REPUBLIC OF KENYA

LAKE BASIN DEVELOPMENT AUTHORITY

SONDU RIVER MULTIPURPOSE DEVELOPMENT PROJECT

VOLUME VI

SUPPORTING STUDY REPORT FOR SOCIO-ECONOMY

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JAPAN INTERNATIONAL COOPERATION AGENCY

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P.O. BOX 50572
NAIROBI, KENYA

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TOKYO, JAPAN

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DECEMBER, 1985

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Preface

This appendix presents the full results of basic studies related to overall settings of the Sondu project and frameworks for its evaluation. First in Chapter 1, socio-economic characteristics of the Lake Basin are described to clarify the relative position of the region in the Kenya's socio-economic development.

The subsequent chapters are respectively devoted to different aspects of project evaluation in the "three-way evaluation system": viz. regional development, environmental quality and national economic efficiency. In Chapter 2, the importance of the project is discussed from a viewpoint of regional development, and in Chapter 3 potential environmental problems and effects related to the project are described, including socio-cultural aspect of relocating people in the proposed project site. Chapter 4 is for the presentation of analyses to evaluate what are called "national parameters" to be used in economic evaluation of the project.

Chapter 1. MACRO SOCIO ECONOMIC SETTINGS OF THE LAKE BASIN

1.1 Peoples and Population

1.1.1 Peoples

There exist about forty different tribes and races in Kenya. The ethnic composition of Kenya may be seen from Table 1.1, which presents the population by tribe, race and nationality at the time of 1979 census. The majority of the peoples is broadly divided into three linguistic classes: viz. Cushitic, Nilotic and Bantu (see Figure 1.1).

Although the dominant people in the Lake Basin or the Western Kenya are Nilotic, all the three classes of people are involved to different degrees in the formation of the present ethnic composition in the region. Of course it is beyond the scope of this study to investigate into details of how the peoples in Western Kenya have evolved. However to understand, even to a very limited extent, the evolution and basic lifestyles of the peoples there would help to better comprehend development opportunities and needs in the region.[1/]

The Nilotic-speakers can be divided, according to their general locations of habitation into three groups: Highland or Southern, Plains or Eastern, and River-Lake or Western. They are further classified into several ethnic groups (see Figure 1.2). Most of them are more or less involved in the Western Kenya, but more dominant tribes are the Luo, Kalenjin and Maasai.

The Kalenjin is a collective name for the people who emerged from the incorporation and assimilation of Southern Cushitic-speaking people, who settled in the highlands of Western Kenya by later arrivals, among whom were the Highland Nilotic-speakers. The Kalenjin territory, once reached across the region to the east and the west, and the south of the highlands, gradually decreased as Bantu-speaking population, including Luhya, Kisii and Kuria, were growing in the highlands, and the Nilotic-speaking Maasai in Plains were expanding in a remarkably rapid migratory movement. The Kalenjin still dominant in the region include Kipsigis, Nandi and Sabaot. Also other tribes such as Tugen, Elgeyo, Marakwet and Pokot are marginally involved in the region. General locations of inhabitation by major tribes mentioned above are illustrated by Figure 1.3.

As may be seen from Figure 1.3, the Luo command the largest teritorial area in the region. The Luo constitute the only group of River-Lake or Western Nilotes in Kenya, but the third largest of all the ethnic groups in the country, next to Kikuyu and Luhya (see Table 1.1).

The majority of the River-Lake Nilotes, including the Luo people, are considered to be originally pastoralists, the remnant of which is still seen in their attitude toward cattle, which not only support their economy in many ways but also serve a variety of social functions. With the riverine and lacustrine background, the Luo people were and many of them still are active fisherman. In these days, however, they are largely settled cultivators, growing not only more traditional grains such as sorghum and millet but increasingly more maize and cassava. This basic change in their lifestyles is said to be attributable to several factors.

