No.

THE REPUBLIC OF KENYA

LAKE BASIN DEVELOPMENT AUTHORITY

FEASIBILITY STUDY ON KANO PLAIN IRRIGATION PROJECT

VOLUME I

MAIN TEXT

JANUARY 1992

Japan International Cooperation Agency

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PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a feasibility study on Kano Plain Irrigation Project and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Hiroshi Yamamoto, Nippon Koei Co., Ltd. from August 1990 to November 1991.

The team held discussions with the officials concerned of the Government of Kenya, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

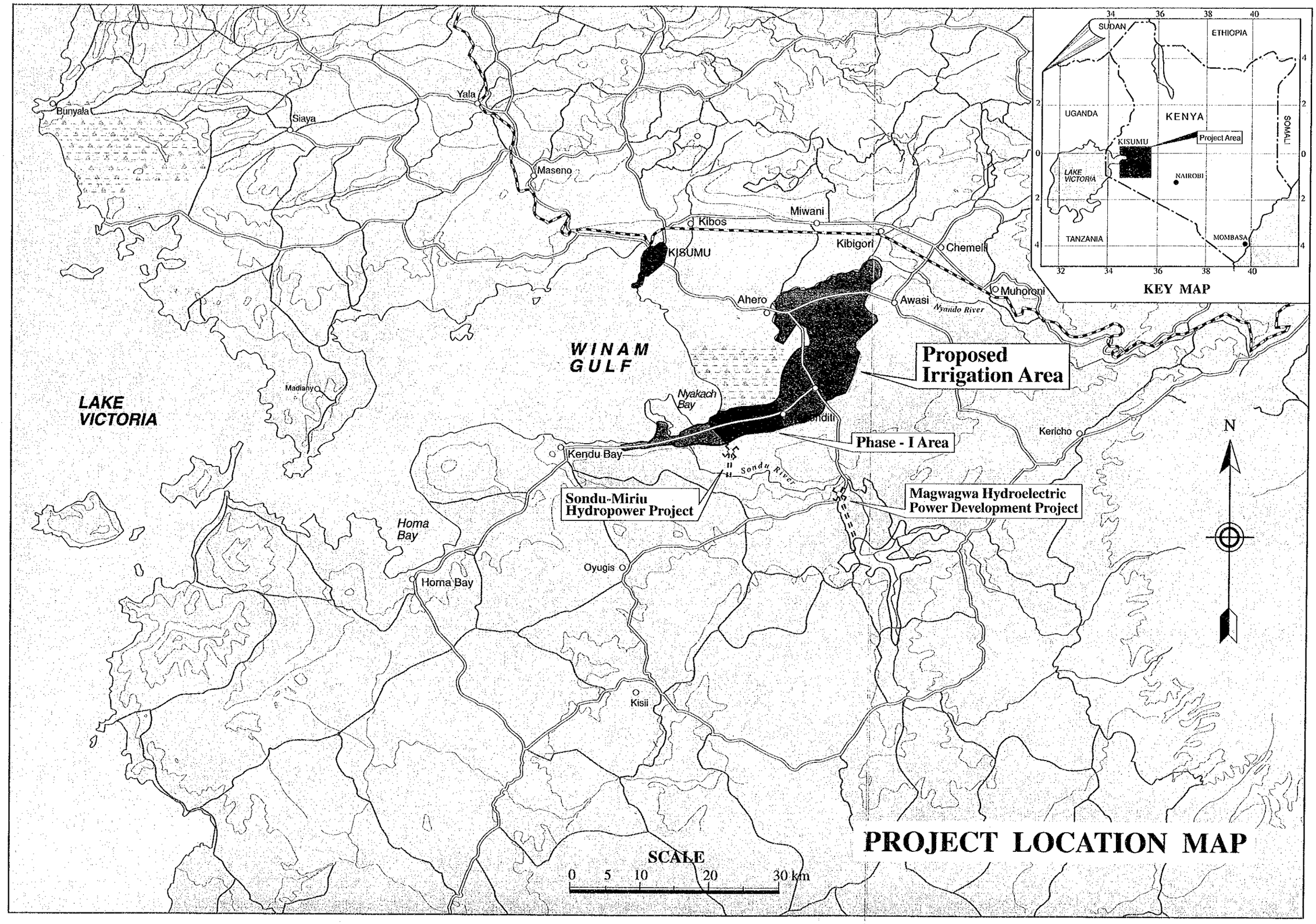
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team

January, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency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KEY MAP
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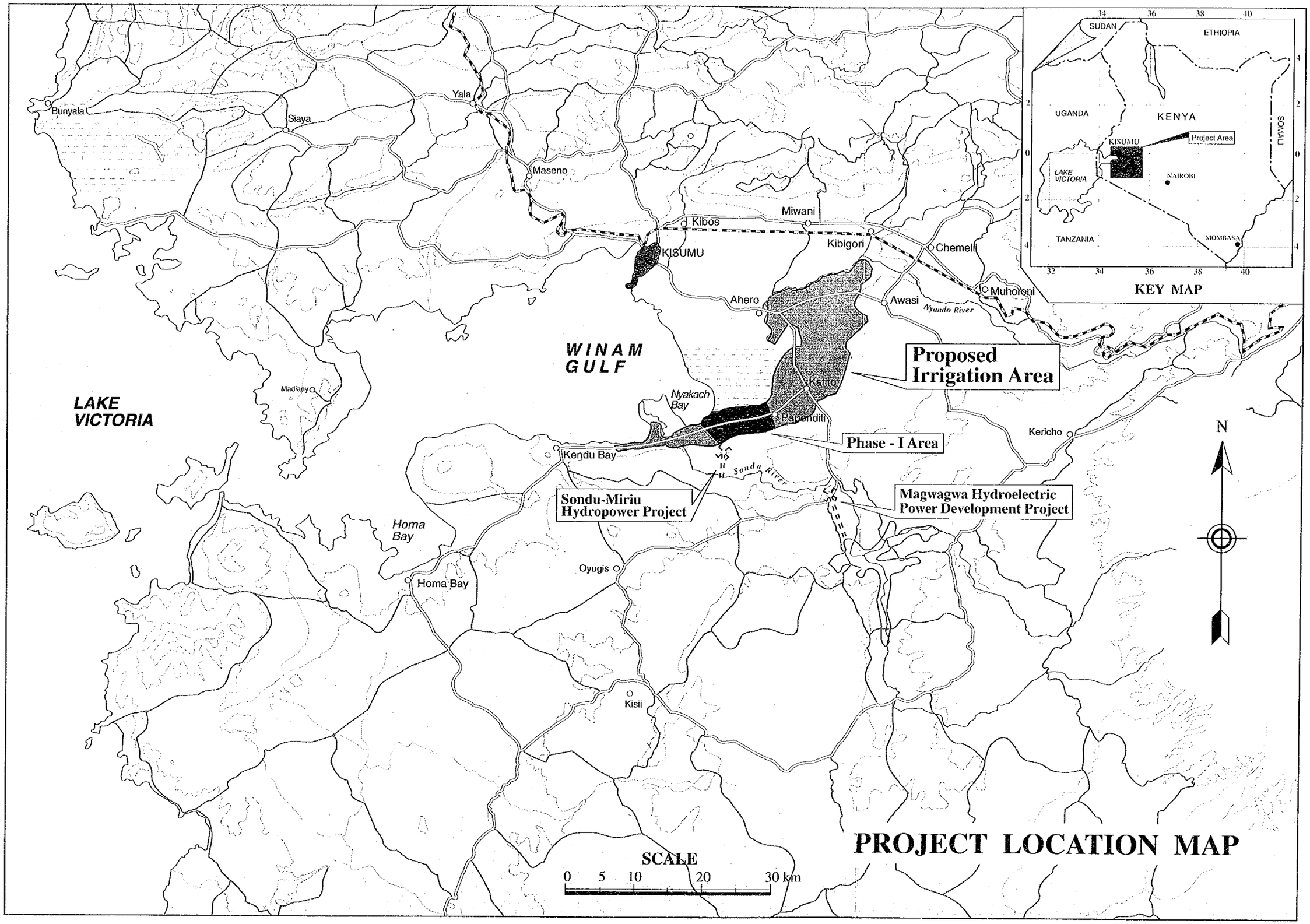
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SUMMARY

Introduction

01 This Final Report has been prepared in accordance with the Scope of Work for the Feasibility Study on the Kano Plain Irrigation Project agreed upon between the Lake Basin Development Authority, the Government of the Republic of Kenya and the Japan International Cooperation Agency, the Government of Japan on the date of November 16, 1989.

02 The main objectives of the study are to conduct a feasibility study of an irrigation project of about 26,000 ha extending over the Nyakach and Kano Plains as a part of the Sondu River Multipurpose Development Project.

03 The study area of about 60,000 ha is located at almost centre of the LBDA Region,which extends at about 380 km northwest along national road route A104 and B1 from Nairobi.

Background

04 Kenya is located in the equatorial zone of the eastern Africa and occupies her territory of about 583,000 km^2, of which about 572,000 km^2 is dry land and 11,000 km^2 is open water. The country exhibits a considerable climatic variation from humid and hot in coastal plain to dry and cool in highland.

05 As of 1988, the total population of Kenya is estimated to be 22.7 million people and it is also forecast at 27.2 million people in 1993 with a growth rate of 3.7% per annum. The population density is also estimated to be 38 persons/km^2 in 1993.

06 The gross domestic product (GDP) of Kenya attained K£ 7,330 million in 1989 at current price basis,corresponding to the per-capita GDP of K£ 343 (US$ 317). The agricultural sector plays a dominant role in the national economy, sharing about 30% in the gross domestic products and contributing nearly 60% of the export earning. The agricultural sector grew 4.2% per annum. Furthermore, this sector provides the largest employment opportunity, produces foodstuff for the national population, and supplies raw materials for the industrial sector.

07 The average annual production of staple food in Kenya has reached 3.5 million ton in total during 1985 thru 1989. Cash crop such as coffee, tea, sugarcane,pyrethrum, and horticulture is important in Kenya as well as the staple food crop. The export amount of horticultural products has been recently expanding in this country; it has reached more than 150 thousand tons or over 10% of the export earnings

08 Agricultural production in this country remains mostly under rainfed condition and is directly affected by the climate. Irrigation development is hence essential for self-sufficiency of the staple food in this country.

09 Land tenure in Kenya is divided into two categories, i.e. small holders including landless tenant farmers and large scale farmers. Small scale holders are the majority of farmers,but produce mainly staple food crops for subsistence and very little surplus for marketing. Large scale farmers conduct commercial farming and produce both cash and food crops for local export market.

10 The Sixth National Development Plan covering the period of 1989 thru 1993 ha been issued. In the Plan agriculture continues to play a leading role in feeding population, generating employment and incomes, contributing to foreign exchange earnings and inducing growth in other sectors of the economy. During the Plan period, this sector is targeted to grow at the rate of 4.5% per annum.

11 Irrigation development makes a major contribution to the attainment of objectives of the development plan. However, irrigation requires highly specialized agronomic and water management technologies. As of 1986, it was estimated that Kenya had irrigation potentials of about 500,000 ha and about 300,000 ha suitable for drainage improvement and valley-bottom reclamation.

12 LBDA region occupies about 39,000 km^2 in the western part of Kenya accounting for about 6.8% of the total land of Kenya. The population in the LBDA Region is estimated to be 8.9 million as of 1988,

corresponding to about 40% of the total population of Kenya. The average population density is calculated to be 170 persons/km^2 for the Region.

13 The gross regional domestic product(GRDP) of the LBDA Region is estimated at K£ 2,670 million in 1989. This GRDP shares 36.4% of the GDP of Kenya. Agriculture is the largest sector in this region, contributing about K£ 1,360 million or nearly 50% equivalence of the total GRDP of the Region.

14 Over 70% of the total land in the Region are classified as either high or medium potential based on average annual rainfall. About 55% of the potential land or about 1,549,000 ha have been developed for agriculture. The remaining vast potential land still has not been fully utilized so far.

15 The Lake Basin Development Authority was established in 1979 on the basis of the Parliament Act. The LBDA set forth its 2nd Five Year Plan (1989-1993) taking into consideration the position of the Region in the national economy, the development potentials and constraints, and the concepts of national development. In the 2nd Five Year Plan about 38 projects are ongoing and planned in the energy resources development, agricultural, livestock, and fisheries development,etc. In this Plan, top priority is given to the Sondu Miriu Multipurpose Project which is comprised with Sondu-Miriu Hydro-power Project, Magwagwa Multi-purpose Water Resources Development Project, and Kano Irrigation Project.

The Study Area

16 The study area extends southeast of Kisumu Municipality, the capital of Nyanza Province. Administratively, the area comes under two districts of the Nyanza Province, viz. Kisumu and South Nyanza.

17 The study area is physiographically divided into three zones, viz. Kendu bay strip, Nyakach plain and Kano Plain. The Kendu bay strip occupies western part of the area and is sharply slanting from the south to north, and rather undulating. The Nyakach plain, gently sloped piedmont plain, extends in the middle of the study area. The Kano plain widely extends in the northern part, and it lies on vast flat alluvials with the elevation between 1,135 m and 1,300 m above MSL.

18 The population in the study area is estimated at about 242,400 as of 1990 and forecasted at about 325,000 at the end of the 20th Century. The population density in the area is estimated at about 349 persons per km^2 for the LBDA Region. About 55% of the population in the study area are engaged in the agricultural sector.

19 The climate in the study area is characterized by two distinct seasons, i.e. rainy season and dry season, according to the distribution of rainfall. The rainy season is further sub-divided into long rainy season from March to May, and short rainy season from October to December. Likewise the rainy season, the dry season is also sub-divided into long dry season and short dry season. Annual rainfall in the area ranges from 1,100 mm in the south and to 1,600 mm in the north.

20 Mean monthly maximum temperature in the study area ranges from about 27ºC to about 32ºC and the annual mean minimum ranges from 14°C to 18°C. The relative humidity rather narrowly varies between 55% in the dry season and 75% in the rainy season. The Kano and Nyakach plains are blessed with favourable climatic conditions for the growth of various agricultural crops.

21 Predominant soils in the study area are black cotton soil, sandy red soil, and lateritic soil. The black cotton is widely spread over in the Kano Plain. The sandy red soil is distributed in foot of slopes and piedmont plains along the escarpment of the granite rocks. Distribution of lateritic soil and lateritic ironstone coincides with phonolite distribution.

22 The potential of land for upland and paddy crop production is appraised as follows:

1) for paddy plant

Suitability Class	Hectarage (ha)	Percentage (%)
S1	9,160	12.6
S2	26,350	36.1
S3	16,690	22.9
NS	20,780	28.4
Total	72,980	100.0

2) for upland Crops

Suitability Class	Hectarage (ha)	Percentage (%)
S1	2,850	3.9
S2	13,950	19.1
S3	36,900	50.6
NS	19,280	26.4
Total	72,980	100.0

23 Water in the Sondu river is a main water resources of the project. Annual mean runoff recorded at lower basin amounts to about 1,293 million m^3. The flow in the Sondu is regulated after Magwagwa dam is constructed. The Sondu-Miriu Power Station intakes required discharge according to the flow released from the Magwagwa dam and send it to its turbine through penstocks. Available mean monthly irrigation water resources with five-year non-exceedence recurrence are estimated as follows:

(unit:m^3/sec)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
18.5	18.4	18.5	19.8	21.2	20.3	19.5	19.8	20.5	19.2	19.1	19.1

24 Nyando river is the second largest river in the study area. Annual runoff of the river is estimated at about 360 million m^3. Non-regulated flow of the Nyando river would be available to supplement the water resources transferred from the Sondu river.

25 Three National roads i. e. Route B1, A104, A1, traverse in the study area. The main railway line extends from Mombasa until Kisumu by way of Nairobi. A domestic airport has been daily operated in the suburb of Kisumu. The lakeside towns and neighbouring countries are linked each other by means of navigation system, such as steamers and cargo ships.

26 In the Nyakach plain, the Ministry of Water Development has constructed pipe line system for domestic water supply. The water for the system is oftaken from the Sondu river and treated in the plant located Sondu village. The total length of the main pipe line in the study area is about 40 km and the number of total taps are about 180 pieces.

27 Meanwhile, LBDA commenced Rural Domestic Water Supply and Sanitation Programme (RWSSP) in South Nyanza, Siaya, Kisii, and Kisumu District in 1985. This project involves construction of bore holes, hand dug wells, dams, small pipe water scheme, spring protection, and roof catchments. Within the current Development Plan, 180 number of water points will be developed in Kisumu District through the RWSSP.

28 Twenty seven irrigation schemes have been developed with a total irrigation area of about 4,300 ha in the study area since late 1960s. These schemes can be classified into i) National Irrigation Board (NIB) schemes and ii) Provincial Irrigation Unit (PIU) schemes. Firstly, the Ahero scheme of 870 ha was

implemented by NIB as a pilot scheme for paddy cultivation in 1966, followed by the West Kano scheme implemented also by NIB in 1969.

