REPUBLIC OF KENYA

KENYA POWER COMPANY LIMITED

FEASIBILITY STUDY ON MAGWAGWA HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

EXECUTIVE SUMMARY

OCTOBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

NAIROBI OFFICE
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TOKYO JAPAN

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This Report consists of

Volume I	*Executive Summary*
Volume II	*Main Report*
Volume III	*Supporting Report (1)*
Volume IV	*Supporting Report (2)*
Volume V	*Data Book (1)*
Volume VI	*Data Book (2)*

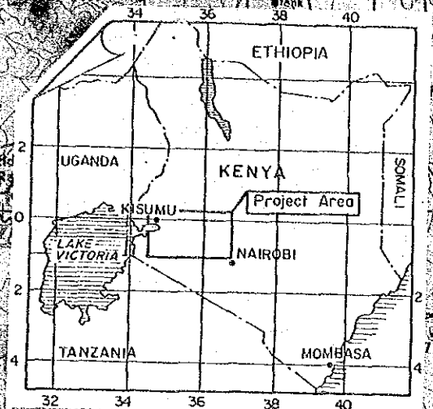
PROPOSED MAGWAGWA PROJECT

KANO PLAIN IRRIGATION AREA

SONDU/MIRIU DIVERSION

MAGWAGWA RESERVOIR

KEY MAP



LEGEND

- Basin Boundary
- Reservoir
- Intake, Waterway & Power Station
- Main Irrigation Canal
- Provisional Irrigation Canal
- Irrigation Area
- Extensible Irrigation Area
- Swamp

SCALE 0 5 10 20km

PROJECT LOCATION MAP

REPUBLIC OF KENYA
MAGWAGWA HYDROELECTRIC POWER DEVELOPMENT PROJECT
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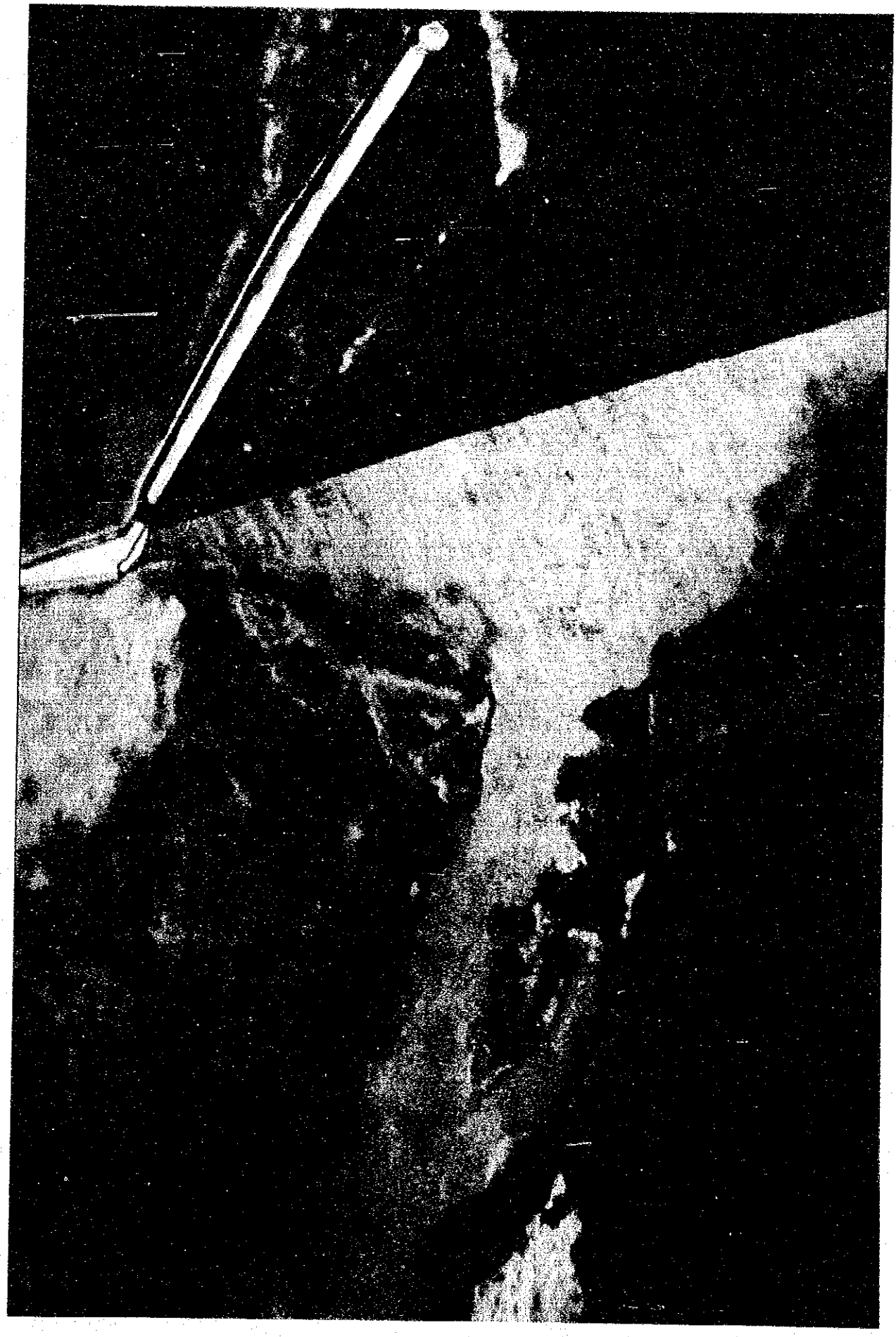

