REPUBLIC OF KENYA

LAKE BASIN DEVELOPMENT AUTHORITY

[illegible] RIVER MULTIPURPOSE

[illegible] PROJECT

VOLUME [illegible]

EXECUTIVE SUMMARY REPORT

[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

NAIROBI OFFICE
P.O. BOX [illegible]
NAIROBI KENYA

TOKYO HEAD OFFICE
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TOKYO, JAPAN

REPUBLIC OF KENYA

LAKE BASIN DEVELOPMENT AUTHORITY

SONDU RIVER MULTIPURPOSE

DEVELOPMENT PROJECT

VOLUME - I

EXECUTIVE SUMMARY REPORT

DECEMBER, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

It is with great pleasure that I present to the Government of the Republic of Kenya this report on the SONDU RIVER MULTIPURPOSE DEVELOPMENT PROJECT.

A survey team, headed by Mr. Kumeo Nakamura, was dispatched to Kenya by the Japan International Cooperation Agency following the request of the Government of Republic of Kenya to the Government of Japan. The team carried out a wide-ranging field survey in the Lake Victoria basin area from January to November 1984.

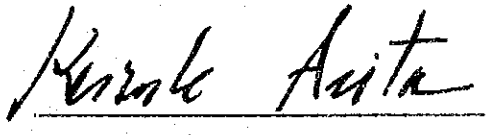
After the team returned to Japan, further studies were made based on the collected data and the results of field survey, and the present report has been prepared.

In the course of the survey, steering committee meeting was held three times and the team exchanged views on the project with the officials concerned of the Government of Kenya.

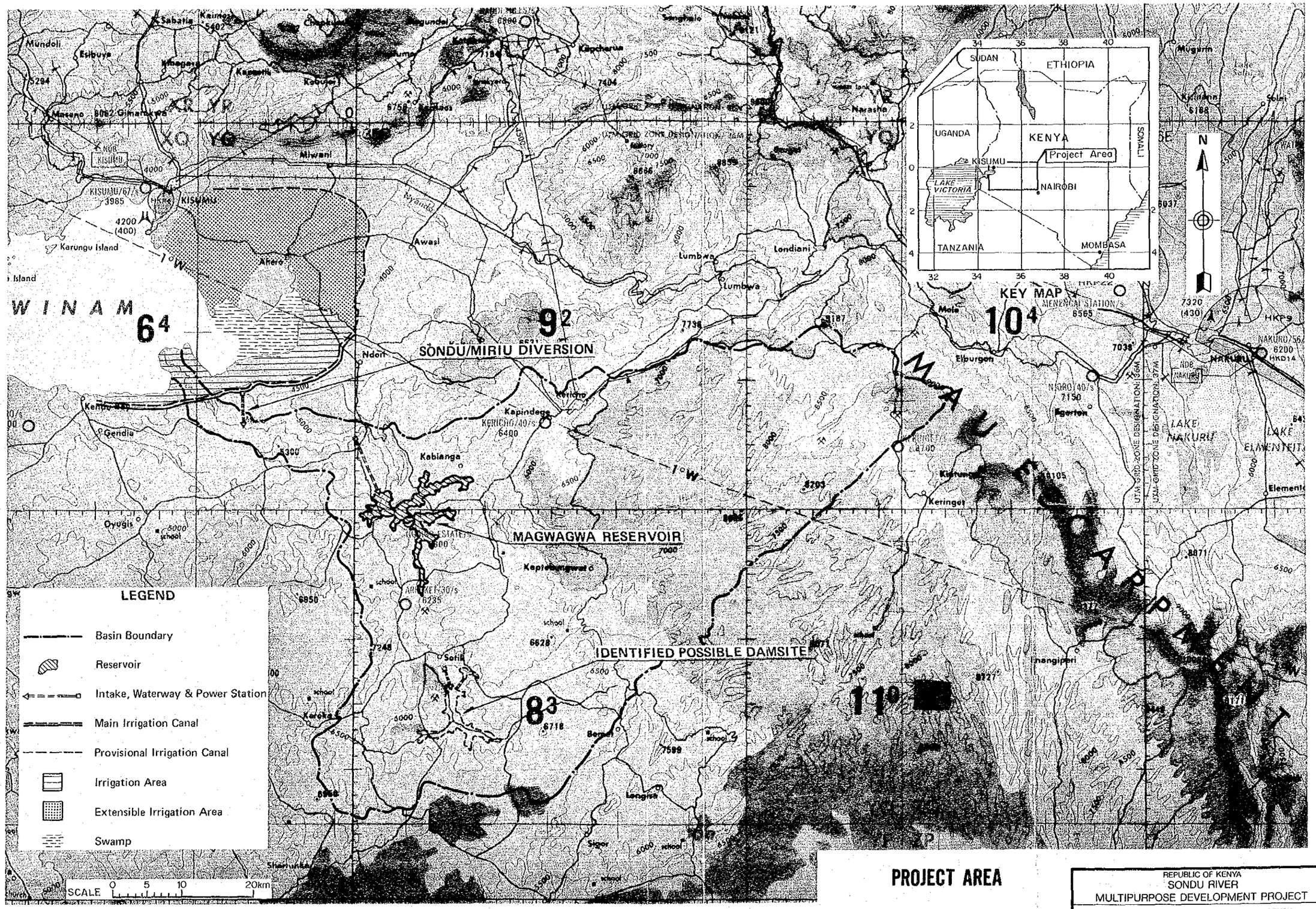
I hope that this report will be useful for the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Kenya, particularly Lake Basin Development Authority for their close cooperation extended to the team.

December 1985



Keisuke ARITA
President
Japan International Cooperation Agency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3/ International Development Centre of Japan (IDCJ) and Nippon Koei (NK), Sondu River Multipurpose Development Project in Lake Victoria Basin, Reconnaissance Report,1981

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimetre
cm = centimetre
m = metre
km = kilometre

Area

cm^2 = square centimetre
m^2 = square metre
km^2 = square kilometre
ha = hectare

Volume

cm^3 = cubic centimetre
l = lit = litre
m^3 = cubic metre

Weight

kg = kilogram
ton = metric ton

Time

sec = second
min = minute
h = hour
yr = year

Electrical Measures

kW = kilowatt
MW = Megawatt
GW = Gigawatt
KV = Kilovolt

Other Measures

% = percent
o = degree
' = minute
^oC = degree in Celsius
10^3 = thousand
10^6 = million

Derived Measures

m^3/sec = cubic meter per second
KWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
KVA = kilovolt ampere
cct = circuit

Money

KShs = Kenya Shilling
K£ = 20 Kenya Shillings
US$ = US dollar
US¢ = US cent
¥ = Japanese Yen

NOTATIONS

(1) Organization/Plan

EAP&L	:	East African Power and Lighting Co. Ltd.
GRDP	:	Gross Regional Domestic Product
IBRD	:	The International Bank for Reconstruction and Development
IMF	:	International Monetary Fund
JICA	:	Japan International Cooperation Agency
KPC	:	Kenya Power Co. Ltd.
KP&L	:	Kenya Power and Lighting Co. Ltd.
LBDA	:	Lake Basin Development Authority
LDC	:	Load Dispatching Centre
MERD	:	Ministry of Energy and Regional Development
MOWD	:	Ministry of Water Development
NPGS	:	National Power Grid System
PLC	:	Power Line Carrier
S/W	:	Scope of Works
TARDA	:	Tana and Athi Rivers Development Authority
TRDC	:	Tana River Development Co. Ltd.
UEB	:	Uganda Electricity Board
UNDP	:	United Nations Development Programme
WHO	:	World Health Organization

(2) Others

Alt.	: Altitude above Mean Sea Level	FRR	: Financial Internal Rate of Return
C.I.F.	: Cost, Insurance & Freight	FSL	: Full Supply Level
D/D	: Detailed Design	GDP	: Gross Domestic Product
dia.	: Diametre	GNP	: Gross National Product
El.	: Elevation above Mean Sea Level	LRMC	: Long-run Marginal Cost
ERR	: Economic Internal Rate of Return	MOL	: Minimum Operation Level
F.O.B.	: Free on Board	O&M	: Operation and Maintenance

I. FEASIBILITY STUDY ON THE SONDU HYDROPOWER DEVELOPMENT PROJECT

I.1 Introduction

In response to the request of the Government of Republic of Kenya, the Government of Japan decided to extend technical cooperation in carrying out a feasibility study for the Sondu River Multipurpose Development Project, one of the most promising projects in the Western Kenya. The feasibility study on this multiple objective project was conducted in accordance with the scope of work (S/W) concluded between the Lake Basin Development Authority (LBDA), representative of the Kenyan Government, and the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programmes of the Japanese Government.

