irrigation)	130	Apr-Aug	Aug-Jan
Total	1,370		

* : Eco-system

2.7 Present Farming Practices and Farm Inputs

Farm operation in the project area is mostly carried out by man power. Animal power by oxen, is sometimes used for soil preparation. The agricultural machinery is not commonly used yet. Maize and sorghum are planted in density of 90 cm x 30 cm. Beans to be intercropped are usually planted two weeks later than sowing of maize or sorghum. In some fields maize and sorghum are planted in alternate row, this method is enable to secure the minimum food in case of failure of maize due to severe draught, since sorghum can resist draught hazard. Cotton is mostly cultivated in the area in pure stand and sometimes cultivated in relay with maize or sorghum. Sowing of cotton for intercropping method is done about two months later than that of the preceding crops. Cassava is grown as a reserve for staple food mainly on the high permeable soils in Sub-areas I and II. Vegetables and fruits are grown mainly in the homeyard and the area covered by these crops are very limited. Rice is cultivated as one of the important cash crops in the area, but the paddy field is developped in the very limited area, i.e. a part of Gem Rae Sub-location and Wasare area of Middle Jimo Sub-location. Cultivation method of rice is the ordinary transplanting. Sowing is done in the nursery about three weeks before transplanting.

The varieties of maize and rice grown in the area are mostly improved varieties: hybrid varieties like H-622, H-511 for maize, IR1561-228-3-3, Sindano and Basmati 217 for rice. The sorghum variety cultivated in the area is mostly the local variety.

Some pests and diseases are frequently found on crops in the area. The most common insects and diseases found on rice are stem borers, stalkeyed fly, blast, blight and rice yellow mottle virus, etc. Pests found on maize, sorghum, cotton, groundnut are such as stalk borers, aphids, midge and bugs, ballworms, etc. Diseases for groundnut are leaf spots, rosette, blight, etc. Wilt and spots are found for cotton. Birds like weaver are also very damageable on the crops in the area. Almost all of those crops are grown without applying chemical fertilizers and agricultural chemicals like insecticides and fungicides. Only cotton is sprayed in some cases with insecticides for twice to four times during a crop season.

Present requirement of the farm inputs and the labours per ha for crop cultivation under the present condition are summarized as seen in Table 2.6.

2.8 Present Crop Yield and Production

Present crop yield and production in the command area are estimated on the basis of data of the cropped area and production obtained from Kisumu District Agricultural Office, Nyakach Division Agricultural Extension Office, Kendu Division Agricultural Extension Office and data cited in the Farm Management Handbook of Kenya. Unit yields of main crops in and around the project area are summarized as follows:

(Unit : ton/ha)

	Nyakach*	Nyakach**	Wang Chieng***	Handbook 1/
Maize	2.8	1.8-2.3	1.1	1.3
Sorghum	0.9	0.8-1.0	0.3	1.2
Beans	0.4	0.9	0.1	0.4
Rice	2.2	3.4	-	-
Groundnut	0.8	0.8	0.1	0.5
Cotton	0.2	0.3-0.4	0.3	0.2
Maize/Beans	-	-	-	1.3/0.2
Sweet potato	8.9	10	-	5
Cassava	7.9	5	0.5	3

*: Data are derived from Table 2.5, the unit yield of crops is average value for the whole Nyakach Division.

**: Data are obtained from Agricultural Extension Office.

***: Data are derived from Table 2.4.

Besides the above data, some interviews with farmers in the area were made to obtain information about unit yield and production of main crops in the area. The information from the farmers indicated that the crop yield and production in the project area fluctuate year by year. Yield of maize, for example, reaches to 50 bags (about 3.7 t/ha) in the best year and falls down to only 3 bags (200 kg/ha) in the worst year.

Based on the above data and information, the unit yield of main crops in the project area under the present condition is estimated as seen below:

(Unit : ton/ha)

Crops	Yield
Maize & Beans:	
Maize (Hybrid)	1.3
Beans	0.2
Sorghum	1.2
Beans	0.4
Rice	2.4
Groundnut	0.5
Cotton	0.2
Cassava	3.0

Present crop production in the command area is estimated based on the unit yield of crops mentioned above and the cropped area with the present cropping pattern. The estimated crop production is as seen below:

Crops	Planted area (ha)	Unit yield (ton/ha)	Production (ton)
Maize	370	1.3	480
Sorghum	250	1.2	300
Rice	130	2.4	310
Cotton	370	0.2	70
Groundnut	125	0.5	60
Cassava	125	3.0	380

As seen in the above, the food production in the average year is very short to maintain the population (26,990 persons) in the area.

2.9 Livestock Production

Livestock raising is not mainline of agricultural activities in the project area at present, however it is important as source of farm power. Cattle is the most important livestock. For a long time most of the farmers have been keeping indigenous one, say zebus. Sheep and goats are the second important livestock species in the area. Livestock is traditionally grazing in the field after harvest, in pasture of natural grass or in fallow field. Number of livestock in North and West Nyakach Locations are presented in Table 2.7. Refering to the data shown in the table, the average holding number of livestock per household in the project area is estimated at 3 cattle, 1 goat, 2 sheep and 3 poultry. The estimated number of livestock in the area is seen below:

Description	Livestock	
1. No. of Household		5,660
2. Average Number[2/] of Livestock per Household	Goat	1
	Sheep	2
	Poultry	3
3. Estimated Number of Livestock	Cattle	16,980
	Goat	5,660
	Sheep	11,320
	Poultry	16,980

The slaughtered numbers of cattle raised in Kisumu District per year are about 7,600 heads or 3.5% of the total head of cattle in the district. Applying the production ratio of 3.5%, the present cattle production in the area is estimated at about 450 heads per year.

2.10 Marketing and Prices

2.10.1 Present Marketing System

Since marketing policy in Kenya is tied up with pricing policy, the various agricultural produce in the country and abroad are dealt with mainly through the parastatal marketing bodies. Some deal with an individual crop while others deal with a number of different crops. Some of the bodies also provide quality control services for crop development through licensing procedures, supply of inputs to the growers, credit and extension services, as well as providing research services.

(1) Marketing of Maize, Sorghum, Rice and Beans

With regard to food crops, the monopoly in buying and selling is held by the National Cereals and Produce Board (NCPB). The Board is responsible for purchasing maize from farmers. Besides maize, the Board handles other crops such as beans, oil crops, millet, sorghum and rice. Farmers who produce any of the above crops have to send their produce to the nearest buying centre, depot, or certain agents appointed by NCPB.

(2) Marketing of Cotton

The Cotton Lint and Seed Marketing Board (CLSMB) is responsible for all purchase of seed cotton, ginning and the sale of lint and cotton seed. The Board also supplies farmers cotton seed in free of charge. Purchasing of seed cotton is mostly done by cooperative societies or unions. In the project area, however, the societies have not function due to improper management and the Board is buying directly at present.

(3) Marketing of Other Products

The marketing of vegetables or fruits is mainly handled by the private sector, which is bound to the general regulations of the Horticultural Crops Development Authority (HCDA). The livestock market relevant for the project area is located in Ahero. There, private traders, mostly from Kisumu, buy cattle, sheep and goats from the local farmers.

(4) Supply of Farm Inputs

Most of farm inputs are distributed by Kenya Grain Growers Cooperation Union (KGGCU) through its nationwide network. There is one of the branches in Kisumu dealing with necessary inputs. The co-operative unions and societies also play a significant role in the supply of inputs. With regard to seeds, Kenya Seed Company (KSC) is responsible for the supply of commercial seeds for most crops. Various chemicals and equipment are also often handled by private companies as well as by KGGCU.

2.10.2 Prices of Agricultural Commodities

In 1972 the Government introduced price control system for important basic food. Under this system major crops such as maize and rice on all marketing levels are controlled by fixed prices, while meat is controlled on its rated prices. Those government controlled prices on various commodities for producers are shown in Table 2.8. The market prices of farm inputs and outputs in and around the project area are presented in Table 2.9 and Table 2.10. Besides, farm gate prices are shown in Table 2.11 and Table 2.12.

2.10.3 Existing Processing Facilities

Rice Mills

Paddy produced in and around the project area is processed at the privately owned rice mills in Kisumu and Ahero, and also processed by hand pounding for home consumption. The total milling capacity of mills in Kisumu and Ahero is estimated at about 20,000 tons per year, as follows:

- Kisumu, 3 ton/hr. x 20 hr/day x 250 days/year = 15,000 ton/year.
- Ahero, 1 ton/hr. x 20 hr/day x 250 days/year = 5,000 ton/year.

Present annual paddy production milled by these existing mills amounts to about 9,500 tons. Out of 9,500 tons of paddy, about 8,400 tons are produced in NIB Schemes, at Ahero, West Kano and Bunyala, and the rest is produced mainly in the Small-Scale Irrigation Projects as seen below:

(Unit : ton)

	1979	1980	1981	1982
1. Small-scale schemes 3/	-	1,000	1,100	1,300
2. NIB Schemes 4/				
Ahero	3,600	4,100	-	-
West Kano	2,100	3,400	-	-
Bunyala	700	800	-	-
Total	6,400	9,300	-	-

Chapter 3. INSTITUTIONS AND SUPPORTING SERVICES FOR AGRICULTURE

3.1 Research Stations and Pilot Schemes

Ahero Irrigation Research Station (AIRS) of NIB is located in the Ahero Irrigation Scheme (AIS), adjacent to the project area. The station has been operated since 1969 with objectives to carry out applied research to assess optimum methods for the cultivation of rice and other crops under irrigation and the most appropriate irrigation system for full exploitation of irrigation potential of the Kano plain.

AIRS has about 800 ha of irrigated rice field which was opened in 1966. Besides AIRS and AIS, West Kano Pilot Scheme (900 ha) was established in 1976 to grow rice and sugarcane by pump irrigation from Lake Victoria. For other crops there are two national research stations, i.e. Cotton Research Station and Sugarcane Research Station at Kibos. These research stations are responsible to carry out experimental work and provide information to improve their productivity.

3.2 Credit Services

Agriculture credit in Kenya is supported by four main sources: Cereals and Sugar Finance Corporation, foreign donors, selling of promissory notes, and mobilization of savings. There are five channels through which these funds are transmitted to farmers, i.e. Agricultural Finance Corporation (AFC), Co-operative Bank of Kenya (CBK), parastatal organizations, and commercial banks and companies. The main agencies involved in lending are AFC and CBK. The farmers are applicable advance credit for purchase of livestock, equipment, machinery, even for land. Most of the credit lent are short term and unsecured basis for growing crops, mainly maize and wheat. There have been formed a variety of programme and scheme such as;

Smallholder Production and Service Credit Program (SPSCP)
Integrated Agricultural Development Programme (IADP Phase I and II)
Farm Input Supply Scheme (FISS)
Smallholder Credit Scheme (New Seasonal Credit Scheme) (NSCS)
Smallholder Coffee Improvement Scheme (SCIP)
Cooperative Production Credit Scheme (CPCS)
Factory Improvement Loan ,and Others

3.3 Extension Services

The extension services not only provide technical information and skills to farmers for intensifications of the production process, but also coordinate complementary services such as input supply, credit and marketing. The Ministry of Agriculture has the Extension and Manpower Development Division headed by a Deputy Director of Agriculture under the Agriculture Department at the national level. At the provincial level the Department of Agriculture is represented by an Assistant Director of Agriculture (ADA) who is usually referred to as Provincial Director of Agriculture. He is assisted by a team of specialists. At district level the Department is represented by a Senior Agriculture Officer and a team of specialists. This line is continued up to the locational level where the Locational Extension Office comes into direct contact with the farmers. The organization lines are illustrated in Figure 3.1. The project Sub-areas II and III come under the Nyakach Division Agricultural Extension Office of Kisumu District and Sub-area I under that of Kendu Division of South Nyanza District. The officers of the Nyakach Agricultural Extension Office are shown in Table 3.1.

3.4 Seed Multiplication

In the project area, the farmers generally retain seeds from their own produce of the local varieties. Cotton seed is available from the Cotton Lint and Seed Marketing Board in free of charge as described at preceding section. Improved seeds for all crops are available on the

Kenyan market as well as from Kenyan Seed Company. Rice seeds which are tested and released at Ahero Irrigation Research Station are available for the farmers.

Chapter 4. BASIC CONCEPT FOR AGRICULTURAL DEVELOPMENT

4.1 Government Development Policy on Agriculture

Agricultural sector is the main stay of Kenya's economy. The increase of agricultural production is the nation's highest development priority. LBDA has set out their objectives for agricultural development in their Five Year Development Plan (1983 - 88) in line with the Government development strategy for agriculture; increase of staple food production, farmer's income and production of foreign exchange earners.

LBDA has adopted to the development of Lake Basin two pronged agricultural strategy; i) to achieve self sufficiency of food in the region, ii) to increase raw material supply for agro-processing industries and iii) to export agricultural surpluses outside the region. One is to meet the food needs by developing major food crops such as maize, rice, sorghum, beans, bananas and millet. The other is to promote production of industrial crops such as cotton, sugar cane, horticultural crops, tea, tobacco, pyrethrum and coffee.

4.2 Agricultural Constraints in the Project Area

Cultivated land in the project area is being developped for upland crop field including very limited irrigated rice field. Crop cultivation is generally made under rainfed condition. Irrigation facilities are quite limited in the area. Even the existing irrigation for rice field is accomodated with water from small streams of which water sources are also completely dependent on rainfall. The cultivation pattern is, therefore, directly affected by seasonal distribution of rainfall, and the crop cultivation area and production fluctuate year by year, depending on available rainfall.

The road network in the area is not well developed except main road. In the wet season the road condition becomes muddy and lack of bridges on the streams makes transportation of farm inputs and products so difficult, especially in the poorly drained areas. The present poor road condition also hampers agricultural activities in the area.

The average holding size of farm land in the area is rather small and there is very limited availability of additional arable land to be newly reclaimed. It means that the holding farm size of farmers tends to become smaller with population growth. Under such circumstances, only way to maintain growing population will be attributable to the improvement of unit land productivity.

As far as cultivation techniques are concerned, there is much room for improvement to increase crop production with applying fertilizers and chemicals. The agricultural extension services have been making much efforts to introduce advanced cultivation techniques. In spite of such efforts, the farmers in the area are mostly continuing traditional cultivation method with very low-inputs level. The reason of this situation is mainly due to the rainfed cultivation which does not ensure constant hard income.

The constraints which hinder the improvement of land productivity, are manifold as mentioned above. The decisive constraint among them is, however, lack of infrastructural facilities like perennial irrigation and drainage systems and farm road network.

4.3 Basic Concept for Agricultural Development

The principal aims for agricultural development are placed on introduction of perennial irrigation farming which can be envisaged by incidental use of water of the Sondu river to be diverted for hydropower development to increase agricultural production and employment opportunity and thereby improvement of the farmer's living standard in the project area. The project should contribute to the realization of the Government policy to the maximum extent through effective use of land and water resources as well as human resources. With this in view, the main concept for agricultural development in the area would be set up as follows:

(1) Unit yield and production of staple food crop should be stabilized and increased through the establishment of irrigation system and the introduction of improved irrigation farming practices,

(2) Increase of irrigation area to the maximum extent as far as water is available should be conceived in conformity with the Government policy for equalization, as well as maximum total benefits,

(3) Improvement of land use through increase of cropping area and intensity should be promoted with year-round irrigation system,

(4) Production of industrial crops to supply raw materials to agro-based industries should be promoted,

(5) Present farm road network should be improved and,

(6) The agricultural activities should be more improved through well organized extension services and water management.