> ... a progressively increasing population, the limited movement imposed by the boundaries instituted during colonial times, the resulting shortage of land and the introduction of a variety of new crops -- maize and cassava, and cash crops such as sugar cane and cotton -- to supplement the traditional ones of sorghum and millet, brought about the shift in emphasis from pastoralism to agriculture (op. cit.).

Probably this is one of the keys to understand the present status of development in the region and opportunities for the future. That is, there is a good reason to believe that the present relatively low level of development in the region is substantially due to the fact that the peoples there have not sufficiently adapted their traditional pastoral life to the new way of settled life which was partly enforced.

1.1.2 Population

The population of the LBDA area stands at some seven million, which accounts for over 40% of the Kenya's total. The population, its density and growth rates of four districts in the Nyanza Province, the Western Province and also the Kericho district are compared in Table 1.2. As seen from the table, the population density in Western Kenya is much higher than the average in Kenya. Except for Nairobi, the Lake Basin as a whole is the most densely populated region, supported by favourable natural conditions.

The population distribution observed in the region is a result of various factors, including historical evolution of the peoples in Western Kenya as outlined above, the management of the colonial government, climate, endemics and other natural conditions. For instance, the Kericho district, where large tea estates developed in the highlands during colonial times, has comparatively low population density despite its relatively high land productivity. The Kisii district, also in the highlands, represents one of the highest density (395 per km2 in 1979). The population density in the lowlands is still relatively low, except those areas around major towns.

The inter-census growth rates of population, also given in Table 1.2, show that they are considerably lower in Western Kenya than the average growth rate of Kenya. These characteristics may indicate that land resources are already becoming a limiting factor for further development of the area as long as the production activities there stay at the subsistance level.

With already high population density and limited land resources, the population in the Lake Basin appears to be becoming more stable. This may also be a reflection of territorial boundaries among different tribes and clans that have been established in the past decades. Also rural to urban drift of people does not seem to be a major factor, except in the areas around the Kisumu municipality.

These apparent phenomena concerning population in the region, however, do not automatically mean that the mobility of the peoples is low; major population re-distribution is not precluded. In fact, significant intra-region migration has occurred in the past in connection with major development projects - e.g. the Chemelil Sugar Company in Kisumu district, tea plantations in Kericho, Sotik settlement scheme in Kisii and Awendo Sugar Development Project in South Nyanza.

1.2 Economy

1.2.1 GDP/GRDP and Income

The gross domestic product (GDP) of Kenya in the past few years is presented in Table 1.3 by economic sectors. The share of agriculture, forestry and fishery sector has been steadily declining, and in 1983 it accounts for about one-third of the Kenya's GDP. In the meantime, however, the manufacturing sector has not increased its share in any appreciable degree, although the total product in this sector almost doubled in current prices between 1978 and 1983.

Reliable statistics on regional economies are most scarce in Kenya, despite the recent efforts by the Central Bureau of Statistics to compile them. There exist no reliable data on the gross regional domestic product (GRDP) of any region, but the shares of the GRDP in the Nyanza and the Western Provinces in the GDP of Kenya are estimated to be significantly lower than their population shares.

The contribution of the agriculture, forestry and fishery sector to the economy of Western Kenya is estimated to be well over 50 percent. A recent study estimated that the agricultural activities in the Kano Plain area are responsible for some 65 percent of the total products.[2/]

The same study on the Kano Plain estimated the per capita annual income for the area to be 640 Kenya Shillings. Current five-year development plans for the districts in the region provide additional information on the per capita or the household incomes. The Siaya district plan reports that the average income per capita from crop cultivation was estimated to be 617 Shillings in 1982. The Kisii district plan estimated the average household income for the last five-year plan period to be about 6,000 Shillings per annum. The current five year plan of the Busia district, which is comparatively less developed in the Western Province, reports that the annual per capita income in the district, was about 520 Shillings in 1983.