The objectives of this study stipulated in the S/W consist of the following;

(1) to undertake a feasibility study of the Sondu River hydroelectric power development, and

(2) to undertake a pre-feasibility study of the irrigation development in the area delineated by S/W, by making use of the Sondu River flow.

The feasibility study of the Sondu River Multipurpose Development Project was initiated with a dispatch to Kenya of an inception work team in January 1984, and has been completed with the submission of this Final Report in December, 1985 under cooperative work of the Kenyan counterpart team who devoted to data collection and field work with JICA study team.

The past studies envisage a few plans for multipurpose development of the Sondu River and Kano Plain. Those plans were, therefore, reviewed and are referred to this study.

I.2 Background

Project History

For decades, the Sondu River has been noted for its potentials on hydropower development and also as water sources for irrigated agriculture in its own and neighbouring basins. A study[1/] during 1954 through 56 was conceived to be incipient for the development of hydropower and the Kano Plain irrigation by the inter-basin transfer of the Sondu River.

The second[2/] study identified two hydropower development schemes in the Sondu River; the Magwagwa and Sondu/Miriu reservoir plans in the middle and the downstream reaches respectively.

After the establishment of LBDA in 1979, the third study[3/] reconnoitered the Sondu River basin and its surroundings in December 1980 to identify various aspects. The study report submitted to LBDA in February 1981 identified the Sondu River development as the top priority project in the region.

An official request of technical assistance for the feasibility study of the Sondu hydropower development project was submitted by the Kenyan Government to the Japanese Government following to the results of the latest study. The S/W for the study to be undertaken was subsequently concluded in October 1983 between LBDA and JICA.

National Economy

Kenya's economy made a steady growth with the annual growth rate averaged 5.8 percent in the first five years since its independence in 1963. The economic growth accelerated in the early 1970's, but thereafter it slowed down significantly except the period of coffee boom (1977 to 1978) primarily affected by a series of sharp increases in prices of crude oil.

The economy has been generally slow-moving in the early 1980's, reflecting international recession. In 1982, the growth rate of GDP fell

below the population growth, resulting in a decrease in the per capita GDP. The outlook for the coming years is generally better than the performance in the past few years, and the growth target of 4 percent per annum may be attained in 1985.

As in most other developing countries, agriculture is by far the most important sector of Kenya's economy, accounting for about one-third of the GDP (Table 1). Dependence on this sector is in fact much heavier than appears from its share in the GDP, since over 80 percent of the country's population lives in rural areas, deriving their income primarily from agricultural activities.

I.3 Lake Basin Area

The Lake Victoria Basin occupies some 47,709 km^2 in the western part of Kenya and about 8.4 percent of total land area of Kenya of 569,137 km^2. The area under the jurisdiction of LBDA is the entire Lake Victoria catchment area which consists of the whole of Nyanza and Western Provinces and some parts of Rift Valley Province (Figure 1). Six major rivers traverse the catchment area.

LBDA area has a population of some 7 million, which accounts for over 40 percent of Kenya's total, and is characterized as the one of area with high population density. In fact, Kisii district of Nyanza Province has a density of 395 per km^2 in 1979.

There exist little reliable data on the gross regional domestic product (GRDP), but the recent official report for Nyanza and Western Provinces estimated that average per capita income in the area ranges in 1,200 to 1,500 Kenyan Shillings per annum in 1983 compared to about 3,500 Kenyan Shillings in the whole Kenya.

I.4 Project Site Conditions

Topography

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, respectively. Both rivers originate from Mau Forest on the western slope of Mau Escarpment (altitude 2,500 to 2,800 m).

After the Yurith and the Kipsonoi rivers merge, the Sondu River comes into the narrow gorge penetrating Nyakach Escarpment and falls in cascade with scenery waterfalls called Odino falls to the flood plains at Nyakwere. Elevation falls of some 300 m exist for river channel distance of some 25 km between Sondu village (alt. 1,500 m) located 12 km downstream from the confluence of both rivers and the foot of the escarpment (alt. 1,200 m), Nyakwere. The Sondu River finally drains into Winam Gulf of Lake Victoria.

The proposed site of the Sondu/Miriu hydropower plan is located about 18 km downstream from Sondu village. Topography at this site favours trans-basin transfer of the water of the Sondu River flow to the Nyakach Plain which can be made with a 4 km long waterway heading Thurdibuoro village from the site.

This trans-basin plan not only creates high head difference of 145 m (river bed elevation at the damsite, 1,350 m, minus tailwater level, 1,205 m), but also makes it possible to utilize water released from the tailrace of power plant for irrigation in the Nyakach and Kano plains.

Geology

Basement rock of the project area consists mainly of granodiorite, which is intrusive rock of post-Cambrian period, with minor occurrence of diorite, hornblende, gneiss and dolerite. The area is divided by a prominent escarpment, Kendu fault, running in almost east-west direction.

Geological investigation made for the potential project sites along the lower reaches of the Sondu River indicates that local geology of the potential project sites is suitable for constructing major structures of the Sondu/Miriu project such as a dam, waterway, power station and so on.

Hydro-meteorology

The climate of the Sondu River basin located at high lands of altitude 1,300 m to 2,800 m is, in general, gentle with small variation of air temperature of 19°C to 25°C throughout a year, whilst daily temperature varies much larger, ranging from 15°C to 30°C.

Rainfall in the Sondu River basin is in abundance with annual rainfall of 1,500 mm to 1,600 mm, varying 2,000 mm in high lands to 1,200 mm in low lands. Rainfall is abundant in the period of March to May with a peak of more than 200 mm/month, but there is no remarkable dry month. It is however pointed out that over-year variation of annual rainfall is considerably large.

The Sondu River is characterized as the river with ample flow replenished by abundant rainfall of the basin, as monthly mean discharge was obtained to be 41.6 m^3/sec at the stream gauge called 1JG1 located near Sondu village.

I.5 Power Supply and Demand

Existing Power Plant and Power Supply Expansion Plan

The total installed capacity of all the power plants in Kenya is 526.7 MW (Table 2) excluding import of hydropower from Uganda. The composition is 66.2 percent of hydro plants, 28.1 percent of fossil fuel fired plants and 5.7 percent of geothermal plants.

The electricity supply (30 MW) from Uganda started in 1955 is expected to continue at least up to the year 2005. KP&L, however, does not consider it to be firm power from 1988 onward in its supply expansion programme.

The third unit of geothermal plant at Olkaria was commissioned in 1985. Furthermore, the Kiambere hydroelectric plant under construction will come in the system in 1988. The Turkwell hydroelectric project is planned to be installed at the beginning of the year 1993. Whilst, a diesel (20 MW) and two oil-fired plants (2 x 5 MW) are planned to be retired in 1988.

Power Consumption

The availability of electricity in Kenya is generally limited to the densely populated narrow strip running across the southern part of the country from Mombasa through Nairobi to Kisumu in parallel with the major highways. Other areas have little access to electricity. Only about 6 percent of the total population has access to electricity, and the average per capita consumption of electricity was estimated to be about 134 KWh in 1981, even if the electric energy consumed by private industries was included.

The average load growth in Kenya during 1970's was about 8 percent per annum, but thereafter it has slowed down considerably, reflecting generally slow-moving economic activities. The average load growth in the first three years of 1980's was just 5 percent per annum, and the growth in the following years was even slower.