Chapter 5. AGRICULTURAL DEVELOPMENT PLAN

5.1 Assumptions

Under such stagnant condition as described in the preceding chapters, the agricultural economy of the area will sustain at current level and no significant improvement is expected unless large scale irrigation project is implemented. Whereas, the agricultural production can be surely increased by introduction of new varieties, efficient use of fertilizers and chemicals to some extent. These changes are, however, neglected in the estimation of possible increase of production attributable to the irrigation project, because they are essential for both with and without irrigation. The future agricultural economy of the area is projected on the conditions reflecting the changes attributable to the irrigation. Although the agricultural productivity in the project area may gradually increase to a slight extent even in the future without the irrigation, such changes are disregarded in the analyses of agricultural benefit.

5.2 Change in Land Use

The area to be covered by the Project consists of well developed arable land, natural vegetation and land for homestead and infrastructures. These lands are estimated at about 3,030 ha, 6,030 ha and 1,620 ha, respectively. The project changes the land use in the area by developing year round irrigation system.

The change in land use prospected is as seen below:

(Unit : ha)

Land use categories	Present condition	With project	Change in land use
1. Arable land:	3,030	8,540	(+) 5,510
1) Planted land	1,370	8,540	(+) 7,170
- Upland crops	1,240	7,540	(+) 6,300
- Wetland rice	130	1,000	(+) 870
2) fallow land	1,660	0	(-) 1,660
2. Natural vegetation:	6,030	0	(-) 6,030
1) Tree and Bush	1,420	0	(-) 1,420
2) Grass land	4,610	0	(-) 4,610
3. Infrastructures and others	1,620	2,140	(+) 520
Total	10,680	10,680	

By the project most of the natural vegetation lands are to be developed as arable land, and then the arable land in the gross irrigable area is increased to 8,540 ha. Out of the total arable land, about 1,000 ha can be used as wetland rice field, the rest is for upland crops.

5.3 Proposed Cropping Patterns

5.3.1 Basic Principles

The proposed cropping patterns are formulated on the basis of the following basic principles which govern the selection of crops and cropping seasons to be introduced under the project:

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

(2) The crops and cropping patterns must make optimum utilization of water to be supplied by the project,

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

(4) The crops and cropping patterns must conform with the existing social tradition, and be acceptable to the farmers.

5.3.2 Selection of Crop

The most promising crops are selected in view of the above mentioned principles, and in due consideration of the results of investigation on the natural and social conditions in the project area. Besides the above, the basic agricultural data collected through relevant national agricultural or irrigation stations were carefully referred to clarify the possibility of introduction and improvement of cultivation of these crops. The major crops selected are maize, beans, rice, cotton, groundnut, green gram and fodder crops. Since the farmers in the area are anxious for making sure of their staple food, maize and sorghum will remain as the main food crops even after development of irrigation. Besides these staple food crops, cotton, rice, groundnut, green gram and beans etc. are to be grown as the cash crops. Cotton is the main cash crop in the area at present and rice and the others are also familiar to farmers for their marketing prospects and profitable prices. Fodder crops such as alfalfa and napier grass are essential to develop and maintain livestock, not only to keep cattle as farm power but also to produce animal protein for farmers by keeping incidental livestock such as sheep, goats and poultry etc.

5.3.3 Proposed Cropping Patterns

Three types of cropping patterns are formulated based on the above mentioned principles and conditions. The patterns are differently formulated mainly due to the locational soil conditions in the project area.

The proposed cropping patterns are illustrated on Figure 5.1 and summarized as follows:

Cropping Patterns	Cropping per Year LR* season	Cropping per Year SR* season	Proportion of cropped area (%)	Cropping intensity (%)
Pattern A	Rice	Green gram	40	
(1,990ha)	Maize & Beans	Maize & Beans	40	
	Fodder	Fodder	20	
(Total)	-	-	(100)	(200)
Pattern B	Rice	Green gram	40	
(500ha)	Maize & Beans	Rice	40	
	Fodder	Fodder	20	
(Total)	-	-	(100)	(200)
Pattern C	Cotton	Groundnut	40	
(6,050ha)	Maize & Beans	Groundnut	40	
	Fodder	Fodder	20	
(Total)	-	-	(100)	(200)

*: LR and SR mean long rainy and short rainy, respectively.

5.4 Proposed Farming Practices

Proper farming practices are another essential factor for realizing the full exploitation of agricultural potential in the project area. It is necessary to introduce new high-yielding varieties or hybrid seed with appropriate use of fertilizers and agro-chemicals along with the development of irrigation facilities and institutional support and services. As the main farm power for heavy work like soil preparation or transportation, it is proposed to use oxen instead of farm machinery. Though farm mechanization has a lot of advantage such as speedy and smooth farming, emancipation of farmers from labourous work, etc. but it requires large investment by the individual farmer, research, experiment and guidance services for proper farm mechanization, etc. Taking into consideration these requirements and present circumstances, rapid introduction of full farm mechanization is not practicable in the area, but the light mechanization is necessary especially for plant protection and quality control of production, such as sprayer for chemical application, thresher for rice, sheller for groundnut, etc.

Individual farmer is required to grow fodder crops to feed his cattle as source of farm power, and raising of livestock is also good for maintenance and improvement of soil fertility with application of barnyard manure of livestock.

As regards the plant protection, proper application of chemicals is indispensable for control of insects and diseases. In selecting suitable agro-chemicals, chemical toxicity which directly or indirectly affects the human being and animals should be taken into consideration. Information should be given in advance to authorities and hospitals in areas where pesticides are extensively used. The farmers should choose the chemicals by recommendations from agricultural services and it is recommended that operation of plant protection should be carried out in a systematic way through the farmers group under the operation guidance by the agricultural extension services to attain safe and effective use of pesticides.

The inputs and labour requirement for the proposed farming practice for each crop are summarized in Table 5.1. The farm labour balance between the labour requirement for the proposed practices and the available farm family labour is carefully examined and shown in Table 5.2. The number of workable persons and the available labour for farming for each household are estimated at 2.5 and 2.0, respectively. The typical family farm size is assumed to be 2 ha under each cropping pattern. The total labour requirement for each family farm under the proposed cropping patterns A, B and C are estimated at about 600, 630 and 560 man-days in a year, respectively. Out of 600, 630 and 560 man-days, 540, 540, and 520 are covered by family labour, and each typical family farm is necessary to employ about 40 to 90 man-days additional casual labour at the time of peak operation in every year.

5.5 Anticipated Crop Yield and Production

5.5.1 Target Yield of Crop

The present unit yield of crops in the project area is at rather low level mainly due to lack of irrigation facilities and little application of inputs. After completion of irrigation development, the yield of crops is to be increased and stabilized through getting accustomed to irrigation farming practices accompanied with agricultural support services. The target yield of crops at the full development stage is assumed as shown below:

(Unit : ton/ha)

Crop	Present	Without project	With project
Rice	2.4	2.4	5.0
Green gram	0.2	0.2	1.2
Maize & Beans (mixed)			
- Maize	1.3	1.3	5.0
- Beans	0.2	0.2	0.9
Cotton	0.2	0.2	2.0
Groundnut	0.5	0.5	2.0
Napier grass	-	-	120.0
Alfalfa	-	-	80.0

Notes: Rice in dried paddy, Cotton in seed cotton, Groundnut in shelled seed. Napier grass in fresh weight, Alfalfa in 20% dried matter.

Since the increase of unit yield without the irrigation development project will be insignificant comparing with the profit brought by the irrigation development, the unit yield of crops under without project condition is assumed to stay at the same level of the present yield. For projection of the anticipated unit yield of crops, the data obtained through the Irrigation Research Stations and pilot schemes at Ahero, West Kano, Bunyala and Mwea and also the National Agricultural Research Station at Kitale, Kakamega, Kisii and Kibos were carefully referred.

Most of the farmers in the area are not yet familiar with new farming practices such as proper fertilization, plant protection, water management etc. In order to attain the projected target yield at as earlier stage as possible by applying the proposed farming practices, it is essential to improve and strengthen the present agricultural supporting services in keeping pace with the implementation of the irrigation development. It would take long time to enable the farmers to sufficiently manage the operation of the irrigation facilities so as to attain the projected target yield in success. Taking into consideration the above, a certain build-up period, about 5 to 10 years after completion of the project works, is assumed.

5.5.2 Anticipated Crop Production

The anticipated annual production of each crop is estimated on the basis of proposed cropping patterns and the target yield projected at the full developed stage. The estimated crop production is presented in Table 5.3 and summarized as seen below:

Crop	Planted area (ha)	Production (ton)
Rice (dry paddy)	1,196	5,980
Green gram	996	1,195
Maize	4,212	21,060
Beans	4,212	3,791
Cotton	2,420	4,840
Groundnut	4,840	9,680
Napier grass	854	102,480
Alfalfa	854	68,320

The project area which is under food deficit condition at present is changed to food surplus area by implementation of the project. Regarding maize as food crops, about 2,600 ton is consumed in the project area, and about 10,000 ton can be sold to outside the project area. Besides the foods, stable supply of industrial raw materials like cotton and groundnut is to be achieved.

5.6 Marketing and Price Prospect

5.6.1 Marketing

The Government has projected future food requirements in the Sessional Paper No. 4 of 1981 on National Food Policy. The paper states that the total amount of food consumed in Kenya will continue to increase approximately 4% per annum. The rapid growth in the demand for food has been forecasted primarily as a result of rapid expansion in the population which is growing at a rate of about 4% per annum. By the end of the 1980 the population in Kenya will have expanded to 23.1 million which are corresponded to 42% above the 1980 level.

The projected production of main food stuffs required for self-sufficiency in 1983 and 1989 are shown in Table 5.4. The estimated production of maize required for 1989 is about 3.5 million tons, and the required growth rate during the period of 1980-89 is about 7% per annum. In regard to rice, the estimated production of rice for self-sufficiency in 1989 is 90,000 ton. In order to attain the projected amount, an annual production growth rate of 16.4% is required.

Under the circumstances mentioned above, the expected surplus of food crops, 10,000 ton of maize and 6,000 ton of paddy to be produced in the project area will be acceptable to the domestic market with good prospect.

LBDA identified cotton and groundnut as important oil seed crops to be developed in the Basin, and carried out a feasibility study on the development of cotton in the Basin.5/ The feasibility study aims to develop cotton for increase lint and seed for processing of edible oil and soap. LBDA, in collaboration with the Ministry of Agriculture, has also embarked on groundnut demonstration program. The program has objectives to demonstrate better crop husbandry to the farmers including supply of certified seed in time for planting and adequate shelling equipment, besides effective extension services.

With the above frame works and the current market prospect, the anticipated production of cotton and groundnut as well as other crops from the project area will be duly to be absorbed into domestic market.

5.6.2 Price Prospect

Economic and financial prices of farm outputs and inputs were forecasted in order to evaluate the expected monetary benefits and effects. Economic prices for trade goods such as maize, rice and cotton are estimated on the basis of the projected world market prices of these commodities forecasted by the World Bank in the long term range for the period of 1983 to 1995. The details of those forecasts are presented in Table 5.5. Non-trade goods such as beans, groundnut and green gram etc. are valued at their financial price. Financial prices of farm products are estimated on the basis of current market or farmgate prices prevailing in the project area as of 1984.

Economic and financial prices of farm products are summarized as below:

(Unit: KShs/ton)

Farm Products	Financial Prices as of 1984	Economic Prices in 1995 (1984 constant)
Maize	3,334	2,729
Beans	10,000	10,000
Cotton	7,740	8,362
Rice	2,867	3,592
Green gram	6,667	6,667
Groundnut	9,000	9,000
Sorghum	3,625	3,625
Cassava	2,750	2,750

As for fertilizer and agrochemicals, economic and financial prices are estimated based on market prices at Kisumu. They are listed in Table 5.6.

Chapter 6. IRRIGATION BENEFITS

6.1 Increased Crop Production

The irrigation benefits of the project primarily accrue from the increased crop production attributable to stable irrigation water supplies. The benefits are estimated as the difference of the annual net production values between the conditions under with-and without-the-project. The increased crop products in the project area are mainly marketed for domestic consumption. In this meaning, import substitute prices of agricultural commodities are calculated and applied to estimate the increased net production values. The calculated economic prices of the commodities are given in the preceding chapter. Gross production value, crop production cost and net production value for each crop under the conditions of with-and without-the-project are presented in Table 6.1 and Table 6.2, respectively. The estimated incremental production value is as follows:

Crops	Planted area (ha)	Net production value (KShs/ha)	Amount (KShs x 10^3)
I. With Project:			
Maize & Beans	4,212	17,081	71,945
Cotton	2,420	10,322	24,979
Rice	1,196	11,641	13,923
Green gram	996	5,619	5,597
Groundnut	4,840	12,886	62,368
Fodder *	1,708	-	-
Total			178,812
II. Without Project:			
Maize	370	1,266	468
Sorghum	250	2,516	629
Cotton	370	-1,034 **	-383 **
Groundnut	125	2,457	307
Cassava	125	6,765	846
Rice	130	5,601	728
Total			2,595
III. Incremental Production Value (I - II)			176,217

*: Net production value for fodder crop is counted as raising cost of oxen for farm power.

**: These are negative values.

The estimated annual net production values under the conditions of with- and without-the-project are about KShs 178.8 million and KShs 2.6 million, respectively. The incremental production value attributable to the project is to be KShs 176.2 million per annum at the full developed stage.

6.2 Farm Budget

For preliminary analysis of farm budget, financial crop production values are estimated as shown in Table 6.3 and Table 6.4. Financial aspect of the typical farm household of 2 ha for each proposed cropping pattern is further analyzed under condition of with-the-project. Their results are presented in Tables 6.5 to 6.7. Net family farm income earned by crop production is estimated on yearly basis as summarized below:

(Unit : KShs)

Item	Cropping pattern		
	A	B	C
Gross income *	58,900	49,900	55,500
Direct farming expense **	10,700	11,100	12,900
Net income **	48,200	38,800	42,600

*: Derived from Tables 6.5 to 6.7

**: This income shows crop farming income only

The gross income of farm household of each cropping patern is estimated at KShs 58,900, 49,900 and 55,500, respectively. The expected annual net farm income including family labour return is counted at KShs 48,200, 38,800 and 42,600, respectively. The required family labour for farming of the typical farms under the cropping pattern A, B, and C is estimated at about 540, 540 and

520 man-days in a year, respectively. The labour return can be assessed with KShs 15/day of labour wage as KShs 8,100 per A or B,and KShs 7,800 per C.

The financial aspect of farm household under without-the-project condition is assessed at the same condition of present situation. Without-the-project condition, total financial crop production value (or net farm income) in the project area is estimated at KShs 5,320 x 10^3, as seen below:

Crops	Planted area (ha)	Net crop production value (KShs/ha)	Amount (KShs x 10^3)
Maize	370	4,114	1,522
Sorghum	250	4,331	1,083
Cotton	370	708	262
Groundnut	125	4,272	534
Cassava	125	8,250	1,031
Rice	130	6,831	888
Total	-	-	5,320

(See Table 6.4)

The net income of average farm household without-the-project is calculated at about KShs 1,230/household/year.* It is obvious that the farm household income borne by crop production under with-the-project condition is increased with about 30 times of income under without-the project condition.