Perspective View of the Proposed Dam

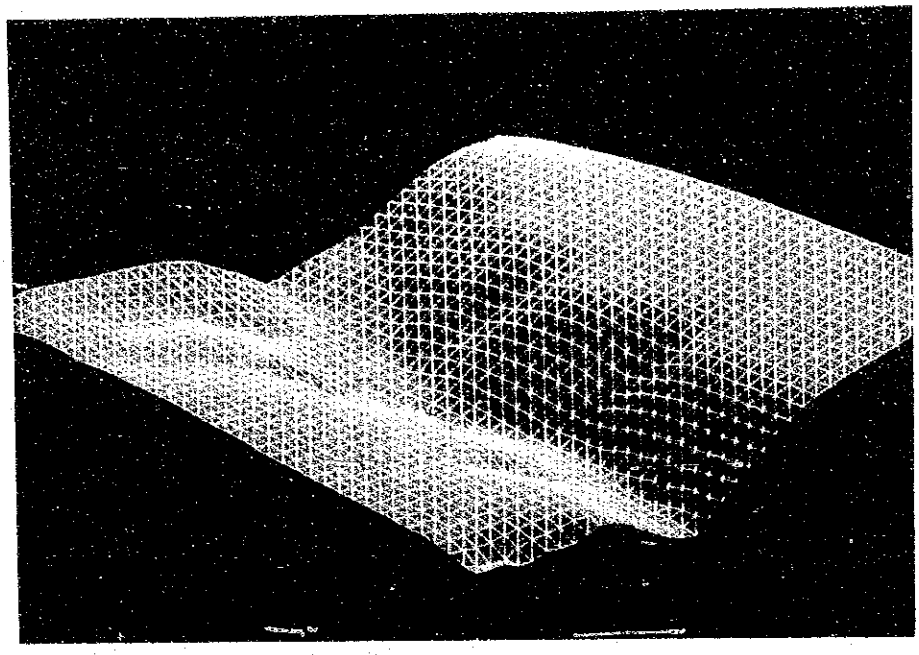

Photo 1 Downstream View of Topography at Proposed Damsite

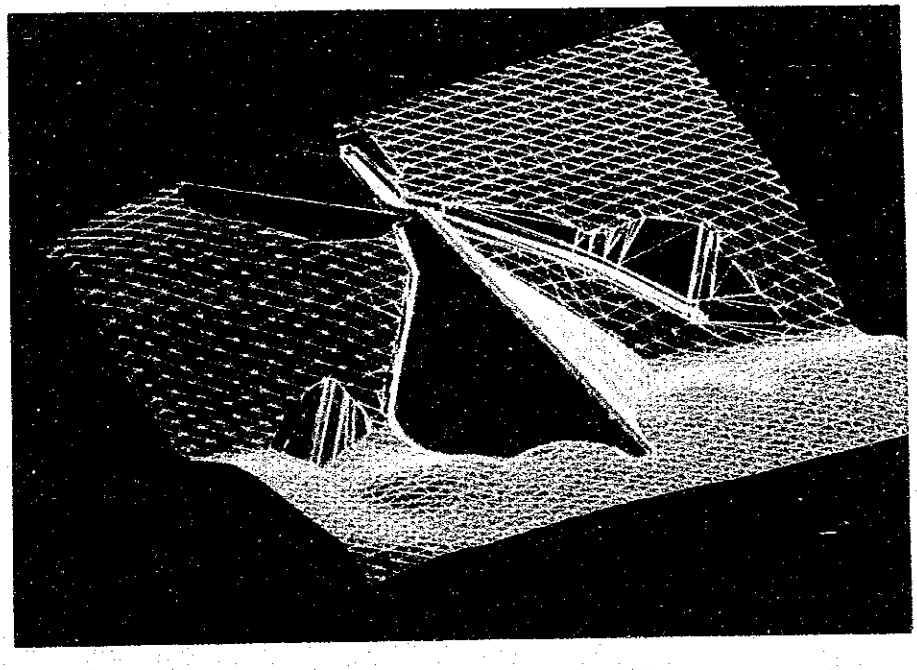

Photo 2 Overall View of Proposed Dam before Reservoir Impounding

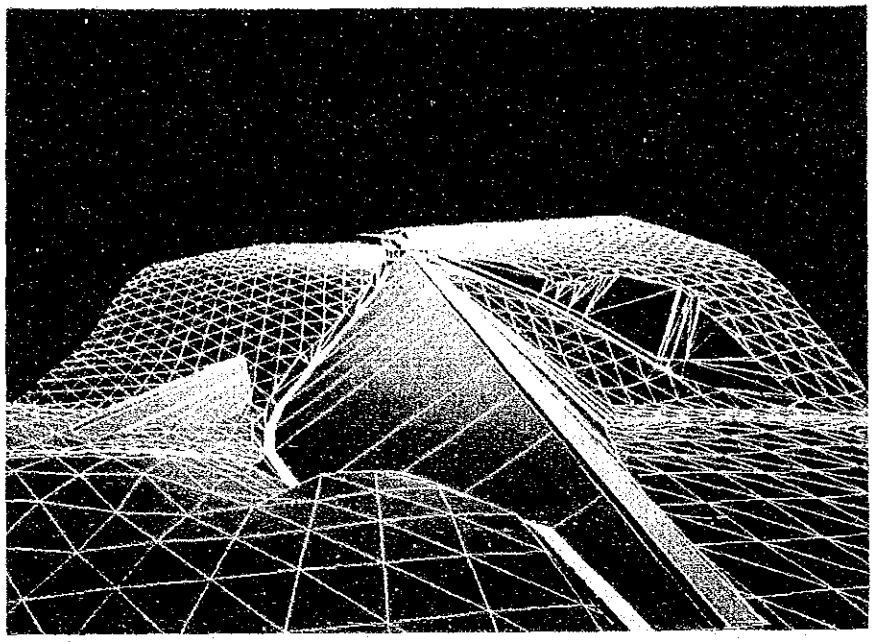

Photo 3 Perspective from Right Abutment

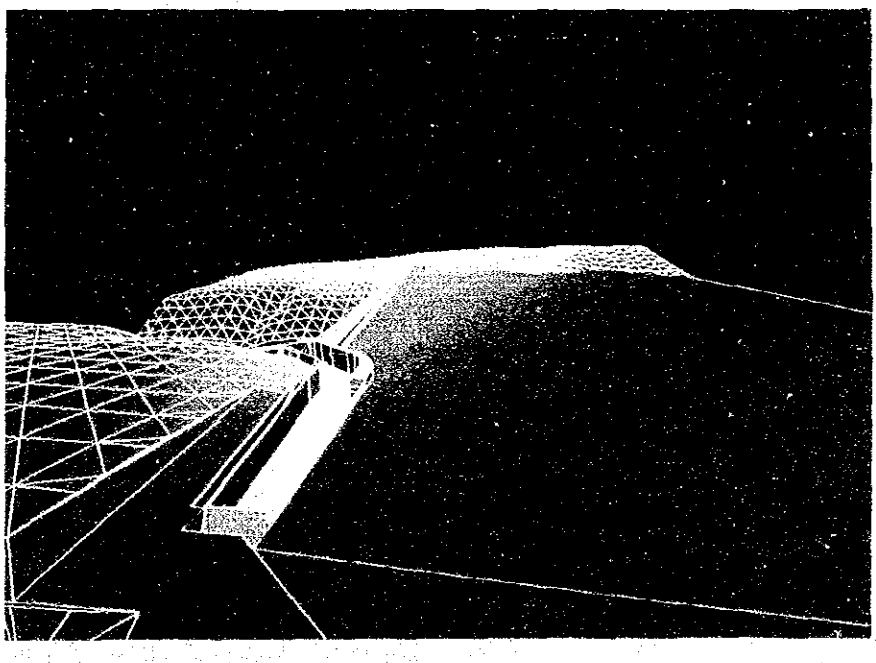

Photo 4 Perspective from Left Abutment with Reservoir Impounding

EXECUTIVE SUMMARY

Background

1. Recent completion of Kiambere hydro plant with an installed capacity of 144 MW and an addition of Turkwel hydro plant with an installed capacity of 106 MW in 1991 will raise the total effective capacity to a level of 750 MW in the Kenya power supply system, in which power supply of 30 MW from Uganda is included. But, recent power supply shortage in Uganda makes hard expect the imported power as firm.

2. Power demand in Kenya increased with a high rate of 6.8% per annum over a period of 1976 to present, varying annual increase rates of 1.7% in 1982 to 1983 and 10.8% in 1985 to 1986. Furthermore, power demand in Kenya is expected to reach 718 MW (3,529 GWh a year) in year 1995 and 938 MW (4,578 GWh a year) in year 2000 according to the recent power demand forecast by Kenya Power and Lighting Limited (KPLC). To meet the growing power demand, such new power plants as Sondu/Miriu hydro of 60 MW and geothermal of 115 MW are planned to be developed in the latter half of 1990's. Even with such new additions of power plants, the power system in Kenya would require the development of some 200 MW by year 2000 to meet the power demand.