29 PIU started construction of small scale paddy field irrigation schemes in early 1980s, and twenty five schemes have been developed so far depending on seasonal water resources in lowlying area. The irrigation system in these schemes is therefore not year-round but seasonal. Most of the PIU schemes are rather small ranging from four ha to 250 ha. Unlike the NIB schemes, the construction and operation of the PIU schemes have been made by the farmers' initiatives.

30 More than thirty rivers and rivulets are identified in the study area. These rivers in the Kano Plain are characterized by extremely gentle gradients of river beds and small cross section compared with their magnitude of floods, resulting in stagnation of flooding. The other major factors causing floods in the Plain are high intensity of rainfall, siltation in the river channel,and incidental rise of the Lake water level,etc.

31 The Ministry of Water Development started a construction of the flood protection dike of the Nyando river in 1985, which consists of three phases. The construction in 1985 completed but none in 1986 due too failure in machinery.

32 About 53,000 ha or 73% of the total land resources (73,000 ha) in the study area are cultivable. Out of this cultivable land, only about 17,000 ha are cultivated and the remainder has been usually left as fallow, pasture, and scrubs. Upland field and pasture have been alternately cultivated with several years interval. Fallow stage of the paddy field in the area has been also used for the pasture.

33 Main crops grown in the area consist of cereals, such as maize, sorghum, and rice, followed by pulses, cotton, and tuber crops. The cultivation pattern and growth period of crops are affected by seasonal distribution of rainfall and flooding. Maize, sorghum, and pulse for the long rainy season are planted during February to March, and harvested during June to August. These crops are mostly inter-cropped each other. Improved hybrid varieties and composite varieties have been introduced so far.

34 Farm operation in the area is mostly carried out by manpower. Cattle power is used for only soil preparation and transportation of farm products. The upland crops except cotton are usually cultivated under no chemical and fertilizer applications. Cotton plant is generally applied pesticides for twice to four times in a season.

35 The cropping season of paddy in the PIU schemes is affected by water condition, rainfall, and flooding. Double cropping of paddy has not been tried so far. Transplanting is made in the paddy field. Land preparation for nursery and before transplanting are mainly carried out by cattle power and manpower in the PIU schemes. In the NIB Schemes, however, ploughing and harrowing are made by tractors and puddling done by cattle. The other farming operations are made by manpower.

36 Yield of maize, sorghum, paddy, cotton, and sugarcane is of about 1.9, 1.1, 3.3, 0.3, and 52 ton/ha respectively. The yield of each crop is relatively low compared with that in the world level. Crop yields fluctuate year by year and place to place. The main reason may be due to low farm input, poor management and some kinds of stress.

37 Farm size in the study area widely ranges from 0.4 ha to 21 ha. Average farm size is estimated at about 3.1 ha, which is comprised with 1.7 ha of cultivated land, 1.0 ha of pasture, and 0.4 ha of homestead. In case that farmer cultivates paddy field, the cultivated land held by the average farm household consists of 1.4 ha of paddy field and 0.3 ha of upland field.

38 Land ownership of agricultural land in the study area can be categorized as owner farmer, share cropper, tenant, squatter, and hired. Among them, the owner farmer shares 63% of total agricultural land, followed by the share cropper of 33%. The share of the remaining three categories are negligible small.

39 There are five rice mills in and around the area including LBDA's rice mill, which total capacity is more than 230 ton/day. There exist many small scale grain mills for maize, sorghum, millet, and cassava. A ginnery owned by Cotton Board of Kenya is located at Kibos. Its capacity is of about 2,000 ton per season. Three large scale sugar factories are located at Chemelil, Muhoroni, and Miwani. Their total capacity of them is of more than 2,000,000 ton per year.

40 Most of farm inputs are supplied by Kenya Grains Growers Cooperative Union Ltd(KGGCU). From the KGGCU, farm inputs are mainly handled to farmers through primary cooperative societies or private dealers. Prices of farm inputs are controlled by the Government. But, the retail prices fluctuate location to location due to the transportation cost. Prices of the main crops are regulated by the Government.

41 Ahero Irrigation Research Station of NIB is established and operated in the Ahero Irrigation Scheme in the study area. The results of the research in the station have been applied both for the NIB and PIU irrigation schemes. Besides, Cotton Research Station and the Sugarcane Research Station, have been operated at Kibos.

42 The Ministry of Agriculture has the Extension and Manpower Development Division which has a responsibility for extension works in the national level. Assistant Director of Agriculture is in charge of at provincial level. Further, Senior Agricultural Officer and specialists are in charge of the extension works at district level. This organizational line continues up to the locational level.

43 There exists hundred fifty six of primary cooperative societies and cooperative unions in the Kisumu District. Most of the purchasing and marketing are made through the cooperative societies. Most of these societies are organized by crop or other exclusive function.

44 A gross income of the average farm household in the study area is analyzed about Ks.28,000 per annum. A 82% of the gross income or Ks.23,000 is generated from farm income. Net annual reserves in the average household are estimated at Ks.2,500 or 9% of the gross income by deducting the gross outgo from the gross income.

Needs of Irrigation Development

45 Despite of endowed natural and human resources and much effort for development by Authorities concerned, the Regional economy in the Lake Victoria Basin remains relatively low level in comparison with the national economy level. In order to improve regional economy , agriculture which is the top leading sector in the Region should be intensively developed. In line with the concepts of the current LBDA's Five Year Plan, the maximum intensification of land use or vertical expansion in the existing agricultural land in the area should be attempted maintaining present cropping pattern as far as possible. Irrigation development will make a sure contribution to the attainment of such intensified land use in the area.

46 The Nyakach and Kano Plains have been noted for long time as the most promising area for irrigated agricultural development due to its endowed land and water resources, favourable climatic conditions, sufficient labour forces, and its strategic location in the centre of the Region. In the 6th National Development Plan, this plain is nominated as one of the most favourable irrigation potential area. Such being the situation, there is pressing needs for implementation of a large scale irrigation scheme in the Nyakach and Kano Plains.

Prospective Development Plan

47 The irrigation project should aim at extension of stabilized irrigated agriculture through exploitation of a large scaled year-round irrigation system. Main concept for agricultural and irrigation development in the area are set forth as follows:

i) Crops and its cultivation area should be determined in consideration of land suitability, knowledge of farmers, existing capacity of processing, marketability and profitability, government policy, etc.,

ii) Cropping intensity should be increased as far as possible to realize the maximum use of newly exploited irrigation water,

iii) Optimal cropping pattern would be laid out in view of agro-water economy: water consumptive crops would be grown in the rainy season, in principle,

iv) Agricultural supporting services would be strengthened for effective farming operation.

v) The available water resources released from the Sondu-Miriu Hydro-power station would be transferred to the Nyakach and Kano Plains to the maximum extent,

vi) The perennial swamps such as the Kano and Central Swamps would be excluded from the project from the viewpoint of ecological conservation, flood detention, and project economy,

vii) An optimum scale of the development would be formulated and unfavourable area would be excluded in order to make the project economically viable and financially bankable,

viii) Irrigation development plan in the Nyando river basin would be formulated on the assumption that a comprehensive flood control and basin development plan would be implemented in parallel with this project. The flood control plan in this project,thus, would be studied only for small rivers developed in the project area.

48 Crops and cropping area are determined based on the concepts described before. The proposed cropping pattern is summarized as follows:

Long rainy Season	Short rainy Season	Hectareage
Paddy	Beans	2,690
Maize	Paddy	1,740
Maize	Cotton/Beans	1,530
Sugarcane	Sugarcane	5,130
Vegetables	Vegetables	1,570
Fruit tree	Fruit tree	1,000
Napier Grass	Napier Grass	1,270
Total		14,930

49 Introduction of the cropping pattern mentioned above brings about change of land use in the project area as tabulated below.

(Unit:ha)

Category of Land	Without Project condition	With Project condition	Balance
Paddy Field	780	4,430	+3,650
Upland Field	5,920	10,500	+4,580
Pasture	7,400	0	-7,400
Scrubs	830	0	-830
Total	14,930	14,930	0

50 Since hectareage of major crops and cropping intensity increase through developing irrigation facilities, labour requirement increases and fallow period of field becomes shorter. The maximum early and late monthly requirements are estimated at 23,130 man-days in early August and 23,760 man-days in late August respectively. Both maximum requirements are nearly covered with the potential labour force of about 24,220.

51 After completion of year round irrigation system in the area, proper farming practices are essential for realizing full exploitation of agricultural potential in the area. For this purpose, it is necessary to introduce new high yielding varieties and varieties resistant to pest and disease, good seeds, appropriate cultivating practice, fertilizer application method and appropriate plant protection method along with development of irrigation facilities.

52 Taking into account of recurrence of available water resources from the Sondu river and rainfall in the project area and making reference to the diversion requirement for the past 19 years the peak diversion water requirement for the 14,930 ha with the proposed cropping pattern is estimated at about 18.5 m^3/sec.

53 Two main canals are proposed originating from the Sondu-Miriu Power Station. Nayakch-Kano Main canal starts from the power station to eastwards and finally debouches into the Nyando river. It

commands about 13,680 ha in the Nyakach and Kano plains, which consists of Sub-area II-2, III, IV, and V. South Nyanza main canal starts from the power station to westwards and cross with the Sondu river from right bank to left bank and finally reaches to Kendu Bay. It covers about 1,250 ha of sub-area II-1 and I.

54 A drainage improvement plan is envisaged so as to drain the drainage water from the project area into the Nyakach Swamp as far as possible for purification of polluted water by irrigated agriculture based on the recommendation by water quality assessment study.

55 Soils in the project area are widely classified into optimum to marginal suitable to surface irrigation. Considering topographic condition and cost required, furrow irrigation is proposed in the project. All crops proposed in the project other than fruit tree are suitable for furrow irrigation. In some areas in which land slope is rather steep, furrow should be made diagonally or parallel to the slope.

56 Existing roads in the project area are low-embanked and rather deteriorated by habitual floods inundations.In order to make the roads all-weathered,the embankment work would be proposed at the portion of roads in the low-lying area.In addition,laterite pavement also would be proposed as required according to soil mechanic condition. Proper number of bridges and causeways would also be proposed to traverse main perennial and seasonal streams.

Project Works

57 All the irrigation and drainage facilities are disposed at proper site and location in order to make the system for 14,930 ha fully function. The main facilities consist of i) regulating pond, ii) main irrigation canals, and its related structures, iii) secondary canals and its related structures, iv) drainage canals , and v) tertiary canal system and on-farm development, and vi) farm roads. Salient features are summarized as follows:

i)	Regulating pond	effective storage 634,000 m^3, effective depth 2.5 m, trapezoidal cross section, bottom width 130 m & 120 m (2 lanes)
ii)	Nyakach-Kano Main Canal	46 km, design discharge 16.4 - 4.4 m^3/sec, trapezoidal cross section earthen type, longitudinal slope 1/7,000 - 1/3,000, bottom width 12.0 - 0.8 m, water depth 2.05 - 1.4 m
iii)	South Nyanza Main Canal	6 km, design discharge 1.5 - 0.9 m^3/sec, trapezoidal cross section earthen type, longitudinal slope 1/5,000 - 1/3,000, bottom width 1.5 m, water depth 1.4 m
iv)	Secondary canals	213 km, design discharge 1.5 - 0.3 m^3/sec, trapezoidal cross section earthen type, longitudinal slope 1/1,000 - 1/500, bottom width 2.0 - 0.5 m, water depth 0.8 - 0.5 m
v)	Main and secondary drains	266 km, design discharge 225 - 13 m^3/sec, trapezoidal cross section earthen type, bottom width 20.0 - 3 m, water depth 3.3 - 2.0 m
vi)	Tertiary canals	414 km, design discharge 70 - 30 lit/sec, bottom width 0.3 - 0.2 m, water depth 0.5 m
vii)	Tertiary drains	415 km
viii)	On-farm works	paddy field 4,430 ha, upland 10,500 ha

58 Stagewise execution would be applied for the proposed project taking into account of project scale, development stage of water resources, and experience of execution body,etc..The execution of construction works would be divided into three phases as listed below in accordance with the sub-area:

Phase	Availability of Water Resources	Sub-Area	Hectareage
I	With Sondu-Miriu Project	Part of II-2	2,380
II	With Sondu-Miriu & Magwagwa	I, II-1, part of II-2 ,III	4,880
III	-ditto-	IV, V	7,670

59 The Sondu-Miriu Hydro-power Project is scheduled to commence its operation in July,1997. Phase-I of the project should be implemented keeping pace with the implementation of the Sondu-Miriu project.in order to divert irrigation water from the Hydro-power plant. Phase-I will start in 1995 and complete in 1998. After completion of the construction of Magwagwa dam and upon financial arrangement, the construction of Phase-II and -III will be commenced in sequence. The period required for the completion of all the works is assumed at 12 years including detailed design.

60 The LBDA will become an executing agency for construction of the Kano Irrigation Project. Taking into account the existing manpower in the LBDA,it would be recommendable to establish a project construction office under the direct control of the Managing Director; the project construction office would be installed as an independent organization from the LBDA, and managed and operated by the project coordinator who will be appointed by the Managing Director of the LBDA.

61 Operation and maintenance of the main project facilities will be undertaken by the project office. At the on-farm level Water Users' Association will be organized for operation and maintenance of the tertiary system.

62 Cooperative societies will be organized by the farmers in order to mutually assist farmers to procure and distribute farm inputs, to collect and handle farm inputs, to supply agricultural credits, etc. Agricultural extension and supporting services is to be reinforced by the project office to guide and assist farmers to the irrigated agriculture.

Project Evaluation

63 Total project cost are estimated at Ks.5,814 million (US$ 207 million) including physical contingency of 10% of total direct construction cost and price contingency. Annual operation and maintenance cost is estimated at Ks.28.5 million at the full development stage. Replacement cost is estimated at Ks.17.4 million for gates having useful life of 25 years and Ks.15.3 million for light O&M equipment of which useful life is of 10 years. The project cost by phase is summarized as follows:

(Unit: million K.)

	Whole Project	Phase-I	Phase-II	Phase-III
Local currency portion	1,446	249	478	719
Foreign currency portion	4,368	1,012	1,413	1,943
Total amount	5,814	1,261	1,891	2,552

64 An annual incremental benefits are estimated at Ks.642 million at full development stage in economic price. An economic construction cost is estimated at Ks.3,534 million and economic operation and maintenance cost is at Ks.23.5 million. The replacement costs are also converted to economic cost and is periodically disbursed according to its useful life.

65 Economic feasibility is assessed in terms of the economic internal rate of return (EIRR), benefit minus cost (B-C), and benefit by cost ration (B/C) on the basis of a 50 year economic project life. The economic internal rate of return is calculated at 13.9%. The B-C and B/C is at Ks.730 million and 1.44 respectively. Thus the project is quite feasible.

66 A financial feasibility of the project is evaluated from the viewpoint of farmer's economy and capital cost repayment capability. From the farmer's economy viewpoint, the project will bring about a great net

reserve. The net reserve is different from sub-area to sub-area i.e. Ks. 68,500 to Ks.129,600 per farm house hold per annum.

67 As for the repayment capability analyses, it is assumed that the capital required for the project construction would be arranged under the following conditions.

i) Eighty-five percent of the project cost is financed with foreign currency by bilateral or international monetary organization with interest rate of 2.5% for repayment period of 30 years including 10 years of grace period.

ii) The remaining 15% of the capital cost is arranged with local currency by the government budget allocation without repayment.

iii) A government subsidy is assumed at income flow side in order to make a balanced cash flow statement and attain re-payment of the financial loan amount.

The loan repayment amount by the Government of Kenya is estimated at about Ks.216 million.

68 In addition to the direct benefits counted in the economic evaluation, various secondary and intangible benefits and/or favourable socio-economic impacts are expected from implementation of the project as follows:

i) Increase in employment opportunities by the construction and intensive farming,

ii) Foreign exchange saving,

iii) Secondary direct benefit to agro-based industry such as millers, merchants and transporters,

iv) Improvement of transportation in the rural area by the construction of road,

v) Mitigation of flood damage,

vi) Improvement of domestic water supply,

vii) Demonstration effects of the project to other project, etc.

Environmental Assessment

69 Environmental study is made to assess impact caused by implementation of the project in particular with water quality in and around the project area and ecological and vector borne diseases.

70 Currently the Nyando river shows more serious condition than the Sondu river due mainly to drainage from several agro-processing factories located in the middle reach of the river. The Winam Gulf and Nyakach Bay seem to be in rather eutrophic condition.