According to current five-year development plan, electricity consumption was expected to grow at the annual rate of about 6 percent during 1984 - 88. Kenya's economy itself was projected to expand by an average annual rate of 4.9 percent in the same period, starting from 3.9 percent in 1984 to 5.6 percent in 1988. It is expected that the annual growth of 6 percent may be attained by the end of the decade as the official development programme is aiming.

Power Demand

A recent study on the Turkwell hydro-electric power development project by Preece, Cardew and Rider Ltd. (PCR) made a most comprehensive review of recent power demand forecasts, and KP&L basically accepted the Turkwell's forecast.

In the study of this Sondu project, was to make sure the reasonableness of the Turkwell forecast. It was judged a couple of tests on the Turkwell forecast proved it to be quite reasonably established and consequently it is used in this study as a guide to future national power demand (Table 3).

The electric power demand in the western Kenya region was projected to the year 2000 in this study (Table 4). The total power demand will be 479 GWh in 1993 and 790 GWh in 2000 in annual energy. By applying the load factor of 70 percent, the peak load was calculated to be about 78 MW in 1993 and 129 MW in 2000.

Power and energy balances of the projected demand and supply capacity were examined in the KP&L system. Even if Kiambere and Turkwell hydropower plants join the system as schedule in 1988 and 1993 respectively, a next project should come into the system by the end of 1993. Potential projects after the Turkwell will be the Sondu/Miriu hydropower plant and the Olkaria IV, Eburru and Lake Bogoria geothermal plants.

I.6 Plan Formulation

Development Plan of the Sondu

The primary objective in this study was placed on searching the efficient use of diverted water of the Sondu for hydropower generation and irrigated agriculture development in the Kano Plain in combination with the Nyando River water. In line with the study objective, six development schemes were identified in the Sondu River basin (Figure 2);

(i) Scheme D-1: Sondu/Miriu diversion scheme

This diversion not only creates some 150 m head, but also makes possible the irrigation development for the left bank areas of the Nyando River in the Kano Plain (15,610 ha).

(ii) Scheme D-2: Nyamarimba diversion scheme

The alternative for D-1 is to create head of some 230 m.

(iii) Scheme D-3: Sondu-Maraboi diversion

The alternative for D-1 is to create head of some 240 m.

(iv) Scheme S-1: Magwagwa reservoir

This is a plan to make possible the power generation and irrigation development for the whole area of the Kano Plain (25,610 ha) by regulating the Sondu River flow with this reservoir.

(v) Scheme S-2: Magwagwa reservoir plus waterway

An 8 km long waterway from the Magwagwa reservoir makes available elevation falls of some 100 m for power generation in addition to the head created by the dam.

(vi) Scheme S-3: Sondu/Miriu reservoir with the diversion scheme

This is a plan to build a reservoir at the Sondu/Miriu diversion site, and the construction of dam makes possible the creation of additional head of nearly 80 m besides the elevation falls by trans-basin (D-1).

Five combination plans were contemplated by combining the diversion, storage and irrigation schemes for searching the optimal development of the Sondu. Those are:

(i) Combination-A: The best run-of-river hydropower scheme out of D-1 (Sondu/Miriu diversion) to D-3 (Sondu-Maraboi diversion) with the irrigation development of 15,610 ha

(ii) Combination-B: Sondu/Miriu reservoir (Scheme S-3) with the hydropower and irrigation development of 25,610 ha in the whole Kano Plain

(iii) Combination-C: Magwagwa reservoir and hydropower (Scheme S-2) plus either of Sondu/Miriu (Scheme D-1) and Nyamarimba (Scheme D-2) with the irrigation development of 25,610 ha

(iv) Combination-D: Magwagwa (Scheme S-2) and Sondu/Miriu (Scheme S-3) reservoirs in a series with the irrigation development of 25,610 ha

(v) Combination-E: Magwagwa reservoir (Scheme S-1) plus Sondu-Maraboi diversion (Scheme D-3) with the irrigation development of 25,610 ha.

Among the above five combinations, Combination-C, the Magwagwa reservoir with a waterway plus the Sondu/Miriu run-of-river, was proposed as an optimum because of highest net benefit (Table 5). The development features of it are:

Magwagwa reservoir plus waterway plan

Firm discharge	:	24.1 m^3/sec
Plant discharge (8-hour peak operation)	:	72.3 m^3/sec
Full supply level	:	EL. 1,662.9 m
Minimum operating level	:	EL. 1,606.3 m
Dam crest elevation	:	El. 1,667.9 m
Dam height	:	100.9 m
Active storage	:	590.7 million m^3
Installed capacity	:	94.6 MW
Firm energy	:	276.2 GWh/yr
Secondary energy	:	57.9 GWh/yr

Sondu/Miriu run-of-river plan

Firm discharge	: 24.1m^3/sec	(3.3 m^3/sec)
Plant discharge	: 39.9 m^3/sec	(29.6 m^3/sec)
Installed capacity	: 48.6 MW	(32.8 MW)
Firm energy	: 237.5 GWh/yr	(32.0 GWh/yr)
Secondary energy	: 14.9 GWh/yr	(155.6 GWh/yr)

Note: Figures in parentheses are the scale of the Sondu/Miriu diversion scheme only (Scheme D-1). The preliminary design of the Sondu/Miriu run-of-river plan in this feasibility study will be done with the premise that the Magwagwa reservoir is constructed.

Outputs from both plans

Installed capacity	: 143.2 MW
Firm energy	: 513.7 GWh/yr
Secondary energy	: 72.8 GWh/yr

Irrigation area

In the left bank of the Nyando	: 15,610 ha
In the right bank of the Nyando	: 10,000 ha

Installation Timing of the Sondu Project

The optimum installation timing of the Sondu hydropower project was determined by examining the time when the Sondu hydropower project is emerged in the least cost sequence of the long-term power plant development. The search for the possibility of stage development in the Sondu hydropower project was worked out with a view to reducing financial burden; first stage (Sondu/Miriu run-of-river plan) and second stage (Magwagwa reservoir plus waterway plan). Besides the Sondu hydropower project, several types of plant were considered as the alternative energy sources which could be coal-fired, oil-fired, diesel, gas turbine, geothermal and hydro plants. Secondary energy generated from hydropower plants are also taken into account as available energy sources from the viewpoint of fuel saving of thermal plants.

The optimum installation timing of the Sondu hydropower project searched by the least cost sequence simulation was reckoned to be 1992 (commissioning at the beginning of 1993) for the first stage (48.6 MW) and 1996 for the second stage (94.6 MW) (Table 6 and Figure 3). The fact that the first stage was emerged three years earlier than the second stage is due to fuel saving effects of secondary energy generated from the Sondu/Miriu run-of-river plant as the first stage.

An implementation time schedule was prepared for both the first and second stages of the Sondu hydropower project according to the lead time necessary for finance and detailed design and construction period assumed in the study to search the least cost sequence (Figure 4). According to it, the financial arrangement especially to the first stage should be taken immediately after this feasibility study.

I.7 Project Design

The preliminary design of major structures on the Sondu/Miriu run-of-river hydropower project selected as the first stage of the Sondu River development was made at a feasibility study level and with the premise that the Magwagwa power plant will come in service as the second stage of the Sondu River development.

The following basic dimensions have been worked out for the project:

. Full supply level of intake pond	:	EL.1368.0 m
. Minimum operation level of intake pond	:	EL.1355.5 m
. Effective regulating storage capacity	:	1.1 million m^3
. Tailwater level at plant peak discharge	:	EL.1205.4 m
. Plant peak discharge	:	39.9 m^3/sec
. Gross head	:	162.6 m
. Installed power capacity	:	48.6 MW (2 x 24.3 MW)
. Annual generating energy	:	32 GWh for primary and 155.6 GWh for secondary

The project involves the construction of a 20 m high gated intake weir on the Sondu River, an intake structure with sand desilting basin feeding 39.9 m^3/sec into the waterway, a 4,314 m long headrace tunnel, an orifice type surge tank, a 1,092 m long penstock line, and a power plant with 48.6 MW installed capacity (24.3 MW x 2 units). The project also includes the construction of a 40 km long 132 kV single circuit transmission line to deliver the generated power to the Muhoroni substation (Figure 5 to 10).