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*:KShs 5,320 x 100^3/ 4,320 (number of household in the command area) = KShs 1,231/household

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Table 2.2 Population Distribution in Nyakach and Kendu Division by Sub-location (1979)

Division: Location, Sub-location	Male	Female	Total	Number of House-hold	Area (km^2)	Density (person/ km^2)	No. of Household per km^2	No. of Person per Household
1. Nyakach Division:	36,046	41,079	77,125	14,747	359	215	41	5.2
North Nyakach,	15,959	18,170	34,129	6,489	183	186	35	5.3
Kabodho East	4,719	5,474	10,193	1,725	40	251	43	5.9
Kabodho West	3,738	4,233	7,971	1,481	48	164	31	5.4
Agoro East	1,909	2,159	4,068	895	16	244	56	4.5
Jimo Middle	1,563	1,830	3,393	666	29	114	23	5.1
Jimo East	1,159	1,387	2,546	528	13	186	41	4.8
Gem Rae	1,729	1,908	3,637	728	21	166	35	5.0
Agoro West	1,142	1,179	2,321	466	12	180	39	5.0
West Nyakach,	8,995	10,062	19,057	4,025	97	195	41	4.7
Lower Kadianga	2,279	2,433	4,712	954	19	241	50	4.9
Kadianga West	3,191	3,651	6,842	1,544	33	170	47	4.4
West Koguta	3,525	3,978	7,503	1,527	43	195	36	4.9
2. Kendu Division:								
Wang Chieng,	9,711	10,242	19,953	3,291	92	216	36	6.1
Kamser-Seka	2,156	2,261	4,417	845	15	285	56	5.2
Karabondi	1,368	1,504	2,872	464	16	178	29	6.2
Kobala	2,050	2,124	4,174	445	16	253	28	9.4
Kobuya	2,103	2,244	4,344	678	25	172	27	6.4
Kajieni	1,434	1,204	2,338	484	13	168	37	4.8
Kogmeno/Rakmano	900	908	1,808	375	5	353	75	4.8

Data source: Kenya Population Census 1979, Control Bureau of Statistics

Table 2.3 Projected Population by Age Group in Kisumu District

Age Group	1980			1985			1990		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 – 4	56,692	56,327	113,019	66,146	65,770	131,916	78,682	78,234	156,916
5 – 9	42,580	42,366	84,946	49,789	49,477	49,477	58,007	57,692	115,699
10–14	33,729	34,963	68,692	40,334	41,422	81,756	47,127	48,337	95,464
Sub-total	133,001	113,656	266,657	156,269	156,669	312,938	183,816	184,263	368,079
(%)	(48.0)	(47.8)	(47.9)	(47.8)	(47.7)	(47.7)	(47.5)	(47.6)	(47.6)
15–19	26,988	28,812	55,800	34,148	36,166	70,314	40,803	42,812	83,615
20–24	22,835	24,602	47,437	27,272	28,974	56,246	34,480	36,340	70,820
25–29	19,705	19,184	38,889	23,838	22,308	46,146	28,507	26,251	54,758
30–34	17,062	14,915	31,977	19,775	17,210	36,985	23,476	19,996	43,472
35–39	13,334	12,670	26,004	15,278	14,583	29,861	17,693	16,814	34,507
40–44	11,015	11,092	22,107	12,645	12,741	25,386	14,476	14,653	29,129
45–49	9,507	10,546	20,053	10,881	12,097	22,978	12,480	13,884	26,364
50–54	7,459	7,805	15,264	8,544	8,974	17,518	9,770	10,285	20,055
55–59	5,831	6,513	12,344	6,651	7,474	14,125	7,611	8,585	16,196
Sub-total	133,736	136,139	269,875	159,032	160,527	319,559	189,296	189,620	378,916
(%)	(48.7)	(48.7)	(48.5)	(48.6)	(48.9)	(48.7)	(49.0)	(49.0)	(49.0)
60–64	4,686	4,539	9,225	5,350	5,207	10,557	6,097	5,970	12,067
65–69	3,014	2,848	5,862	3,447	3,276	6,723	3,932	3,756	7,688
70–74	1,797	1,591	3,388	2,062	1,825	3,887	2,357	2,098	4,455
75+	916	886	1,802	1,001	967	1,968	1,126	1,086	2,212
Sub-total	10,413	9,864	20,277	11,860	11,275	23,135	13,512	12,910	26,422
(%)	(3.7)	(3.5)	(3.6)	(3.6)	(3.4)	(3.5)	(3.5)	(3.3)	(3.4)
Total (100%)	277,150	279,659	556,809	327,161	328,471	655,632	386,624	386,793	773,417

Note: Data source: Populations for Kenya 1980-2000.
Definition of working age of 15-59 is based on the Development Plan 1984-1988.

Table 2.4 Planted Area and Production by Crops in Wang Chieng Location of Kendu Division

	Crops	Area (1982)			1981		1982		Mean of Yield
		Target	Planted area		Production	Yield	Production	Yield	
		(Ha)	(Ha)	(%)		(ton/ha)		(ton/ha)	(ton/ha)
1.	Cotton	4,300	3,575	32	?		1,024	0.3	0.3
2.	Sorghum	2,700	2,360	21	427	0.2	637	0.3	0.3
3.	L. Maize	2,300	1,546	14	498	0.3	696	0.5	0.4
4.	H. Maize	1,520	1,362	12	945	0.7	1,961	1.4	1.1
5.	Serena Sorghum	35	160	1	6	0.04	56	0.4	0.4
6.	Groundnut	1,900	1,035	9	46	0.04	93	0.1	0.1
7.	Green Gram	140	5	-	0.2	0.04	0.45	-	0.4
8.	Soybean	400	Nil	-	-	-	Nil	-	-
9.	Cassava	8,500	500	5	1	0.03	24	0.5	0.5
10.	Other beans	400	30	-		0.1	3	0.1	0.1
11.	Finger millet	60	12	-	1	1.2	2	0.2	0.7
12.	Sweet potato	700	400	4		-	7	-	-
13.	Sim sim	25	0.5	-		-	0.2	-	-
14.	Sunflower	20	Nil	-		-	-	-	-
15.	Sugar cane	20	12	-		1.1	2	0.2	0.6
16.	Rice	3	Nil	-		-	-	-	-
17.	Cowpea	140	7	-		0.03	0.6	0.1	0.06
18.	Cabbage	15	5	-		3.0	14	3.0	3.0
19.	Tomato	8	15	-		8.7	188	13	11.0
20.	Onions	3	5	-		0.6	3	0.6	
21.	Kales	15	16	-		0.6	17	1.1	0.9
22.	Pawpaw	5	1.5	-		-	32	-	-
23.	Citrus	2.5	1	-		4.0	6	6	6.0
24.	Pineapple	2	5	-		19	136	-	19.0
25.	Mangoes	2.5	1	-		1	2	2	2.0
26.	Banana	2.5	2	-		0.5	3	1.5	1.0
	Total	23,218.5	11,056	98					

Note: Data are obtained from Kendu Division Agricultural Extension Office of South Nyanza District.

Table 2.5 Planted Area, Production and Unit Yield of Crops in Nyakach Division

Name of Crop	1977			1978			1979			1980			1983			Mean		
	Planted area (Ha)	Pro-duction (Ton)	Yield (Ton/Ha)	Planted area (Ha)	Pro-duction (Ton)	Yield (Ton/Ha)	Planted area (Ton)	Pro-duction (Ton)	Yield (Ton/Ha)	Planted area (Ha)	Pro-duction (Ton)	Yield (Ton/Ha)	Planted area (Ha)	Pro-duction (Ton)	Yield (Ton/Ha)	Planted area (Ha)	Pro-duction (Ton)	Yield (Ton/Ha)
1. Hybrid Maize 1/	1,546	4,174	3.0	1,739	5,947	3.4	2,573	8,748	3.4	2,210	3,978	1.8	2,100	5,670	2.7	2,034	5,703	2.8
2. Local Maize	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Serena Sorghum	6	11	1.8	9	14	1.6	23	18	0.8	20	16	0.8	-	-	-	15	15	1.0
4. Local Sorghum	-	-	-	320	308	1.0	618	346	0.6	900	504	0.6	3,860	3,706	1.0	1,425	1,216	0.9
5. Finger Millet	30	5	0.2	37	24	0.6	31	20	0.6	18	9	0.5	148	53	0.4	297	129	0.4
6. Beans	388	140	0.4	535	289	0.5	240	86	0.4	175	79	0.5	148	53	0.4	297	129	0.4
7. Rice (small-scale)	400	450	1.1	307	575	1.9	71	266	3.7	125	375	3.0	250	875	3.5	231	508	2.2
8. Rice (irrigated)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Groundnut	414	400	1.0	354	343	1.0	372	357	1.0	600	480	0.8	387	174	0.4	425	351	0.8
10. Sunflower	118	142	1.2	153	184	1.2	-	-	-	-	-	-	-	-	-	136	163	1.2
11. Soyabean	-	-	-	2	0.72	0.4	-	-	-	-	-	-	-	-	-	2	0.7	0.4
12. Sim Sim	-	-	-	-	-	-	-	-	-	-	-	-	18	4.3	0.2	18	4	0.2
13. Green Gram	10	2	0.2	-	-	-	-	-	-	5	2	0.4	95	124	1.3	37	43	1.2
14. Sweet Potato	-	-	-	851	6,808	8.0	650	6,500	10.0	-	-	-	85	850	10	529	4,719	8.9
15. Cassava	390	3,120	8.0	670	5,360	8.0	454	3,178	7.0	540	4,320	8.0	86	860	10	428	3,368	7.9
16. Coffee	34	36	1.0	34	12	0.4	40	14	0.4	66	19	0.3	87	-	-	52	20	0.4
17. Tea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18. Cotton	3,600	720	0.2	-	620	-	-	-	-	-	-	-	1,105	166	0.2	2,353	502	0.2
19. Tobacco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20. Pyrethrum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21. Sugar cane	-	-	-	-	-	-	-	-	-	-	-	-	23	460	20	23	460	20
22. Vegetables	-	-	-	51	408	8.0	-	-	-	-	-	-	27	540	20	39	474	12.2
23. Bananas	-	-	-	76	1,368	18	-	-	-	-	-	-	7	-	-	76	1,368	18
24. Fruits	-	-	-	29	252	8.7	-	-	-	-	-	-	-	-	-	29	252	8.7
Total area	7,246			5,167			5,041			4,659			8,278			6,078	-	-

Note: Data are obtained from Ministry of Agriculture, Kisumu District Annual Report 1977-1983.

1/ The area for hybrid maize includes the local maize cropped area also.

Table 2.6 Farm Inputs and Labour Requirements under Present Condition (per crop per ha)

Input/Operation	Unit	Maize	Cotton	Maize & Beans	Sorghum	Groundnut	Greengram	Rice	Vegetable
I) Inputs									
1) Seed	(kg)	25	22.5	Maize 25 Beans 40	5	50	25	45	0.25
2) Fertilizer									
- T.S.P. 1/	(kg)	-	-		-	-	-	-	-
- C.A.N. 2/	(kg)	-	-		-	-	-	-	-
- Urea	(kg)	-	-		-	-	-	-	-
3) Agro-chemicals									
- Insecticide	(lit.)	-	3		-	-	-	-	2
- Fungicide	(kg)	-	-		-	-	-	-	-
II) Farm Power									
1) Tractor	(hrs)	-	-	-	-	-	-	-	-
2) Oxen ploughing	(times/ha)	2	2	2	-	2	-	2	-
III) Labour	(man/day)	115	120	135	102	90	85	157	600
- Nursery preparation		-	-	-	-	-	-	3	13
- Soil preparation		20	20	20	20	20	10	50	75
- Sowing		15	10	20	12	15	20	2	2
- Transplanting		-	-	-	-	-	-	30	30
- Fertilizing		-	-	-	-	-	-	-	-
- Spraying		-	5	-	-	-	-	-	5
- Weeding		45	55	45	40	20	20	10	60
- Water management		-	-	-	-	-	-	2	250
- Harvesting & threshing		15	20	40	13	20	20	40	130
- Transportation, Drying		15	5	5	12	10	10	15	30
- Miscellaneous		5	5	5	5	5	5	5	5

Note, 1/ Triple Super Phosphate

2/ Calcium Ammonium Nitrate

Table 2.7 Livestock Population in North and West Nyakach Locations 1/

Location: Sub-location	Number 2/ of Household	Cattle		Sheep		Goat		Poultry	
		Number	No. per household	Number	No. per household	Number	No. per household	Number	No. per household
(1) North Nyakach:									
Kabodho-East	1,725	3,250	1.9	846	0.5	375	0.2	1,320	0.8
Kabodho-West	1,481	4,260	2.9	975	0.6	576	0.4	1,250	0.8
Agoro-East	895	5,760	6.4	3,414	3.8	2,115	2.4	3,747	4.2
Jimo Middle	666	3,687	5.5	1,250	1.9	975	1.5	1,655	2.5
Jimo East	528	4,320	8.2	2,076	3.9	1,896	3.6	2,347	4.4
Gem Rae	728	1,377	1.9	678	0.9	775	1.1	925	1.3
Agoro-West	466	2,800	6.0	1,055	2.3	580	1.2	3,900	8.4
Sub-total	6,489	25,454	3.9	9,284	1.4	7,406	1.1	15,144	2.3
(2) West Nyakach:									
Lower Kadianga	954	6,200	6.5	7,000	7.3	1,560	1.6	9,785	10.3
Kadianga West	1,544	1,216	0.8	180	0.1	400	0.3	1,250	0.8
West Koguta	1,527	1,676	1.1	1,825	1.2	295	0.2	1,560	1.0
Sub-total	4,025	9,092	2.3	9,665	2.4	2,255	0.6	12,595	3.1

1/ Data are as of 1983 obtained from Nyakach Division Extension Office.

2/ Data are as of 1979 from Kenya Population Census, 1979.

Table 2.8 Purchasing Prices at Depot of NCPB for 1983/84

	Weight per bag	Price of gunny bag	Price in net
	(kg)	(Ksh.)	(Ksh.)
White maize	90	14.00	134.00
Rosecoco beans	90	8.00	300.00
Canadian Wander beans	90	8.00	300.00
Mixed beans	90	8.00	150.00
Red Haricot beans	80	8.00	250.00
Tender Green beans	80	8.00	200.00
Mevezi Moja	80	8.00	250.00
Mwitamania	80	8.00	250.00
Soya bean	80	8.00	250.00
Yellow beans	80	8.00	150.00
Red boston beans	80	8.00	150.00
Green gram	90	8.00	250.00
Groundnut S/N type	80	8.00	550.00
Groundnut Uganda type	80	8.00	500.00
Wimbi Red mixed	80	8.00	135.00
Wimbi Black mixed	80	8.00	120.00
Mtama Red mixed	80	8.00	80.00
Mtama White mixed	80	8.00	90.00
Sim Sim brown	80	8.00	380.00
Caster seed	65	14.00	150.00
Sunflower black	40	8.00	96.00
Sanflower white	40	8.00	50.00
Sanflower Str. grey	40	8.00	46.00
Sunflower mixed	40	8.00	46.00
Non irrigated paddy	75	8.00	150.00
Cassava	50	-	50.00

Data source: NCPB Kisumu Area Office.

Table 2.9 Market Prices of Farm Inputs (Kisumu, 1984)

	(Ksh.)	(Ksh/kg)
Fertilizer: (50 kg)		
Triple Super Phosphate	175.50	(3.51)
C.A.N (26%)1/	132.60	(2.65)
A.S. (20%)2/	124.75	(2.50)
Urea	170.75	(3.42)
Compound (20:20:0)	193.45	(3.87)
D.A.P. (18:46:0)3/	185.30	(3.71)
Insecticides: (Litter)		
Metasystox (25%)	100.50	
Sumithion (50%)	120.75	
Sumicidin (10%)	206.00	
Fungicide: (kg)		
Dithane M45 WT (80%)	84.75	
Antracol (70%)	75.00	
Herbicide:		
2,4.D4/	54.40/littre	
STCA (95%)5/	29.80/kg	

Data source: KFA shop at Kisumu, 1984.