71 The project might cause more significant impacts on water quality of the Nyakach Bay than that of Winam Gulf. Eutrophication in the Bay might be gradually accelerated by the implementation of the project. Meanwhile, there is less acceleration of the eutrophication in the Gulf even by the implementation of the project. Swamp extended between the Bay and project area has important function for purification of pollution load. Main drainage canals should be aligned not to directly flow into the Bay but to flow into the swamp so as to utilize its purification capacity. Curtailed use of irrigation water by applying proper water management and effective use of rainfall is strongly recommendable. It is essential for the project to establish monitoring and environmental management plan. The existing swamps should not be reclaimed for agricultural production.

72 The study area has a high potential for woodland due to relatively high rainfall, but most of the area has been modified by grazing , burning, and cultivating. The study area has been cultivated and populated, and is not suitable for wildlife. The ecosystem of fish in the Gulf is being changed by migration of nile perch and tilapia. The Kano plain is classified by WHO as a holoendemic malarial zone. Most of the plain is also classified as schistosomiasis infected area.

73 Dosage and application of agricultural chemicals would be limited to high value crops. Low-toxic and decomposable chemicals would be selected. It is possible to reduce soil erosion by applying proper water and farm management. Route of canals would be planned to avoid resettlement. Since the main species such as nile pearch, nile tilapia and rastrineobola seem to be tolerant of the deterioration and eutrophication of water, negative effects on fishery may not serious.

74 Effect on the vector-borne diseases would reach serious condition. The following is the recommendable and practicable countermeasures for prevention of these diseases:

i) To clean canals to remove water weeds,

ii) Introduction of chemoprophylaxis and chemotherapy for inhabitants in the project area,

iii) Dispatch of professional staff such as parasitologist, microbiologist,

iv) Elimination of water pools for mosquito control,

v) Application of mallusciding and insecticide or oiling for breeding sites,

vi) Educational campaign for public health,

vii) Regular house spraying of insecticide in the extended area,

viii) Biological control by introducing predator fishes,

ix) Distribution of mosquito nets by the Authorities concerned,

x) Use of long rubber shoes, etc.

Conclusion and Recommendation

75 The proposed irrigation project is technically and economically feasible. It is, therefore, recommended to implement the project so that the project will substantially contribute to not only the district, but also the LBDA region and national economy.

76 The Gulf is isolated from the Lake Victoria with a narrow mouth. It is therefore difficult to retrieve clean water quality once the gulf would be seriously polluted. Monitoring of water quality and phytoplankton should be started as early as possible.

77 Effect on the vector-borne diseases would reach serious condition. Likewise NIB, LBDA also should strengthen its effort for the public health control through strengthening of section for environment and public health. In addition, regional public health improvement program also should be executed by the LBDA in collaboration with the Authority concerned.

78 In due consideration of the implementation schedule of the Sondu-Miriu Hydro-power project, the detail design works for the Phase-I of the project should have been commenced by early 1993 at the latest. In the detail design stage, further in-depth study should be made on water quality conservation of the water body in and around the project and water borne diseases.

79 Farming practices would be remarkably changed with the implementation of the project. New irrigated farming practices should be attained through strengthening of existing farm support services, and setting-up of the new farmers' organization. In order to execute better agricultural supporting services, the LBDA should start a training of extension workers for smooth introduction of irrigated farming, and the institutional staff who would directly concern the establishment of farmers' organization.

FEASIBILITY STUDY
ON
KANO PLAIN IRRIGATION PROJECT

FINAL REPORT

MAIN TEXT

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Abbreviations

AFC ..... Agricultural Finance Corporation
AIRS ..... Ahero Irrigation Research Station
CBS ..... Central Bureau of Statistics
CLSMB ..... Cotton Lint and Seed Marketing Board
DAO ..... District Agricultural Officer
DC ..... District Commissioner
DDC ..... District Development Committee
DO ..... District Officer
FAO ..... Food and Agriculture Organization of the United Nations
GDP ..... Gross Domestic Production
GNP ..... Gross National Production
GOK ..... Government of Kenya
GRDP ..... Gross Regional Domestic Product
HCDA ..... Horticultural Crops Development Authority
IBRD ..... International Bank for Reconstruction and Development, World Bank
IDA ..... International Development Association
IFAD ..... International Fund for Agricultural Development
ILUS ..... Integrated Land Use Survey
JICA ..... Japan International Cooperation Agency
KGGCU ..... Kenya Grain Growers Cooperative Union
K£ ..... Kenya Pounds (20 Kenya Shillings)
KPLC ..... Kenya Power and Lighting Company Limited
KR ..... Kenya Railway Corporation
KSC ..... Kenya Seed Company
Ks ..... Kenya Shillings
KSS ..... Kenya Soil Survey
LBDA ..... Lake Basin Development Authority
NCPB ..... National Cereals and Produce Board
NGO ..... Non-governmental Organization
NIB ..... National Irrigation Board
OECF ..... Overseas Economic Cooperation Fund
PIU ..... Provincial Irrigation Unit
RWSSP ..... Rural Water Supply and Sanitation Project
SSIU ..... Small-Scale Irrigation Unit, Ministry of Agriculture
T&V ..... Training and Visit
UNDP ..... United Nations Development Programme
UNESCO ..... United Nations Educational, Scientific, and Cultural Organization
UNICEF ..... United Nations International Children's Emergency Fund
VAT ..... Value Added Tax

Abbreviations of Measurement

Length

cm	=	Centimeter
m	=	Meter
km	=	Kilometer
ft	=	Foot
yd	=	Yard

Area

cm^2	=	sq.cm	= Square centimeter
m^2	=	sq.m	= Square meter
ha	=	Hectare	
km^2	=	sq.km	= Square kilometer

Volume

cm^3	=	cu.cm	= Cubic centimeter
l	=	lit = liter	
kl	=	Kiloliter	
m^3	=	cu.m	= Cubic meter
gal.	=	Gallon	
MCM	=	Million Cubic Meters	

Weight

mg	=	Milligram
g	=	Gram
kg	=	Kilogram
ton	=	Metric ton
lb	=	Pound

Time

sec	=	s = Second
min	=	Minute
hr	=	Hour
d	=	Day
yr	=	Year

Electrical Measures

V	=	Volt
A	=	Ampere
Hz	=	Hertz (cycle)
W	=	Watt
kW	=	Kilowatt
MW	=	Megawatt
GW	=	Gigawatt

Other Measures

%	=	Percent
PS	=	Horsepower
o	=	Degree
'	=	Minute
"	=	Second
^oC	=	Degree centigrade
10^3	=	Thousand
10^6	=	Million
10^9	=	Billion (milliard)

Derived Measures

m^3/s	=	m^3/sec = Cubic meter per second
cusec	=	Cubic feet per second
mgd	=	Million gallon per day
kWh	=	Kilowatt hour
MWh	=	Megawatt hour
GWh	=	Gigawatt hour
kWh/yr	=	Kilowatt hour per year
kVA	=	Kilovolt ampere
BTU	=	British thermal unit

Money

Ks.	=	Kenya shilling
K£	=	Kenya pounds (20 Kenya shillings)
US$	=	US dollar
Yen	=	Japanese Yen

Conversion Factors

	From Metric System			To Metric System		
Length	1 cm	=	0.394 inch	1 inch	=	2.54 cm
	1 m	=	3.28 ft = 1.094 yd	1 ft	=	30.48 cm
	1 km	=	0.621 mile	1 yd	=	91.44 cm
				1 mile	=	1.609 km
Area	1 cm^2	=	0.155 sq.in	1 sq.ft	=	0.0929 m^2
	1 m^2	=	10.76 sq.ft.	1 sq.yd	=	0.835 m^2
	1 ha	=	2.471 acres	1 acre	=	0.4047 ha
	1 km^2	=	0.386 sq.mile	1 sq.mile	=	2.59 km^2
Volume	1 cm^3	=	0.0610 cu.in	1 cu.ft	=	28.32 lit
	1 lit	=	0.220 gal. (imp.)	1 cu.yd	=	0.765 m^3
	1 kl	=	6.29 barrels	1 gal. (imp.)	=	4.55 lit
	1 m^3	=	35.3 cu.ft	1 gal. (US)	=	3.79 lit
	10^6 m^3	=	811 acre-ft	1 acre-ft	=	1,233.5 m^3
Energy	1 kWh	=	3,413 BTU	1 BTU	=	0.293 Wh
Temperature	°C	=	(°F-32) 5/9	°F	=	1.8°C + 32
Derived Measures						
	1 m^3/s	=	35.3 cusec	1 cusec	=	0.0283 m^3/s
	1 kg/cm^2	=	14.2 psi	1 psi	=	0.703 kg/cm^2
	1 ton/ha	=	891 lb/acre	1 lb/acre	=	1.12 kg/ha
	10^6 m^3	=	810.7 acre-ft	1 acre-ft	=	1,233.5 m^3
	1 m^3/s	=	19.0 mgd	1 mgd	=	0.0526 m^3/s

1. INTRODUCTION

1.1 Authority of the Report

This report is prepared in accordance with Clause V of the Scope of Work for the Feasibility Study on the Kano Plain Irrigation Project (hereinafter referred to as "the Project") agreed upon between the Lake Basin Development Authority, the Government of the Republic of Kenya (hereinafter referred to as "LBDA") and the Japan International Cooperation Agency, the Government of Japan (hereinafter referred to as "JICA"), on the date of November 16, 1989.

The report presents the final results of the feasibility study on the basis of the 1st, 2nd and 3rd field works and the twice home office works, mainly containing findings of present conditions in and around the study area, the clarification of constraints for development, basic concepts for development, prospective development plan and development of project works.

1.2 History of the Project

The Sondu river and its surrounding basin have been noted for long time for its endowed water resources and potentials for irrigated agriculture. The study entitled "Kenya Nile Basin Water Resources Survey" was firstly undertaken by Sir Alexander Gibb, UK consultants, during 1954 thru 1956. This study seems to be incipient for irrigation development in the Kano plain by inter-basin transfer of the Sondu river.

After establishing LBDA in 1979, a reconnaissance survey for the Sondu River Multipurpose Development Project in the Lake Victoria Basin was made jointly by the International Development Centre, Japan and Nippon Koei Co. Ltd. Tokyo, in 1980. Based on the conclusion and recommendation in the Reconnaissance Report, the Government of the Republic of Kenya (hereinafter referred to as "Kenyan Government") made an official request of technical cooperation for the feasibility study on the said project to the Government of Japan. In response to the request, JICA, an official agency under the Government of Japan, dispatched a contact mission to conclude the scope of work for the study.

In accordance with the scope of work agreed upon between JICA and LBDA, JICA dispatched a team for the implementation of the study for the Sondu River Multipurpose Development Project. The Team undertook the feasibility study for the Sondu Hydropower Development Project and the pre-feasibility study for the Kano Plain Irrigation Project simultaneously during 1984 thru 1985.

Meanwhile, in response to the request of the Kenyan Government, the United Nations Development Programme (hereinafter referred to as "UNDP") also dispatched the C. Lottis Associati Team for the basin study in the Lake Victoria during 1982 thru 1985, as a series of technical assistance to Kenya. This team also undertook an overall master plan study for drainage and irrigation of the Kano Plain Region, and basin water balance and inter-basin transfer studies.

1.3 Summary of Previous Study

1.3.1 Pre-Feasibility Study on Kano Plain Irrigation Project by JICA Study Team

In accordance with the scope of work concluded between LBDA and JICA, the study area was extended to about 20,000 ha from the Kendu Bay in the south-west to left bank of the

Nyando river in the north-east. In the course of the study, it was found that the area extending between the right-bank of the Awach-Kano river and the left bank of the Nyando river had been overlapped with that for the master plan study for the drainage and irrigation of the Kano Plain Region which had been ahead the pre-feasibility study by the JICA Team. In order to adjust between both studies, the said area was thus excluded out of the scope of the study for the JICA Team.

Due to the exclusion of the study area beyond the Awach-Kano river, only one third of the available discharge from the Sondu river system was diverted for the Kano Irrigation Project in this study. The irrigation area of only 8,540 ha was thus delineated between the Kendu Bay and the Awach-Kano river in this study in spite of abundant water resources. Upland crops such as maize, beans, cotton, and groundnuts, and paddy rice were selected in the cropping pattern of the project.

The total construction cost of the project was estimated at Ks 971 million (US$ 64.7 million) including physical and price contingencies. The economic internal rate of return for the project proposed in this study was computed at 16.3% based on 50 years of the project life.

1.3.2 Master plan for drainage and irrigation of Kano plain region by UNDP team

The study was substantially launched in July 1983 and ended in October 1985. The study area covering about 71,000 ha was bounded to the north by the line of the Kisumu-Nairobi railway, to the west by the suburb of Kisumu and by the Lake Victoria, to the south and east by the Asawo river and Awasi-Chemelil road. The master plan proposed the following various measures for agro-economic development in the study area:

1) Construction of main drainage canal networks,

2) Flood control measures by embankment along the Kibos, Nyando, and Awach-Kano rivers,

3) Irrigation system for 15,000 ha depending its water resources on Nyando river, bunded Kano swamp, Sondu river and Yala river, and

4) Construction of infrastructures such as roads, power transmission lines, and drinking water supplies.

The master plan prepared a preliminary design of the proposed measures. The total cost for the plan amounted to Ks 918.5 million. The plan included environmental impacts and soil conservation studies. The economic internal rate of return for the overall plan was estimated at 12%.

1.3.3 Basin water balance and inter-basin transfer studies by UNDP Team (C. Lotti & Associati)

In parallel with the master plan aforementioned, this study also was commenced as a series of the lake basin development, river profile studies, and completed nearly at the same time with the master plan in October, 1985. The following is the summary of the conclusion and recommendation of the study:

1) The assured water supplies from the Nyando runoff river flows should be made for 3,000 ha of the 1st phase development of Kano Plain Irrigation, this area being inclusive of the existing 800 ha of the Ahero rice scheme.

2) The potentials for implementing further 1,200 ha of Kano Plain irrigation should be dependent on a water resources from the proposed bunded Kano swamp detention storage.

3) The potential water resources for further development will be sufficient to support the full development of Kano Plain irrigation (15,000 ha) together with possible development of the Nyakach area (4,500 ha).

Based on the above conclusion and recommendation, the water balance study proposed the following project works for the Nyando and Sondu river basins:

A) Nyando River Basin

1) Natural Nyando river flows after allowance for future public water supplies are sufficient to support only some 3,000 ha of irrigation development,

2) Construction of the Koru dam for regulating the Nyando river would allow this irrigation area (3,000 ha) to be extended by some 9,000 ha,

3) Construction of the bunded detention storage at the Kano swamp would also enable an additional 1,200 ha of irrigation development, and

4) For full development of the Kano Plain irrigation potentials (15,000 ha plus 4,500 ha Nyakach strip), it will be necessary to supplement local water resources with transfer from the Yala and/or Sondu basin.

B) Sondu River Basin

1) Natural Sondu river flows greatly exceed local basin demands; it is possible to consider major water transfers to the Kano Plain without any detriment to the Sondu basin development.

2) The Sondu river also offers major opportunities for hydropower generation through development of the Miriu scheme.

3) The transfer of the irrigation water to the Kano Plain results in some losses of the Miriu hydropower generating potentials. It is therefore necessary to ensure that the design work for the Miriu scheme should be optimized to ensure a proper integration of power and irrigation.

1.4 Scope of Work

1.4.1 Objectives of the study

The objectives of the study are to formulate an optimal development plan through the feasibility study on the Kano Plain Irrigation Project in connection with the hydropower development scheme in the Sondu river.

1.4.2 Study area

The agreed Scope of Work stipulates the study area of about 60,000 ha in the Kano and Nyakach Plains. The study area is bounded on the south-west by the Kendu Bay, on the north by the Kisumu-Nairobi Railway, on the east by the foot of the eastern escarpment, and on the west by the Winam gulf of the Lake Victoria.

1.4.3 Summary of the scope of the study

The feasibility study is broadly divided into the following three work divisions:

1) Work-I: (Preparation of Topographic Map)
   a) Aerial photograph of about 600 km^2,
   b) Ground control survey, and
   c) Topographic mapping.

2) Work-II
   a) Collection and review of existing data and information,
   b) Survey and investigation, and
   c) Formulation of basic concepts.

3) Work-III
   a) Development of various plans,
   b) Preliminary design of major structures,
   c) Implementation schedule of the project, and
   d) Organization and institution plan for the operation and maintenance.

1.5 Activities of the Study Team

1.5.1 Time schedule and work flow

The Work-I (preparation of topographic map) had been already completed before the commencement of this feasibility study in August, 1990. As shown in Fig 1.1 (Work schedule), Work-II was completed by presenting the interim report at the beginning of March, 1991. About seven (7) months had been spent until the termination of the Work-II since the commencement of the study; about five (5) months, for the field works and two (2) months, for the home office works. In this period, three reports such as Inception, Progress-I, and Interim Report were compiled and submitted to the Authorities concerned.