3. Agriculture in Kenya mainly practises in a rainfed condition, much relying on rainfall, so that maize, staple food in Kenya, is vulnerable to the change of climate, and its production largely fluctuates year by year following the climate condition, causing food shortage in dry years. This could result in the import of staple food. In addition, recent shift of consumer's taste from maize to rice on staple food spurs the increase of food import, which is another reason to aggravate the national financial balance.

Under the above condition, the Government of Kenya launched a programme weighing on two points; to achieve the self-sufficiency of maize and rice and to promote agriculture-based industry for increasing the added value of traditional cash crops such as tea and coffee toward year 2000 as part of a long-term economic development strategy.

The project

4. A project to aim at developing hydropower potential in the Sondu River and enhancing agricultural production in the Kano plain in an integrated manner was proposed by Japan International Cooperation Agency (JICA) in 1985, consisting of three

development components; Magwagwa dam scheme, Sondu/Miriu diversion scheme and irrigation scheme in the Kano plain (refer to Figure S.1).

5. The Magwagwa dam scheme has the functions to regulate river flow with its reservoir capacity of some 800 million m^3 for power generation and irrigation water supply and to generate power availing head created by dam itself and 8 km long waterway. The Sondu/Miriu diversion scheme has dual functions of inter-basin water transfer from the Sondu River to the Kano plain and hydropower generation taking advantage of head existing between the intake and outlet sites of the diversion tunnel. The Kano plain irrigation scheme, commanding an area of some 26,000 ha, aims to enhance agricultural productivity by introducing the Sondu River water.

Objective of the study

6. The Government of Kenya envisaged to develop the Magwagwa hydroelectric power development project in light of her energy and agricultural development policies, i.e. exploration of indigenous energy resources and achievement of self-sufficiency on staple food, and requested to the Government of Japan technical cooperation in carrying out its feasibility study.

7. In response to the request of the Government of Kenya, the Government of Japan dispatched a mission consisting of officials of Japan International Cooperation Agency, the official agency responsible for the implementation of technical cooperation programmes of the Japanese Government, to Kenya for discussing the scope of work of the Study with its counterpart agency, the Kenya Power Company Limited (KPC), in August, 1989. According to the scope of work so prepared under the discussions of two agencies, the objective of the Study is to formulate an optimum plan for the Magwagwa Hydroelectric Power Development Project and to assess its technical, economic and financial feasibility.

Work progress

8. The study was commenced by dispatching a study team to Kenya for a period of January to March, 1990, followed by field investigation for a period of June to November, 1990. The study team, returned to Japan with the completion of field work, immediately started the work of selection of optimal development alternative and scale, preliminary design at a feasibility study level, preparation of construction plan and cost estimates. The Interim Report was prepared in March, 1991 by incorporating the results achieved by that time.

The work was continued by July, 1991 for elaborating basic design at the feasibility study level, preparation of construction plan and cost estimates and for assessing economic and financial viability. An overall evaluation of the project was finally made including the assessment for the natural and social impact studies. Draft Final Report was submitted in August, 1991 by dealing with all the results achieved in this study.

The study team came back to Kenya in late August, 1991 and discussed Draft Final Report with KPC, its counterpart agency. By incorporating comments raised from KPC to the report, Final Report was submitted to the Government of Kenya in October, 1991.

Project area and location

(1) Location of the project

9. The Sondu River, one of six major rivers in the Lake Victoria basin, originates from the western slope of Mau Escarpment, neighbouring the Nyando River in the north and the Kuja River in the south. Meandering high lands with gentle undulation and collecting tributaries, the Sondu River generally flows down westwardly. After two major tributaries, the Yurith and Kipsonoi rivers, merge, the Sondu River enters the narrow gorge penetrating the Nyakach Escarpment where the proposed Magwagwa dam lies, and further falls in cascade with scenic waterfalls called Odino falls to the flood plains at Nyakwere. The Sondu River finally drains in the Winam Gulf of Lake Victoria with a catchment area of 3,470 km^2 at the estuary.

(2) Meteorology and hydrology

10. The climate of the Sondu River basin is mild with small variation of 19°C to 25°C on average monthly air temperature throughout the year due to the high elevation of El. 1,600 m to El. 2,700 m. Daily air temperature fluctuates largely, ranging from 15°C to 30°C.

11. Mean annual rainfall of recent 49 years between 1940 and 1988 was obtained to be 1,505 mm by computing arithmetic mean of the selected 13 gauges in the basin, whilst an isohyetal map of annual rainfall in the basin is given in Figure S.2. Annual basin rainfall on the other hand fluctuates between 1,152 mm in 1984 and 1,892 mm in 1978. The distribution patterns of monthly rainfall show a peak over the period of April to May in the central part of the basin, bimodal peaks of April to May and July to August in the eastern part and a peak, even not conspicuous, in April in the western part (refer to Figure S.3).