Note, 1/: Calcium Ammonium Nitrate
2/: Ammonium Sulfate
3/: Diammonium Phosphate
4/: 2,4 - Dichlorophenoxy
5/: Sodium Trichloroacetate

Table 2.10 Market Prices of Farm products (Paponditi)

Unit: Kshs

		1981	1982	1983	1984
Rice (dried paddy)	(75 kg)	180.00 2/ (2.40)	203.00 (2.71)	218.00 (2.91)	273.00 (3.64)
(milled rice)	(1 kg)	-	-	-	8.00
Maize	(90 kg)	293.00 (3.26)	293.00 (3.26)	360.00 (4.00)	390.00 (4.33)
Sorghum	(80 kg)	165.00 (2.06)	180.00 (2.25)	208.00 (2.60)	280.00 (3.50)
Groundnut (shelled)		-	-	-	1,170.00 (14.63)
Green gram	(90 kg)	500.00 (5.56)	500.00 (5.56)	550.00 (6.11)	950,00 (10.56)
Cassava	(80 kg)	100.00 (1.25)	120.00 (1.50)	200.00 (2.50)	220.00 (2.75)
Fingermillet	(80 kg)	518.00 (6.48)	350.00 (4.38)	800.00 (10.00)	850.00 (10.63)
Beans	(90 kg)	-	-	-	1,000.00 (11.11)
Tomato (dabe) 1/		-	-	-	70.00 (3.89)
Irish poteto (debe)		-	-	-	50.00 (2.78)

Date source: Nyakach Division Agricultural Extension Office.

Note; 1/: 1 debt ≒ 18 litre

2/: A number in parentheses shows the unit price i.e. Kshs/kg.

Table 2.11 Farm Gate Prices of Inputs

Unit: kshs

Farm Input	1981	1982	1983	1984
Seed: (kg)				
Rice	1.00	1.00	1.00	1.00
Maize (hybrid)	5.50	7.50	7.50	8.00
Sorghum	7.50	7.50	7.50	9.00
Groundnut	5.25	5.25	7.50	9.00
Green gram	-	-	-	16.00
Fertilizers: (50 kg)				
Ammonium Sulphate		162.65 1/ (3.25)	162.65 (3.25)	169.30 (3.39)
Triple Super Phosphate	179.00 (3.58)	226.70 (4.53)	-	-
Calcium Ammonium Niterate	87.40 (1.75)	142.90 (2.86)	142.90 (2.86)	146.45 (2.93)
Compound (20:20:0)	-	189.90 (3.80)	189.90 (3.80)	-
Compound (15:15:15)				205.65 (4.11)
Agro-chemicals:				
Sevin (liter)	130.00	-	-	-
Labour (per day)				
Man				18.00
Female				18.00
Tractor ploughing				875.00
Oxen ploughing				625.00

Data source: Nyakach Division Agricultural Extension Office.

1/: A number in parentheses shows the unit price i.e, Kshs/kg.

Table 2.12 Farm Gate Prices of Farm Products

Unit: Kshs

Farm Product		1981	1982	1983	1984
Rice (dried paddy)	(75 kg)	144.00 3/ (1.92)	180.00 (2.40)	180.00 (2.40)	215.00 (2.87)
Maize (shelled)	(90 kg)	250.00 (2.78)	225.00 (2.50)	240.00 (2.67)	300.00 (3.33)
Sorghum	(80 kg)	160.00 (2.00)	180.00 (2.25)	200.00 (2.50)	290.00 (3.63)
Groundnut (shelled)	(80 kg)	540.00 (6.75)	480.00 (6.00)	-	-
Green gram	(90 kg)	400.00 (4.44)	400.00 (4.44)	450.00 (5.00)	600.00 (6.67)
Cassava (chips)	(70 kg)	180.00 (2.57)	200.00 (2.86)		
Finger millet	(80 kg)	500.00 (6.25)	640.00 (8.00)	800.00 (10.00)	850.00 (10.63)
Cotton 1/ (kg)	AR 2/	3.60	3.60	3.80	4.30
	BR 2/	1.75	1.75	1.85	2.15
Beans (Rosecoc)	(90 kg)				900.00 (10.00)
Tomato	(1 kg)				5.00
Cow	(per head)				1,000-1,500
Bull	(")				1,200-2,000
Calf	(")				1,500-2,500
Sheep	(")				200.00
Poultry	(")				3.00

Data source: Nyakach Division Agricultural Extension Office.

1/: At local buying centre of Cotton of Lint and Seed Marketing Board.

2/: These show the qualities of lint harvested, i.e.,

- AR (A Rank) for good quality
- BR (B Rank) for fair quality, but no better than AR

3/: A number in parentheses shows the unit price i.e, Kshs/kg.

Table 3.1 Staff of Nyakach Division Agricultural Extension Office

		(persons)
1.	Technical officers:	
	Divisional Extension Officer	1
	Land Development Officer	1
	Animal Production Officer	1
	Horticultural Officer	1
	Rice Production Officer (Japan Overseas Cooperation Volunteers)	1
2.	Technical assistants:	
	Locational Extension Officer (North Nyakach, South Nyakach and West Nyakach)	3
	Sub-location Extension Officer	12
3.	Junior Technical Assistants	12
	Total	32

Note: The data are as of July, 1984, obtained through Nyakach Division Agricultural Extension Office.

Table 5.1 Farm Inputs and Labour Requirements under Proposed Farming Practices (per crop per ha)

Input		Unit	Maize & Beans	Cotton	Rice	Green gram	Groundnut	Alfalfa	Napier grass
1. Seed		Kg/ha (Maize) (Beans)	15 20	20	30	20	90	10	20 ton
2. Fertilizers	A.S.[1/]	Kg/ha	300	450	-	-	100	270	700
	Urea	Kg/ha	-	-	225	-	-	-	-
	T.S.P.[2/]	Kg/ha	100	100	100	-	100	140	150
3. Agr. Chemicals	Seed dress	g/ha	-	-	90	-	270	-	-
	Insecticide	lit./ha	3	4	3	2	3	2	2
	Fungicide	lit./ha	2	2	3	-	3	2	2
4. Farm Power	Labour	M.D./ha	150	160	190	90	110	170	200
	Oxen	time/ha	2	2	3	-	2	2	2
	Machinery	hrs /ha	10	20	20	5	20	5	5
5. Miscellaneous (about 15% of item 1 to 4)									

Remarks, 1: Machinery required are sprayer, thresher and sheller etc. for light mechanization.

2: Cane of Napier grass of 20 tons/ha is required very 4 years for renewal.

Note, 1/: Ammonium Sulfate

2/: Triple Super Phosphate

Table 5.2 (1/3) Labor Balance under Proposed Cropping Pattern (A)

Month Per 5 Days Unit	Rice Man-Days/ 0.8Ha	Greengram Man-Days/ 0.8Ha	Maize& Beans (1) Man-Days/ 0.8Ha	Maize& Beans (2) Man-Days/ 0.8Ha	Napier-Grass Man-Days/ 0.2Ha	Alfalfa Man-Days/ 0.2Ha	Keeping Livestocks Man-Days	Total Labor Require-Ment Man-Days/ 2Ha	Labor Deficiency Man-Days/ 2Ha
JAN.		0.47		0.71	0.04	0.04	0.30	1.56	
		0.47		1.07	0.04	0.04	0.30	1.92	
		0.47		1.07	0.04	0.04	0.30	1.92	
		0.47		1.07	0.04	0.04	0.30	1.92	
		0.47	0.27	1.07	0.04	0.04	0.30	2.19	-0.19
			0.27	0.78	0.04	0.04	0.30	1.43	
FEB.	0.34		0.27	0.78	0.04	0.04	0.30	1.77	
	0.34		0.33	0.78	0.04	0.04	0.30	1.83	
	0.47		0.62	0.42	0.04	0.04	0.30	1.89	
	0.47		0.62	0.42	0.04	0.04	0.30	1.89	
	0.53		0.80		0.04	0.04	0.30	1.71	
	0.53		1.07		0.04	0.04	0.30	1.98	
MAR.	1.39		1.12		0.04	0.04	0.30	2.89	-0.89
	1.39		1.27		0.04	0.04	0.30	3.04	-1.04
	1.64		1.27		0.04	0.04	0.30	3.29	-1.29
	1.70		1.33		0.04	0.04	0.30	3.41	-1.41
	1.70		1.00		0.04	0.04	0.30	3.08	-1.08
	1.70		0.79		0.04	0.04	0.30	2.87	-0.87
APR.	1.75		0.84		0.04	0.04	0.30	2.97	-0.97
	1.95		0.66		0.04	0.04	0.30	2.99	-0.99
	1.87		0.39		0.04	0.04	0.30	2.64	-0.64
	2.90		0.34		0.04	0.04	0.30	3.62	-1.62
	0.70		0.19		0.04	0.04	0.30	1.27	
	0.45		0.19		0.04	0.04	0.30	1.02	
MAY.	0.39		0.14		0.04	0.04	0.30	0.91	
	0.39		0.14		0.04	0.04	0.30	0.91	
	0.39		0.08		0.04	0.04	0.30	0.85	
	0.34		0.02		0.04	0.04	0.30	0.74	
	0.09		0.02		0.04	0.04	0.30	0.49	
	0.03		0.02		0.04	0.04	0.30	0.43	
JUN.	0.14		0.02		0.04	0.04	0.30	0.54	
	0.14		0.02		0.04	0.04	0.30	0.54	
	0.14		0.34		0.04	0.04	0.30	0.86	
	0.14		0.34		0.04	0.04	0.30	0.86	
	0.57		0.34		0.04	0.04	0.30	1.29	
	0.63		0.71		0.04	0.04	0.30	1.72	
JUL.	0.63		0.71		0.04	0.04	0.30	1.72	
	0.81		1.07		0.04	0.04	0.30	2.26	-0.26
	0.75		1.07		0.04	0.04	0.30	2.20	-0.20
	0.67		1.07		0.04	0.04	0.30	2.12	-0.12
	0.67		1.07	0.27	0.04	0.04	0.30	2.39	-0.39
	0.67		0.78	0.27	0.04	0.04	0.30	2.10	-0.10
AUG.	0.23	0.09	0.78	0.27	0.04	0.04	0.30	1.75	
	0.23	0.09	0.78	0.33	0.04	0.04	0.30	1.81	
	0.23	0.35	0.42	0.62	0.04	0.04	0.30	2.00	
	0.23	0.35	0.42	0.62	0.04	0.04	0.30	2.00	
	0.07	0.48		0.80	0.04	0.04	0.30	1.73	
		0.54		1.07	0.04	0.04	0.30	1.99	
SEP.		0.54		1.12	0.04	0.04	0.30	2.04	-0.04
		0.54		1.27	0.04	0.04	0.30	2.19	-0.19
		0.67		1.27	0.04	0.04	0.30	2.32	-0.32
		0.64		1.33	0.04	0.04	0.30	2.35	-0.35
		0.64		1.00	0.04	0.04	0.30	2.02	-0.02
		0.38		0.79	0.04	0.04	0.30	1.55	
OCT.		0.38		0.84	0.04	0.04	0.30	1.60	
		0.38		0.66	0.04	0.04	0.30	1.42	
		0.32		0.39	0.04	0.04	0.30	1.09	
		0.32		0.34	0.04	0.04	0.30	1.04	
		0.19		0.19	0.04	0.04	0.30	0.76	
		0.19		0.19	0.04	0.04	0.30	0.76	
NOV.		0.13		0.14	0.04	0.04	0.30	0.65	
		0.13		0.14	0.04	0.04	0.30	0.65	
		0.47		0.08	0.04	0.04	0.30	0.93	
		0.47		0.02	0.04	0.04	0.30	0.87	
		0.47		0.02	0.04	0.04	0.30	0.87	
		0.47		0.02	0.04	0.04	0.30	0.87	
DEC.		0.47		0.02	0.04	0.04	0.30	0.87	
		0.47		0.02	0.04	0.04	0.30	0.87	
		0.47		0.34	0.04	0.04	0.30	1.19	
		0.47		0.34	0.04	0.04	0.30	1.19	
		0.47		0.34	0.04	0.04	0.30	1.19	
		0.47		0.71	0.04	0.04	0.30	1.56	
Total (Per 5 Days Unit)	30.40	14.40	24.00	24.00	2.88	2.88	21.60	120.16	-12.98

Remarks, Available Family Labor=Number of Workable Family(2.5) X Labor Efficiency(80%)=2.0 Man-Days

-Total Labor Requirement(Man-Days/Year): 120.16 X 5 = 600.8
-Family Labor(Man-Days/Year): (120.16 - 12.98) X 5 = 535.90
-Hired Labor(Man-Days/Year): 12.98 X 5 = 64.90

Table 5.2 (2/3) Labor Balance under Proposed Cropping Pattern (B)

Month Per 5 Days Unit	Rice (1) Man-Days/ 0.8Ha	Greengram Man-Days/ 0.8Ha	Maize& Beans Man-Days/ 0.8Ha	Rice (2) Man-Days/ 0.8Ha	Napier-Grass Man-Days/ 0.2Ha	Alfalfa Man-Days/ 0.2Ha	Keeping Livestocks Man-Days	Total Labor Require-Ment Man-Days/ 2Ha	Labor Deficiency Man-Days/ 2Ha
JAN.		0.47		0.63	0.04	0.04	0.30	1.48	
		0.47		0.81	0.04	0.04	0.30	1.66	
		0.47		0.75	0.04	0.04	0.30	1.60	
		0.47		0.67	0.04	0.04	0.30	1.52	
		0.47	0.27	0.67	0.04	0.04	0.30	1.79	
			0.27	0.67	0.04	0.04	0.30	1.32	
FEB.	0.34		0.27	0.23	0.04	0.04	0.30	1.22	
	0.34		0.33	0.23	0.04	0.04	0.30	1.28	
	0.47		0.62	0.23	0.04	0.04	0.30	1.70	
	0.47		0.62	0.23	0.04	0.04	0.30	1.70	
	0.53		0.80	0.07	0.04	0.04	0.30	1.78	
	0.53		1.07		0.04	0.04	0.30	1.98	
MAR.	1.39		1.12		0.04	0.04	0.30	2.89	-0.89
	1.39		1.27		0.04	0.04	0.30	3.04	-1.04
	1.64		1.27		0.04	0.04	0.30	3.29	-1.29
	1.70		1.33		0.04	0.04	0.30	3.41	-1.41
	1.70		1.00		0.04	0.04	0.30	3.08	-1.08
	1.70		0.79		0.04	0.04	0.30	2.87	-0.87
APR.	1.75		0.84		0.04	0.04	0.30	2.97	-0.97
	1.95		0.66		0.04	0.04	0.30	2.99	-0.99
	1.87		0.39		0.04	0.04	0.30	2.64	-0.64
	2.90		0.34		0.04	0.04	0.30	3.62	-1.62
	0.70		0.19		0.04	0.04	0.30	1.27	
	0.45		0.19		0.04	0.04	0.30	1.02	
MAY.	0.39		0.14		0.04	0.04	0.30	0.91	
	0.39		0.14		0.04	0.04	0.30	0.91	
	0.39		0.08		0.04	0.04	0.30	0.85	
	0.34		0.02		0.04	0.04	0.30	0.74	
	0.09		0.02		0.04	0.04	0.30	0.49	
	0.03		0.02		0.04	0.04	0.30	0.43	
JUN.	0.14		0.02		0.04	0.04	0.30	0.54	
	0.14		0.02		0.04	0.04	0.30	0.54	
	0.14		0.34		0.04	0.04	0.30	0.86	
	0.14		0.34		0.04	0.04	0.30	0.86	
	0.57		0.34		0.04	0.04	0.30	1.29	
	0.63		0.71		0.04	0.04	0.30	1.72	
JUL.	0.63		0.71		0.04	0.04	0.30	1.72	
	0.81		1.07		0.04	0.04	0.30	2.26	-0.26
	0.75		1.07		0.04	0.04	0.30	2.20	-0.20
	0.67		1.07		0.04	0.04	0.30	2.12	-0.12
	0.67		1.07		0.04	0.04	0.30	2.12	-0.12
	0.67		0.78		0.04	0.04	0.30	1.83	
AUG.	0.23	0.09	0.78	0.34	0.04	0.04	0.30	1.82	
	0.23	0.09	0.78	0.34	0.04	0.04	0.30	1.82	
	0.23	0.35	0.42	0.47	0.04	0.04	0.30	1.85	
	0.23	0.35	0.42	0.47	0.04	0.04	0.30	1.85	
	0.07	0.48		0.53	0.04	0.04	0.30	1.46	
		0.54		0.53	0.04	0.04	0.30	1.45	
SEP.		0.54		1.39	0.04	0.04	0.30	2.31	-0.31
		0.54		1.39	0.04	0.04	0.30	2.31	-0.31
		0.67		1.64	0.04	0.04	0.30	2.69	-0.69
		0.64		1.70	0.04	0.04	0.30	2.72	-0.72
		0.64		1.70	0.04	0.04	0.30	2.72	-0.72
		0.38		1.70	0.04	0.04	0.30	2.46	-0.46
OCT.		0.38		1.75	0.04	0.04	0.30	2.51	-0.51
		0.38		1.95	0.04	0.04	0.30	2.71	-0.71
		0.32		1.87	0.04	0.04	0.30	2.57	-0.57
		0.32		2.90	0.04	0.04	0.30	3.60	-1.60
		0.19		0.70	0.04	0.04	0.30	1.27	
		0.19		0.45	0.04	0.04	0.30	1.02	
NOV.		0.13		0.39	0.04	0.04	0.30	0.90	
		0.13		0.39	0.04	0.04	0.30	0.90	
		0.47		0.39	0.04	0.04	0.30	1.24	
		0.47		0.34	0.04	0.04	0.30	1.19	
		0.47		0.09	0.04	0.04	0.30	0.94	
		0.47		0.03	0.04	0.04	0.30	0.88	
DEC.		0.47		0.14	0.04	0.04	0.30	0.99	
		0.47		0.14	0.04	0.04	0.30	0.99	
		0.47		0.14	0.04	0.04	0.30	0.99	
		0.47		0.14	0.04	0.04	0.30	0.99	
		0.47		0.57	0.04	0.04	0.30	1.42	
		0.47		0.63	0.04	0.04	0.30	1.48	
Total (Per 5 Days Unit)	30.40	14.40	24.00	30.40	2.88	2.88	21.60	126.56	-18.10