The JICA Study Team presented, at the time of its inception works, a typical farm budget of small holders in the project area. The average gross annual income of a typical small farm household was estimated to be 4,080 Kenya Shillings, consisting of 1,900 Shilling from crops, 1,080 Shillings for livestock and 1,000 Shillings off-farm income.

From the fragmented data and information presented above, the average per capita income in the project area at present seems to be between 1,200 and 1,500 Shillings per annum. This is still considerably lower than the average figure for the whole of Kenya, which is estimated to be 264 U.S. Dollars or about 3,500 Kenya Shillings in 1983.[3/]

1.2.2 Agriculture and Other Primary Production Sectors

A variety of crops are cultivated in Western Kenya, favoured with fertile highlands in the east, flat plains in the west and rich water resources. However, most food crops are grown by small scale farmers under rather primitive farm practices with little application of fertilizers and chemicals. The productivity is naturally low for these crops; average figures are 2.5 ton/ha for maize, 1.1 ton/ha for sorghum, 0.9 ton/ha for sweet potatoes and 0.7 ton/ha for bean. On the other hand, greater parts of cash crops are cultivated in large scale under modern and intensive farming techniques. Food crops grown in the region include maize, sorghum, millet, rice, potatoes, cassava and beans, and dominant cash crops are coffee, tea, sugarcane, cotton and sisal.

Planted areas and production of selected crops are presented in Table 1.4 in order to see the position of the region in Kenya's agricultural activities. The production of maize in the region accounts for about a half of total production in Kenya, indicating the position of the region as a potential granary for the country, especially in view of still low productivity mentioned above.

Production of two major cash crops in the region, viz. cotton and sugarcane, has been increasing rapidly in recent years due to the existence of processing plants in the region and promotion policies taken by LBDA. Both crops now claim major shares in Kenya's total production (see Table 1.4). The region contributes about 400,000 metric tons of white sugar to the country's total of some 460,000 metric tons.

Activities in other primary production sectors, including livestock, fishery and forestry, are comparatively more important in Western Kenya than other regions. The importance of livestock and fishing activities is attributable primarily to cultural heritage of the dominant population in the region as mentioned in the previous chapter.

Table 1.5 summarizes the fishing activities in Kenya. As seen from the table, the total catch of Lake Victoria fisheries has been rapidly increasing to account for over 80 percent of fresh water fish production in Kenya in the past few years. There is an evidence, however, the lake fish has been over-exploited in the past few years, and the sustainable maximum yield may be around 40,000 tons per year.

Fishing activities in the region are gaining momentum recently. LBDA has initiated a few programmes with the financial and technical cooperation of international aid organizations to increase inland fish production by rehabilitating existing fish ponds and establishing new fish farms. Targets set by the current five-year development plan (1983-88) are as follows.

(1) Rehabilitation of existing fish ponds 3,000 ponds/year x 5 x 500 m2 - 750 ha Production target 4 tons/ha	3,000 tons/year
(2) Riverine fisheries	3,500 tons/year
(3) Commercial fish farms 5,000 ha Production target 5 tons/ha	25,000 tons/year
(4) Fish fry production centers 1,700 ha Production target 5 tons/ha	8,500 tons/year
Total by 1988	40,000 tons/year

Source: LBDA, Five Year Development Plan 1983-88

Thus the region is likely to remain a chief supplier of fresh water fish in Kenya, probably with increasing margins for inter-region exports.

1.2.3 Other Sectors

Gold and associated minerals were extensively mined in Western Kenya in the 1930's by small-scale operators. Gold is still considered to offer the foremost mineral development potential and easy to develop of all the mineral resources from technical point of view. There are several promising reserves identified in South Nyanza, Kisii, Kakamega and Siaya districts as well as many small deposits.

It is reported that there exist promising mineral deposits of various types, both metalic and non-metalic within the LBDA area. They include the following.