I.8 Construction Plan and Cost Estimate

The construction plan and cost estimate of the Sondu/Miriu run-of-river hydropower project were prepared based on the preliminary design of the major structures on it. The construction period of the project is scheduled to extend over 7 years from the beginning of 1986 (Figure 11). First 3 years are allocated for the arrangement of construction finance, the selection of engineering consultant, the detailed engineering services and the tendering time, and latter 4 years from 1989 are required for the construction work of the project, as detailed below:

a)	Financial arrangement	:	For 9 months from January 1986 to September 1986
b)	Contracting for engineering services	:	For 3 months from October 1986 to December 1986
c)	Engineering services for detailed design	:	For 14 months from January 1987 to February 1988
d)	Tender and contract	:	Completion in December 1988
e)	Main construction works	:	Commencement in January 1989 to Completion in December 1992, Within 48 months
f)	Commissioning of commercial operation of power station	:	Beginning of January 1993.

Construction cost for the implementation of the project was estimated on the basis of the preliminary design and the proposed

construction plan and schedule. The total construction cost (financial cost) required for the project is the equivalent of KShs. 1,320.9 million in total, consisting of the equivalent of KShs. 1,004.0 million in foreign currency portion (US$ 66.9 million, 76 percent) and KShs. 316.9 million in local currency portion (24 percent) (Table 7).

The annual disbursement of construction cost for foreign and local currency portions was estimated as follows, on the basis of the construction schedule (Table 8):

	Foreign currency		Local Currency	Total
Year	Mill. US$	Mill. KShs.	Mill KShs.	Mill. KShs.
1987	(3.00)	45.00	-	45.00
1989	(16.66)	249.94	82.04	331.98
1990	(15.93)	238.98	110.98	349.96
1991	(23.30)	349.54	82.58	432.12
1992	(8.04)	120.58	41.27	161.85
Total	(66.93)	1,004.04	316.87	1,320.91

I.9 Project Evaluation

Economic Evaluation

The economic viability of the Sondu multipurpose project (Sondu/Miriu run-of-river hydropower project plus 15,610 ha irrigation project in the Nyakach Plain) was first evaluated here, based on all the costs of and benefits from the implementation of the project, combining both the hydropower and irrigation components. Secondly, the economic viability of the hydropower component was evaluated, based on power benefits alone and excluding from the total project costs those costs (called specific or direct costs) of the irrigation component.

Following conditions were applied for the calculation of economic costs and benefits:

(i) All equipment and materials to be newly imported for the project were costed at their C.I.F. prices.

(ii) Competitive rates applicable to services provided by the expatriate were used as economic costs of foreign labour.

(iii) Shadow pricing was applied to common labour and goods to be procured in local markets. The F.O.B. prices for exportable goods represent the shadow prices to be used in economic analysis.

(iv) Internal transfer portions were excluded from local currency costs, but indirect taxes on commodities in a competitive market were not excluded, since consumers express their willingness-to-pay by market prices including taxes.

(v) US dollars were converted to Kenya shillings at the rate of US$1.00 = KShs15.00 (as of November 1984), since a prevailing exchange in Kenya is regarded as a fair reflection of the real value of foreign exchange for nation's economy.

(vi) The long-run marginal cost (LRMC) of power supply calculated to be 0.86 Kenya shillings per KWh was used to estimate economic benefits.

The internal economic rate of return (ERR) for the Sondu River multipurpose development project was calculated to be 13.6 percent. In view of the opportunity cost of capital in Kenya, i.e. 10 percent return on capital, this multipurpose development is assessed to be sufficiently viable. Meanwhile, if the irrigation area is limited to 8,540 ha delineated in the S/W instead of the 15,610 ha irrigable with diverted water from the Sondu River, the ERR became 12.2 percent.

The economic viability of the Sondu multipurpose project (irrigation area: 15,610 ha) was tested against major factors where uncertainties are involved in power and/or irrigation benefits and in investment costs. The results of this sensitivity analysis are summarized as follows:

Case 1	Standard	13.6%
Case 2	Power benefit decrease by 10%	13.2%
Case 3	Irrigation benefits decrease by 10%	13.0%
Case 4	Investment costs increase by 10%	12.7%
Case 5	Combination of Cases 2, 3, and 4	11.8%.

The hydropower and irrigation components can not be really separated in evaluating the Sondu project, as it is a multipurpose project. It would still be helpful in obtaining further insights to calculate the ERR for hydropower component alone. The ERR was calculated to be 10.4 percent, higher than the rate corresponding to the opportunity costs of capital.

In Kenya, it has not become a standard practice to the LRMC and to use it for evaluating power projects. Instead, power benefit is estimated multiplying the average electricity tariff by the energy available at sales ends. The ERR in the Kenyan method was calculated to be 8.6 % by applying the average electricity tariff (1985) of 0.78 Kenya shilling per KWh and by assuming that the value of secondary energy is as same as that of primary energy. It has been informed by KP&L that the ERR calculated in the same way was 8 % for the Turkwell gorge hydropower project. The first stage development of the Sondu River hydropower project may be concluded to be economically viable, provided that there exist sufficient users for the secondary energy, i.e. pumped irrigation along the rain-shadow of Lake Victoria shores.

Financial Evaluation

Financial viability of the Sondu/Miriu run-of-river hydropower project was assessed by the internal financial rate of return (FRR) and the financial statement. Financial costs of the project were estimated at the price level of December, 1984. Price escalation was counted by applying annual inflation rates of 3 percent for foreign currency costs and 9 percent for local currency costs.

The financial cash flow for the Sondu/Miriu run-of-river project was prepared based on the investment costs, the O&M costs and revenue received from energy sales with the average tariff in 1985, 0.78 Kenya shillings per KWh. Based on it, the FRR was calculated to be 4.2 percent.

Revisions of the average tariff would certainly be introduced before the Sondu hydropower project is commissioned. The effects of raising the average tariff have been analyzed, and the following results were obtained.

Average electricity tariff	ERR	Average annual rate of tariff increase necessary
0.78 KShs/kWh	4.2 %	0 %
0.90	6.6	1.8
1.00	7.6	3.2
1.10	8.7	5.5
1.25	10.1	6.1

Naturally the intake weir and diversion work will serve not only the hydropower generation but also the irrigation in the Nyakach and Kano plains. A part of the costs for these works may be borne by the irrigation sector. The financial performance of the hydropower development was therefore assessed under the condition of cost allocation, and consequently the FRR will increase to 4.8, 5.1 and 5.4 percent respectively, as 20, 30 and 40 percent of the common costs are allocated to the irrigation sector.

Project Finance and Loan Repayability

The Sondu project is likely to be implemented by introducing external loans to cover some part of project costs. The repayability of loans was thus tested by assuming following conditions:

(i) All the foreign currency portion of the investment costs would be financed by a loan from an international financing agency.

(ii) The terms of this external loan are assumed as follows:

Interest rate : 4.0 percent per annum
Grace period : Construction period (4 years)
Repayment period: 30 years including the grace period.

(iii) All the repayments would be constant over the maturation period, corresponding to increasing principal repayment and decreasing interest payment.

(iv) All the local portions of investment costs and annual expenses would be provided by the Government contribution.

Gross revenue was calculated by assuming the average tariff of 1.25 Kenya shillings per KWh. This represents the 6 percent annual increase in the average electricity tariff.

Under these conditions assumed above, a simple financial statement was prepared (Table 9). It should be noted that this is the financial statement for the project, but not the one for KP&L as other associated costs (e.g. sub-transmission and distribution cost) are not included. It is observed from the table that the annual balance would turn positive as the project starts operation in 1993 and the accumulated surplus would become positive eight years thereafter. At the end of repayment period, the accumulated surplus would exceed one billion Kenya shillings, equivalent to about 80 percent of the initial investment costs.