Remarks, Available Family Labor=Number of Workable Family(2.5) X Labor Efficiency(80%)=2.0 Man-Days

-Total Labor Requirement(Man-Days/Year): 120.56 X 5 = 632.80
-Family Labor(Man-Days/Year): (126.56 - 18.10) X 5 = 542.30
-Hired Labor(Man-Days/Year): 18.10 X 5 = 90.50

Table 5.2 (3/3) Labor Balance under Proposed Cropping Pattern (C)

Month Per 5 Days Unit	Cotton Man-Days/ 0.8Ha	Groundnut Man-Days/ 1.6Ha	Maize& Beans Man-Days/ 0.8Ha	Napier-Grass Man-Days/ 0.2Ha	Alfalfa Man-Days/ 0.2Ha	Keeping Livestocks Man-Days	Total Labor Require-Ment Man-Days/ 2Ha	Labor Deficiency Man-Days/ 2Ha
JAN.		0.05		0.04	0.04	0.30	0.43	
		0.05		0.04	0.04	0.30	0.43	
	0.25	1.51		0.04	0.04	0.30	2.14	-0.14
	0.25	1.45		0.04	0.04	0.30	2.08	-0.08
	0.25	1.45	0.27	0.04	0.04	0.30	2.35	-0.35
	0.25	1.45	0.27	0.04	0.04	0.30	2.35	-0.35
FEB.	0.25	1.45	0.27	0.04	0.04	0.30	2.35	-0.35
	0.33	1.45	0.33	0.04	0.04	0.30	2.49	-0.49
	0.72	0.36	0.62	0.04	0.04	0.30	2.08	-0.08
	0.72	0.36	0.62	0.04	0.04	0.30	2.08	-0.08
	0.89	0.36	0.80	0.04	0.04	0.30	2.43	-0.43
	1.03		1.07	0.04	0.04	0.30	2.48	-0.48
MAR.	1.20		1.12	0.04	0.04	0.30	2.70	-0.70
	1.27		1.27	0.04	0.04	0.30	2.92	-0.92
	1.01		1.27	0.04	0.04	0.30	2.66	-0.66
	1.19		1.33	0.04	0.04	0.30	2.90	-0.90
	1.19		1.00	0.04	0.04	0.30	2.57	-0.57
	0.84		0.79	0.04	0.04	0.30	2.01	-0.01
APR.	0.84		0.84	0.04	0.04	0.30	2.06	-0.06
	0.67		0.66	0.04	0.04	0.30	1.71	
	0.60		0.39	0.04	0.04	0.30	1.37	
	0.43		0.34	0.04	0.04	0.30	1.15	
	0.43		0.19	0.04	0.04	0.30	1.00	
	0.43		0.19	0.04	0.04	0.30	1.00	
MAY.	0.34		0.14	0.04	0.04	0.30	0.86	
	0.25		0.14	0.04	0.04	0.30	0.77	
	0.33		0.08	0.04	0.04	0.30	0.79	
	0.33		0.02	0.04	0.04	0.30	0.73	
	0.40		0.02	0.04	0.04	0.30	0.80	
	0.33		0.02	0.04	0.04	0.30	0.73	
JUN.	0.40		0.02	0.04	0.04	0.30	0.80	
	0.33		0.02	0.04	0.04	0.30	0.73	
	0.75		0.34	0.04	0.04	0.30	1.47	
	0.68		0.34	0.04	0.04	0.30	1.40	
	0.68		0.34	0.04	0.04	0.30	1.40	
	0.60		0.71	0.04	0.04	0.30	1.69	
JUL.	0.60		0.71	0.04	0.04	0.30	1.69	
	0.54		1.07	0.04	0.04	0.30	1.99	
	0.54		1.07	0.04	0.04	0.30	1.99	
	0.47		1.07	0.04	0.04	0.30	1.92	
	0.47		1.07	0.04	0.04	0.30	1.92	
	0.42		0.78	0.04	0.04	0.30	1.58	
AUG.	0.42		0.78	0.04	0.04	0.30	1.58	
	0.42	0.54	0.78	0.04	0.04	0.30	2.12	-0.12
	0.42	0.54	0.42	0.04	0.04	0.30	1.76	
	0.42	0.54	0.42	0.04	0.04	0.30	1.76	
	0.42	0.65		0.04	0.04	0.30	1.45	
		1.43		0.04	0.04	0.30	1.81	
SEP.		1.43		0.04	0.04	0.30	1.81	
		1.71		0.04	0.04	0.30	2.09	-0.09
		1.82		0.04	0.04	0.30	2.20	-0.20
		1.82		0.04	0.04	0.30	2.20	-0.20
		2.10		0.04	0.04	0.30	2.48	-0.48
		2.21		0.04	0.04	0.30	2.59	-0.59
OCT.		2.21		0.04	0.04	0.30	2.59	-0.59
		1.56		0.04	0.04	0.30	1.94	
		0.85		0.04	0.04	0.30	1.23	
		0.96		0.04	0.04	0.30	1.34	
		0.96		0.04	0.04	0.30	1.34	
		0.85		0.04	0.04	0.30	1.23	
NOV.		0.85		0.04	0.04	0.30	1.23	
		0.57		0.04	0.04	0.30	0.95	
		0.46		0.04	0.04	0.30	0.84	
		0.46		0.04	0.04	0.30	0.84	
		0.18		0.04	0.04	0.30	0.56	
		0.18		0.04	0.04	0.30	0.56	
DEC.		0.07		0.04	0.04	0.30	0.45	
		0.07		0.04	0.04	0.30	0.45	
		0.07		0.04	0.04	0.30	0.45	
		0.07		0.04	0.04	0.30	0.45	
		0.05		0.04	0.04	0.30	0.43	
		0.05		0.04	0.04	0.30	0.43	
Total (Per 5 Days Unit)	25.60	35.20	24.00	2.88	2.88	21.60	112.16	-8.92

Remarks, Available Family Labor=Number of Workable Family(2.5) X Labor Efficiency(80%)=2.0 Man-Days

-Total Labor Requirement(Man-Days/Year): 112.16 X 5 = 560.8
-Family Labor(Man-Days/Year): (112.16 - 8.92) X 5 = 516.20
-Hired Labor(Man-Days/Year): 8.92 X 5 = 44.60

Table 5.3 Anticipated Annual Crop Production (Full developed stage)

Pattern/crops		Target yield	Subarea I		Subarea II		Subarea III		Total	
			Planted area	Production	Planted area	Production	Planted area	Production	Planted area	Production
		(ton/ha)	(ha)	(ton)	(ha)	(ton)	(ha)	(ton)	(ha)	(ton)
A	Rice	5.0			116	580	680	3,400	796	3,980
	Green gram	1.2			116	139	680	816	796	955
	Maize	5.0			232	1,160	1,360	6,800	1,592	7,960
	Beans	0.9			232	209	1,360	1,224	1,592	1,433
	Napier grass	120			29	3,480	170	20,400	199	23,880
	Alfalfa	80			29	2,320	170	13,600	199	15,920
B	Rice	5.0			56	280	344	1,720	400	2,000
	Green gram	1.2			28	34	172	206	200	240
	Maize	5.0			28	140	172	860	200	1,000
	Beans	0.9			28	25	172	155	200	180
	Napier grass	120			7	840	43	5,160	50	6,000
	Alfalfa	80			7	560	43	3,440	50	4,000
C	Cotton	2.0	380	760	1,488	2,976	552	1,104	2,420	4,840
	Groundnut	2.0	760	1,520	2,976	5,952	1,104	2,208	4,840	9,680
	Maize	5.0	380	1,900	1,488	7,440	552	2,760	2,420	12,100
	Beans	0.9	380	342	1,488	1,339	552	497	2,420	2,178
	Napier grass	120	95	11,400	372	44,640	138	16,560	605	72,600
	Alfalfa	80	95	7,600	372	29,760	138	11,040	605	48,400

Note: The unit yield and production are estimated as following conditions:
rice in dried paddy, maize and groundnut in shelled seed, cotton in seed cotton,
alfalfa in 20% dried matter, napier grass in fresh weight.

Table 5.4 Domestic Requirements of the Main Foodstuffs in 1983 and 1989 and the Rates of Growth of Production Necessary to Achieve Self-sufficiency

Foodstuffs	Estimated Production (000 tons)	Estimated Domestic Requirement (000 tons)		Annual Production Growth Rate required for Self-sufficiency (per cent)	
	1980	1983	1989	1980-83	1980-89
1. Maize:					
(a) 1980 production as base	1,620	2,777*	3,514	19.7	9.0
(b) 1976 production as base	(2,264)**	2,777*	3,514	7.0	4.9
(c) Mean of 1976 and 1980 production as base	(1,942)**	2,777*	3,514	12.7	6.8
2. Wheat Flour	142	292*	493	27.2	14.8
3. Sorghum/Millet	369	445*	563	6.4	4.8
4. Rice	23	66	90	42.1	16.4
5. Beans	140	253	344	21.8	10.5
6. Potatoes	450	655	828	13.3	7.0
7. Sugar	4,402	342	571	-5.2	4.0
8. Beef	147	188	314	8.5	8.8
9. Milk***	1,259	1,615	2,058	8.7	5.6

* The figure exludes the production required to rebuild the strategic reserve.

** Hypothetical level of production.

*** Liquid milk and milk products expressed in whole milk equivalent.

Note: The source of this table is the Sessional Paper No.4 of 1981 on National Food Policy.

Table 5.5 (1/3) Economic Prices of Agricultural Commodities (Maize)

	Steps in the calculation	Currency	Value per tonne
1.	World price (F.O.B. U.S. Gulf)	US$	116.96 1/
2.	(+) Freight and Insurance	US$	37.00
3.	Value C.I.F. Mombasa (US$1 = Kshs 15.00)	US$ Kshs	153.96 2,309.40
4.	(+) Port handling charge	Kshs	180.60
5.	(+) Bagging and weighing	Kshs	203.30
6.	(+) Transport (Mombasa to Kisumu)	Kshs	433.68
7.	Value at Kisumu warehouse = Wholesale value	Kshs	3,126.98
8.	(-) NCPB charge 2/	Kshs	350.00
9.	(-) Transport (NCPB buying center to farm gate)	Kshs	48.00
10.	Farm gate price	Kshs	2,728.98

Note,

1/: Forecast from "Updating of Commodity Price Forecasts and Quarterly Review of Commodity Markets for September 1984", Office Memorandum, World Bank, Oct. 3, 1984.

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

Table 5.5 (2/3) Economic Prices of Agricultural Commodities (Rice)

	Steps in the calculation	Currency	Value per tonne
1.	World price (F.O.B. Bangkok)	US$	338.45 1/
2.	Price adjustment for lower quality (85% of world price)	US$	287.68
3.	(+) Freight and Insurance (Bangkok to Mombasa)	US$	80.00
4.	Value C.I.F. Mombasa (US$1 = Kshs 15.00)	US$ Kshs	367.68 5,515.24
5.	(+) Port handling charge	Kshs	180.60
6.	(+) Bagging and weighing	Kshs	183.02
7.	(+) Transport by railway (Mombasa to Kisumu)	Kshs	433.68
8.	Value at Kisumu warehouse = Wholesale value	Kshs	6,312.54
9.	(-) Transport (warehouse to mill gate), including handling charges	Kshs	4.32
10.	Value in term of paddy (milling rate: 65%)	Kshs	4,100.34
11.	(+) Value of bran	Kshs	65.00
12.	(-) Milling charge	Kshs	175.00
13.	(-) NCPB charge 2/	Kshs	350.00
14.	(-) Transport (NCPB buying center to farm gate)	Kshs	48.00
15.	Farm gate price	Kshs	3,592.34

Note,

1/: Forecast from "Updating of Commodity Price Forecasts and Quarterly Review of Commodity Markets for September 1984", Office Memorandum, World Bank, Oct. 3, 1984.

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

Table 5.5 (3/3) Economic Prices of Agricultural Commodities (Cotton)

	Steps in the calculation	Currency	Value per tonne
1.	World price (C.I.F. Mombasa) (US$1 = Kshs 15.00)	US$ Kshs	1,811.25 1/ 27,168.75
2.	(-) Price adjustment of 10% for lower quality	Kshs	2,716.88
3.	(+) Port handling charge	Kshs	180.60
4.	(+) Transport (Mombasa to Kisumu)	Kshs	433.68
5.	Value at Kisumu warehouse = Wholesale value	Kshs	25,066.16
6.	(-) Transport (Kisumu to ginnery), including handling charges	Kshs	4.32
7.	Value of lint at ginney	Kshs	25,061.84
8.	Value of cotton seed at ginnery 2/	Kshs	2,911.00
9.	(-) Ginning costs	Kshs	2,400.00
10.	Value in terms of lint	Kshs	25,572.84
11.	Value in terms of seed cotton 3/	Kshs	8,950.94
12.	(-) Loss in ginnery store (1%)	Kshs	89.51
13.	(-) Transport (buying center to ginnery), and storage	Kshs	285.00
14.	(-) Charge of buying operation	Kshs	130.00
15.	(-) Loss at buying center (1%)		84.46
16.	Farm gate price	Kshs	8,361.97

Note,

1/: Estimated based on "Updating of Commodity Price Forecasts and Quarterly Review of Commodity Markets for September 1984", Office Memorandum, World Bank, Oct. 3, 1984.

2/: 2.05 kg of seed are produced for every kg of lint, sales proceeds amount to Kshs 1.42/kg cotton seed.

3/: 1 ton of lint would be produced out of 2.857 tons of seed cotton.