- Copper, cobalt and base metals
- Radio-active minerals, rare earths and niobium
- Kisii soapstone
- Limestone, and gypsum
- Apatite (for fertilizer)
- Sulphur (for sulfuric acid)
- Brick earths and clays
- Iron and Manganese
- Graphite
- Tin

A preliminary exploration is currently going on in a few areas in the South Nyanza District.

Existing agro-industries include coffee processing, flour mills, dairy factories, sugar factories, jaggeries, cotton mills, tea factories and recently inaugurated breweries. Most manufacturing establishments are of a small/cottage industry type. There exist only a few major factories - viz. Kisumu Cotton Mills, six sugar factories, Panafrican Paper Mill at Webuye and Kenya Breweries in Kisumu. The six sugar factories employ over 20,000 people in total.

Tourism is another sector that is important for the development of the area due to the climatic conditions, the vicinity to Lake Victoria and a few other major tourism objects. The area is also located in a strategically important position, being central in the East African Community, which may be reformulated after opening-up of borders with Uganda and Tanzania in 1983.

1.3 Relative Position of the Lake Basin

The foregoing descriptions and analyses, though sketchy, illustrate the relative position of the Lake Basin area or the Western Kenya as compared with Kenya as a whole. Favourable factors that the region has include the following.

(1) Water and related land resources

Table 1.6 shows area by province and district of different classes of agricultural land assessed based on the average annual rainfall. As seen from the table almost the entire land area of the Nyanza and Western Provinces is classified as either high or medium potential, while in Kenya as a whole only 19% of the land area is ranked as high or medium potential. Soil conditions are also generally favourable for cultivating one or more crops.

(2) Human resources

The large population itself is a potential benefit for the development of the region. Moreover the population is comparatively evenly distributed with a few relatively small population centers. This is also a favourable factor for balanced development.

(3) Other factors

As outlined in the previous section, the region is rich in mineral resources of various kinds. Other favourable factors, also mentioned already, include the central location in the defunct but to-be-reborn East African Community, the vicinity to Lake Victoria and existence of a few major tourism objects.

Despite these favourable factors, Western Kenya has remained to be a less developed region in Kenya. This may be primarily due to the following.

(i) Peripheral location in the country -- especially remoteness from the coastline, which caused high transportation costs of imported goods including petroleum

(ii) Insufficient public investment in the past, which caused the delay in infrastructural development

(iii) Colonial policies for land use and settlement, which hampered the adaptation process of the people to changing environment

Increasing attention is now directed to this region by the Kenyan Government. This is quite natural and sensible, considering the high development potential of the region is recognized. The region, in fact, holds a key to the balanced development of Kenya.

Chapter 2. REGIONAL DEVELOPMENT AND THE SONDU PROJECT

2.1 Regional Development Policies

The long-term development objectives of Kenya have in substance remained unchanged since the independence and continue to provide guidelines for the formulation of development policies and strategies. They include sustained economic growth and equitable development as well as other objectives related to basic human needs and socio-cultural ideas. Particular development policies and strategies, however, are necessarily geared to emerging problems and needs. Also the progress itself requires changes in emphasis, such as the higher priority accorded to rural development vis-a-vis the progress in urban development.

The Kenyan Government has been placing increasing emphasis on regional balance in the country's socio-economic performance, as the overall development of its economy steadily progresses. This is not only in accordance with the Nation's long-term objective of equitable development, but also based on the unerring recognition that the full realization of development potentials in relatively less developed regions could contribute to other objectives including food self-sufficiency, diversification of economy and improvement of export performance.

As a strategy to realize the idea of regional balance, the responsibility for planning and implementing rural (or equivalently regional for this matter) development is being shifted from the headquarters of ministries to the districts. This strategy, now known as the "District Focus for Rural Development," was at first naturally no more than mere rhetoric, but is now becoming more and more substantial, as reflected for instance in the improvement of district development plans from the past to the current five-year plan periods.