12. Monthly runoff recorded at 1JG1, a stream gauge standing near Sondu Township, estimates mean annual runoff of 42.0 m^3/sec. A duration curve drawn by the series method at the Magwagwa damsite based on the daily runoff recorded at 1JG1 (refer to Figure S.4) gives 4.3 m^3/sec as the 95% guarantee flow over a period of 1946 to 1990.

13. Mean annual sediment yield at the damsite was estimated by simulating daily runoff data of 1947 to 1990 to the developed runoff-sediment yield curve, resulting in 531,000 m^3/year or 0.168 mm/km^2/year in terms of the denudation rate.

(3) Geology

14. The upstream areas of the Sondu River basin form gentle flat highlands reflecting the geology composed of strata comparatively younger than that of the downstream area, and are covered with Tertiary andesite lava called phonolite. The areas in the lower reaches on the other hand expose the basement of metasedimentary rocks, igneous rocks in Pre-Cambrian and granitic rocks in Post Cambrian. Predominant in the project area located in the middle to lower reaches are Pre-Cambrian andesite, felsite and sedimentary rocks (refer to Figure S.5).

15. According to the seismic zoning map of Kenya and earthquake data collected from International Seismological Centre, the project site falls into the rather low seismicity zone of "VI" (21.0 to 44.0 gal, i.e. 0.05 G) in Modified Mercalli Intensity Scale. The results of seismic analysis revealed to be 0.10 G as the coefficient of dam design, in which the recurrence interval of earthquake is adopted at 100 years.

16. It is reported in the 1988 meeting of ICOLD (International Commission of Large Dams) and by T. Vladut (August, 1989 Water Power & Dam Construction) that Reservoir Induced Seismicity (RIS) is recognised as a significant environmental issue related to dam safety. The risk of RIS in this area was predicted by the approach proposed by T. Vladut, indicating rare occurrence of induced seismic phenomena as the result of RIS analysis shows a value of 0.05 G. The risk of RIS is thus within the range of safety for the dam designed with a value of k = 0.10 G.

(4) Natural environment

17. The objectives of the natural environmental study for the project are as follows:

i) To identify impacts which are expected to cause negative effects for the natural environment by the Project,
ii) To evaluate magnitude/significance of the impacts,
iii) To propose countermeasures for the mitigation of the magnitude of impacts,
iv) To evaluate the acceptability of the Project from the viewpoint of the natural environment, and to recommend further studies, if any.

To attain the objectives mentioned above, the screening and scoping approaches were applied for the study. The screening approach was conducted to assess whether the Environmental Impact Assessment (EIA) should be studied based on the existing guidelines set by the Government of Kenya and the World Bank related to the environmental assessment in Kenya, judging that the EIA should be studied obviously due to a large reservoir scheme with an impounding volume of some 800 million m^3. The scoping approach intends to extract environmental items and to define the scope of study to examine the Environmental Impact Assessment (EIA) by carrying out the Initial Environmental Examination (IEE) for the Project prior to the EIA.

18. The results of IEE for 23 environmental items based on the existing data and the field reconnaissance are given in Table S.1 with preliminary evaluation of the expected effects, showing that the change of water temperature, water contamination in the downstream area, eutrophication, vector borne diseases and disturbance of health facility utilization were identified as the impacts which would cause negative effects to the natural environment in and around the Project area.

19. The subsequent EIA to the above five environmental items revealed that only the effect on the public health especially spread of vector borne diseases was considered significant, and the others were not. The effect of the vector borne diseases could be reduced its magnitude by taking appropriate countermeasures. Therefore, it was concluded that the project would not cause any unavoidable effects on the natural environment in and around the Project area. Consequently, the proposed project was considered acceptable through the viewpoint of the natural environment.

(5) Social environment

20. The study on social environment aims to assess the soundness of the project mainly from the local people's point of view in terms of socio-cultural and economic aspects. The main objectives of the Study are i) to clarify the current conditions of the socio-economic characteristics in the affected areas, ii) to analyse socio-economic impacts of the project, iii) to provide basic data and information concerning compensation and countermeasures including resettlement, and iv) to recommend further studies.

21. An initial screening of socio-economic impacts of the project, which includes interview surveys to each household to be displaced, assessed that the causes of the most severe impacts are likely to be displacement of people (some 700 households including resettlement of the affected areas, when the dam crest elevation is set at El.1,670 m, as seen in Figure S.6) and submergence of land (26 km^2), infrastructures and facilities. Some 95% of total households surveyed expressed their concerns about a negative impact of land loss, while 86% for the impact of resettlement.

22. Compensation is usually rewarded in the form either of land or of cash in national projects. Apparently, however, the form of compensation in recent projects in the world has shifted from "cash for land" to "land for land", especially in the case that the displaced people largely depend on land, typically farmers.

The Project should choose the "land for land" approach as a resettlement plan because there are not a few conditions indicating a high possibility that the negative impacts would take place: A large scale of displacement; almost all the local people prefer the "land for land"; most of the displaced people are traditional farmers who are less educated; high population pressure on land and diminishing available land and kinship systems and other socio-cultural factors still pay important roles.