Table 5.6 Economic and Financial Farm Gate Prices of Farm Inputs

Unit: Kshs

Farm Input	Unit	Financial Price	Economic Price
1. Seed			
Maize	kg	8.0	8.0
Beans	kg	10.0	10.0
Cotton	kg	3.0	3.0
Rice	kg	1.0	1.0
Green gram	kg	16.0	16.0
Groundnut	kg	9.0	9.0
Sorghum	kg	3.5	3.5
Cassava	kg	Nil	Nil
Alfalfa	kg	160.0	160.0
Napier (cane)	ton	10.0	10.0
2. Fertilizer			
Ammonium Sulphate	kg	3.39	3.26
Urea	kg	4.63	4.48
Triple Super Phosphate	kg	4.53	4.60
3. Agrochemical			
Seed Dressing	g	0.30	0.30
Insecticide 1/	liter	150.0	150.0
Fungicide 2/	kg	90.0	90.0

Remarks; 1/: Based on the prices of insecticides which are commonly used in Kenya, i.e. Metasystox, Sumithion and Sumicidin

2/: i.e. Dithane M45 WT and Antrocol

Table 6.1 Economic Crop Production Value under With-Project Condition

Item	Unit	Mixed Cropping Maize	Mixed Cropping Beans	Cotton	Rice	Green-gram	Ground-nut	Alfalfa	Napier
FARM INPUT									
1. Seed	kg	15	20	20	30	20	90	10	20 ton1/
2. Fertilizer									
Ammonium Sulphate	kg	300		450	0	0	100	270	700
Urea	kg	0		0	225	0	0	0	0
Triple Super Phosphate	kg	100		100	100	0	100	140	150
3. Agrochemical									
Seed Dressing	g	0		0	90	0	270	0	0
Insecticide	liter	3		4	3	2	3	2	2
Fungicide	kg	2		2	3	0	3	2	2
4. Farm Power									
Labor	man-day	150		160	190	90	110	170	200
Oxen	time	2		2	3	0	2	2	2
Machinery	hours	10		20	20	5	20	5	5
DIRECT PRODUCTION COST	Unit Price2/								
5. Seed									
Maize	8.0	120							
Beans	10.0		200						
Cotton	3.0			60					
Rice	1.0				30				
Greengram	16.0					320			
Groundnut	9.0						810		
Alfalfa	160.0							1,600	
Napier	10.0								200
6. Fertilizer									
Ammonium Sulphate	3.26	978		1,467	0	0	326	880	2,282
Urea	4.48	0		0	1,008	0	0	0	0
Triple Super Phosphate	4.60	460		460	460	0	460	644	690
7. Agrochemical									
Seed Dressing	0.30	0		0	27	0	81	0	0
Insecticide	150	450		600	450	300	450	300	300
Fungicide	90	180		180	270	0	270	180	180
8. Farm Power									
Labor	15	2,250		2,400	2,850	1,350	1,650	2,550	3,000
Oxen	-	-		-	-	-	-	-	-
Machinery	20	200		400	400	100	400	100	100
9. Others (15% of item 5 to 8)		726		835	824	311	667	938	1,013
10. Total Crop Production Cost	Ksh/ha	5,564		6,402	6,319	2,381	5,114	7,192	7,765
CROP PRODUCTION VALUE									
11. Yield	ton/ha	5.00	0.90	2.00	5.00	1.20	2.00	80	120
12. Unit Price	Ksh/ton	2,729	10,000	8,362	3,592	6,667	9,000	-	-
13. Gross Production Value	Ksh/ha	13,645	9,000	16,724	17,960	8,000	18,000	-	-
14. Net Production Value	Ksh/ha	17,081		10,322	11,641	5,619	12,886	-3/	-3/
(13 - 10)	US$/ha	1,139		688	776	375	859	-	-

Remarks; 1/: 20 ton/ha of seed cane for every 4 years

2/: See Table 5.6

3/: These net production values are counted as raising cost of oxen for farm power.

Table 6.2 Economic Crop Production Value under Without-Project Condition

Item	Unit	Maize	Sorghum	Cotton	G. Nut	Cassava	Rice
FARM INPUT							
1. Seed	kg	25	5	20	23		45
2. Fertilizer							
Ammonium Sulphate	kg						
Urea	kg						
Triple Super Phosphate	kg						
3. Agrochemical							
Seed Dressing	g						
Insecticide	liter			3			
Fungicide	kg						
4. Farm Power							
Labor	man-day	125	110	130	110	90	180
Oxen	time	2	2	2	2		2
Machinery	hours						
DIRECT PRODUCTION COST	Unit Price 1/						
5. *Seed*							
Maize	8.0	200					
Morghum	3.5		17.5				
Cotton	3.0			60			
Groundnut	9.0				207		
Cassava	nil					0	
Rice	1.0						45
6. Fertilizer							
Ammonium Sulphate	3.26	0	0	0	0	0	0
Urea	4.48	0	0	0	0	0	0
Triple Super Phosph.	4.60	0	0	0	0	0	0
7. Agrochemical							
Seed Dressing	0.30	0	0	0	0	0	0
Insecticide	150	0	0	450	0	0	0
Fungicide	90	0	0	0	0	0	0
8. Farm Power							
Labor	15	1,875	1,650	1,950	1,650	1,350	2,700
Oxen							
Machinery	20	0	0	0	0	0	0
9. Others (10% of item 5 to 8)		207	167	246	186	135	275
10. Total Crop Production Cost	Ksh/ha	2,282	1,834	2,706	2,043	1,485	3,020
CROP PRODUCTION VALUE							
11. Yield	ton/ha	1.30	1.20	0.20	0.50	3.00	2.40
12. Unit Price	Ksh/ton	2,729	3,625	8,362	9,000	2,750	3,592
13. Gross Production Value	Ksh/ha	3,548	4,350	1,672	4,500	8,250	8,621
14. Net Production Value (13-10)	Ksh/ha	1,266	2,516	-1,034	2,457	6,765	5,601
	US$/ha	84	168	-69	164	451	373

Remarks; 1/: See Table 5.6

Table 6.3 Financial Crop Production Value under With-Project Condition

Item	Unit	Mixed Cropping: Maize	Mixed Cropping: Beans	Cotton	Rice	Green-gram	Ground-nut	Alfalfa	Napier
FARM INPUT									
1. Seed	kg	15	20	20	30	20	90	10	20 ton 1/
2. Fertilizer									
Ammonium Sulphate	kg	300		450	0	0	100	270	700
Urea	kg	0		0	225	0	0	0	0
Triple Super Phosphate	kg	100		100	100	0	100	140	150
3. Agrochemical									
Seed Dressing	g	0		0	90	0	270	0	0
Insecticide	liter	3		4	3	2	3	2	2
Fungicide	kg	2		2	3	0	3	2	2
4. Farm Power									
Labor	man-day	150		160	190	90	110	170	200
Oxen	time	2		2	3	0	2	2	2
Machinery	hours	10		20	20	5	20	5	5
DIRECT PRODUCTION COST	Unit/Price 2/								
5. Seed									
Maize	8.0	120							
Beans	10.0		200						
Cotton	3.0			60					
Rice	1.0				30				
Greengram	16.0					320			
Groundnut	9.0						810		
Alfalfa	160.0							1,600	
Napier	10.0								200
6. Fertilizer									
Ammonium Sulphate	3.39	1,017		1,526	0	0	339	915	2,373
Urea	4.63	0		0	1,042	0	0	0	0
Triple Super Phosphate	4.53	453		453	453	0	453	634	680
7. Agrochemical									
Seed Dressing	0.30	0		0	27	0	81	0	0
Insecticide	150	450		600	450	300	450	300	300
Fungicide	90	180		180	270	0	270	180	180
8. Farm Power									
Labor	15	-		-	-	-	-	-	-
Oxen	-	-		-	-	-	-	-	-
Machinery	20	200		400	400	100	400	100	100
9. Others (15% of item 5 to 8)		393		483	401	108	420	359	575
10. Total Crop Production Cost	Ksh/ha	3,013		3,702	3,073	828	3,223	4,288	4,408
CROP PRODUCTION VALUE									
11. Yield	ton/ha	5.00	0.90	2.00	5.00	1.20	2.00	80	120
12. Unit Price	Ksh/ton	3,334	10,000	3,870 5/	2,867	6,667	9,000	-	-
13. Gross Production Value 4/	Ksh/ha	16,670	9,000	7,740	14,335	8,000	18,000	-	-
14. Net Production Value (13 - 10)	Ksh/ha	22,657		4,038	11,262	7,172	14,777	- 3/	- 3/

Remarks; 1/: 20 ton/ha of seed cane for every 4 years.

2/: Using farm gate price, see Table 5.6

3/: These net production values are counted as raising cost of oxen for farm power.

4/: Excludes labor cost

5/: Quality of lint harvested is supposed to be, Rank A for 80% of them, Rank B for 20% of them.

Table 6.4 Financial Crop Production Value under Without-Project Condition

Item	Unit	Maize	Sorghum	Cotton	G. Nut	Cassava	Rice
FARM INPUT							
1. Seed	kg	25	5	20	23		45
2. Fertilizer							
Ammonium Sulphate	kg						
Urea	kg						
Triple Super Phosphate	kg						
3. Agrochemical							
Seed Dressing	g			3			
Insecticide	liter						
Fungicide	kg						
4. Farm Power							
Labor	man-day	125	110	130	110	90	180
Oxen	time	2	2	2	2		2
Machinery	hours						
DIRECT PRODUCTION COST	Unit/Price 1/						
5. Seed							
Maize	8.0	200					
Sorghum	3.5		17.5				
Cotton	3.0			60			
Groundnut	9.0				207		
Cassava	nil					0	
Rice	1.0						45
6. Fertilizer							
Ammonium Sulphate	3.39	0	0	0	0	0	0
Urea	4.63	0	0	0	0	0	0
Triple Super Phosph.	4.53	0	0	0	0	0	0
7. Agrochemical							
Seed Dressing	0.30	0	0	0	0	0	0
Insecticide	150	0	0	450	0	0	0
Fungicide	90	0	0	0	0	0	0
8. Farm Power							
Labor	15	-	-	-	-	-	-
Oxen		-	-	-	-	-	-
Machinery	20	0	0	0	0	0	0
9. Others (10% of item 1 to 4)		20	1.5	6	21	0	5
10. Total Crop Production Cost 2/	Ksh/ha	220	19	66	228	0	50
CROP PRODUCTION VALUE							
11. Yield	ton/ha	1.30	1.20	0.20	0.50	3.00	2.40
12. Unit Price	Ksh/ton 1/	3,334	3,625	3,870	9,000	2,750	2,867
13. Gross Production Value	Ksh/ha	4,334	4,350	774	4,500	8,250	6,880
14. Net Production Value (13-10)	Ksh/ha	4,114	4,331	708	4,272	8,250	6,831

Note; 1/: See Table 5.6

2/: Excludes labor cost

Table 6.5 Typical Farm budget with Proposed Cropping Pattern (A)

I. GROSS INCOME (1)

Crop	Planted Area (ha)	Gross Income
Rice	0.8	14,355 x 0.8 = 11,468
Greengram	0.8	8,000 x 0.8 = 6,400
Maize & Beans	1.6	25,670 x 1.6 = 41,072
Alfalfa	0.2	- 1/
Napier grass	0.2	-
		Total Kshs 58,940 ... (1)

II. DIRECT FARMING EXPENSE (2)+(3)

1. Farm Input (2) 2/

Crop	Planted Area (ha)	Cost of Farm Input
Rice	0.8	3,073 x 0.8 = 2,458
Green gram	0.8	828 x 0.8 = 662
Maize & Beans	1.6	3,013 x 1.6 = 4,821
Alfalfa	0.2	4,288 x 0.2 = 858
Napier grass	0.2	4,408 x 0.2 = 882
		Total Kshs 9,681 ... (2)

2. Hired Labor (3) 3/

Kshs 15 x 64.5 man-days = Kshs 968 .... (3)

III. NET INCOME (1) - [(2)+(3)] Kshs 48,291

Remarks; 1/: Production values of fodder crops are counted as raising cost of oxen for farm power.

2/: See Table 6.3

3/: See Remarks of Table 5.2 (1/3)

Table 6.6 Typical Farm Budget with Proposed Cropping Pattern (B)

I. GROSS INCOME (1)

Crop	Planted Area (ha)	Gross Income
Rice	1.6	14,335 x 0.8 = 22,936
Green gram	0.8	8,000 x 0.8 = 6,400
Maize & Beans	0.8	25,670 x 0.8 = 20,536
Alfalfa	0.2	- 1/
Napier grass	0.2	-
		Total Kshs 49,872 ... (1)

II. DIRECT FARMING EXPENSE (2)+(3)

1. Farm Input (2) 2/

Crop	Planted Area (ha)	Cost of Farm Input
Rice	1.6	3,073 x 1.6 = 4,917
Green gram	0.8	828 x 0.8 = 662
Maize & Beans	0.8	3,013 x 0.8 = 2,410
Alfalfa	0.2	4,288 x 0.2 = 858
Napier grass	0.2	4,408 x 0.2 = 882
		Total Kshs 9,729 ... (2)

2. Hired Labor (3) 3/

Kshs 15 x 90.2 man-days = Kshs 1,353 .... (3)

III. NET INCOME (1) - [(2)+(3)] Kshs 38,790

Remarks; 1/: Production values of fodder crops are counted as raising cost of oxen for farm power.

2/: See Table 6.3

3/: See Remarks of Table 5.2 (2/3)

Table 6.7 Typical Farm Budget with Proposed Cropping Pattern (C)

I. GROSS INCOME (1)

Crop	Planted Area (ha)	Gross Income
Cotton	0.8	7,740 x 0.8 = 6,192
Groundnut	1.6	18,000 x 1.6 = 28,800
Maize & Beans	0.8	25,670 x 0.8 = 20,536
Alfalfa	0.2	- 1/
Napier grass	0.2	-
		Total Kshs 55,528 ... (1)

II. DIRECT FARMING EXPENSE (2)+(3)

1. Farm Input (2) 2/

Crop	Planted Area (ha)	Cost of Farm Input
Cotton	0.8	3,702 x 0.8 = 2,962
Groundnut	1.6	3,223 x 1.6 = 5,157
Maize & Beans	0.8	3,013 x 0.8 = 2,410
Alfalfa	0.2	4,288 x 0.2 = 858
Napier grass	0.2	4,408 x 0.2 = 882
		Total Kshs 12,269 ... (2)

2. Hired Labor (3) 3/

Kshs 15 x 44.4 man-days = Kshs 666 .... (3)