The Sondu River multipurpose development project is really viable, as the ERR is 13.6 percent based only on the direct benefits of electricity and irrigated agriculture. The financial feasibility of the project of course is subject to future revisions of electricity tariff as well as terms of external loans to be introduced to implement the project.

II. PRE-FEASIBILITY STUDY ON KANO PLAIN IRRIGATION PROJECT

II.1 Background

The western Kenya region has been relatively less developed notwithstanding favourable endowment of natural resources. LBDA was established in 1979 aiming at development of the region's potential to contribute the economic growth to the region in particular and to the nation in general. LBDA then prepared its Five-Year Development Plan in 1983 which laid emphasis on agricultural development to increase the per capita income in the region to the national average level and to raise the standard of living above the national average. In 1984, the government of Kenya has launched her Fifth Development Plan (1984 - 1988) having the theme of mobilization of domestic resources and equitable development. The development policy of LBDA has been endorsed by the nation's policy and the agricultural development, especially introducing the irrigated farming, is being placed at his priority undertaking as well as the Sondu hydropower development.

II.2 Project Area

The Project area is located in the central part of Nyanza Province in West Kenya. The area extends over Kendu division in South Nyanza district and Nyakach division in Kisumu district. The area lies on flat terrain bordered by the Lake Victoria to the north, Nyabondo Escarpment to the south, Kendu Bay village to the west and the Awach Kano River to the east. The Project area can be divided by the two major rivers into the following three sub-areas (Figure 12):

Sub-area	Location	Project Area (ha)
I	Kendu Bay - Sondu R.	1,790
II	Sondu R. - Asawo R.	7,190
III	Asawo R. - Awach Kano R.	5,000
	Total	13,980

Topographic conditions in the area sloping down toward Lake Victoria are hilly in the southern piedmont plain and flat in northeast lacustrine plain (Kano Plain).

Climate in the area is characterized by the bimodal rainy seasons. Annual average rainfall is 982 mm. Seasonal temperature change is not conspicuous throughout the year. Monthly mean temperature ranges from 29°C to 31°C.

The source of water for irrigation in the area is the tailrace water of hydropower station which will be diverted from the Sondu River with sufficient volume for irrigation.

The population and households of the Project area are estimated at 36,300 and 7,120, respectively. The average growth rate of population in the area is about 3.3% per annum. Most of the people in the area, are engaged in agriculture. They cultivate only about 1,400 ha out of Project Area of nearly 14,000 ha.

The average holding size of agricultural land is estimated at about 2 ha per household in the Project Area.

Main crops in the area are maize and sorghum followed by cotton and beans. Paddy is also planted in a part of low-lying land of the area. Average yields of these upland crops and paddy are in rather low level mainly due to the absence of adequate irrigation facilities, farming

technique and farm inputs. Present unit yield and crop production of the main crops are estimated as follows:

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

Livestock raising is not mainline of agricultural activities, although it is important for farm power and also for form of saving as a security against years of crop failure. The present number of livestock in the area is estimated as follows:

Livestock	Heads
Cattle	16,980
Goat	5,660
Sheep	11,320
Poultry	16,980

The agricultural produce in the country is dealt with mainly through the parastatal marketing bodies, such as National Cereals and Produce Board (NCPB), Grain Growers Cooperative Union (KGGCU), Cotton Lint and Seed Marketing Board (CLSMB) etc.

In 1972 the Government introduced price control system for important basic food and other items. This system fixes the purchasing prices of

major crops and foods like rice, maize etc. time to time.

Existing on-going irrigation projects in the Kano Plain are operated by the NIB or Ministry of Agriculture, covering about 2,700 ha of irrigated lands. Figure 13 shows the locations of present irrigation project in the Kano Plain.

II.3 Agricultural Development

The present irrigation development project aims at the increase in agricultural production and thereby improvement of the farmer's living standard in the area through implementation of irrigation facilities. Maximum effective use of water and land resources, and introduction of improved irrigation farming are the most important key factor for the development of the project area. With this in view, the major concept for agricultural development in the irrigation area would be set up as follows;

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

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

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

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

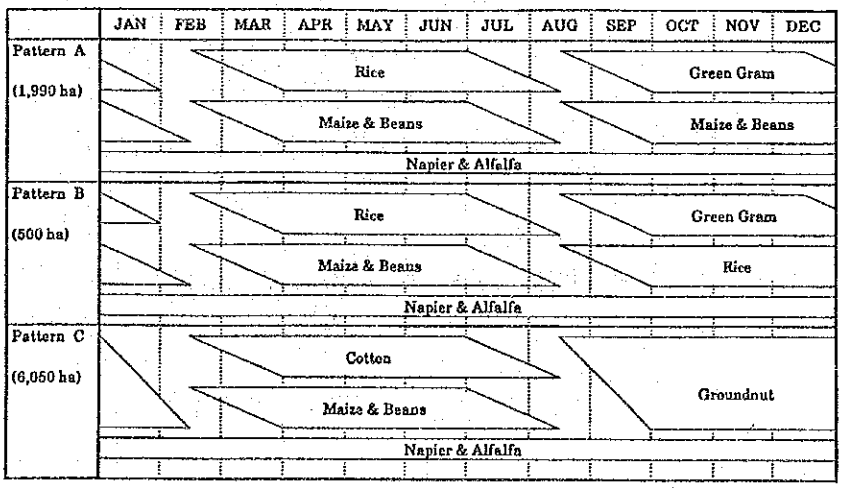
(5) Present farm road network should be improved, and

(6) The agricultural development should be strengthened, especially in the field of agricultural extension services and water management.

The irrigable areas in the Project area have been demarcated mainly from topographic, soil and drainage conditions studied. The project area has 8,540 ha of net irrigable area out of a total area of 13,980 ha as shown below.

Description	Sub-area (ha)			Total
	I	II	III	
Project area	1,790	7,190	5,000	13,980
Unsuitable area for irrigation	600	2,090	610	3,300
Commanded area	1,190	5,100	4,390	10,680
20% deduction for road, canal, village, stream, etc.	240	1,020	880	2,140
Net irrigable area	950	4,080	3,510	8,540

The most promising crops with irrigation are selected in due consideration of the results of investigation on the natural and social conditions in the area. The selected crops to be developed are; Maize, Beans, Rice, Cotton, Groundnuts, Greengrams and Fodder crops. The proposed cropping patterns for the project are three as illustrated below:



With introduction of irrigation farming supported by efficient water management and proper farm inputs, the yield of each crop introduced is expected to be increased remarkably.

The anticipated crop yield and production of each crop at the full development stage are shown below:

Crop	Yield (ton/ha)	Area (ha)	Production (ton)
Rice	5.0	1,196	5,980
Greengram	1.2	996	1,195
Maize	5.0	4,212	21,060
Beans	0.9	4,212	3,791
Cotton	2.0	2,420	4,840
Groundnuts	2.0	4,840	9,680
Napier	120.0	854	102,480
Alfalfa	80.0	854	68,320

II.4 The Project

The Project comprises of a net irrigable area of 8,540 ha, out of which 200 ha are suitable for paddy field, 796 ha for paddy and upland fields, and 7,544 ha for fields.

The water requirement for the proposed irrigation area was estimated using the modified Penman formula, rainfall data and irrigation efficiency of 40%. Following table shows seasonal irrigation requirement.

(m^3/sec)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.8	2.0	3.0	3.6	4.6	6.2	3.3	0.9	3.6	7.4	6.8	6.1

The water requirement for the proposed irrigation area was calculated at 7.4 m^3/sec in peak time.

The main features of the proposed project works are the construction of two main canals, secondary canals, structures related to water distribution and tertiary development (Table 10 and Figure 14).

Since the present study is still in pre-feasibility level, the feasibility study should be carried out before implementation of this irrigation project. The feasibility study will take up about 16 months (Figure 15) and about 8 years will need for detailed design and construction works (See Figure 16).