The Work-III has been implemented since early June, 1991. About seven (7) months have been also spent until the termination of the Work-III, since the commencement;about two (2) months, for field works and two (2) months, for home office works, and the remaining period, for explanation of the draft final report, compilation of the Feasibility Report, and various arrangement. In this period, three (3) reports such as Progress-II, draft Feasibility and final Feasibility Report have been compiled and submitted to the Authorities concerned

Fig 1.2 illustrates the work flow for the feasibility study. By the end of the Work-II, most of the survey and investigation had been almost completed and the basic development plan had been formulated in the Interim Report on the basis of the basic development concepts envisaged in the Progress Report-I. Following the Work-II, supplemental studies and investigations in the various fields were undertaken for formulation of the definite development plan in the field works of the Work-III. In the later stage of the Work-III, various studies including implementation plan, benefits and costs estimates, project evaluation and environmental assessment have been made through the home office works for the compilation of the feasibility report.

1.5.2 Assignment schedule

As shown in Fig 1.3 (Assignment Schedule), man-months of 26.6 had been consumed by the end of the Work-II since the commencement of the study comprising 24.5 man-months of field work and 2.1 man-months of home office work. Meanwhile, man-months of 27.0

have been consumed during the Work-III, comprising 16.0 man-months of field work and 11.0 man-months of home office work.

1.5.3 Activities of the study team

Major activities of the team undertaken during the Work-II and III can be summarized as described bellow:

1) Compilation of draft Inception Report,

2) Approval of the Inception Report by JICA,

3) Presentation of the Inception Report to LBDA,

4) Execution of 1st field work
   - Soil survey and laboratory analysis
   - Cylinder intake rate test
   - Test pitting, auger boring, core boring, penetration test
   - Farmer's economy survey
   - Market survey
   - Data collection of meteorology, hydrology, irrigation, agriculture, agro-economy, etc.
   - Topographic survey.

5) Compilation and presentation of Progress Report-I,

6) Execution of 2nd field work
   - Additional data collection and field investigation,
   - Review and analysis of the collected data,
   - Layout of basic development plan,

7) Compilation and presentation of Interim Report

8) Execution of 3rd field work
   - Optimization study on project scale and determination of project area,
   - Supplemental investigation and studies,
   - Final checking and supplemental survey on geological condition for canal and related structure,
   - Formulation of final development plan, and
   - Environmental studies,

9) Compilation and presentation of Progress Report-II

10) Execution of home office work
   - Preliminary design of irrigation canal system,
   - Implementation plan of the project,
   - Cost and benefit estimate,
   - Project evaluation, and
   - Environmental assessment,

11) Compilation of (draft) Feasibility Report

12) Presentation and discussion of (draft) Feasibility Report

13) Compilation and submission of (final) Feasibility Report

2. BACKGROUND OF THE PROJECT

2.1 Land and Population

Kenya is located in the equatorial zone of the eastern Africa and occupies her territory of about 583,000 km^2, of which about 572,000 km^2 is dry land and 11,000 km^2 is open water. The country exhibits a considerable climatic variation from humid and hot in coastal to dry and cool in highland.

About four fifth of the land or about 473,000 km^2 are classified into arid or semi-arid area. Only about 18% of the land or about 105,000 km^2 are classified into medium and high potential arable land. Most of the arable land has been utilized for agricultural production. Of the remaining land, about 36,000 km^2 have been reserved for wildlife conservation, while only about 2,000 km^2 have been left to natural and exotic plantation forest.

LBDA region occupies about 39,000 km^2 in the western part of Kenya accounting for about 6.8% of the total land of Kenya. The region lies between latitude 1°16'N and 1°54'S; longitude 33°55' and 35°51'E. Over 70% of the total land in the Region are classified as either high or medium potential based on average annual rainfall. About 55% of the potential land or about 1,549,000 ha have been developed for agriculture. The remaining vast potential land still has not been fully utilized for economic activities so far.

As of 1988, the total population of Kenya is estimated to be 22.7 million people and it is also forecast at 27.2 million people in 1993 with a growth rate of 3.7% per annum, out of which 21.6 million people are populated in rural area and the remaining 5.6 million in urban area. The population density is also estimated to be 38 persons/km^2 in 1993.

Meanwhile, the population in the LBDA Region is estimated to be 8.9 million as of 1988, corresponding to about 40% of the total population of Kenya. The population in the Region is projected to be 10.2 million people in 1993 with a growth rate of 3.3%. The average population density is estimated to be 170 persons/km^2 for the Region.

2.2 National and Regional Economy

Kenya has inherited rural economy based primarily on subsistence agriculture with a very few industrial and commercial activities. The development of agriculture, industry, and commerce in this country were contingent on the existence of sound basic infrastructures and attendant services.

Over the period of 1964 thru 1971, the Kenya's economy recorded an annual average growth rate of 6.5%. This growth was based mainly on (1) transfer of land from large to small farm use, (2) extension of area under cultivation of high value crops, and (3) industrialization based on a strategy of import substitution. After the first oil crisis, the economic growth rate in Kenya was slow down due to increase in prices of crude oil and global recession, excepting the period of worldwide coffee boom from 1977 thru 1978. In early 1980's, the Kenyan economy has been generally stagnant caused by the second oil crisis in 1979, worldwide economic recession during 1981 thru 1983, and severe drought in 1984. Since then, however, the economic performance in Kenya has been steadily recovered year by year.

The gross domestic product (GDP) of Kenya attained K£ 7,330 million at current price basis with growth rate of 5.1% in 1989, and K£ 8,634 million in 1990, corresponding to per-capita GDP of K£ 343 (US$ 317) in 1989 and K£ 360 (US$ 313) in 1990 respectively.

Meanwhile, the gross regional domestic product (GRDP) of the LBDA Region is estimated at K£ 970 million with the growth rate of 3.8% in 1985. This GRDP shares 23.5% in the Kenya's GDP in 1985.

Agricultural sector plays a dominant role in the national economy, sharing about 30% in the gross domestic products and contributing nearly 60% of export earning. Furthermore, this sector provides the largest employment opportunity, produces foodstuff for the national population, and supplies row materials for the industrial sector.

The agricultural sector, the largest sector in Kenyan economy, grew 4.2% per annum and its share of total output was about 33% in 1971, while the growth rate and the shares of total output in 1988 were 4.5% and 28.9% respectively.

A favourable balance of payments position was attained in 1986 due to a combination of high coffee prices and a drastic fall in world oil prices. In addition, agricultural output also benefited from favourable climatic condition. The following is the summary of the balance of payments in selected years in Kenya:

(Unit:K£ million)

Items	1986	1987	1988	1989
Balance of trade	-351	-641	-813	-1,219
Current A/C balance	-31.1	-406.6	-408.1	-604.2
Overall balance	+73.0	-104.4	-67.7	80.5

As shown above, a deficit of K£ 104.4 million in 1987 and 67.7 million in 1988 was incurred respectively on the overall balance of payments. The down-turn in 1987 and 1988 on the balance of payments resulted from a sharp fall in the world price of coffee and tea and rise in the price of crude oil in both years. Meanwhile, the balance of payments in 1989 was remarkably improved with overall surplus of K£ 80.5 million, owing to large inflow of official capital from international agencies and tourism earnings.

2.3 Characteristics of Agriculture in Kenya

Land tenure in Kenya is divided into two categories, i.e.small holders including landless tenant farmers and large scale holders. Small scale holders are majority of the farmers, but produce mainly staple food crops for subsistence and very little surplus for marketing. Large scale farmers conduct commercial farming and produce both cash and food crops for local export market. In accordance with the Government policy for promoting transfer of large scale holders to small holders, the area under such commercial farm has recently occupied a considerably large portion of cropped land.

Average annual production of staple food in Kenya such as maize, beans, wheat, and rice has reached 3.5 million ton in total during 1985 thru 1989. Cash crops such as coffee, tea, sugarcane, pyrethrum, and horticulture are important in Kenya as well as staple food crop. Export amount of horticultural products such as fresh vegetables and fruits has been recently expanding in this country;it has reached more than 150 thousand tons or over 10% of the export earnings

2.4 National Development Plan

2.4.1 General

In 1984, the Government of Kenya launched Fifth National Development Plan in order to follow the Fourth Development Plan which had terminated in 1983. Despite of the rapid strides of the development during the period of the previous Plan, Kenya has faced various complex economic problems, such as rural poverty, income disparities, deficit balance of payments, deterioration of external financial position, etc. Following the Fifth Development Plan, the Sixth National Development Plan covering the period of 1989 thru 1993 was issued by the Ministry of Planning and National Development. The development plan mainly campaigns the following major objectives:

1) Economic expansion so as to create productive employment,

2) Economic growth depending mainly upon agriculture, re-vitalized industry, and small-scale enterprises sector,

3) Greater foreign exchange generation through expansion of the capacity of export oriented industrial sector,

4) Moderation in Government's provision of basic needs services,

5) More significant role of Government in caring for environment,

6) Greater role of private sector in economic activities,

7) Due regard to judicious management of public debt, stability of currency, and balance of payments, and

8) Equitable distribution of benefits of economic growth in order to improve welfare of people.

Kenya's economy has experienced various structural changes since the independence. In the light of the past population growth in Kenya, a consequential increase in labour force is inevitable. There are two (2) million people who will inter labour market during the Plan period, swelling the current estimated number of 8.6 million to 10.6 million. The challenge is how to provide adequate and productive employment for the labour force.

In due consideration of the current confronting issues and the economic trends in Kenya to be anticipated during the Sixth Development Plan period, the Government of Kenya sets forth the following development targets in the Plan in order to alleviate the problems and to adjust the economic and social structures:

(a) Sectorial Target

- Most important target is the growth rate in per capita income which is set at 1.6% per annum. With population expected to grow at 3.7% per annum;the implied annual growth rate of total GDP is 5.4% per annum.

- Agriculture continues to play a leading role in feeding population, generating employment and incomes, contributing to foreign exchange earnings and inducing growth in other sectors of the economy. During the Plan period, this sector is targeted to grow at the rate of 4.5% per annum. Based on past performance, this target growth rate is rather realistic.

- Growth of manufacturing sector has been weak in recent years. An Industrial Sector Adjustment programme mounted in 1988, together with a range of other measures aimed at raising growth of investment. The 6.4% average target growth rate during 1988-1993 is expected to be met in the light of this consideration.

- Actual GDP growth rate in trade sector was higher in the years of 1984 thru 1987. The relatively high rate of growth during 1988 was anticipated, thus making the average annual rate of growth over the Fifth Plan period higher than 7.0% per annum. During subsequent years, the growth rate was expected to stabilize at around 7.0% per annum.

- The target growth rate for the sectors of transport and communication, building and construction, and ownership of dwellings for the Plan period has been set at 5.7, 4.5, and 3.4% per annum, compared to the low growth rates of 3.4, 1.1, and 1.0% per annum respectively for the last Plan period.

(b) Projected Sectorial Shares

- Share of agriculture is targeted to go down from 31.6% in 1983 to 28.3% in 1993 or by the end of this Plan period. The share of the other two sectors will go up correspondingly. The rise in the share of industry is a movement in the right direction in view of Government's commitment to making it a leading sector. The share of industry and services (includ. Government) is targeted to be 18.3% and 53.4% respectively in the Plan.

(c) Terms of Trade

- Kenya's agricultural and industrial sectors are heavily dependent on imported inputs such as fuel, fertilizers, machinery and spareparts which are purchased with foreign exchange mainly generated from exports of tea and coffee, and earnings from tourism.

- Kenya's terms of trade have generally been unsteady and often unfavourable. In 1986, Kenya's terms of trade index stood at 103.4 with 1982 as base. Due mainly to a substantial fall in the prices of coffee and tea and a rise in price of fuel, the terms of trade deteriorated to 84.6 in 1987. Coffee and tea prices recovered to some extent during 1988, while the price of oil weakened again. As a consequence, the terms of trade are expected to improve somewhat in 1988 to a projected level of 94.6.

2.4.2 Agriculture development

Agriculture is the mainstay of Kenya's economy and provides the basis for development of other economic sectors. Priority in the agricultural sector centres on food production, generation of raw materials for local industries and graduated processing of production for export. Overall thrust of the agricultural policy in Kenya is firstly, to achieve internal self-sufficiency; secondly, to maintain adequate levels of strategic reserves; and thirdly, to generate additional supplies for export.

Feeding of Kenya's growing population requires increasing supplies of staple foods. Production of these foods is stepped up during the Plan period in order to meet the country's needs for internal self-sufficiency in the first instance. In particular, scientific and technological applications are fully employed to ensure adequate supplies of all staples.

In addition to production of enough food to meet domestic demands, production levels will also be geared towards meeting strategic reserves sufficient to carry the country for at least

six (6) months in the worst of times. This will entail the development of adequate storage facilities at appropriate location in all districts alongside national storage facilities.

Traditional cash crops--coffee and tea-- continue to make major contribution to export earnings. With diminished import substitution in consumer goods industry, production orientation changes in favour of exportable. Under this policy framework, it is imperative to boost production and productivity so that there are sufficient supplies of relevant commodities available for export.

The Kenyan Government aims at diversification of agricultural production as a matter of policy. Promotion of seven major commodities is central to achieving the development goals and targets established for agriculture;these are coffee, tea, maize, wheat, milk, meat, and horticultural crops.

Development and expansion of coffee and tea are foundation for growth of both agricultural incomes and exports. Development and expansion of maize, wheat, and meat aim at achieving domestic food security, while that of milk and horticultural products aim at achieving both goals.

Production of maize, beans, and milk utilizes approximately two third of the land area devoted to agricultural production. There are, therefore, limited possibilities for further expansion of land development to the production of these commodities because this leads to a reduction in outputs of the higher valued commodities, resulting in a sharp fall in the per capita value of agricultural production.

It is expected that the highest level of employment in agriculture comes from increased productivity in the small-holder agricultural area as a result of impact of the incentive schemes to be implemented during the Plan period. A considerable number of jobs also are created through expansion of small-scale irrigation schemes and valley-bottom land reclamation projects.

2.4.3 Irrigation development

Irrigation development makes a major contribution to attainment of the objectives of the development plan. However, irrigation requires highly specialized agronomic and water management technologies. As of 1986, it was estimated that Kenya has irrigation potential lands of about 500,000 ha and the lands of about 300,000 ha suitable for drainage improvement and valley-bottom reclamation. Currently, the area under irrigation in Kenya covers only 36,000 ha of which 12,600 ha are under public management in Bunyala, Kano plain, Mwea and Bura, and some 23,000 ha under private management. Thus, the country has been able to utilize only 4% of her irrigation potential land.

In the past, the Government policy on irrigation has trended to favour large-scale irrigation schemes. However, the experience has shown that such schemes are costly to implement and operate. On the other hand, small-holder irrigation schemes based on self-management group of farmers have proved to be relatively more successful. Such schemes are basically oriented toward more employment generation, local foods security, and increased incomes. Owing to their low costs, the development of such small-scale irrigation schemes are preferred during the Plan period.

The Kenyan Government also works out the long term irrigation development strategy which will solve the conflict between small-scale and large-scale irrigation projects taking into account the availability of land, water, financial and manpower resources and the need for better institutional coordination between agencies involved in irrigation development.

Irrigation for strategic commodities such as coffee, rice, and horticultural crops are given top priority since they show high irrigation yield potentials, which in turn, translate into high farm incomes and foreign exchange earnings. Thus, by the end of the Plan period, the total area under irrigation has been expanded to 45,550 ha.

In this expansion programme, priority is given to the following measures:

1) Establishing operational irrigation units in the district having considerable irrigation potentials such as Kisumu, Taita Taveta, Elgeyo Marakwet and Meru,

2) Maintaining training programmes aimed at imparting to meet needs of irrigation development

3) Creating a career structure for professional irrigation staff and

4) Encouraging lending institutions such as AFC (Agricultural Finance Corporation), cooperative and commercial banks and other financial institutions to seek investment opportunities in the irrigation sub-sector.

2.5 Five Year Development Plan in LBDA

2.5.1 LBDA region

LBDA region occupies about 39,000 km^2 in the western part of Kenya accounting for about 6.8% of the total land area of Kenya. The region administratively comes under Nyanza, Rift Valley, and Western Province. About 55 % of the potential land in the region or about 1.5 million ha have been developed for agricultural production so far. The population in the region is estimated at 8.9 million as of 1988, corresponding to about 40 % of the total population of Kenya;the average population density in the region is computed at 170 persons per km^2.

Gross regional domestic product (GRDP) in the region is estimated at about K£ 2,670 million as of 1989, sharing 36.4 % of the GDP of Kenya. The agriculture is the largest sector in this region, contributing about K£ 1,360 million or nearly 50% equivalence of the total GRDP of this region. The regional share of production for major crops is so high compared with hectareage of the agricultural land, i.e, 70% of maize, 80% of root crops, 98% of sugarcane, 60% of cotton, 66% of tea and 80% of wheat in the total production in Kenya.