Another major organizational strategy taken by the Kenyan Government for regional development is the establishment of regional development authorities. Following the Tana River Development Authority (now amplified to become the Tana and Athi Rivers Development Authority), the Kerio Valley and the Lake Basin Development Authorities were established in 1979 by Acts of Parliament. The main objective of these authorities is to plan, to coordinate and to implement development project in the respective catchment areas.

These regional development policies are most straightforwardly and succinctly expressed in the main theme of the current five-year development plan (1984-88): "mobilization of domestic resources for equitable development." Among the sub-themes of equitable development are the provision for basic human needs, rural-urban balance and regional balance. Moreover, the plan stipulates the consolidation of regional development authorities with further delegation of authority and responsibilities.

More particular emphasis is placed in the current five-year plan on the development of Western Kenya, which is worth a special reference here.

> Somewhat greater emphasis will continue to be given to urban and rural development in western Kenya including all of Western and Nyanza Provinces and the Districts of Kericho, Nandi, Trans-Nzoia and Uasin Gishu in the Rift Valley Province. This area has great agricultural potential and a large population but has lagged behind the development of other areas. The key cities marked for concerted effort are Kisumu and Eldoret, both lying on the main East-West axis. As these municipalities grow, they will provide a base for the development of related metropolitan centres, such as Kakamega, Kitale, Bungoma, Kericho and Kisii. As the social and economic infrastructure in and around these centers develops, the opportunities for rural development in the areas they serve will also expand. Indeed, rural and urban development are interdependent.

2.2 LBDA and Its Five-Year Plan

2.2.1 Lake Basin Development Authority

The Lake Basin Development Authority (LBDA) is a statutory organization established in 1979 by an Act of Parliament for the purpose of planning and coordinating the implementation of development projects in the Lake Victoria catchment area. The functions of the Authority are cited from the Act as follows.[5/]

(1) To plan for the development of the area and initiate project activities identified from such planning in the development area through the Government generally;

(2) To develop an up-to-date long range development plan for the area;

(3) To initiate such studies, and carry out such surveys, of the area as may be considered necessary by the Government or the Authority, and to assess alternative demands within the area on the natural resources thereof, including agriculture (both irrigated and rainfed), forestry, wildlife and tourism industries, electric power generation, mining, and fishing, and to recommend economic priorities;

(4) To co-ordinate the various studies of schemes within the area such that human, water, animal, land and other resources are utilized to the best advantage and to monitor the design and execution of planned projects within the area;

(5) To effect a programme of both monitoring and evaluating the performance of projects within the development area so as to improve such performance and establish responsibility therefore, and to improve future planning;

(6) To co-ordinate the present abstraction and use of natural resources, especially water, within the area and to set up an effective monitoring of such abstraction and usage;

(7) To cause and effect the construction of any works deemed necessary for the protection and utilization of the water and soils of the area;

(8) To ensure that landowners in the Area undertake all the measures specified by the Authority to protect the water and soils of the area;

(9) To identify, collect, collate and correlate all such data related to the use of water and other resources and also economic and related activities within the area as may be necessary for the efficient forward planning of the area;

(10) To maintain a liaison between the Government, the private sector and other interested agencies in the matter of the development area with a view to limiting the duplication of effort and to ensuring the best use of the available technical resources;

(11) To examine the hydrological effects and the subsequent ecological changes on the development programmes and evaluate how they effect the economic activities of the persons dependent on river and lake water environment;

(12) To consider all aspects of the development of the area and its effects on the lake inflow and outflow;

(13) To monitor the operations and provide technical reports on the operations of any agreement or other arrangements between Kenya and other states relating to the use of the waters of Lake Victoria or of the River Nile.

The jurisdiction of LBDA as the entire catchment area presupposes the importance of water resources management for the region's development, in all its aspects including irrigation, hydropower generation, flood control and water supply.

2.2.2 Five-Year Development Plan

LBDA is in the middle of implementing the current five-year development plan (1983-88), the first substantial one since its inception. The current plan places much emphasis on the increase in food production with a view to achieving regional food balance and providing raw materials for agro-industrial processing and surpluses for export outside the region.