On the basis of the current market price in Kenya and worldwide price as of 1984, the total construction cost of the Project was estimated to be KShs 971 million (US$64.7 million) consisting of KShs 622 million for foreign portion and KShs 349 million for local portion including physical and price contingencies (Table 11).

The economic feasibility of the project was evaluated in terms of the economic internal rate of return. In the calculation of rate of return, the project benefit was estimated only for direct benefit derived from crop production as shown below.

Crops	Planted area (ha)	Net production value (KShs/ha)	Amount (KShs/ha)
I. With Project:			
Maize & Beans	4,212	17,081	71,945
Cotton	2,420	10,322	24,979
Rice	1,196	11,641	13,923
Greengram	996	5,619	5,597
Groundnut	4,840	12,886	62,368
Fodder *	1,708	-	-
Total			178,812

II.	Without Project:			
	Maize	370	1,266	468
	Sorghum	250	2,516	629
	Cotton	370	-1,034	-383
	Groundnut	125	2,457	307
	Cassava	125	6,765	846
	Rice	130	5,601	728
	Total			2,595
III.	Direct Benefit (I - II)			176,217

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

The economic cost is obtained by deducting price contingency, land acquisition cost and transfer payment from the financial cost. The total economic cost of the irrigation development was estimated to be KShs 617.1 million.

The economic internal rate of return for Kano Plain irrigation project was computed at 16.3 %, based on 50 years of the project life with the implementation schedule as shown in Figure 16 and excluding the common cost of the diversion scheme.

With completion of the Project, annual net farm income will be KShs 48,300 for typical farm household of cropping pattern A, KShs 38,800 for pattern B and KShs 42,600 for pattern C.

III. PROJECT IMPLEMENTATION

III.1 Selected Development Plans

The Sondu River Multipurpose Development Project will ultimately comprise the following three independent components as described in the preceding chapters. Those are;

(1) Sondu/Miriu run-of-river hydropower project,
(2) Kano Plain irrigation project utilizing the Sondu River water, and
(3) Magwagwa dam and hydropower project.

The present status of undertaking for those projects is, however, different one another as follows.

	Undertaking completed	Undertaking followed by
Sondu/Miriu Hydropower	Feasibility	Detailed Engineering and Implementation
Kano Plain Irrigation		
(i) for 8,540 ha	Pre-feasibility	Feasibility
(ii) for 7,560 ha*	Master plan	(Feasibility)
(iii) for 10,000 ha*	Master plan	(Feasibility)
Magwagwa Dam and Hydropower	Master plan	Feasibility

* Tentative figures derived from the areas demarcated by UNDP/LOTTI study

III.2 Necessity of Feasibility Study for the Second Stage Projects

As dealt with this study, the first stage development of the Sondu River Multipurpose Project comprised the Sondu/Miriu run-of-river hydropower project and the irrigation of 8,540 ha in Nyakach Plain.

Since the irrigation project was proven to be feasible although the study level was in pre-feasibility, the study level of the irrigation project should be graded up to feasibility study in the earliest opportunity. Moreover, the water after hydropower generation is ample for irrigating nearly 16,000 ha. In this respect, recommended for the feasibility study of the irrigation project is to incorporate the possibly extensible area of 7,560 ha with 8,540 ha dealt with this study.

The development following the first stage will be the construction of Magwagwa dam and hydropower project as the second stage. Additional firm water is to be available with this project for the further extension of irrigation area of 10,000 ha or more in Kano Plain. With this view, the feasibility study of those two, Magwagwa dam and 10,000 ha irrigation projects, is desired to be undertaken in a single package as a multipurpose project in appropriate time.

III.3 Stage Implementation

Taking into account the results of the study and probable times to be required for accomplishing the undertakings in several phases until the commission of each project, a tentative implementation schedule of three projects in the first and second stages will be set out as follows.

	F/S*	D/D**	Construction	Commissioning
Sondu/Miriu Hydropower	1985	1987	1989-1992	1993
Kano Plain Irrigation				
(i) for 8,540	1986/87	1988/89	1991-1996	1993-1997
(ii) for 7,560	(1986/87)	(1991/92)	(1992-1997)	(1994-1998)
(iii) for 10,000	(1988/89)	(1991/92)	(1994-2000)	(1996-2000)
Magwagwa Dam and Hydropower	1988/89	1990/91	1992-1995	1996

* : Feasibility Study

**: Detailed Engineering

In this schedule, the following consideration is taken into account. The implementation of irrigation project is usually affected by the progress of construction of the tertiary and on-farm units. Especially the on-farm development should require participation of the farmers, who have the land, and land levelling and reformation sometimes. Moreover, most of the farmers are not so familiar with irrigation farming and probably need a considerable time for water management. It is, therefore, deemed practical to develop the tertiary units by 2,000 ha or so successively every year.

TABLES

Table 1 GDP by Sector at Current Prices, 1970, 1979 and 1983

(Unit: 10^3 kℓ, % shares in parentheses)

Sector	1970	1979	1983
Agriculture, forestry and fishery	173.0 (33.1)	679.0 (34.4)	1,091.6 (33.2)
Mining and quarrying	2.4 (0.5)	5.0 (0.3)	6.2 (0.2)
Manufacturing	62.2 (11.9)	249.8 (12.6)	408.3 (12.4)
Electricity and water	12.0 (2.3)	42.3 (2.2)	76.8 (2.3)
Construction	62.4 (5.1)	117.5 (5.9)	180.2 (5.5)
Wholesale and retail trade, hotels and restaurants	55.8 (10.7)	209.2 (10.6)	346.3 (10.5)
Transport & communications	40.8 (7.8)	114.7 (5.8)	195.3 (5.9)
Government services	76.5 (14.7)	290.3 (14.7)	481.4 (14.6)
Other services	72.8 (13.9)	267.2 (13.5)	505.2 (15.4)
Total GDP at factor cost	521.9	1,975.0	3,291.2

Sources: Statistical Abstracts 1979 and 1983

Table 2 Existing Generating Plants on Interconnected System (1/2)

Plant	No. and Capacity of Generator (No. x MW)	Gross Head(m)/ Steam Pressure	Total installed Capacity (MW)	Effective Capacity (MW)	Annual average Energy 1979 - 1983 (GWh)	Year of Commissioning
(A) Hydro Power Plants						
(I) Upper Tana						
1) Tana (KPC)	-	56.5-62.0	14.4	12.4	69.8	1953
2) Wanjii (KPC)	-	-	7.4	7.4	43.6	1952
Sub-total (I)			21.8	19.8	113.4	
(II) Seven Forks						
3) Kindaruma (TRDC)	2 x 22	34.0	44.0	44.0	170.4	1968
4) Kamburu (")	2 x 30.5	66.6-81.5	91.5	84.0	342.2	1974
	1 x 30.5					1976
5) Gitaru (")	2 x 72.5	142.0	145.0	145.0	638.8	1978
6) Masinga (TARDA)	2 x 20	25.8-49.8	40.0	40.0	(59.7)	1981
Sub-total (II)			320.5	313.0	(1,193.1)	
(III) Small Hydro						
7) Ndula	-	-	2.0	2.0		-
8) Mesco	-	-	0.4	0.4		-
9) Sagana Falls	-	-	1.5	1.5	22.4	-
10) Selby Falls	-	-	0.3	0.3		-
11) Gogo Falls,	2 x 1.0	-	2.0	2.0*/		-
Sub-total (III)			6.2	6.2	22.4	
Total Capacity of Hydro (I+II+III)			348.5	339.0	(1328.9)	
(B) Thermal Power Plants						
(I) Oil-Fired Steam						
1) Mombasa-Kipevu	1 x 5	-	5	4		1958
	"	-	5	4		1958
	1 x 12.5	-	12.5	10*/	239.0	1961
	"	-	12.5	10		1962
	1 x 30	-	30	27		1973
	1 x 33	-	33	30		1976
Sub-total (I)			98.0	85	239.0	

Table 2 Existing Generating Plants on Interconnected System (2/2)