2.5.2 Development problems and constraints

The Lake Basin Development Authority was established in 1979 on the basis of the Parliament Act. First (1st) Five Year Development Plan was launched by LBDA in 1983 and covered the period until 1988. Following the 1st plan, 2nd Five Years Development Plan was launched covering the period of 1989 thru 1993 keeping step with the Sixth National Development Plan.

Despite the high development potentials, the Lake Basin Region faces various problems and constraints for the development. They are classified into three major categories, i.e.natural factors, institutional factors, and human factors. Of the natural factors affecting the development, the most critical ones are as mentioned below:

1) Uneven distribution of water resources in time and place,

2) Shortage of exploitable energy sources,

3) Environmental condition to promote communicable and vector-borne disease,

4) Lack of health services,

5) Insufficient opportunities for higher education and economic activities

2.5.3 Regional development objectives

Based on the position of the region in the national economy, the development potentials and constraints, and the concepts of national development, the development objectives for the LBDA region are set forth as follows in the 2nd Five Year Plan:

1) To provide the necessary infrastructure for creating an atmosphere inductive to agricultural and industrial development.

2) To contribute to national economic development and food security by maximizing agricultural production,

3) To improve the Region's economic structure by promoting a manufacturing industry capitalizing on its agricultural base, and

4) To narrow the income disparity between the Region's K£ 204 per annum (1985 price).

2.5.4 Basic development strategy

Among the problems and constraints aforementioned, the following are fundamental problems which should be directly dealt with during the plan period:

- Uneven distribution of water resources,
- Shortage of energy sources, and
- Under utilization of land and problems affecting land tenure systems

The first problem above calls for "proper management of water resources", which can contribute to coping with the second problem through hydropower development. Watershed management is another aspect related to energy problem through enhancement of forest resources. Another way of alleviating these natural and inherent problems is to improve provision of other infrastructures and public facilities in order to increase land, water and energy productivity. The basic strategy for the regional development is therefore set forth as follows;

1) To develop and control water resources for primary production activities and for improved sanitation practices and facilities, so that development potentials in different areas of the Region can be realized

2) To improve provision of infrastructures for agricultural and related economic activities, such as agro- and aqua- based industries

3) To rationalize land use;firstly, by intensifying cultivation in existing agricultural lands and secondly, by expanding the agricultural area in accordance with land suitability as well as existing land tenure system, and

4) To develop human resources to meet the increasing requirement of higher technologies and wider expertise.

3. THE STUDY AREA

3.1 Location

The study area of about 60,000 ha is located at almost centre of the LBDA region which extends at about 380 km northwest along the national road route A104 and B1 from Nairobi, the capital of the Republic of Kenya by way of Nakuru and Kericho. The area extends southeast of Kisumu Municipality, the capital of Nyanza Province, and is approximately bounded by Nyamondo Escarpment in the south, contour line of 1,200 m above MSL in the east, the Nairobi-Kisumu railway in the north, and the Kendu bay, the Nyakach bay and the Kibos river in the west.

Administratively, the area comes under two districts of Nyanza Province, viz. Kisumu and South Nyanza, and covers six (6) divisions and twelve (12) locations under both districts; only one division and one Location belong to the South Nyanza, and the remaining, to the Kisumu District. (Fig.3.1)

3.2 Human Resources

Population in the study area is estimated at about 242,400 as of 1990 and forecast at about 325,000 at the end of the 20th Century on the basis of the Kisumu and the South Nyanza District Development Plan and the Population Projection prepared by CBS. Population density in the area is estimated at about 349 persons per km^2; the area is rather highly populated compared with the averaged density of 170 persons per km^2 in the LBDA region.

Population by age-group in 1990 and 2000 is estimated on the basis of population data for the Kisumu District compiled in the Population Projection for Kenya, 1980 thru 2000 by CBS. The total working population in the study area in 1990 is estimated at 97,600 persons which corresponds to 49% of the total population in the area; it comprises 48,700 persons of male and 48,800 of female respectively. The demographic feature in the area seems to be rather normal and well-balanced.

According to demographic data compiled in the current Five Year Plan, population annual growth rate in the Kisumu District during the period of 1988 thru 1992 is estimated at about 3.2% per annum. This rate is a little less than that for the whole Kenya of 3.6% per annum. In the light of the demographic data in the Kisumu District Development Plan, 1989-1993, about 55% of the population in the study area are engaged in the agricultural sector. Agriculture is still a top leading economic sector in the area.from demographic viewpoint.

3.3 Natural Resources

3.3.1 Land resources

About 60,000 ha of arable land resources are endowed in the study area. Out of them, about 20,200 ha have been developed for upland cultivation, and about 22,700 ha have been used for low productive pasture for cattle grazing. Furthermore, about 4,000 ha, convenient for getting of irrigation water, have been developed for paddy field, and about 10,000 ha have been mainly used for homesteads and public usage. The remaining about 4,000 ha have been abandoned as scrubs.

Most of upland and all of paddy field, and a large part of pasture land have a high potential for irrigated agriculture as far as irrigation water is available without any limitation.

3.3.2 Water resources

There are two major water sources for irrigation development for the Kano and Nyakach Plains, viz. the Sondu and the Nyando river. The water resources blessed on both rivers are as summed up below:

The Sondu river drains the total area of 3,470 km^2 and has two major sub-basins in the upstream. The south basin of about 1,510 km^2 is drained by the Kipsonoi river and the east basin of about 1,580 km^2 by the Yurith river. Both rivers originate from the Mau forest on the western slope of the Mau Escarpment. After the both rivers confluence, the Sondu river comes into narrow gorge penetrating Nyakach Escarpment and falls in cascade. Then, the river flows down the flood plains and finally debouches into the Winam Gulf of the Lake Victoria.

The Sondu river has negligible small fluvial plain suitable for agricultural development. In order to effective use the endowed water resources, most of them should be transferred to the Kano and Nyakach plains which are closely located to the Sondu river basin. The annual mean runoff recorded at the lower reach amounts to about 1,293 million m^3 (about 404 mm equivalence).

Nyando river basin of about 3,000 km^2 is divided into four sub river basin, viz. the Asawo river, Awach-Kano river, the Nyaido river and the Nyando river sub-basin. Among them, the first three rivers are ephemeral or intermittent flow. They are insignificant in water resources viewpoint. The Nyando river sub-basin has a catchment area of 2,520 km^2 and it has two major tributaries, viz. Masaita and Mbogo river. Both tributaries confluence in the vicinity of the 1GD04 Gauging Station. After the confluence and changing the name, the Nyando river turns its route to the southwest and disappears into the Nyando swamp. The lower reach of this river is unstable and habitually changed by flooding.

The annual runoff of the Nyando river at the said station is estimated at about 360 million m^3 (143 mm equivalence) based on the record from 1956 thru 1984. In comparison with the catchment area, the dependable water resources in the Nyando sub-basin is rather small;it is only 28% equivalence of that in the Sondu river. Fig 3.2 shows physiography of both river basins.

3.4 Physical Features

3.4.1 Topography

The study area is physiographically divided into three, viz. Kendu bay strip, Nyakach plain and Kano Plain. The Kendu bay strip extends between the Awach Kibuon and the Sondu river, and slenderly lies on the foot of the Nyabondo Escarpment, facing to the Kendu bay. Topographically, the strip is sharply slanting from the south to north, and rather undulating.

The Nyakach plain, gently sloped piedmont plain, extends between the Sondu river and the Asawo river. The plain is rather elevated hilly area, extending from the foot of the Nyamondo Escarpment to northward. And it is also gently slanting from south to north, and slightly undulating. There have developed a lot of dry wadis across the plain.

The Kano plain widely extends from the Asawo river to northward, and it lies on the vast flat alluvials with the elevation between 1,135 m and 1,300 m above MSL. The plain has been developed mostly for agricultural land and grazing pasture.

3.4.2 Climate

Kenya climatically belongs to tropical savanna zone, but exhibits considerable climatic variation from humid and hot coast lands to dry and cool highlands. About four fifth of the land is arid and/or semi-arid. Only 18% of the total lands constitutes climatically moderate and favourable for agricultural production. The climate in the study area is characterized by two distinct seasons, i.e.rainy season and dry season, according to distribution of rainfall. The rainy season is further sub-divided into long rainy season and short rainy season, according to length of the rainfall season. Likewise the rainy season, the dry season is also sub-divided into long dry season and short dry season.

The long rainy season starts in March and lasts for three (3) months until May, followed by the long dry season which starts in June and ends in September. The short rainy season starts in October and lasts for three (3) months until December, followed by the short dry season which starts in January and ends in February.

The Kano and Nyakach plains are blessed with favourable climatic conditions for growth of various agricultural crops, excepting uneven annual and seasonal distribution of rainfall.

Seasonal trend of temperature in the study area is characterized by its relatively wide variation. The annual mean maximum ranges from about 27ºC to about 32ºC and the trough of the mean maximum temperature is recorded in June through July;the annual mean minimum ranges from 14°C to 18°C, and peak of the annual mean minimum temperature is recorded in August through September.

Relative humidity in the study area relatively narrowly varies between 55% in the dry and 75% in the rainy seasons; peak of the relative humidity is observed during May or July, and the trough, in January during the short dry season or in October during the long dry season.

Annual mean A-pan evaporation in the study area ranges from about 1,900 mm at Chemelil to about 2,200 mm at Ahero. Monthly mean evaporation ranges from about 130 mm to about 220 mm; maximum monthly evaporation is recorded in March and the minimum, in June or July. Monthly A-pan evaporation far exceeds monthly rainfall throughout the year.

Areal distribution of the rainfall in the study area has a trend to decrease from north to south and to increase from west to east. Annual mean rainfall ranges from about 1,100 mm to about 1,600 mm in the study area. Maximum monthly mean rainfall of 243 mm is recorded in April in the Kibos station; minimum monthly mean rainfall of 72 mm, in September in the Ahero station. Table 3.1 shows the summary of meteorological data in the Kano Plain.

3.4.3 Geology and soil mechanics

(A) Stratigraphy

Fig. 3.3 illustrates general geology in the study area. Precambrian intrusives composed of mainly granite rocks extends widely in the Kendu hills, Nyabondo Escarpment and Nandi hills. Tertiary volcanic rocks involves tiff, agglomerate and phonolite lava. Tuffaceous and agglomeratic beds of miocene age seem to underlie in the Kano plain. Phenolite lava of pliocene age is found in Nyabondo plateau of the Nyakach division, in the east of Nyando division and around Kisumu township.

Sediments of pleistcene age are mainly composed of deposits being both laucustrine and fluviatile of Lake Victoria. They seem to distribute generally in the Kano plain but they are mostly covered with colluvial or alluvial deposits.

The recent system consists of talus scree, colluvium and alluvium. Its composition of clays, silts, sands, gravels and lateritic iron stones. Talus screes are found along the foot of the Escarpment. Colluvium occurs from widespread hill or wash accumulation. Alluvium is formed by a large quantities of silt and sand carried by several rivers flow. Reddish brown lateritic ironstones develop usually on the bed of phonolite lava.

(B) Soils and rocks concerned

Predominant soils in the Kano and Nyakach plains are black cotton soil, sandy red soil, and lateritic soil. The black cotton soil originates from tuffaceous beds and is mainly composed of clay minerals. The peculiar black colour comes from humus;it is the result of strong combination of clay minerals and humus. The wide-spread black cotton soil in the Kano plain is weathered and/or transported materials of tuffaceous beds.

Sandy red soil is derived from granite, since it consists of quartz grain and is distributed in foot of slopes and piedmont plains along escarpment of granite rocks. It seems to be a result of wash-out deposits of weathered granite by water in pluvial season.

Lateritic soil and lateritic ironstone are produced of iron-rich soils and/or rocks by leaching action due to strong rainfall as a result of weathering and decomposition by strong drying etc.. Phonolite is chemically iron-rich, so that lateritic soils and ironstone seem to be derived from phonolite. Its distribution also coincides with phonolite distribution.

3.4.4 Soils and land classification

(A) Soil classification

On the basis of field survey and laboratory test, soils are classified into 14 soil units according to the FAO-UNESCO soil classification system and its modification so called "Kenya Concept".

Mapping units are differentiated in the extending soils of the Kano-Nyakach plains. Distribution of each mapping unit is presented on the semi-detailed soil map in Fig.3.4. Physical and chemical properties of each soil extending the plain can be summed up as follows:

- Soil texture

  Soil of the Nyakach plain broadly varies from coarse to fine texture. Soil on the fan base and lacustrine is rather finer, while some coarse textured soils are observed in piedmont plain. Almost all the soils distributed in the Kano plain are fine-textured. Some soils in the piedmont plain have coarse-textured or moderately coarse.

- Soil reaction

  Soil reaction is measured in the laboratory. PH value of soils in the plain widely ranges from 4.5 to 10.4. In cuspate delta, high pH of 9 or more is observed, and humic Gleysols near swamp indicates low pH value at 4.5.

- Salinity

  EC value of all samples is measured in extraction from soil-water (1:2.5) suspension. The EC of the whole surveyed area ranges from 0.02 to 1.25 mmho/cm. Therefore, almost all of the soils in the plain are "non-saline".

(B) Land classification

The land classification system modified by the Kenya Soil Survey (KSS) is applied in this study. In order to clarify the land suitability for the alternative crop production, the appraisal is made for both wetland paddy and the common upland. In order to clarify the suitability for future development,an appraisal is made by potential land suitability.

Land classification map is presented in Figs.3.5 and 3.6. The following is the summary of the appraisal of land suitability in the study area:

(a) Paddy plant

Suitability class	Hectarage (ha)	Percentage (%)
S1	9,160	12.6
S2	26,350	36.1
S3	16,690	22.9
NS	20,780	28.4
Total	72,980	100.0

(b) Upland Crops

Suitability class	Hectarage (ha)	Percentage (%)
S1	2,850	3.9
S2	13,950	19.1
S3	36,900	50.6
NS	19,280	26.4
Total	72,980	100.0

It is appraised that, out of 72,980 ha of land in the study area, 52,200 (about 72%) are suitable for paddy cultivation and 53,700 ha (about 74%) are suitable for upland crops cultivation.

3.5 Infrastructures

3.5.1 Road and transportation

Four national roads are networked in and around the LBDA basin;Route A1 traverse almost the centre of the basin from the north to the south and Route B1, B2 and B3, from the east to the west. Among them, trunk line of Route B1 extends about 300 km from Londiani to Busia by way of, Kericho, and Kisumu and this line links to Route A104 to reach to Nairobi.;another trunk line A1 extends about 600 km from Lodwar to Tanzanian border by way of Kisumu and Kisii.

In addition to the trunk roads, many primary roads, such as C19, C26, C34,and C37 are networked in the study area. Roads of about 1,590 Km and about 1,930 km are networked in Kisumu district and South Nyanza district respectively The road density is roughly estimated at 0.75 km/km^2 in Kisumu district and 0.34 Km/km^2 in South Nyanza district.

The main railway line extends about 800 km from Mombasa until Kisumu by way of Nairobi. Another branch line also extends about 70 km from the Kisumu port to Butera via Yala. These lines are daily operated to transport passengers and cargoes. A domestic airport has been daily operated in the suburb of Kisumu. Thirteen (13) flights a week are available between Nairobi and Kisumu at present. Expansion plan of the airport has been prepared to

facilitate tourism and marketing of horticultural products in the western Kenya. Lakeside towns and neighbouring countries are liked each other by means of navigation system, such as steamers and cargo ships.

3.5.2 Post and telecommunications

There are one head post office and twenty four (24) branches in Kisumu district. Exchange capacity of telephone services in the District is approximately 8,170 lines with eleven (11) exchange centres and sixty six (66) public telephone booths. Out of them, only about 3,800 or 47% are utilized at present. There are two exchange centres in Ahero and Koru with the capacity of 70 lines respectively.

3.5.3 Energy

Principal energy sources in Kisumu district are fuelwood charcoal, paraffin, liquefied petroleum gas and electricity. In Kisumu district, charcoal is the most popular in urban and firewood in rural area. Annual charcoal consumption per household is estimated at 720 kg in the urban area and 50 kg in the rural area. Annual firewood consumption per household is estimated at 600 kg in the rural area. About 84% of lighting are depending on paraffin in Kisumu district; lighting by electricity is still negligible low percentage in the district.

3.5.4 Water supply

Two Authorities, viz. Ministry of Water Development and LBDA, are concerned with domestic water supply. In the Nyakach plain located in the southern part of the study area, the Ministry of Water Development has constructed pipe line system for domestic water supply. Water for the system is offtaken from the Sondu river and treated in the plant located near Sondu village. The total length of the main pipe line in the study area is about 40 km and the number of total taps is about 180 pieces.

Meanwhile, LBDA commenced Rural Domestic Water Supply and Sanitation Programme (so-called RWSSP) in South Nyanza, Siaya, Kisii, and Kisumu district in 1985. This project involves construction of bore holes, hand dug wells, dams, small pipe water scheme, spring protection, and roof catchments. Within the current development plan, 180 nos of water points are developed in Kisumu district through the RWSSP.