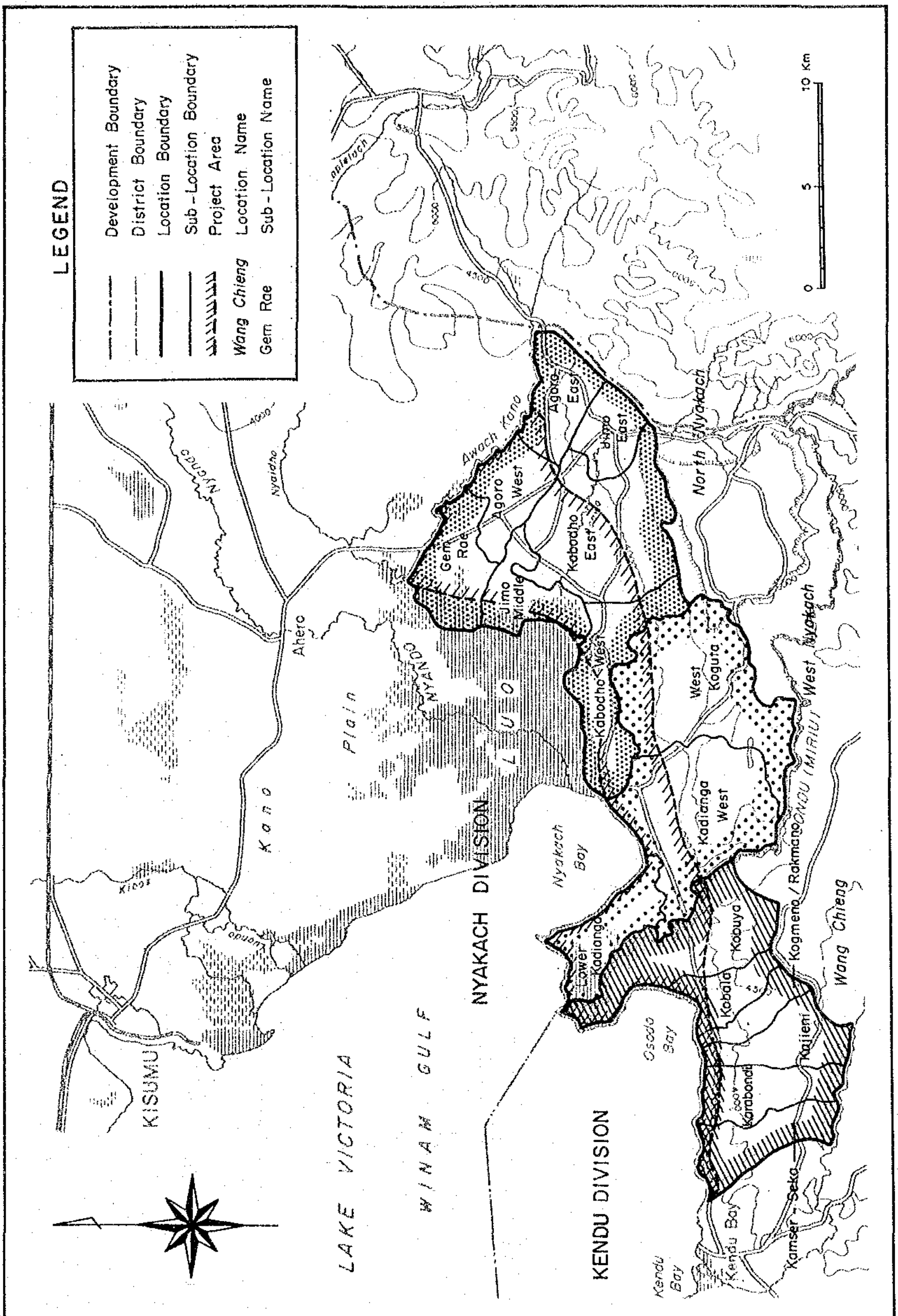
III. NET INCOME (1) - [(2)+(3)] Kshs 42,593

Remarks; 1/: Production values of fodder crops are counted as raising cost of oxen for farm power.

2/: See Table 6.3

3/: See Remarks of Table 5.2 (3/3)

FIGURES



<table>
<tr><td rowspan="3">Figure 2.1 Administrative Boundaries</td><td>REPUBLIC OF KENYA
SONDU RIVER
MULTIPURPOSE DEVELOPMENT PROJECT</td></tr>
<tr><td>JAPAN INTERNATIONAL COOPERATION AGENCY</td></tr>
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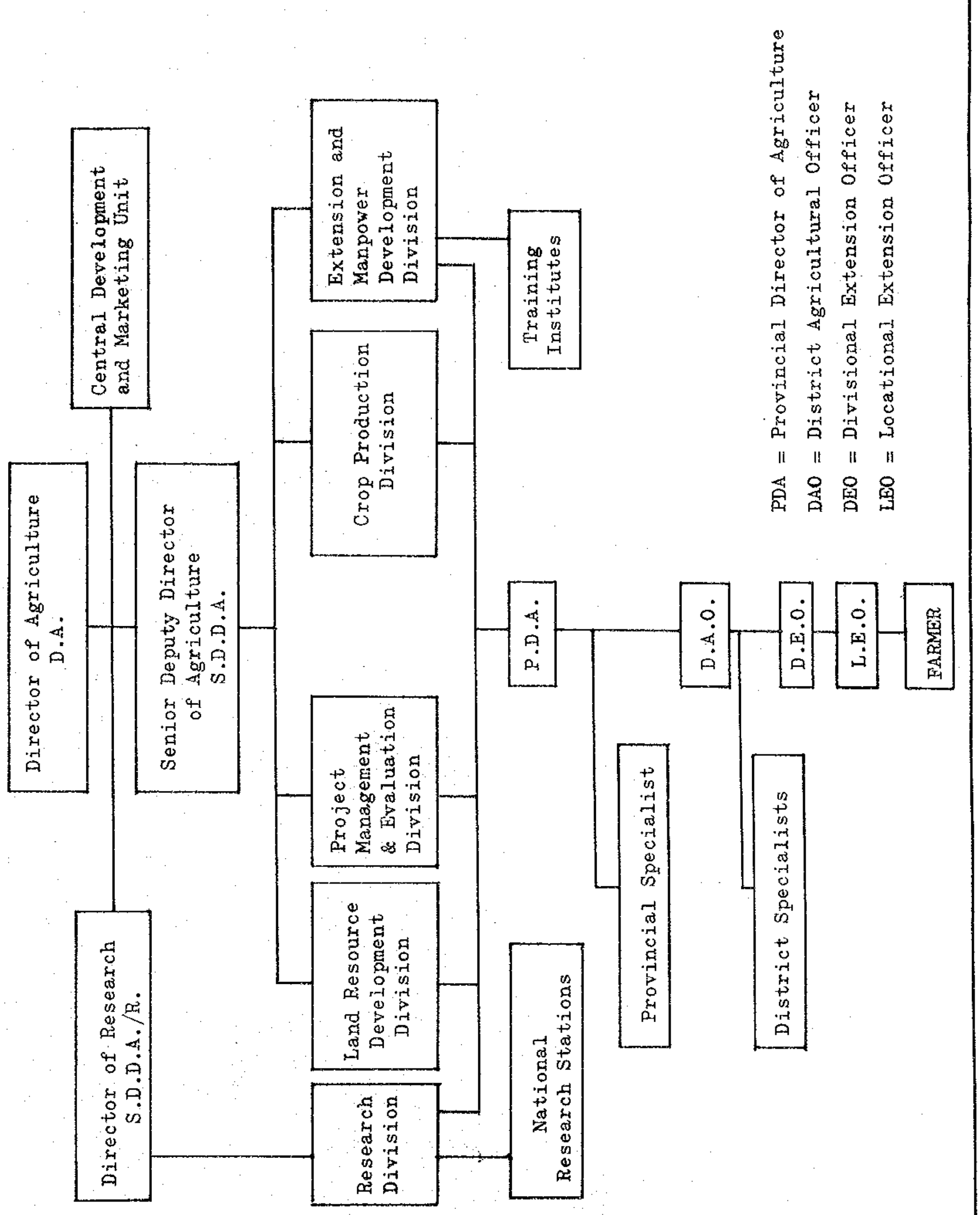
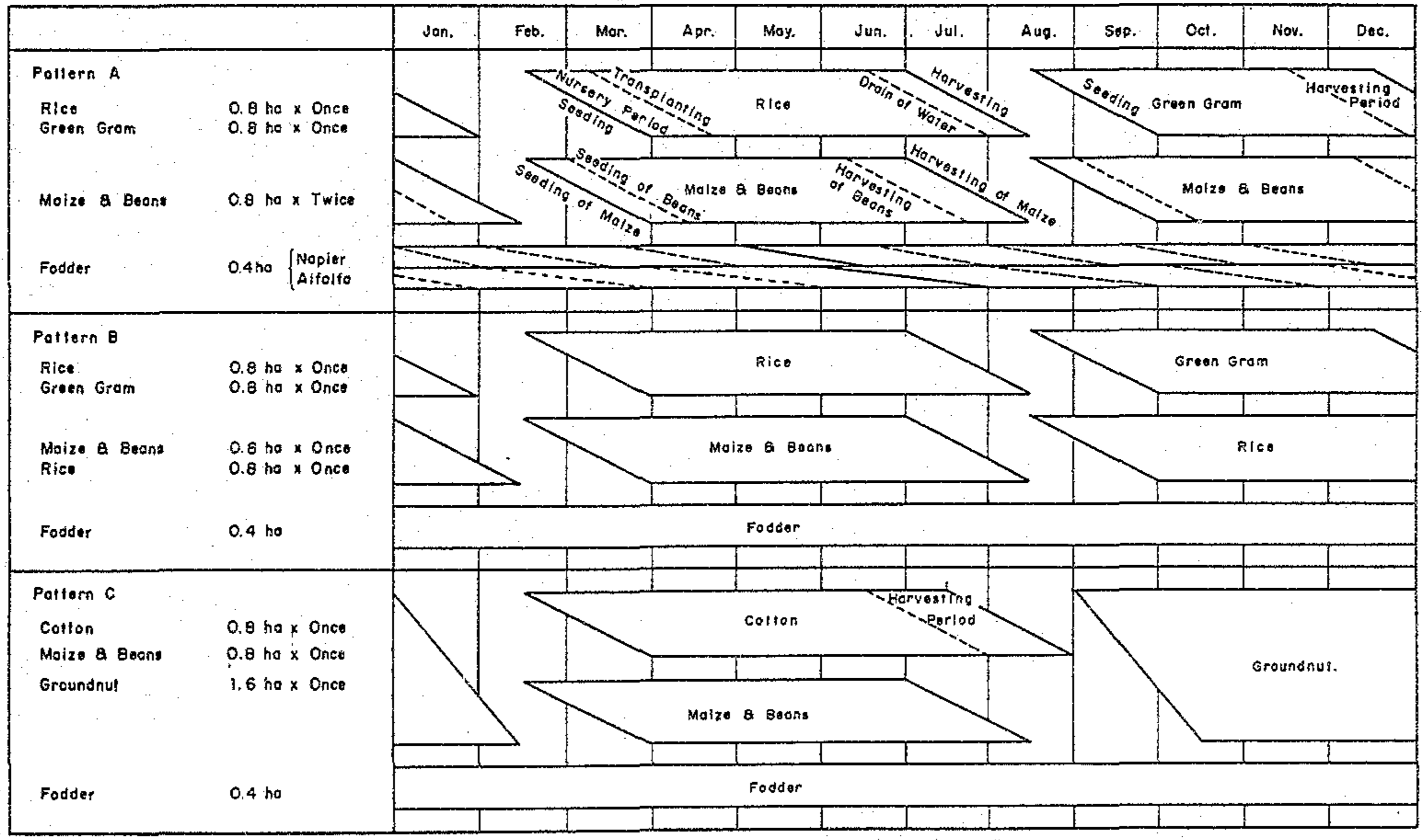


Figure 3.1 Systematic Structure of Agricultural Supporting Institutions

REPUBLIC OF KENYA
SONDU RIVER
MULTIPURPOSE DEVELOPMENT PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY



Notes: Rice, growth period, 135 days, nursery stage for about 3 weeks, water in the field will be drained 2 weeks before harvesting.
Green Gram, growth period, 120 days, harvesting period lasts for about 1 month.
Maize, growth period, 135 days.
Beans, growth period, 105 days, planted 2 weeks later than sowing of maize, intercropped with maize.
Cotton, growth period, 150 days, harvesting lasts for about 1 month.
Groundnut growth period, 120 days.
Fodder crops, Napier and Alfalfa, Napier is cut at every 45 days interval, and alfalfa is cut at every 60 days, respectively, both are planted every 4 years.

Figure 5.1 Proposed Cropping Patterns

REPUBLIC OF KENYA
SONDU RIVER
MULTIPURPOSE DEVELOPMENT PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX V. IRRIGATION AND DRAINAGE

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1. ILACO, "Ahero Irrigation Research Station", General Report, 1974
2. I.D.Teare & M.M.Peet, "Crop-Water Relations"
3. JICA, "Feasibility Study on the Sondu Multipurpose Development Project", Interim Report, March 1985
4. ITALCONSULT, "Pre-Feasibility Study for Water Management and Development of the Nyando and Nzoia River Basins", Preliminary Report, April 1981
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Chapter 1. WATER REQUIREMENT

1.1 Irrigation Water Requirement

1.1.1 General

Irrigation water requirement is defined as volume of water to be supplied to the specific crop area and the basic determinant for capacity of the supply sources and irrigation systems to distribute the water.

The estimate of the irrigation water requirement is made as follows:

$$WR = (CU + OR - ER)/E$$

where, WR: Water requirement
CU: Consumptive use of water
OR: Other water requirement
ER: Effective rainfall
E : Total irrigation efficiency

1.1.2 Consumptive Use of Water

The consumptive use of water is estimated based on the empirical prediction method using the climatic data and crop coefficients relating to crop growth stage. It can be calculated by the following formula for each month:

$$CU = Kc \times ETo$$

where, CU : Consumptive use of water
ETo: Potential evapotranspiration
Kc : Crop coefficient

(1) Crop coefficient (Kc)

Crop coefficients are employed to relate the potential evapotranspiration to the consumptive use of water. Values of crop coefficients vary with the crop characteristics, time of planting and/or sowing and climatic conditions. Crop coefficients are quoted from the experimental results of AIRS,[1/] and shown in Table 1.1. The crop coefficients of fodders, such as alfalfa and napier of 0.5[2/] are employed.

(2) Potential evapotranspiration (ETo)

Potential evapotranspiration is defined as the rate of evapotranspiration from an extensive water surface covered by green grass of uniform height, completely shading the ground. Among the various prediction methods developed so far, the modified Penman method is selected as the best applicable method in consideration of the availability of climatic data and wider acceptance in similar projects.

The meteorological station at Ahero provide such data as temperature, relative humidity, sunshine hours and wind velocity on daily basis. The climatic data used in the estimate are shown in Table 1.6, 1.8, 1.9, and 1.11 in Appendix II.

The calculation results of ETo from 1970 to 1983 on monthly basis are shown in Table 1.2 and summarized below.

Unit: mm/day

J	F	M	A	M	J	J	A	S	O	N	D
5.89	6.11	5.93	5.22	4.72	4.39	4.31	4.68	5.32	5.69	5.32	5.53

(3) <u>Consumptive use of water (CU)</u>

The consumptive use of water is calculated by production of crop coefficient (Kc) and potential evapotranspiration (ETo) as calculated above on monthly basis.

The monthly consumptive use of water for each crop are summarized as follows.

Unit: mm/day

	J	F	M	A	M	J	J	A	S	O	N	D
LR Paddy			5.9	5.3	4.8	4.4	4.1					
SR Paddy	5.6								5.3	5.8	5.4	5.5
LR Maize		2.4	2.9	3.6	4.4	4.3	4.0	3.7				
SR Maize	5.4	4.9						1.9	2.6	3.9	5.0	5.4
Cotton		2.1	2.5	3.1	3.9	4.1	4.1					
Groundnut	4.0	3.1							2.7	3.9	4.7	4.3
Green gram	3.0							2.3	3.1	4.4	4.6	3.9
Fodder	3.0	3.1	3.0	2.6	2.4	2.2	2.2	2.3	2.7	2.9	2.7	2.8

1.1.3 <u>Effective Rainfall</u>

To estimate the effective rainfall, rainfall records at Nyakwere rainfall station are adopted. The rainfall data of 80% probability of exceedance are shown below:

Unit: mm

J	F	M	A	M	J	J	A	S	O	N	D	ANNUAL
41	48	78	105	100	47	45	68	41	43	59	61	736

The effective rainfall for paddy is assumed to be 70% of the above rainfall data. On the other hand, to estimate the effective rainfall for upland crops, the procedure of the U.S. Department of Agriculture's Soil Conservation Service is adopted. This method is introduced in the FAO series No. 25 "Irrigation and Drainage Paper". In this method, the effective rainfall values are computed from monthly mean rainfall and mean monthly consumptive use as shown in Table 1.3.