23. A preliminary survey identified six possible resettlement sites, i) settlement schemes, ii) swamp/marsh areas, iii) Ngoina tea estate and other adjoining estates, iv) ADC farms in Trans Nzoia district, v) Simbauti farm and vi) government land in Kericho district, based on the information derived from officials and local people. Table S.2 summarizes a result of preliminary investigation on those possible resettlement sites mostly based on impressions without detailed survey, so that assessment should be used just for reference.

24. It cannot be conclusive that the Project is socially acceptable and sound since resettlement plans including compensation, restoration plans and associated regional development plans in the affected areas have not been completely formulated yet. To pursue the acceptability and soundness of the project from the social environmental point of view, following are, in particular, recommended among others for further studies:

a) Appropriate understandings of involuntary resettlements and other socio-economic impacts of the project

It is quite indispensable to recognize the substantial impacts of the Project specially due to the inundation of the reservoir area, the necessity of "land for land" approach as well as the impacts of failure in resettlement and restoration not only on the affected people but on the Project, the regional development and national development. This component is an integral part of the Project and not taken as the secondary status.

b) Institutional set-up for formulating the required plans and countermeasures as early as possible

The institutional set-up is a prerequisite to carry out the further studies to formulate the required plans. The KPC is expected to establish such special unit of function, of which tasks include public relations with the affected people to smoothly carry out the studies and coordination with the required line agencies/ministries.

c) Involvement of the affected people and the officials concerned

To get the plans feasible, it is essential to involve the affected people, as well as the officials concerned, in formulating those plans and countermeasures. Many resettlements in the past projects in the world have failed mainly due to less involvement of them and institutional/organizational incapability.

d) Full costing of all the components of the plans and countermeasures

As underestimate of the costs of the required plans leads to underfinancing, all the costs required for implementing those plans and countermeasures should be estimated based on detailed surveys.

e) Commencement of the further studies as early as possible with adequate resources and experts

It will take time to carry out the further studies, especially the identification of resettlement sites, which will come the first among others in the resettlement plan and be the most important component, which will require qualified and sufficient number of experts. Also, comprehensive and detailed base-line information will have to be collected in both the reservoir and its vicinity and the resettlement sites. Thus, unlike other components of the Project, the further studies will need comprehensive fields of experts and details.

Power survey

25. The country is divided into five regions in terms of the power supply as follows:

(1) Nairobi region,
(2) Coast region,
(3) Rift Valley region,
(4) Western region, and
(5) Mt. Kenya region.

Energy sales in the whole of the KPLC's network were 2,434 GWh in 1987/88, of which the sales in the Nairobi region shared 1,303 GWh, followed by the Coast region of 544 GWh, the Western region of 346 GWh, the Rift Valley region of 137 GWh and the Mt. Kenya region of 104 GWh. This implies that more than 75% of KPLC's sold energy was consumed in the Nairobi and Coast regions.

26. A total of installed capacity of the generating facilities was 702 MW as of June, 1990 in the interconnected power system. In addition, there are such energy sources as isolated power plants with a total of installed capacity of about 4 MW and energy imports from Uganda.

By type, hydropower plant shares 70% of the installed capacity, 79% of the effective capacity and 85% of the 1989/90 annual energy production. Imports from Uganda are equivalent to about 6% of energy production. Following are a summary of installed capacity, effective capacity and average annual energy production in 1989/90 by generating type in the country:

Sources	Installed Capacity (MW)	Effective Capacity (MW)	Annual Production (GWh)
Hydro	492.5	479.0	2,517.0
Conventional Thermal	145.9	69.8	107.0
Geothermal	45.0	43.0	336.0
Diesel (incl. Isolated Diesel)	22.2	11.9	14.0
Imports from Uganda (agreed max. power)	—	(30.0)	(174.0)
Total	705.6	633.7	3,148.0

27. Electric power in the nation is supplied by the transmission line with voltages of 220 kV, 132 kV, 66 kV, 40 kV and 33 kV. The length of 220 kV line is 647 cct-km as of June, 1989, whilst 1,786 cct-km for 132 kV, 389 cct-km for 66 kV, 121 cct-km for 40 kV and 2,955 cct-km for 33 kV. The routes of transmission lines as well as the locations of main substations located on them are shown in Figure S.7.

28. Power and energy demands (refer to Figure S.8) were forecast for three scenarios, high, median and low, using the latest power data, resulting in:

(1) Demands of energy and peak power on the median scenario will continuously and steadily increase in the nation at annual growth rates of 5.3% and 5.5% respectively over a period of 1987/88 to 2014/15 (the experienced rate at 6.63% in the years 1979 - 1988).

(2) Gross generation required will be 4,275.0 GWh in 1995/96, 5,535.8 GWh in 2000/01, 7,170.6 GWh in 2005/06 and 11,509.1 GWh in 2014/15.