3.6 Existing Irrigation and Drainage System

3.6.1 Irrigation

Twenty seven (27) irrigation schemes have been developed with a total irrigation area of about 4,300 ha in the study area since late 1960s. Among them, two pilot schemes of 1,770 ha in total were firstly implemented in Ahero and West Kano by the National Irrigation Board (NIB) under the Ministry of Regional Development in 1966.

Following the success of the two pilot schemes, the remaining twenty five (25) small scale irrigation schemes have been developed in the lowlying Kano plain by the Provincial Irrigation Unit (PIU) under the Ministry of Agriculture since late 1980s. It should be mentioned hereto that all the schemes developed so far in the Kano plain are only for paddy field irrigation; there is no upland irrigation scheme at all in and around the Kano plain at this moment. Table 3.2 summarizes the existing irrigation schemes in the Kano plain, and Fig.3.7 illustrates the location of each existing irrigation scheme.

(A) Ahero pilot scheme

The scheme is located at about 20 km westward of the Kisumu township along Route B3 and it commands 870 ha, depending its irrigation water on the Nyando river. The irrigation water is lifted up by motor-driven pumping units; he maximum pumping requirement is estimated at about 1.2 m^3/sec. The drainage in the scheme is made in the Nyando river by gravity.

(B) West Kano scheme

The scheme is located at southeast of the Kisumu township and it is about 12 km remote from the township along Route B3 and unpaved access road. The scheme commands 900 ha of paddy field, depending its irrigation water upon the Lake. The irrigation water is lifted up by motor driven pumping units. The scheme area is lowlying and it is impossible to drain excess water by gravity; the drainage of the scheme is also dependent on the exclusive drainage pumping units.

(C) PIU schemes

The twenty five (25) PIU schemes are scattered in the vast Kano plain as shown in Fig. 3.7. The area for these schemes widely ranges from three (3) ha of Aguko scheme to 1,130 ha of South West Kano scheme, and totals about 2,500 ha. Almost all the schemes, excepting one scheme, depend their irrigation water on adjacent ephemeral wadis or spring water. Therefore, these schemes are provided with no year-round irrigation system. Only one small scheme with area of four (4) ha is provided with a year-round irrigation system, lifting the irrigation water from the Lake by pumping unit.

3.6.2 Drainage

There extend three (3) major perennial swamps in the Kano Plain, such as Central Kano swamp, Nyando swamp, and Coastal swamp; the area of these three swamps totals about 10,000 ha or about 15% of the Kano and Nyakach Plains.

Between the Nyando river and the Nyakach Escarpment,three (3) rivers,such as the Nyaidho, the Awach Kano, and the Asawo river,flow into the Nyando swamp. These rivers in the Kano Plain are characterized by extremely gentle gradients of riverbeds and small cross section compared with their magnitude of foods,resulting in stagnation of flooding. The area along the Kisumu-Sondu (Route A1) and Kisumu-Kendu bay (Route C19)roads is habitually flooded due to flood stagnation of these rivers. The other major factors causing floods in the Plain are high intensity rainfall,siltation in river channel,and incidental rise of the Lake water level,etc.

The Ministry of Water Development started a construction of the flood protection dike along the Nyando river in 1985. The project consists of three (3) phases as follows:

Phase-1: Construction of dike of 12 km from the Ahero bridge downstream,
Phase-2: Construction of dike of 8 to 10 km from the Ahero bridge upstream, and
Phase-3: Strengthening of dikes which were constructed in Phase-1 and-2.

The dikes constructed by the Ministry are about 2.7 to 3.0 m high and about 4 m wide at top of dike. The alignment between both banks was made at 200 m interval near the Ahero and 500 m interval near the swamp. The Ministry has another plan to extend the flood protection to the Kibos and Lielango rivers,and drainage improvement plan in swampy area.

3.7 Present Condition of Agriculture

3.7.1 Present land use and cropping pattern

(A) Land use

About 53,000 ha or 73% of the total land resources (73,000 ha) in the study area are cultivable. Fig 3.8. shows situation of the present land use. Out of the agricultural land, only about 17,000 ha are cultivated and the remainder has been usually left as fallow, pasture, and scrubs. It is said that upland field and pasture in the area have been rotated at several years interval. Fallow stage of the paddy field in the area has been also used for the pasture.

(B) Cropping calendar

The major crops grown in the area consist of cereals, such as maize, sorghum, and rice, followed by pulses, such as beans, greengrams, cowpeas, and ground nuts, and cotton, and tuber crops, such as cassava and sweet potato. Cultivation pattern and growth period of crops are largely affected by seasonal distribution of rainfall and flooding over the land. Planting and harvesting times have a wide range and fluctuate year by year, because these crops are usually planted at onset of the rainy season or the end of flooding period.

Maize, sorghum, and pulses for the long rainy season are planted during February to March, and harvested during June to August. These crops are mostly intercropped each other. Cotton is mainly intercropped or relay-cropped with maize or sorghum and is planted two months after sowing of maize or sorghum, and is harvested during end of October to January. Vegetables are cultivated throughout the year under irrigation condition. Cropping intensity of upland crops at present ranges from 41% to 118% on an average in the cultivating land.

3.7.2 Present farming practices

(A) Upland crops

Farm operation in the area is mostly carried out by manpower. Cattle power is used for only soil preparation and transportation of farm products. These upland crops excepting cotton are usually cultivated under no chemical and fertilizer applications. Cotton plant is generally applied pesticides for twice to four times a season.

Variety of maize, sorghum in the area are mostly improved; hybrid varieties, such as H-622 and H-511, and composite varieties, such as Katumani for maize and Serena, Seredo, and E52R for sorghum have been introduced so far.

(B) Paddy

Sowing is made in nursery bed. At three to five weeks after the sowing, transplanting is made in a density at 30 to 50 hills per m^2. Land preparation for nursery and transplanting are mainly carried out by cattle power and manpower in the PIU schemes. In the NIB Schemes, however, ploughing and harrowing are made by tractors and puddling done by cattle. The other farming operations are made by manpower.

Variety of paddy rice in the area is fairly improved;IR2793, BW196, Sindano and Basmati have been introduced so far. Meanwhile,the insects and diseases,such as stem bores and rice yellow mottling virus are observed on paddy plant in the area. Damages by diseases are serious in some schemes and rapidly extended to the other surrounding schemes.

3.7.3 Crop yield and production

Table 3.3 indicates a present crop yield in the area based on the data in the Kisumu district. Yield of each crop is relatively low compared with that in the world level. Table 3.3 also indicates a crop production in the area based on the data in the Kisumu district. According to the data, the production gradually increases year by year. But, the current production of staple food is still in short to maintain the population in the Kisumu district. Production value of the main crops in the area in 1989 is equivalent to about Ks 75 million.

3.7.4 Livestock production

Livestock raising is also one of the main line in agricultural activities in the area, and is given high priority in the current Five Year Development Plan of LBDA. The production value in 1989 is estimated at Ks 22 million or 28% equivalence of the production value of the major crops. Cattle is the most important, followed by sheep and goats. Some farmers raise their incomes from poultry. Varieties of almost all the cattle and chicken are indigenous. Cattle is also important as a source of farming power. Livestock is traditionally grazed in pasture, fallow, and farm land after harvest.

3.7.5 Land tenure and land holding

Farm size in the study area widely ranges from 0.4 ha to 21 ha. Average farm size is estimated at about 3.1 ha, comprising 1.7 ha of cultivated land, 1.0 ha of pasture, and 0.4 ha of homestead. In case that farmer cultivates paddy field, the cultivated land held by the average farm household consists of 1.4 ha of paddy field and 0.3 ha of upland field.

Land ownership of agricultural land in the study area can be categorized as owner farmer, share cropper, tenant, squatter, and hired. Among them, the owner farmer shares 63% of total agricultural land, followed by the share cropper of 33%. The share of the remaining three categories are negligible small; the squatter shares only 2%, and the tenant and the hired share only 1% respectively.

3.7.6 Processing

There are various processing industries of agricultural products in and around the study area. These are rice mill, maize mill, wheat mill, cotton ginnery, sugar mill, and jaggery factory.

(A) Rice mills

Two large scale and some medium scale rice mills are operated in and around the study area. These mills can be as summarized below:

Name of Mill	Location	Capacity
United Millers	Kisumu Township	125 t/24 hrs
Kibos Industries	Kibos	48 t/24 hrs
Nyando Millers	15 Locations	60 t/day
Nyando Enterprise	Ahero	N.A

(B) Posho mills

There exist many small scale grain mills, so called "posho mill"for maize, sorghum, millet, and cassava by customer milling base. These mills are mainly located adjacent local markets. People around markets mill their grains for home consumption. Milling charge ranges from Ksh.0.6/kg to Ksh. 1.5/kg.

(C) Ginnery

Ginnery owned by Cotton Board of Kenya is located at Kibos in the project area. The capacity is about 2,000 ton per season. Machinery in the ginnery is very old over 50 years. Recovery of lint from seed cotton is estimated at about 33%. Cotton seeds separated from seed cotton are partly used for seeds as planting material and remainder is sold to oil millers.

(D) Sugar factories

Three (3) large scale sugar factories are located around the study area. These are Chemelil Sugar Company at Chemelil, East African Sugar Industry Co.Ltd at Muhoroni, and another in Miwani. Factory at Miwani was formerly operated by a private sector, but has stopped at present due to financial reason. Now, the factory is under rehabilitation by the Government Authority. Before long, it will resume the operation. The remaining two factories are operated by the parastatal bodies.

The Chemelil and Muhoroni factories are provided with a milling capacity of 3,000 ton and 2,000 ton per 24 hrs respectively. Both factories shut down for regular maintenance in the long rainy season from March to April. Accordingly, the annual capacities are estimated at about 800,000 ton at Chemelil and 500,000 ton at Muhoroni.

3.7.7 Marketing and prices

(A) Marketing

Main marketing channel of agricultural products is classified into i) channel handled by private sectors, and ii) channel provided by parastatal bodies. Besides them, local markets under County Council and Municipal market of Kisumu play an important role of marketing of agricultural products.

Cereals such as maize, sorghum, millet, rice and pulses are marketed by private millers or agent, and also National Cereal and Produce Board (NCPB) is buying and selling them. Rice produced in NIB schemes is collected by NIB and sold to private millers. After milling, rice is mainly transported to other district. Rice produced in PIU schemes is mostly collected by the private millers, and partly sold at local markets mainly by Women's Group. Maize and other cereals, and pulses produced in the study area are mostly used for local consumption.

The Cotton Board of Kenya fully supports the cotton growers in marketing and processing. Seed cotton is collected by cotton cooperatives and is purchased by the Board. Then the Board transport it to the ginnery at Kibos.

Most of sugarcanes are grown by contract growers of the large scale sugar mill factories at Chemelil and Muhoroni. Transportation of sugarcane is provided by the factory;the cost is born by the grower. Some farmers sometimes sell their sugarcane to jaggery factories which produce brown sugar cluster in village.

Most of farm inputs are supplied by Kenya Grains Growers Cooperative Union Ltd. (KGGCU). It has two branch offices in Kisumu and Muhoroni. From these branches, farm inputs are mainly handled to farmers through primary cooperative societies or private dealers so called stockist. Individual farmers, also can buy such inputs directly from the branch office.

(B) Prices

Prices of farm inputs are controlled by the Government. But, retail prices fluctuate location to location due to transportation cost. Prices of major crops are handled by the parastatal bodies such as NCPB, Cotton Board of Kenya, and Sugar Mill Factories are regulated by the Government. Prices of cereals in 1990, handled by the NCPB are shown in Table 3.4.

3.8 Agricultural Support Services

3.8.1 Research

Ahero Irrigation Research Station (AIRS) of NIB is established and operated in Ahero Irrigation Scheme (AIS) in the study area. Research station has been operated since 1969, aiming at applied research for cultivation of rice and sugarcane under irrigation condition. The results of the research in the station have been applied both for the NIB and PIU irrigation schemes.

Besides, two national research stations, i.e Cotton Research Station and Sugarcane Research Station, have been operated at Kibos. These stations have a responsibility for improvement of farming technology and increase of productivity through experiments and research. The private sugar factories at Chemelil and Mohoroni also have their own agricultural research section.

3.8.2 Credit

In order to transmit credit money to farmers, there are five (5) channels, i.e.Agricultural Finance Corporation (AFC), Cooperative Bank of Kenya (CBK), parastatal organization, commercial banks, and companies. Main agency for agricultural credit is AFC and CBK. Farmers can apply advance credit for purchase of livestock, equipment, machinery, even for land.

Agricultural credit can be classified into three (3) categories,i.e,long term, medium term, and short term by type of loan; the long term credit is for the period of 3 to 30 years for large capital investment; the medium term, for the period of 2 to 7 years;the short term, for the period of several month to 2 yeas mainly for purchase of farm inputs. Interest rate of the credit is around 12%. Farmers in the study area usually use credit for cash crops through cooperative societies and parastatal bodies for commodities.

3.8.3 Extension

The Ministry of Agriculture has the Extension and Manpower Development Division which has a responsibility for extension works in the national level. Assistant Director of Agriculture (usually referred to as "Provincial Director of Agriculture"), assisted by specialist team, is in charge of extension works at provincial level.Further, Senior Agricultural Officer and specialists are in charge of the extension works at district level. This organizational line continues up to location level.

In addition to the above, parastatal bodies such as the Cotton Board of Kenya, Horticultural Crop Development Authority, NIB schemes, sugar factories have exclusive staff for the extension of framing practices to their own farmers concerned.

3.8.4 Cooperatives

Hundred fifty six (156) of primary cooperative societies and cooperative unions have been established in the Kisumu district. Most of purchasing and marketing are made through cooperative societies. The District Cooperative Office frequently provides a training programme for improvement of their cooperative activities for leaders of the societies. The following is a classification of operating cooperative societies in the Kisumu district:

	Type	Active	Dormant	Liquidation	Total
1.	Coffee	3	-	-	3
2.	Cotton	5	-	-	5
3.	Sugarcane	39	6	-	45
4.	Dairy	3	-	-	3
5.	Multipurpose	4	14	-	18
6.	Poultry	1	1	-	2
7.	Farm Purchase	3	-	-	3
8.	Consumer	1	1	-	2
9.	Housing	4	2	-	6
10.	Saving & Credit	31	14	3	48
11.	Fisheries	10	3	-	13
12.	Transport	-	1	-	1
13.	Building	-	1	-	1
14.	Cooperative Union	5	1	-	6
	Total	109	44	3	156

3.8.5 Farm budget

Farm budget of average farm household in the study area is analyzed based on the data collected through farm survey. It is estimated that gross income of farm household is about Ks.28,000 per annum;this amount accounts approximately Ks 4,000 of income per person in consideration of family size of average farm household. The 82% of the gross income or Ks.23,000 is generated from farm income. Total outgo consisting of farm expense and living expense amounts to Ks.25,550. Net annual reserves in the average household are estimated at Ks.2,500 or 9% of the gross income.

4. CONSTRAINTS FOR IRRIGATED AGRICULTURE DEVELOPMENT

4.1 Summary of Current Situation in the Study Area

4.1.1 Agriculture

Most of upland and paddy field in the study area have a high potential for irrigated agriculture. Soil texture in the Nyakach plain broadly varies from coarse to fine; almost all the soil texture in the Kano plain is rather fine. Out of 72,980 ha of the land resources in the area, 51,940 ha (about 71% equivalence) are suitable for paddy cultivation and 53,440 ha (about 73% equivalence) are suitable for upland crops cultivation.

Major crops grown in the area consist of cereals, such as maize, sorghum, and rice, followed by pulses, cotton, and tuber crops. Cultivation pattern and growth period of crops are affected by seasonal distribution of rainfall and flooding. Maize, sorghum, and pulse for the long rainy season are planted during February to March, and harvested during June to August. These crops are mostly intercropped each other. The cropping season of paddy rice under the PIU schemes is affected by water condition, rainfall, and flooding. Double cropping of paddy rice has not been tried so far in the PIU schemes. Farm operation in the area is mostly carried out by manpower. Cattle power is used for only soil preparation and transport of farm products. Sowing of rice is made in nursery bed. At three to five weeks after sowing,transplanting is made. Land preparation for nursery and transplanting are mainly carried out by cattle power and manpower respectively.

Yield of each crop grown in the area is relatively low and it fluctuates year by year and place to place. Main reason of low productivities in the area may be due to low farm input and poor maintenance. Current production of staple food in the area is still short to maintain population in Kisumu district. Production value of major crops in the area in 1989 is about Ks.75 million. Livestock raising is also one of the main line in agricultural activities in the area. The production value of the livestock in the area is estimated at Ks.22 million, or 28% equivalence of that of the major crops.