1.1.4 Other Requirement

The other water requirements such as land preparation, topping up and re-flooding are quoted from the AIRS General Report. The values are shown below:

Unit: mm

Crop	Land preparation	Topping up	Re-flooding
Paddy	200	90	150
Maize	100	-	-
Cotton	100	-	-
Green Gram	100	-	-
Groundnut	100	-	-

1.1.5 Irrigation Efficiency

The overall irrigation efficiency combined with canal conveyance efficiency, operation efficiency and application efficiency is estimated to be 40%.

1.1.6 Diversion Water Requirement

The calculation procedures and results of unit irrigation requirements for each crop are shown in Table 1.4 and summarized below:

Unit: l/sec/ha

	J	F	M	A	M	J	J	A	S	O	N	D
LR Paddy		0.23	1.16	1.80	0.76	0.86	0.30					
SR Paddy	0.44							0.16	1.39	2.56	1.32	1.08
LR Maize		0.17	0.22	0.33	0.66	0.87	0.53	0.05				
SR Maize	0.85	0.08						0.10	0.55	0.86	0.97	1.08
Cotton		0.05	0.15	0.23	0.53	0.76	0.27					
Groundnut	0.59	0.04							0.29	0.86	0.89	0.77
Green gram	0.20							0.11	0.66	1.02	0.88	0.63
Fodder	0.59	0.51	0.37	0.09	0.16	0.29	0.28	0.27	0.51	0.56	0.34	0.37

The unit irrigation water requirements on monthly basis for each proposed cropping pattern are shown in Table 1.5 and summarized below.

Unit: l/sec/ha

	J	F	M	A	M	J	J	A	S	O	N	D
Pattern A	0.54	0.29	0.63	0.87	0.60	0.76	0.39	0.16	0.59	0.87	0.81	0.76
Pattern B	0.38	0.26	0.63	0.87	0.60	0.76	0.39	0.19	0.92	1.55	0.95	0.76
Pattern C	0.59	0.22	0.23	0.24	0.51	0.72	0.38	0.08	0.33	0.80	0.78	0.69

Based on above table, the diversion requirement at delivery point of water source is calculated as shown in Table 1.6 and summarized below.

Unit: m3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
Sub-area I	0.56	0.21	0.22	0.23	0.48	0.68	0.36	0.08	0.31	0.76	0.74	0.66
Sub-area II	2.38	0.92	1.08	1.20	2.11	2.95	1.55	0.36	1.46	3.34	3.20	2.84
Sub-area III	1.89	0.90	1.66	2.18	1.98	2.61	1.35	0.46	1.86	3.25	2.87	2.57
Total	4.83	2.03	2.96	3.61	4.57	6.24	3.26	0.90	3.63	7.35	6.81	6.07

The above table shows the peak requirement occurs in October and unit peak water requirement is 0.86 l/sec/ha.

1.2 Drainage Requirement

1.2.1 General

In general, unit drainage requirement depends on the rainfall intensity with certain probability and a drain period necessary for removal of excess water to an allowable extent.

The drainage water requirement of the project is estimated for:

- removal of excess rainfall in the paddy field and upland,and
- transporting the runoff coming from the inside and outside Project area mainly escarpment

1.2.2 Drainage Requirement for Paddy Field and Upland

The drainage requirement for the paddy field and upland are estimated based on the following assumptions:

- The design rainfall is estimated to be 100 mm of three consecutive days rainfall at Nyakwere with a 5-year return period,

- The excess water by the design rainfall is drained during three days for paddy, one day for upland, respectively, and
- The average surcharge of on-field storage is to be 50 mm for paddy, and 0 mm for upland, respectively.

The drainage requirements are calculated by using the following equation.

$$q = \frac{(R - h) \times 10^{-3} \times 10{,}000 \times 10^{3}}{86{,}400 \times d}$$

where, q: unit drainage requirement (l/sec/ha)

R: design rainfall (100 mm)

h: average surcharge of on-field storage (mm)

d: allowable duration of inundation (days)

Unit drainage requirement is determined at 1.9 l/sec/ha for paddy field and 11.6 l/sec/ha for upland respectively.

1.2.3 Drainage Requirement from Escarpment

It is difficult to estimate the peak flood discharge by using rational method since there is no meteorological station in escarpment. Then, the peak flood discharge with 5-year return period are estimated from the specific discharge of the Sondu, the Nyando, the Awach Kano and the Kibos. The following table shows the peak flood discharge and the catchment area of each river.

River (Station)	Catchment Area (km2)	Peak Discharge (m3/sec)	Specific Discharge (m3/sec/km2)
Sondu (1JG1)	3,260	296 3/	0.09
Nyando (1GD3)	2,594	440 4/	0.17
Awach Kano	380	170 5/	0.45
Kibos (1HA16)	247	270 4/	0.91

The specific discharge for each tributary and stream are estimated from the above table.

Chapter 2. WATER BALANCE STUDY

To examine the water availability, water balance study is carried out on the basis of runoff data and irrigation water demand for 37 years. (1948 - 1983)

The calculations are made on the following assumptions:

- Runoff data used for the water balance study are the data observed at 1GJ1 from 1948 to 1983 which are shown in Table 2.1,
- Irrigation water requirement is estimated in Section 1.1, and
- No river maintenance flow in downstream of the Sondu is estimated.

The result of water balance study are shown in Figure 2.1. The figure shows that water deficit occurs six times during 37 years. So, it is concluded the proposed irrigation plan covering whole Nyakach Plain of 8,540 ha can be accomodated with 84% dependability by even the diversion of the Sondu run-of-river plan.

Chapter 3. PLANNING AND PRELIMINARY DESIGN OF PROJECT FACILITIES

3.1 General

The facilities required for the project include irrigation canals, drainage canals, farm roads, and their related structures. The project facilities should be provided in the most effective and economical manner so that each function can be fully compatible with farming operation introduced in the project area. In consideration of the above, the preliminary design of the facilities is carried out as mentioned below.

3.2 Irrigation Canal System

3.2.1 General

The proposed irrigation system consists of main, secondary, tertiary and distribution irrigation canals. Tertiary and distribution irrigation canals are described in Section 3.5.2. Design of these canals and related structure is carried out according to the following programme, and the route alignment of the proposed canal is shown in Figure 3.1.

3.2.2 Design Condition

The canal system design is carried out by the following criteria:

(1) Canal section

In principle, the type of all irrigation canals are unlined open channel with trapezoidal section. In the area where soil condition is so susceptible to leakege, masonry lining is proposed.

(2) Hydraulic Calculation

(a) Flow formula

The Manning formula is used for determination of hydraulic characteristics of irrigation canal.

(b) Roughness coefficient

Roughness coefficient in the Manning formula varies depending on the perimeter conditions of canals.

Canal	Roughness Coefficient
Earth canal	0.033
Masonry lined	0.025
Concrete lined	0.017

(c) Velocity

Maximum and minimum allowable flow velocity in the canal is as follows:

Unit: m/sec

Canal	Min	Max
Earth	0.3	0.7
Masonry	0.3	2.0
Concrete	0.3	3.0

3.2.3 Main Irrigation Canal

In the project area, two main canals, i.e. Left Main Canal and Right Main Canal, are required. The alignment of both main canals are made based on the field canal route survey executed by the Contractor (Gauff, Nairobi). Both main canals start at the tailrace channel of the proposed hydroelectric power station with the intake water level of EL. 1205 m.

The Left Main Canal is proposed to run along the foot of Nyakach escarpment from the intake to the end point of vicinity of Nyakwere in total distance of 5.6 km. The irrigation area commanded by the canal is 1670 ha in net, which consists of 950 ha of Sub-area I and 720 ha of Sub-area II, respectively. The canal capacity at its head is about 1.4 m3/sec.

The Right Main Canal is designed to supply the irrigation water for the area of 6,870 ha, which consists of 3,360 ha of Sub-area II and 3,510 ha of Sub-area III, respectively, and to regulate diurnal outflow from the power station. The canal runs eastward from the intake along the foot of the escarpment, crossing the Asawo river with siphon, after crossing A-1 highway, the canal runs northward and terminates at Awach Kano in total distance of 18.7 km. The canal capacity at its head is about 5.9 m3/sec.

Figure 3.2 and 3.3 show the longitudinal sections and typical cross sections of the main canals.

3.2.4 Secondary Irrigation Canal

Secondary irrigation canals are to be branched off from the main canal at several locations to command topographic units of about 100 ha to 1500 ha. The layout of secondary irrigation canals are preliminary determined on the maps of scale 1:50,000 with a contour interval of 50 ft. 17 secondary canals would be necessary with the total length of about 66 km. Because of rather steep topography, a number of drops and water level regulating structures are to be necessary.

The characteristic of each secondary canal and the typical cross section of secondary canal are shown in Table 3.1.

The total length of the main and secondary canals and the number of their related structures are shown below:

Description	Sub-area I	Sub-area II	Sub-area III	Total
Main canals				
- Canal length (km)	-	21.1	3.2	24.3
- Related structure (Nos.)				
Turnout	-	27	3	30
Check	-	7	1	8
Culvert	-	12	2	14
Drop	-	3	-	3
Siphon & Aqueduct	-	9	1	10
Cross drain	-	20	-	20
Spillway and Wasteway	-	7	2	9
Secondary canals				
- Canal length (km)	17.9	28.4	19.6	65.9
- Related structures (Nos.)				
Turnout	16	65	41	122
Check	4	65	41	110
Culvert	38	71	43	152
Drop	-	495	155	650
Spillway and wasteway	7	13	3	23
Siphon and cross drain	20	-	-	20

Figure 3.4 shows the irrigation diagram of the Project area.

3.2.5 Related Structures

Various related structures would be provided for crossing of road, tributaries, and rivers, for regulating and control of discharge, and for distribution of irrigation water.

The structures to be required are listed below:

- Turnout and measuring device
- Check structure
- Siphon
- Cross drain
- Aqueduct
- Culvert
- Spillway & Wasteway
- Drop

(1) Turnout & Measuring device

Turnout is constructed to distribute the required water from a parent canal to a branch canal. A control gate and a staff gauge as measuring device are provided. A precast concrete pipe with 300 mm to 1,000 mm in diameter or a recutangular concrete barrel is laid under canal embankment.

(2) Check structure

A check gate is provided in the main canal at the downstream of a turnout and/or a spillway to raise the water surface to the required level during the period of small discharge. The check structure is also provided at spillway to aid to drain the excess water flow out through a spillway. In case a drop structure is needed closely to a check gate, a check cum drop structure is provided.

(3) Culvert

Culvert is constructed to convey canal water under roads. The culverts in the proposed canal system are classified into two types depending on their discharges. The one type has box barrels and the other has pipe barrels. Design water depth in the barrel is taken to be about 80% of barrel height, and design velocity is to be 150% of canal water velocity.

(4) Siphon and Aqueduct

Inverted siphons or aqueduct are provided in the proposed canal system at river crossings. In general, the siphon is superior to the aqueduct in view of the structural stability, however high head loss and complicated maintenance is required. In the project, aqueduct is proposed where river bed is too deep to construct the siphon. A siphon has a barrel with a rectangular section and design velocity is to be 150% of canal water velocity.

(5) Cross drain

A number of cross drains are provided to drain excess runoff from hill sides extending along irrigation canal. The design discharge of the cross drain is determined based on the specific discharge as mentioned in Section 2.1.3.

(6) Spillway and Wasteway

The spillway which has a overflow portion is provided at the upstream of siphon or turnout to drain out excess water in irrigation canals. Wasteway is provided at the tail of the irrigation canals to drain out all water from the canal.

(7) Drop

The function of this is to dissipate excess energy.

3.3 Drainage Canal System

3.3.1 General

The drainage system consists of major, tertiary and field drain. The tertiary and field drainage canals are described in Section 3.3.3. Design of these canals and related structures is carried out according to the following programme, and drainage networks is shown in Figure 3.1. Natural stream are used for the major drainage as much as possible.

3.3.2 Design Condition

(1) Canal section

All drainage canals are designed to be unlined canal with trapezoidal section.

(2) Hydraulic calculation

(a) Flow formula

The Manning formula is employed for determination of mean velocity, hydraulic gradient, water depth etc.

(b) Roughness coefficient (n)

Canal	n
Artificial drainage canal	0.033
Natural channel	0.040

(c) Velocity

Drainage canal	Maximum Velocity (m/sec)
Main	1.2
Secondary	1.0
Tertiary	0.6

3.3.3 Proposed Drainage System

The function of drainage canals are to convey the excess water to outlets or disposal points and to control the groundwater table. The layout of the irrigation system and topography are the main factor for determining the location of the drainage canal.

The major drains act to collect water from tertiary drains and field drains which are constructed within the tertiary blocks, and to transport collected water inclusive of stream flows to the Lake Victoria. The natural streams are used for the major drains without improvement as much as possible in order to minimize the cost for main drains.

As mentioned in Section 2.1.2, the unit drainage requirement is 1.9 l/sec/ha for paddy field, and 11.6 l/sec/ha for upland. On the other hand, all lands has an opportunity to use as upland, because rotation cultivation would be practiced under the proposed cropping pattern. So unit drainage requirement of all lands is designed to correspond to that of upland field i.e. 11.6 l/sec/ha.

Using the above unit design drainage requirement, the drainage system is preliminarily designed.

3.3.4 Related Structures

The related structures on the proposed drainage system consist of drainage culvert. The function and the design condition of these structures are same as those of irrigation system.

3.4 Farm Road Networks

For making construction, operation and maintenance of the project efficient, well arranged road network is of importance. Main, secondary and tertiary farm roads are provided along irrigation canals. Each road is paved with laterite with the following width:

Main road	7 m, pavement 5.5 m
Secondary road	4 m, pavement 3 m
Tertiary road	4 m, unpaved
Field road	4 m, unpaved

The length of the respective farm road are shown below:

Unit: km

Roads	Length
Main farm road	24
Secondary farm road	66
Tertiary farm road	180
Field road	445

3.5 Tertiary Development

3.5.1 General

Tertiary development aims at efficient water management through rotation irrigation farming by establishing well designed tertiary system programme. The tertiary development programme is prepared for every tertiary block. The tertiary block is further subdivided into several field blocks. The typical layout of tertiary system is designed as shown in Figure 3.5.

3.5.2 Tertiary Irrigation System

A tertiary block of 50 ha is covered by one tertiary canal. The distribution of irrigation water in the tertiary block is managed by farmers themselves. The tertiary canal derives irrigation water from the secondary irrigation canal or sometimes directly from the main canal.

The irrigation water to field block is served by the respective distribution canals. The size of a field block is proposed to be about 10 ha considering the appropriate organization of water users' group in future. The rotation irrigation is practiced on this basis.

The size of one plot in a field block is 0.4 ha (1 acre) considering the average land holding. The field borders are constructed along the counter line so as to reduce the construction cost of land levelling.

The related structures of tertiary irrigation system comprise tertiary division box, field division box, and culvert.

3.5.3 Tertiary Drainage System

In the tertiary block, the field drains and tertiary drains are provided to evacuate excess water. Field drains are to collect excess water in the field block and drain off the water to the tertiary drain. Tertiary drains in each tertiary block are to lead the excess water collected by the field drain to the nearby river which acts as major drain. In order to function the drainage system properly, the drainage drop and drainage culvert are provided on the drainage canal.

The total length of tertiary and distribution irrigation canals, tertiary and field drains and number of structures are as follows:

Tertiary Canal (km)	180
Distribution Canal (km)	400
Related Structures (Nos.)	
- Tertiary division box	900
- Field division box	5,400
- Culvert	900
Tertiary drain (km)	180
Field drain (km)	400
Related Structures (Nos.)	
- Drainage culvert	900