Plant	No. and Capacity of Generator (No. x MW)	Gross Head(m)/ Steam Pressure	Total installed Capacity (MW)	Effective Capacity (MW)	Annual average Energy 1979 - 1983 (GWh)	Year of Commissioning
(II) Gas-turbine						
2) Nairobi South	1 x 13.5	-	13.5			1972
	2 x 2.2	-	4.4	14	(13.0)	-
3) Mombasa-Kipevu	1 x 12.2	-	12.2	8*/	-	1972
Sub-total (II)			30.1	22	(13.0)	
(III) Diesel						
4) Nairobi South	-	-		8		before 1955
5) Mombasa-Ruiru	-	-	20.1	2	(6.3)	"
6) Mombasa-Mbaraki	-	-		2		
Sub-total (III)			20.1	12	(6.3)	"
(IV) Geo-thermal						
7) Olkaria (KPC)	1 x 15	5 bars press.(152°C)	15	15	(132.3)	1981
	"	"	15	15		1982
Sub-total (IV)			30.0	30.0	(132.3)	
Total Capacity of Thermal (I+II+III+IV)			178.2	149.0	(390.6)	
(C) Import from Uganda (UEB)			30.0	30.0	212.0	Since 1958
Grand Total (A+B+C)			556.7	518.0	(1931.5)	

(Source: KP&L statistics & Turkwell Report by PCR)

Note: 1) Small isolated stations are not included herein.
2) UEB hydropower is considered to be non-firm power from 1988 onward.
3) Annual average energy is worked out based on actual generation for 5 years. Figures in parenthesis means data being not available for 5 years.
4) Asterisked figures mean the effective capacity after duly repair in due time.

Table 3 Electric Power Forecast in Kenya

Year	Demand (MW Sent Out)			Energy (GWh Sent Out)		
	Low	Median	High	Low	Median	High
1983	328	328*	328	1,984	1,984*	1,984
1984	341	341	341	2,060	2,060	2,060
1985	355	355	355	2,148	2,148	2,148
1986	371	371	371	2,240	2,240	2,240
1987	382	387	393	2,314	2,340	2,379
1988	395	406	420	2,392	2,457	2,542
1989	409	429	452	2,473	2,592	2,730
1990	424	454	487	2,564	2,747	2,945
1991	447	482	519	2,705	2,912	3,136
1992	472	511	553	2,853	3,087	3,340
1993	498	541	589	3,010	3,272	3,557
1994	525	574	627	3,176	3,489	3,789
1995	554	608	668	3,351	3,677	4,035
1996	584	645	711	3,535	3,898	4,297
1997	617	683	757	3,729	4,131	4,576
1998	650	724	807	3,934	4,379	4,874
1999	686	768	859	4,151	4,642	5,191
2000	724	814	915	4,379	4,920	5,528
2002		915			5,528	

Source: Generation and Economic Study for the Turkwell Gorge Project, Preece, Cardew and Rider, July 1984

* Actual values

Table 4 Projected Power Demand in Western Kenya

	Year		
	1983*/	1993	2000
Domestic & small commercial	48 GWh	127 GWh	2969 GWh
	(19.0%)	(26.5%)	(34.1%)
Public	8	17	35
	(3.2%)	(3.5%)	(4.6%)
Industrial & large commercial	197	335	486
	(77.9%)	(69.9%)	(61.5%)
Total	253 GWh	479 GWh	790 GWh
Maximum	41 MW	78 MW	129 MW
Turkwell forecasts**/		74 MW	123 MW

*/ Actual converted to value on sent-out basis

**/ "Sent-out" basis

Table 5 Plan Optimization

Work Item	Combination-A			Combination-B	Combination-C		Combination-D		Combination-E	
	Sondu /Miriu R-O-R	Maraboi R-O-R	Nyamari-mba R-O-R	Sondu /Miriu Reservoir	Magwagwa Reservoir	Sondu /Miriu R-O-R	Magwagwa Reservoir	Sondu /Miriu Reservoir	Magwagwa Reservoir	Maraboi R-O-R
1. Firm Discharge (m^3/sec)	3.30	3.30	3.30	17.10	24.10	24.10	16.00	25.60	24.10	24.10
2. Plant Discharge (m^3/sec)	29.60	29.60	29.60	28.40	72.30	39.90	48.00	42.70	72.30	39.90
3. Optimum Power Scale										
Installed Capacity (MW)	32.83	50.49	55.05	46.90	94.60	48.60	54.90	72.90	50.70	69.22
Firm Energy (GWh/yr)	32.01	49.23	53.68	246.30	276.20	237.48	160.20	383.30	147.90	364.05
Secondary (GWh/yr)	155.55	239.21	260.86	54.60	57.90	14.91	87.50	36.20	32.70	22.86
Dump Energy (GWh/yr)	14.45	22.22	24.23	-	-	46.08	-	-	-	70.63
4. Economic Scale on Power Sector										
Benefit (mil. US$) *	79.23	121.85	132.87	174.40	351.19		386.00		345.18	
Cost (mil. US$) *	72.14	113.70	143.26	202.30	305.85		450.60		300.93	
B -C (mil.US$) *	7.09	8.15	-10.39	-27.90	45.34		-64.60		44.25	
EIRR	10.95	10.70	9.28	8.69	11.36		8.63		11.36	
Cost per Energy (US¢/KWh)	5.74	5.88	6.80	7.31	5.49		7.36		5.49	
5. Economic Scale on Irrigation Sector										
Irrigation Area (ha)	15,610	15,610	15,610	25,610	25,610		25,610		25,610	
Benefit (mil. US$) *	94.16	94.16	94.16	121.88	121.88		121.88		121.88	
Cost (mil. US$) *	52.08	52.08	52.08	78.64	78.64		78.64		78.64	
B - C (mil. US$) *	42.08	42.08	42.08	43.24	43.24		43.24		43.24	
6. Total Economic Scale										
Benefit (mil. US$) *	173.39	216.01	227.03	296.28	473.07		507.88		467.06	
Cost (mil. US$) *	124.22	165.78	195.34	280.94	384.49		529.24		379.57	
B - C (mil. US$) *	49.17	50.23	31.69	15.34	88.58		-21.36		87.49	

* Discounted value at 10 %

Table 6 Optimal Planting-up Sequence in the KP&L System (1986 to 2005)

Plant	Type	Capacity MW	Installation Year	Notes
Kiambere	Hydro	144	1988	Under Construction
Turkwell	Hydro	100	1992	Committed (the first date of 1993)
Sondu/Miriu 1	Hydro	48.6	1992	
Olkaria IV	Geothermal	30	1993	
Coal-1	Coal	60	1993	
Sondu/Miriu	Hydro	94.6	1996	
Eburru	Geothermal	15	1998	
Coal-2	Coal	120	1998	
Coal-3	Coal	60	2001	
Coal-4	Coal	60	2002	
Coal-5	Coal	120	2003	
Coal-6	Coal	60	2004	

Table 7 Construction Cost

Description	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total (1,000 KShs.)
1. Preparatory works	4,005.0	14,631.6	74,706.6
2. Civil works	14,009.8	106,884.5	317,031.5
3. Metal works	8,338.0	11,815.4	136,885.4
4. Generating equipment & substation equipment	15,928.0	22,152.0	261,072.0
5. Transmission line	1,774.0	5,464.0	32,074.0
Total (1 - 5)	44,054.8	160,947.5	821,769.5
6. Land acquisition & compensation	-	194.1	194.1
7. Administration expenses	-	16,435.4	16,435.4
8. Engineering services	6,030.0	-	90,450.0
Total (1 - 8)	50,084.8	177,577.0	928,849.0
9. Physical contingency	3,706.5	15,786.2	71,383.7
10. Price escalation	10,144.4	123,510.7	275,676.7
Grand total	63,935.7	316,873.9	1,275,909.4

Note: A cost of US$ 3 million (KShs 45 million) is necessary for detailed design and preparation of tender document on the pre-construction stage besides the above costs.