29. The transmission line system in the project area should be designed so that power outputs from the Sondu/Miriu and Magwagwa power plants can contribute to the stable power supply in the project area; that is, a ring supply system is recommended to connect such substations and power stations as Kisumu - Muhoroni - Chemosit - Magwagwa - Sondu/Miriu - Kisumu (refer to Figure S.9). The system voltage employed will be selected from either 220 kV or 132 kV.

Plan formulation

30. The project intends to develop the hydropower potential in the Sondu River and the agriculture potential in the Kano plain by integrating three schemes, Magwagwa, Sondu/Miriu and Kano schemes as explained early. The optimal development scale of the Magwagwa reservoir was thus examined by maximizing the net benefit gained from the three schemes and was worked out as follows (refer to Figure S.10):

- Full supply level (FSL) : El. 1,665.00 m
- Minimum operating level (MOL) : El. 1,609.00 m
- Tail water level for the maximum plant discharge : El. 1,458.00 m
- Gross storage : 808 million m^3
- Active storage : 701 million m^3.

31. A study to search for the optimal installation capacity and year of the Magwagwa hydropower project was furthermore carried out taking into consideration other promising hydro and thermal candidates, revealing the addition of the Magwagwa project to the national power grid in year 2003 with a capacity of 120 MW (refer to Figure S.11). A general feature of the proposed Magwagwa hydropower plant is summarized as follows:

Installed capacity	:	120 MW
Plant discharge	:	82 m^3/sec
Firm energy	:	243.9 GWh/year
Average energy	:	510.9 GWh/year
Incremental energy from the Sondu/Miriu	:	158.4 GWh/year.

It is noted that average annual energy generated from the Magwagwa plant and incremental energy generated from the Sondu/Miriu after the completion of the Magwagwa reservoir are estimated based on the multi-reservoir operation of the reservoirs existing in Kenya for power generation.

32. Sensitivity tests were carried out for assessing uncertainties involved in the future costs and assumptions applied to the study to seek the optimal installation capacity and year of the Magwagwa hydropower project, showing the viability to install the Magwagwa with a capacity of 120 MW in year 2003.

Basic design

33. Basic design for the Magwagwa dam scheme (refer to General Layout of the Project in Figure S.12) was carried out on a feasibility study level with the optimization studies of structures, and the main project features so obtained are summarized as follows:

(1) River diversion

- Diameter of the diversion tunnel	:	D = 6.20 m (circular section)
- Total length of the diversion tunnel	:	1,291 m (No. 1: 628 m, No. 2: 663 m)
- Crest elevation of the U/S cofferdam	:	El. 1,580.00 m

(2) Main dam (refer to Figures S.13 and S.14)

- Type	:	Concrete facing rockfill dam
- Dam crest elevation	:	El. 1,670.0 m
- Dam height	:	110 m
- Dam embankment volume including the cofferdams	:	4,387,900 m^3

(3) Spillway

- Type	:	Ungated
- Energy dissipation	:	Flip bucket
- Length of weir	:	160 m

(4) Waterway (refer to Figure S.15)

- Elevation of the intake invert	:	El. 1,598.0 m
- Diameter of the headrace tunnel	:	5.4 m
- Length of the headrace tunnel	:	7,190 m
- Headrace surge tank	:	Restricted orifice type
- Diameter of the penstock line	:	4.4 m to 2.1 m
- Length of the penstock line	:	174 m
- Tailrace surge tank	:	Restricted orifice type
- Diameter of the tailrace tunnel	:	5.4 m
- Length of the tailrace tunnel	:	1,850 m

(5) Powerhouse (refer to Figure S.16)

- Type	:	Underground type
- Dimensions of the cavern	:	22 m wide, 38 m high and 60 m long

(6) Saddle dam (refer to Figure S.17)

- Type	:	Homogeneous earthfill type
- Length	:	710 m
- Dam height	:	20 m

(7) Generating equipment

- Maximum plant discharge	:	82 m^3/sec
- Rated head	:	170.4 m
- Type of turbines	:	Francis type
- Type of generators	:	Vertical-shaft semi-umbrella type synchronous generator
- Number of units (turbines and generators)	:	Two
- Rated output	:	2 x 61,500 kW

(8) Transmission line

- Voltage	:	132 kV
- Conductor size	:	14.5 mm in an outer diameter.

Construction plan and cost estimate

34. Construction works will be divided into four packages as shown below and will be executed by the contractor selected by international competitive tenders for respective packages including prequalification:

(1) Civil works including preparatory works
(2) Metal works
(3) Generating equipment
(4) Transmission lines and substation equipment.

35. Construction works are scheduled to commence in July, 1997 after contract award (refer to Figure S.18). The project is planned to be completed by the end of December, 2002, giving a time period of 5.5 years (66 months).