Farm size in the area ranges from 0.4 ha to 21 ha, averaging 3.1 ha. Land ownership in the area can be categorized owner farmer, share cropper, tenant, squatter, and hired. Among them, the owner farmer shares 63% of the total land, followed by the share cropper of 33%.

There are various processing industries of agricultural products in and around the area. These mills have enough capacities to process agricultural products in the area at present. Main marketing channel of agricultural products is classified into i) channel handled by private sectors and ii) channel provided by parastatal bodies. Besides,local market under the County Council and Municipal market of Kisumu district plays an important role of marketing of agricultural products.

Hundred fifty six (156) of primary cooperative societies and cooperative unions have been established in Kisumu district; cooperative for sugarcane is in majority of 39, followed by that for savings and that for fisheries of 10.

4.1.2 Irrigation

No upland irrigation has been practiced in and around the study area. Meanwhile, twenty seven(27) paddy field irrigation schemes have been developed with a total irrigation area of about 4,300 ha since late 1960s. These schemes can be categorized into i) NIB schemes and PIU schemes.

Firstly, Ahero scheme of 870 ha was implemented by NIB as a pilot scheme for paddy cultivation in the Lake Basin in 1966, followed by West Kano scheme implemented also by NIB in 1969. Both schemes are provided with a all-weathered irrigation system installing pumping units. In particular, the Ahero scheme is provided with a separated network for irrigation and drainage canal system. Construction and operation of both schemes have been made by NIB initiative.

After verification of viability of paddy cultivation in the Ahero and the West Kano pilot scheme, PIU started construction of small scale paddy field irrigation scheme in early 1980s, and twenty five(25) schemes have been developed so far depending on ephemeral water sources in lowlying area. The irrigation system in these schemes is therefore not year-round but seasonal. The schemes are rather small excepting the South West Kano, ranging from four (4) ha to 250 ha. Unlike the NIB schemes, the construction and operation of the PIU schemes have been made by the farmers' initiatives.

4.2 Constraints for Agricultural Production

The study area is graced with vast land resources quite suitable for agricultural production. Nevertheless, land productivity thereabout is still low because of various constraints for agricultural production. Major constraints foreseen are as summed up below:

1) Annual shortage and uneven seasonal distribution of rainfall,
2) Serious shortage of irrigation water resources endowed in the study area,
3) Lack of perennial irrigation system for upland cultivation,
4) Poor farm road networks and crossing bridges,
5) Habitual flooding and inundation,and deficiencies of drainage system,
6) Improper application of agricultural inputs,
7) Insufficient and improper plant protection,
8) Insufficiency and improper management of credit services,
9) Insufficiency of extension services, and

Crucial constraints among them are i) serious shortage of irrigation water resources, and ii) lack of perennial irrigation system for upland cultivation, and iii) habitual flooding and inundations.

5. NEEDS FOR IRRIGATION DEVELOPMENT

In spite of endowed natural and human resources and much effort for development by Authorities concerned, Regional econom in the Lake Victoria basin remains relatively low level in comparison with national economy level in Kenya. GRDP per capita in the LBDA region has been estimated at K£.120 per annum. This is only 59 % equivalence of the per-capita GDP of Kenya, averaging K£.204 in 1985.

In order to improve such a regional disparity in per-capita income, agriculture which is the top leading sector in the region should be intensively developed. Existing agricultural land in the area,however,remains very low productivity due to various agricultural constraints as mentioned in the previous chapter. In line with concepts of the current LBDA's Five Year Plan, maximum intensification of land use or vertical expansion in the existing agricultural land in the area should be attempted maintaining present cropping pattern as far as possible. Irrigation development makes a sure contribution to attainment of such intensified land use in the area.

According to the scenario envisaged in the current LBDA's Five Year Plan, the region should increase food crop production as much as possible, aiming at making the region a granary of Kenya or even the whole East Africa. Maize and rice are considered more important strategic crops in view of regional food security. These staple crops production sharply increases with provision of irrigation system in the area.

The Kano Plains has been noted for long time as the most promising area for irrigated agricultural development due to its endowed land and water resources, favorable climatic conditions, sufficient labour forces, and its strategic location in the center of the region. In the 6th National Development Plan, this plain is nominated as one of the most favorable irrigation potential area. Such being the situation, there is pressing needs for implementation of a large scale irrigation scheme in the Kano Plain.

6. PROSPECTIVE DEVELOPMENT PLAN

6.1 Basic Development Concepts

In conformity with the objectives of the 6th National Development Plan and in the light of the LBDA's 2nd Five years Development Plan, LBDA has made a best effort for basin development aiming at provision of necessary infrastructure,contribution to food security, improvement of regional economic structures, and amendment of income disparity. To contribute to such major objectives in the LBDA basin development,the project would aim at extension of stabilized irrigated agriculture through exploitation of a large scaled year-round irrigation system. Major concepts for agricultural development in the area would be set forth as follows:

1) The most profitable crops would be selected in consideration of land suitability, knowledge of farmers, marketing, the Government policies, etc.,

2) Proper size of forage land would be arranged in consideration of population of livestocks, amount of crop residue, etc.,

3) Cultivation area for each crop would be determined in consideration of profitability of crops, demand and supply, existing capacity of processing, marketability, etc.,

4) Paddy field would be rotationally used between paddy crops and upland crops ,

5) Cropping intensity should be increased as far as possible to make the maximum use of newly exploited irrigation water,

6) Special attention would be paid to crop diversification in consideration of farmers' income, marketing, the Government policies,

7) Optimal cropping pattern would be laid out in view of agro-and-water economy; water consumptive crops would be planted during rainy season in principle, and

8) Agricultural support services, such as credits, extension, marketing, and research, would be improved and strengthened for effective farming operation.

In order to realize the above-mentioned major concepts for agricultural development in success, the following basic concepts for irrigation development are envisaged:

1) Available water resources released through the Sondu-Miriu Hydropower Station would be transferred to the Kano and Nyakach Plains to the maximum extent,

2) Perennial swamps such as the Kano and Central Swamps would be deleted out of the project area from ecological conservation, flood detention, and project economic viewpoints,

3) Paddy field development would be made in lowlying alluvial lands in the vicinity of the existing paddy irrigation schemes,

4) An extensive irrigation development plan on vast land resources in the Kano and Nyakach Plains would be envisaged for the time being in conformity with the available water and land resources. But, in order to make the project economically viable and financially bankable, unfavourable area might be excluded out of the project area.

5) Comprehensive study would be necessary for flood control and drainage improvement in the Nyando river basin. Irrigation development plan in the Nyando river basin would be formulated on the assumption that such a comprehensive basin development would be implemented in parallel with this project. The flood control plan in this project, thus, would be studied only for small tributaries, such as the Asawo, Awach Kano, and Nyaidho rivers and other small wadis develped in the project area, and

6) Existing poor farm roads in the project area would be densely networked with perennial crossing structures.

6.2 Selection of Optimum Project Scale

6.2.1 General

In the Interim Report compiled in March, 1991, as the results of the 2nd field works, the project area of 24,180 ha was delineated on the basis of water balance study. An agricultural and irrigation development plan for the Kano and Nyakach Plains was tentatively proposed on this project scale. In the meantime, it was pointed out through discussion on the Interim Report between LBDA and JICA Study Team that the project should be formulated on the optimum scale, maintaining economic viability and financial bankability.

In line with the mutual agreement in the Minutes of Meeting dated in March, 1991, a comparative study was undertaken for determination of the optimum project scale in the early stage of the 3rd Field Work which commenced in early June, 1991.

6.2.2 Procedure of study

1) Alternative project scale

In due consideration of dependable water and land resources, topography and physiography, flooding and inundation conditions, soil and land capability, concepts of the LBDA's Five Year Development Plan, and the agreed Scope of Work for the Feasibility Study, three (3) Alternative project scales are selected as given below and as illustrated in Fig.6.1:

Alternative	Extent	Hectareage(ha)
1	Kendu Bay to Kibos River	24,000
2	Kendu Bay to Nyando right bank	20,000
3	Kendu Bay to Nyando left bank	15,000

2) Aspects for Assessment of Alternatives

The selected alternative scales are assessed in view of economic viability and environmental impacts. In advance of the economic evaluation, land suitability, marketability and profitability of crops, and available water resources are scrutinized by each alternative scale.

3) Procedure

Based on results of scrutinizing agro and engineering aspects, irrigation canal system is laid out, and preliminary cost estimate is made for each alternative scale. Meanwhile, based on

results of examining agro-economic aspect, incremental benefits are estimated by each alternative scale. Then, the economic evaluation for the alternative scale is made in terms of internal rate of return (IRR), B-C, and B/C on the estimated benefits and costs.

In addition to the assessment by economic viability of the project, impacts of water pollution caused by implementation of the project are assessed by each alternative scale. Such an environmental assessment is also highly regarded in coming to conclusion for the optimum project scale.

6.2.3 Layout of irrigation and drainage system

Based on the diversion water requirement for each alternative which is determined through water balance study, irrigation and drainage system is laid out on topo map of 1/5,000 scale. Main features of the facilities by Alternatives can be summarized as given below:

Description	Alternative-1	Alternative-2	Alternative-3
1) Regulating Pond	510,000 m^3	510,000 m^3	340,000 m^3
2) Main Irrigation Canal			
Sondu Main	46 km	46 km	46 km
South Nyanza	22 km	22 km	22 km
South Nyando	30 km	30 km	-
North Nyando	31 km	-	-
3) Secondary Canal	283 km	255 km	220 km
4) Sondu Siphon	1,000 m	1,000 m	1,000 m
5) Nyando Siphon	120 m	-	-
6) Nyando Intake Weir	1 no.	1 no.	-
7) Drainage & Flood C.	184 km	158 km	103 km

6.2.4 Preliminary cost estimate

Capital cost is estimated at price level in March 1991 on the basis of layout of the system for each alternative scale. The following is the summary of the estimated cost.

(million Ks.)

Description	Alternative-1	Alternative-2	Alternative-3
A. Construction Cost	7,578	6,568	3,072
1) Preparatory Works	530	459	215
2) Direct Cost. Cost	5,299	4,588	2,149
3) Contractor's Expense	1,060	917	430
4) Physical Contingency	689	596	278
B O/M Equipment	49	37	26
C Administration Cost	229	198	93
D Engineering Cost	762	660	310
TOTAL	**8,618**	**7,455**	**3,501**

6.2.5 Net incremental benefit

Net incremental benefit is defined as difference of net production value under the with-project condition and without-project condition. On the basis of the proposed cropping pattern

and the net production value estimated in the Interim Report, total net incremental benefit is calculated by each alternative scale as summarized below:

(Unit : Ks.)

Alternative	With-Project	Without-Project	Incremental
1 (24,000 ha)	818,000,000	61,000,000	757,000,000
	(33,800/ha)	(7,600/ha)	(31,300/ha)
2 (20,000 ha)	749,000,000	52,000,000	697,000,000
	(37,000/ha)	(7,600/ha)	(34,500/ha)
3 (15,000 ha)	547,000,000	30,000,000	518,000,000
	(36,700/ha)	(6,500/ha)	(34,700/ha)

As clarified above, Alternative-1 accrues the largest total net production value with project and total net incremental benefit, while Alternative-3 accrues the smallest net incremental benefit,but the highest unit net incremental benefit per ha.

6.2.6 Economic evaluation

Three alternative scales are evaluated in terms of internal rate of return (IRR), and B-C, and B/C at discount rate of 10%. The detailed caliculation is given in ANNEX-VII, and the following is a summary of the economic evaluation by each alternative scale:

Alternative	IRR	B-C	B/C
1 (24,000 ha)	7.3 %	-577	0.75
2 (20,000 ha)	7.7 %	-446	0.79
3 (15,000 ha)	12.2 %	267	1.24

6.2.7 Impacts study on water quality in Nyakach Bay and Winam Gulf

1) Objectives

Impacts on implementation of large scale irrigation project in the Kano plain causes a considerable reduction of annual inflow. In addition, polluted water by irrigation might be drained into the Nyakach bay. Magnitude of water pollution in the Nyakach bay, therefore, might be directly concerned to project development scale. In order to clarify such a magnitude of the impacts on water quality caused by the implementation of the Kano Irrigation Project, a preliminary assessment is made in the Nyakach bay and the Winam Gulf.

2) Tentative assessment

Hydrological condition in the Bay and the Gulf is assumed based on the study in the Interim Report and other available reports. Present water quality and pollution load are also estimated by using available reports and documents. Additional pollution load caused by each alternative scale is estimated based on the data available in Japan because no data is available at present in the study area. The following is a tentative assessment of the water quality in the Bay and the Gulf on the basis of various assumptions mentioned above:

1) The proposed project would cause more significant impacts on water quality in the Bay than that in the Gulf. More attention should be paid to the water quality in the Bay accordingly.

2) Water quality of the Bay would mostly depends on the quality and quantity of the diverted water from the Nyando river and the drained water from the Kano Irrigation Project, and

3) Alternative-3 (about 15,000 ha) would be recommendable to avoid high magnitude of the impact on water quality of the Nyakach bay.

6.2.8 Conclusion for optimum project scale

The following is the conclusion for the assessment of three (3) alternative scales from overall viewpoint:

1) Alternative-3 is the optimum scale in terms of economic internal rate of return (IRR), and the B-Cand B/C at discount rate of 10%,

2) Water quality assessment shows that Alternative-3 causes the least water pollution in the Nyakach bay. Irrigation development in any case may not cause so serious water pollution in the Winam Gulf,

3) Alternative-3 would be therefore selected as the optimum development scale in this study from overall viewpoints, and

4) Based on Alternative-3, the project area would be delineated at the extent between the Kendu bay on the south-west and the left bank of the Nyando river on the north-east.

6.3 Agricultural Development Plan

6.3.1 Selection of crops

Crops and cropping pattern for the project would be formulated.based on the national food policy, the National Development Plan, and the Five Year Development plan of the Lake Basin Development Authority, The following is a basic principle for selection of the crops and layout of the cropping pattern:

1) Creation of the maximum benefit for farmers and national economy,
2) Effective use of available water resources,
3) Farmers' familiarity for farming practices and
4) Conformity to existing socio-economic condition.

In due consideration of physical and social condition, demand and supply of crops, and farming profits as mentioned in the later section, tea, arabica coffee and wheat are excluded for layout of the cropping pattern because of less suitable for irrigated agriculture in the area. Robusta coffee and sorghum are also excluded because of low economic return. Tuber crops should be cultivated non-irrigated area. The following seven categories of crops are thus selected for the agricultural development plan:

1) Cereals, such as maize and paddy,
2) Pulses, such as beans, cowpeas and greengrams,
3) Vegetables, such as tomato, onion, cabbage and kale,
4) Sugarcane,
5) Cotton,
6) Fruit tree, such as passion fruit, and
7) Forage crops for dairy and working cattle.

6.3.2 Cropping pattern and change of land use

Cropping area would be determined taking into account of i) demand and supply, ii) farming profits, iii) marketability, iv) processing capacity, v) soil characteristics and vi) available irrigation water. Basic principles for determination of cropping area would be itemized as mentioned below:

i) Staple food production is still short to maintain the population in the Kisumu district. The hectareage of maize would be therefore extended by 3,500 ha to supply in and around the project area. What is more, the hectareage of pulses also would be extended to 3,500 ha for the regional food self-sufficiency.

ii) Hectareage of paddy field could be possibly extended as far as soil characteristics and availability of irrigation water would be allowable.

iii) Hectareage of sugarcane and cotton would be mainly determined on the basis of the existing processing capacity of factories around the study area. Cropping of sugarcane in the area would be hence limited to about 5,000 ha.

iv) Hectareage of vegetables and fruit tree would be determined depending on amount of local consumption, marketability and processing capacity of factories expected in the near future.

v) Hectareage of forage crops for dairy cattle would be determined taking account of the local milk consumption in and around the area.

vi) Hectarage of Napier grass for working cattle would be determined on the basis of feed requirement, which would be supplemented by rice straw, sugarcane top and other crops.

Based on the principles mentioned above, cropping pattern and calendar are laid out as given in Table 6.1 and Fig.6.2. The following is the summary of the proposed cropping pattern:

Long Rainy Season	Short Rainy Season	Hectareage
Paddy	Beans	2,690
Maize	Paddy	1,740
Maize	Cotton/Beans	1,530
Sugarcane	Sugarcane	5,130
Vegetables	Vegetables	1,570
Fruit tree	Fruit tree	1,000
Napier Grass	Napier Grass	1,270
Total		14,930

Cereals are mainly cropped during the long rainy season, and pulses and cotton, during the short rainy season. Vegetables are planted in relatively elevated area in order to avoid moisture stress. In the short rainy season, paddy should be planted in early February to late March and harvested in late June to early August to avoid cold temperature during the period from panicle initiation to the flowering stage.

Sugarcane and paddy plant would be cultivated in the area covered with heavy clay soil (mainly sub-area III, IV and V), meanwhile vegetables and fruit trees would be mainly planted in the area covered with light loamy sandy soil (mainly sub-area I and II).