Table 8 Disbursement Schedule

(Unit: F.C. 1000 US$, L.C. 1000 KShs)

Description	Total		1989		1990		1991		1992	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
1. Preparatory Works	4,005.0	14,631.6	4,005.0	14,631.6	-	-	-	-	-	-
2. Civil Works										
2.1 River Diversion	401.8	2,254.4	395.4	2,233.7	-	-	6.4	20.7	-	-
2.2 Waterway	10,995.1	86,590.7	2,946.0	23,861.9	6,068.8	46,507.8	1,282.8	10,102.0	697.5	6,119.0
2.3 Power Station	1,927.1	13,769.7	192.7	1,377.0	1,013.0	6,933.0	699.6	5,236.7	21.8	223.0
2.4 Outlet Channel	101.6	514.0	10.1	51.4	-	-	67.7	227.4	23.8	235.2
2.5 Road Construction	584.2	3,755.7	584.2	3,755.7	-	-	-	-	-	-
Sub-total (2)	14,009.8	106,884.5	4,128.4	31,279.7	7,081.8	53,440.8	2,056.5	15,586.8	743.1	6,577.2
3. Metal Works										
3.1 Weir Metal Work	758.5	1,211.4	118.4	-	209.6	476.5	430.5	734.9	-	-
3.2 Intake Metal Work	1,600.3	2,553.8	249.7	-	394.7	699.1	955.9	1,854.7	-	-
3.3 Penstock Metal Work	5,979.2	8,050.2	703.0	-	1,205.2	1,712.9	2,511.6	3,692.1	1,559.4	2,645.2
Sub-total (3)	8,338.0	11,815.4	1,071.1	-	1,809.5	2,888.5	3,898.0	6,281.7	1,559.4	2,645.2
4. Generating Equipment and Substation Equipment										
4.1 Generating Equipment	11,908.0	16,001.0	1,765.0	-	1,474.0	1,668.1	6,924.4	10,611.6	1,744.6	3,721.3
4.2 Substation Equipment	4,002.0	6,151.0	586.6	-	-	-	2,449.1	2,772.9	984.3	3,379.0
Sub-total (4)	15,928.0	22,152.0	2,351.6	-	1,474.0	1,668.1	9,373.5	13,383.6	2,728.9	7,100.3
5. Transmission Line	1,774.0	5,464.0	235.0	-	490.5	555.3	737.9	3,029.9	310.6	1,878.8
Total (1 - 5)	44,054.8	160,947.5	11,791.1	45,911.3	10,855.8	58,552.7	16,065.9	38,282.0	5,342.0	18,201.5
6. Land Acquistion and Compensation	-	194.1	-	194.1	-	-	-	-	-	-
7. Administration Expenses	-	16,435.4	-	4,455.6	-	4,427.8	-	5,585.4	-	1,966.6
8. Engineering Services	6,030.0	-	1,634.7	-	1,624.5	-	2,049.3	-	721.5	-
Total (1 - 8)	50,084.8	177,577.0	13,425.8	50,561.0	12,480.3	62,980.5	18,115.2	43,867.4	6,063.5	20,168.1
9. Physical Contingency	3,706.5	15,786.2	1,159.7	5,056.1	1,059.3	6,042.5	1,111.1	3,252.0	376.4	1,435.6
10. Price Escalation	10,144.4	123,510.7	2,077.0	26,423.7	2,392.4	41,959.1	4,076.0	35,462.1	1,599.0	19,665.8
Grand Total	63,935.7	316,873.9	16,662.5	82,040.8	15,932.0	110,982.1	23,302.3	82,581.5	8,038.9	41,269.5

Note: A cost of US$ 3 million (KShs 45 million) is necessary for detailed design and preparation of tender document on the pre-construction stage besides the above costs in 1987.

Table 9 Financial Cash Flow for the Sondu River Hydropower Development (Average tariff = 0.78 KShs/KWh) (1/2)

(Unit: 10^3 KShs)

No.	Year	Financial Costs		Subtransmission and distribution costs	Revenue
		Investment costs	O & M costs		
1.	1987	45,000			
2.	88	0			
3.	89	264,449			
4.	90	272,268			
5.	91	309,155			
6.	92	105,605			
7.	93	0	8,302	27,893	89,003
8.	94	0	8,302	27,893	89,003
9.	95	0	8,302	27,893	89,003
10.	96	0	8,302	27,893	89,003
11.	97	0	8,302	27,893	89,003
12.	98	0	8,302	27,893	89,003
13.	99	0	8,302	27,893	89,003
14.	2000	0	8,302	27,893	89,003
15.	01	0	8,302	27,893	89,003
16.	02	0	8,302	27,893	89,003
17.	03	0	8,302	27,893	89,003
18.	04	0	8,302	27,893	89,003
19.	05	0	8,302	27,893	89,003
20.	06	0	8,302	27,893	89,003
21.	07	0	8,302	27,893	89,003
22.	08	0	8,302	27,893	89,003
23.	09	0	8,302	27,893	89,003
24.	10	0	8,302	27,893	89,003
25.	11	0	8,302	27,893	89,003
26.	12	0	8,302	27,893	89,003
27.	13	0	8,302	27,893	89,003
28.	14	0	8,302	27,893	89,003
29.	15	0	8,302	27,893	89,003
30.	16	0	8,302	27,893	89,003
31.	17	0	8,302	27,893	89,003
32.	18	0	8,302	27,893	89,003
33.	19	0	8,302	27,893	89,003
34.	20	0	8,302	27,893	89,003
35.	21	0	8,302	27,893	89,003
36.	22	0	8,302	27,893	89,003
37.	23	0	8,302	27,893	89,003
38.	24	0	8,302	27,893	89,003
39.	25	0	8,302	27,893	89,003
40.	26	0	18,708	27,893	89,003
41.	27	0	18,708	27,893	89,003

Table 9 Financial Cash Flow for the Sondu River Hydropower Development (Average tariff = 0.78 KShs/KWh) (2/2)

(Unit: 10^3 KShs)

No.	Year	Financial Costs		Subtransmission and distribution costs	Revenue
		Investment costs	O & M costs		
42.	28	0	8,302	27,893	89,003
43.	29	0	8,302	27,893	89,003
44.	30	0	8,302	27,893	89,003
45.	31	0	8,302	27,893	89,003
46.	32	0	8,302	27,893	89,003
47.	33	0	8,302	27,893	89,003
48.	34	0	8,302	27,893	89,003
49.	35	0	8,302	27,893	89,003
50.	36	0	8,302	27,893	89,003

Table 10 Main Features of the Proposed Project Works

(1) Main & Secondary irrigation canals and structures

Description	Main canal	Secondary canal
Canal length (km)	24.3	65.9
Trunout (nos.)	30	122
Check	8	110
Culvert	14	152
Drop	3	650
Siphon/Aqueduct	10	1
Others	29	42

(2) Tertiary and on-farm development

Description	Irrigation	Drainage
Tertiary Canal (km)	180	180
Division box (nos.)	6,300	-
Culvert (nos.)	900	900
Distribution canal (km)	400	-
Field drain (km)	-	400

Table 11 Breakdown of the Project Cost

	Description	F/C	L/C	Total
		(1,000 US$)	(1,000 KShs)	(1,000 KShs)
1.	Preparatory works	2,035	10,222	40,747
2.	Main irrigation system	5,331	34,461	114,426
3.	Secondary irrigation system	3,906	19,652	78,242
4.	Tertiary and on-farm development	8,044	35,761	156,421
5.	Land levelling	1,942	6,718	35,848
6.	Office and quarters	1,125	5,625	22,500
	Sub-total (item 1 to 6)	22,383	112,439	448,184
7.	Land acquisition	-	8,494	8,494
8.	O&M equipment	852	666	13,446
9.	Administration expenses	-	31,373	31,373
10.	Engineering services	5,976	-	89,640
11.	Price escalation	8,507	164,171	291,776
	Sub-total (item 1 to 11)	37,718	317,143	882,913
12.	Physical contingency	3,772	31,714	88,294
	Total:	41,490	348,857	971,207