36. The construction cost of the project excluding price escalation is estimated at KShs. 7,555 million (US$328.48 million) equivalent in total, consisting of KShs. 4,963 million in the foreign currency portion (US$215.78 million, 65.7%) and KShs. 2,592 million in the local currency portion (34.3%). While, the total construction

cost of the project including price escalation is estimated at KShs. 11,478 million (US$499.03 million) equivalent in total, consisting of KShs. 5,922 million equivalent in foreign currency portion (US$257.45 million, 51.6%) and KShs. 5,556 million in local currency portion (48.4%) as summarized below:

	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total Equivalent (1,000 KShs.)
Direct cost	176,999.24	1,542,713	5,613,696
Land acquisition	0	804,000	804,000
Administration expenses	0	28,068	28,068
Engineering services	21,477.00	63,048	557,019
Physical contingency	17,307.98	154,135	552,219
Subtotal	215,784.22	2,591,964	7,555,001 (US$328.48 million)
Price escalation	41,662.07	2,964,499	3,922,727
Total	257,446.29	5,556,463	11,477,728 (US$499.03 million)

37. Annual disbursement of the construction cost for the foreign and local currencies is estimated on the basis of the construction schedule as summarised below:

Year	Foreign Currency (1,000 US$)	Local Currency (1,000 KShs.)	Total Equivalent (1,000 KShs.)
1992	788.72	522	18,663
1993	4,018.99	2,868	95,305
1994	3,279.92	2,524	77,962
1995	0	494,396	494,396
1996	0	815,738	815,738
1997	27,837.86	478,604	1,118,875
1998	24,497.32	485,876	1,049,314
1999	56,095.76	758,533	2,048,736
2000	56,897.22	1,060,239	2,368,875
2001	68,412.71	1,109,614	2,683,106
2002	15,617.79	347,549	706,758
Total	257,446.29	5,556,463	11,477,728

Project evaluation

(1) Economic evaluation

38. Economic viability of the project, in which three components of Magwagwa, Sondu/Miriu and Kano projects are included, was re-assessed by taking into account the

studies carried out after the plan optimization, showing high viability of the integrated development project by a net benefit of US$135.00 million (a discount rate of 10%) and EIRR of 13.54%.

39. Although the Magwagwa project is a component of the integrated development in the Sondu River and the Kano plain, the project is considered to be independently developed as a single purpose project of hydropower generation. In this context, the Magwagwa project was assessed on the condition that energy generated from the Magwagwa power plant excluding incremental benefits from the Sondu/Miriu by installing the Magwagwa is only counted as benefits and that all the construction costs of the Magwagwa dam are borne by the Magwagwa power plant, revealing a net benefit of US$23.56 million for a discount rate of 10% and EIRR of 11.29%. It can be concluded that the Magwagwa project is viable even in developing independently as a single purpose project of hydropower generation.

40. There would be another interest to evaluate viability of serial development of the Sondu/Miriu and the Magwagwa, since the earlier development of the Sondu/Miriu, which is now in the stage of detailed design, is more realistic. The viability of serial development of both projects was verified with a net benefit of US$91.64 million for a discount rate of 10% and EIRR of 13.52%.

(2) Financial evaluation

41. Financial viability of the project was evaluated in terms of the financial internal rate of return (FIRR) applying the conditions of project cost excluding price escalation, average electricity tariff as of November 1990, US$0.060/kWh, and addition of incremental energy generated from the Sondu/Miriu after the completion of the Magwagwa besides energy generated from the Magwagwa itself as benefits, revealing viability with a FIRR of 11.14%.

42. Table S.3 presents an examination of loan repayability based on the foreign loan condition as follows :

- Amount of loan : 85% of total cost
- Interest rate : 2.5%
- Repayment period : 30 years
- Grace period : 10 years.

As shown in the said table, annual balance of the revenue and expenditures of the Project would become surplus from Year 12, when the revenue of the Project is expected to be obtained for the first time. From that year, the revenue would counterbalance the cumulative deficit and get it surplus in Year 29. It is noted that average electricity tariff is fixed at US$0.060/kWh which prevails at the level of November, 1990 and that incremental energy generated from the Sondu/Miriu after the completion of the Magwagwa is included as the benefit of the Magwagwa.

(3) Overall evaluation

43. The Project was assessed viable in economic and financial terms. On the other hand, the project would inundate an area of 26 km^2, resulting in causing an issue to displace some 700 households, or 4,300 people, which would be the most severe impact for the project. To obtain the soundness and acceptability of the project from the social and natural environmental viewpoints besides the technical, economic and financial viability, reasonable and acceptable measures should be taken for the 4,300 people who would involuntarily be displaced from the submerged area of the Magwagwa reservoir.

44. A "land for land" compensation principle is recommended to be applied for the acquisition of land to be submerged in the reservoir area considering the kinship and other socio-cultural factors of the local people, the Kipsigis and the Kisii. A preliminary survey in this study identified six possible resettlement sites, which still require in-depth studies including hearings to local people to assess suitability as the resettlement sites.

45. Finally, institutional set-up is desired to be formulated to handle the resettlement issue as early as possible. KPC is expected to play a role as a pivot agency, and its main tasks will include public relations with the affected people to smoothly carry out the studies and coordination with the required line agencies and ministries.