Introduction of the cropping pattern mentioned above brings about change of land use in the project area as tabulated below. Further details are given in Table 6.2.

(Unit:ha)

Category of Land	Without Project condition	With Project condition	Balance
Paddy Field	780	4,430	+3,650
Upland Field	5,920	10,500	+4,580
Pasture	7,400	0	-7,400
Scrubs	830	0	-830
Total	14,930	14,930	0

6.3.3 Farming practices

Farming practices in the project area are so extensive at present; the practices are characterized with low farm inputs, low cropping intensity and mixed cropping. After completion of year round irrigation system in the area, proper farming practices are essential for realizing full exploitation of agricultural potential in the area. For this purpose, it is necessary to introduce new high yielding varieties and varieties resistant to pest and disease, good seeds, appropriate cultivating practice, fertilizer application method and appropriate plant protection method along with development of irrigation facilities. Since hectareage of major crops and cropping intensity increase through developing irrigation facilities, labour requirement increases and fallow period of field becomes shorter.

Introduction of such improved farming practices need much labour requirement. Potential labour forces in the project area are estimated at 24,220 based on the statistic data in the Kisumu district. In the meantime, seasonal daily labour requirement is estimated by cropping at half month basis in accordance with the proposed cropping calendar and pattern, as given in ANNEX-V. The half monthly labour requirement is also estimated by multiplying the daily labour requirement for the proposed cropping pattern with the cropping area, as summarized below:

(Man-Days)

Month	Early 15 Days	Late 15 Days
January	18,650	20,430
February	22,180	21,360
March	19,690	17,940
April	16,280	16,280
May	14,600	14,040
June	13,370	14,730
July	18,020	21,230
August	23,130	23,760
September	22,280	18,760
October	17,710	15,860
November	14,850	13,940
December	15,740	16,530
Potential Labour Force	24,220	24,220

As shown above, the maximum early and late monthly requirements are estimated at 23,130 man-days in early August and 23,760 man-days in late August respectively. Both maximum requirements are nearly covered with the potential labour force.

For heavy farming works like soil preparation and transportation, it is proposed to use mainly oxen power and supplementally machinery. In spite of a lot of advantages to farm management,it is difficult to introduce substantial mechnized farming in the project area for the

time being in view of farmers'technique for operation and maintenance and investment cost for machinery. Light mechanization is,however,essential for plant protection and post harvest of crops such as chemical sprayer, thresher for rice, sheller for maize and groundnut.

Since heavy farming works would be made by oxen power, a large number of cattle would be required for farm operation in the project area. The number of cattle at present and in 2010 is forecast to be 22,620 and 26,830 heads respectively depending on trend of cattle population during the period of 1984 through 1989. In the meantime,work cattle requirement at early and later development stage of the project is also estimated at 9,940 and 25,600 heads respectively by multiplying per-hectare head requirement with cropped hectareage. Cattle population at present and in the near future (2010) can fully cover the cattle requirement for the farming works in the project.

Furrow irrigation practices would be employed for upland crops. All the upland crops would be mono-cropped. Pests and diseases control by chemicals should be minimized as far as possible in view of water pollution by drainage. In this view, varieties resistant to pests and diseases would be introduced and ecological control of pests and diseases should be also employed under improved farming practices.

6.3.4 Anticipated crop yield and production

Present yield of crops in the project area remains at low level due to low input, poor farm management and some stresses. After the completion of year-round irrigation system, yield of crops is sharply increased and stabilized through being accustomed to irrigation farming practices and intensive agriculture. Target yield and production of crops in future with-project condition are set forth as given in Table 6.3, making reference to various data in Kenya and in the country with a similar climatic condition and publication of FAO.

Yield of crops grown under non-irrigated condition is so assumed to stay at the same level of present yield. Under with-project condition, cropping intensity becomes doubled. Non-harvested area is sharply decreased; to the contrary, yield of each crop is sharply increased.

6.4 Agro-Economy

6.4.1 Population in project area

Population in the project area is estimated at 41,400 in 1979 and 55,200 in 1989 on the basis of the Population Census, 1979 and the provisional results of Population Census 1989. Average annual growth rate during 1979 thru 1989 was 2.91%. Population density was 249 persons/km^2 in 1979 and 332 persons/km^2 in 1989 as summarized as follows:

	1979*		1989		Growth
	Population	Density	Population	Density	rate
Kisumu District	537,000	230	674,000	288	2.30%
Project area	41,400	249	55,200	332	2.91%

*: Census data in 1979 was under estimated in Nyanza Province and is estimated on the basis of the Population Projection 1980-2000.

Population growth rate in the project area in past several decades shows a declining tendency,and it is estimated that future growth rate slightly decreases from 2.91% during 1989 thru 1990 to 2.5% during 1990 thru 2010. On the basis of these population growth rate, future

population in the project area is projected at 93,100 in the year of 2010 with a population density of 630 persons/km^2 in the project area as follows:

Area	1990	2000	2005	2010
Kisumu District	690,000	847,000	940,000	1,045,000
Project area	56,800	72,700	82,300	93,100

6.4.2 Marketing prospect

(1) Demand of Food Crops

On the basis of staple food production such as maize sorghum, rice, beans and potatoes in Kisumu in 1987 to 1989, average annual production is estimated at 109 kg/person, while target of per capita consumption of foods in the National Sixth Five Year Development Plan (1989-1993) is 177 kg/person/year, as shown below.

Crops	Average*1 production 1987-1989	Per capita*2 production 1987-1989	National Target of per capita consumption
	(ton)	(kg/person)	(kg/person)
Maize	31,120	46.2	100.0
Wheat	0	0.0	19.4
Sorghum	10,300	15.3	7.7
Rice	7,240	10.7	3.0
Beans*3	3,920	5.8	13.2
Potatoes*4	21,040	31.2	33.5
Total	73,620	109.2	176.8

*1: Annual Report of District Agricultural Office, 1978, 1988 and 1989.
*2: Population in 1989 is estimated at 674,000 according to the provisional figure of Census 1989.
*3: Beans includes greengram and cowpeas.
*4: Potatoes includes sweet potatoes and cassava.

To achieve the national target of per capita staple food consumption in Kisumu district by self-sufficiency, it is estimated that 185,000 ton of food crops would be necessary for 1,045 thousand of the population in the district. In consideration of increase of production of cereals and pulse, the project would supply maize, sorghum and pulses to the population of the project and its surrounding area.

(2) Processing and marketing of sugarcane and cotton

Three large scale sugar mills are under operation in and around the project area at present. The annual milling capacity of these mills is 2,000,000 ton in total. In addition to the present capacity, these mills have a plan to expand the milling capacity upto 2,500,000 ton/year. Present production of sugarcane in Kisumu district is estimated at 1,950,000 ton in comformity with the present milling capacity. Approximately 500,000 ton of sugarcane are allowed to be harvested by the project accordingly.

Present production of cotton around the project area is estimated at about 1,750 ton per year on an average. Market channel of seed cotton has been recently shifted from Cotton

Board of Kenya to private dealers to bring outside the project area. The cotton of 2,000 ton to 3,000 ton is therefore allowed to be harvested in the project area.

(3) Vegetables

Vegetables introduced in the project area are tomato, onion, kale, cabbages and capsicum (sweet pepper), which are suitable in view of climate and soils in the project area. These vegetables are cropped twice in a year and are harvested throughout the year.

On the assumption that per capita production is almost nearly equal to per capita consumption, the per capita consumption of vegetable in 2005 and in 2010 is estimated at 31 kg/year and 36 kg/year respectively by regression analysis of per capita production during 1985 thru 1990.

Population of Nyanza Province in 2005 and in 2010 is estimated at 4.66 million and 4.99 million for Nyanza Province, and 940,000 and 1,045,000 for Kisumu district respectively based on the Population Census 1979 and the provisional result of Population Census 1989. On the basis of the above projections, the future demand of vegetables in 2005 and in 2010 is estimated as follows:

	Year	Population (persons)	per capita consumption (per year)	Demand (ton)
Kisumu District	2005	940,000	31 kg	29,000
	2010	1,045,000	36 kg	38,000
Nyanza Province	2005	4,660,000	31 kg	144,000
	2010	4,991,000	36 kg	180,000

Future production of vegetable is estimated on the basis of production trend during 1985 thru 1990 using regression analysis. Future balance of demand and supply is summarised as follows:

(unit:ton)

Region	Year	Demand	Production	Deficit
Kisumu District	2005	29,000	6,000	22,000
	2010	38,000	8,000	30,000
Nyanza Province	2005	144,000	91,000	53,000*
	2010	180,000	104,000	76,000*

Note;*: This amount includes deficit of Kisumu District.

In order to supplement the above-mentioned deficit amount of 76,000 ton for Nyanza Province in 2010, the Project would supply 63,000 ton of vegetables from 1,570 ha of the project area.

(4) Fruit tree

Fresh fruit market is not so large in and around the project area at present, and estimate of future market is rather hard because of no data available for the demand. Meanwhile,LBDA has been promoting small scale processing plants for such tropical fruit as passion fruit, citrus, banana, and pineapple. Such being the situation,fruit tree represented by passionfruit would be introduced in this project at small scale for the time being.

(5) Dairy

Population projection in 2005 and 2010 is estimated to be about 82,000 and 93,000 respectively in the project area. Target of per capita consumption of fresh milk is 91 lit.per annum according to the Sixth Five Year Development Plan. To achieve this level ,demand of milk in the project area is estimated at 7.46 million lit.in 2005 and 8.46 million lit.in 2010. To produce this amount, 1,650 cow units in 2005 and 1,870 cow units in 2010 would be required respectively. To maintain these cow units, following managed forage and annual supply of grade cattle would be necessary:

Year	Cow units	Managed forage	Annual supply of grade cattle
2005	1,650	680 ha	260 heads/year
2010	1,870	770 ha	300 heads/year

6.4.3 Net production value per hectare

Financial and economic prices at farm gate are shown in Table 6.4. Economic prices of paddy, maize, cotton and sugarcane are estimated on the basis of projected international market prices. Other commodities in the table are estimated on the basis of the financial prices and the standard conversion factor of 0.82.

On the basis of yield, farming practice,and economic prices mentioned above, unit net production value for crops under the present condition is calculated as shown in ANNEX-VI, and summarized as follows:

Net Production Value in the Present Condition

Crop	Yield per ha	Gross Production Value	Production Cost	Net Production Value
	(ton/ha)	(Ks./ha)	(Ks./ha)	(Ks./ha)
Maize	1.9	8,850	3,570	5,280
Sorghum	1.1	4,770	2,510	2,260
Paddy	3.3	20,390	4,110	16,280
Beans	0.7	7,120	2,570	4,550
Cotton	0.3	5,190	3,100	1,870
Sugar cane	40.0	20,040	1,400	18,640
Sweet Potato/Cassava	6.1	5,190	3,390	1,800
Pasture, upland and paddy field for grazing				2,240

Net Production Value in the Future Condition under the Project

Crop	Yield per ha	Gross Production Value	Production Cost	Net Production Value
	(ton/ha)	(Ks./ha)	(Ks./ha)	(Ks./ha)
Maize	5.0	23,300	6,040	17,260
Paddy*	6.0	37,080	6,100	31,650
Sorghum	3.5	17,600	5,090	6,670
Greengrams/cowpeas	1.5	17,270	5,250	12,020
Groundnuts	1.5	17,600	8,550	9,050
Cotton	2.2	37,200	7,820	29,380
Vegetable	20.0	55,800	15,350	40,450
Sugarcane**	100.0	50,920	3,910	47,010
Managed fodder for dairy	400.0	34,100	7,290	26,810
Pasture for working cattle	400.0	32,480	7,290	25,190
Fruit tree (Passion fruit)	10.0	41,000	15,700	25,300
Robusta coffee	4.0	18,040	13,040	4,240

*: Net production value of paddy and sugarcane include Ks.670 of value of straw to feed cattle and Ks.820 of value of cane top to feed cattle.

As far as net production value is concerned, sorghum and coffee are rather low. These crops would be,therefore, excluded out of the project. Therefore, per-hectare net production value of each cropping pattern is estimated as follows:

Pattern		Unit net production value		
Long rainy season	Short rainy season	Long rainy season	Short rainy season	Total
		(Ks/ha)	(Ks/ha)	(Ks/ha)
Paddy	Beans/Greengrams	31,650	12,020	43,670
Maize	Paddy	17,260	31,650	48,910
Maize	Cotton/Beans	17,260	20,700	37,960
Vegetable	Vegetable	40,450	40,450	80,900
Sugar cane		-	-	47,010
Managed fodder for dairy	-	-	26,810	
Pasture for working cattle		-	-	25,190
Fruit tree		-	-	25,300

6.5 Irrigation and Drainage Development

6.5.1 Delineation of irrigation area under the project

As mentioned in the previous chapter, the optimization study is made in order to clarify the optimum project scale from viewpoints of land suitability, available water resources, economic viability and environmental conservation. On the basis of the conclusion of the study, about 15,000 ha are selected as the optimum scale for the Kano Irrigation Project.

Following the optimum scale,irrigation area is finally delineated on a topo-map of 1/5,000. The irrigation area extends southeast of Kisumu municipality and is approximately bounded by Nyabondo escarpment in the south, contour line of 1,200 m above MSL in the east, left bank of the Nyando river in the north and the Nyakach swamp in the west.

The delineated area of 14,930 ha is physiographyically divided into six (6) sub areas by four (4) major rivers such as the Sondu, Asawo, Awach-Kano and Nyaidho rivers and location of the Sondu-Miriu Hydropower Station, as given below:

Sub-Area	Hectareage	Boundary
I	600 ha	Kendu Bay to left bank of Sondu river.
II - 1	650 ha	Right bank of Sondu river to Sondu-Miriu P/S
II - 2	3,230 ha	Sondu-Miriu P/S to left bank of Asawo river
III	2,780 ha	right bank of Asawo river to left bank of Awach-Kano river
IV	4,170 ha	right bank of Awach Kano river to left bank of Nyaidho river
V	3,500 ha	right bank of Nyaidho river to left bank of Nyando river
Total	14,930 ha	Kendu Bay to left bank of Nyando river

6.5.2 Irrigation water requirement

Irrigation requirement by growing stage of each crop and cropping pattern on half monthly basis is estimated based on i) consumptive use, ii) effective rainfall, iii) other water requirements and iv) irrigation efficiency.

ANNEX-VII gives detailed calculation sheets of the seasonal irrigation requirement by crops and by cropping patterns respectively. The following is the summary of the max.unit

diversion requirement averaged for 19 years and unit diversion requirement in early March,1966 in which the max. diversion requirement of 18.5 m^3/sec with 5-years probability has occurred.

(lit/sec/ha)

Long Rainy Season	Short Rainy Season	Averaged Max.Unit Requirement	Unit Requirement in March 1991
Paddy	Beans	2.04	2.34
Maize	Paddy	1.92	1.04
Maize	Groundnuts	1.05	1.07
Maize	Cotton/Beans	1.11	0.79
Vegetable	Vegetable	1.30	0.99
Sugarcane	Sugarcane	1.00	1.07
Fruit tree	Fruit tree	0.69	0.75
Pasture	Pasture	1.00	1.07

As mentioned above, the maximum peak unit diversion requirement of 2.04 lit/sec/ha occurs on the cropping pattern of paddy-beans in early March; the minimum peak unit diversion requirement of 0.69 lit/sec/ha, on the cropping pattern of fruit tree-fruit tree in late February.

Based on the unit diversion requirement by croppin pattern in early March,1966 as shown in the above table.and hectareage of each cropping pattern allocated in each sub-area (ANNEX-VII,Table.VII-18),diversion requirement in sub-area is computed as given in ANNEX-VII. The following is the summary of the max. diversion requirement by sub-area .

The detail is given in Table.VII-19 of ANNEX-VII.

Sub-Area	Command Area (ha)	Max. D. Req. (m^3/sec)
I	600	0.9
II-1	650	0.5
II-2	3,230	3.0
III	2,780	4.2
IV	4,170	5.6
V	3,500	4.3
Total	14,930	18.5

6.5.3 Water balance study

Water balance study is made between available water from the Sondu-Miriu Hydropower Station and the diversion water requirement estimated above on the basis of the data for the past 19 years from 1960 to 1978 on half monthly basis.

Water resources for irrigation would be released through the Sondu-Miriu Hydropower Station after regulated by the Magwagwa dam which has been feasibility-studied by JICA. After deducting volume for water supply and mandatory releases to downstream, the available water is estimated on the basis of five (5) years return period or 20 % of recurrence.

As shown in Fig.6.3, the water balance study clarifies that irrigation water supply for the delineated area of 14,930 ha would be stablely made depending on the available water resources released through the Sondu-Miriu Hydropower Station which would be further increased by the exploitation of water resources in the Magwagwa dam in the future.