There exist numerous projects of various kinds planned or implemented in the region under the five-year plan. The on-going projects are relatively of small scale but cover a wide range of sectors, reflecting the aspiration and realism of this young organization. they include upland rice cultivation, bee keeping, horticulture project, rehabilitation of fish ponds, bricks and roofing tiles manufacturing, shallow wells development for domestic water supply, public health projects and several others.

Long-term projects are naturally more ambitious, including large- and small-scale irrigation, many industrial projects, fisheries development as well as other infrastructure projects. Of them, the top priority seems to be given to the Sondu/Miriu multi-purpose development project, as the synopsis of the five-year plan issued in January 1984 starts with this long-term project. Major infrastructure and agricultural projects included in the five-year plan are illustrated in Figure 2.1.

The current Five-Year National Development Plan takes note of the importance of the regional development authorities as well as the importance of Western Kenya as already mentioned. Specifically concerning the power development, the plan stipulates the following.

"There will be an expanded role for Regional Development Authorities in electrical facility planning, development and generation. The KP&L will have transmission and distribution responsibilities, while the Ministry of Energy and Regional Development will provide policy guidance."

2.3 Importance of the Sondu Project for Regional Development

2.3.1 Constraint to Development

As outlined in Chapter 1 of this appendix, the Western Kenya is still one of comparatively less developed regions in Kenya, despite the recent efforts for development. There are a few major constraints to the development that the people in the region and LBDA are trying to overcome in cooperation with the central government paying increasing attention to the region.

The highlands of Western Kenya are densely populated and extensively cultivated, resulting in deforestation and land erosion, while the low-lands have been susceptible to floods during rainy seasons, which do not preclude occasional shortage of water in dry seasons. Although the region is endowed with rich water resources, the lack of proper management of these resources and watersheds is still a major constraint to the development.

The region is endowed also with large areas of fertile soils, and the climate is generally favourable for agriculture. At present, however, a major part of the region's agriculture stays at the subsistence level due to rather less advanced farming techniques and the lack of appropriate infrastructure such as improved feeder roads and storage facilities as well as irrigation and drainage.

Establishment of more agro-related industries and expansion and consolidation of existing ones are hampered by insufficient supply of inputs. Other than agricultural products themselves, the most essential input in short supply is electricity. Another essential input is fuel, whilst high transport costs of petroleum from Mombasa certainly constitute another major constraint to the industrial development in the region. In this respect, the substitution of energy sources for some industrial processes by electricity poses good prospects.

A fundamental and long-term solution to this problem may be found in an improved transportation network with railways and navigation on Lake Victoria as well as roads, which would expand the supply and demand areas for the region. Also proper institutional and policy measures have to be taken to complement such public investment and make the most of the infrastructural development.

2.3.2 Development Potentials and the Project

As described in Chapter 1, the Lake Basin area has fairly good potentials for development in view of its resource endowments including soils, water, fish stocks and minerals as well as human resources and its geographic location itself. What is required is an initial breakthrough, and the Sondu multi-purpose project would serve just as such a trigger.

First the electricity to be generated by the project will add to comparative advantages of the region for future industrial development as well as serve for domestic uses. Also the increase in agricultural production as a result of project implementation will expand and consolidate the bases for establishing agro-related industries of various kinds.

As part of the present study, some of the prospects for such industrial development were investigated in cooperation with the LBDA staff. The result indicates that potential industrial projects may be more diversified than those included in the five-year plan of LBDA. Table 2.1 summarizes the prospective industrial development projects, some of which will be benefitted more from improved power supply capacity. For those electricity-intensive projects that have high probability of being established in the next decade or so, power requirements are roughly estimated as presented in Table 2.2.

Secondly the project will provide opportunities to improve farming techniques. As stated in Chapter 1, the region's agriculture largely stays at subsistence level, but high potentials exist for expanding agricultural activities of various kinds. Especially potentials for irrigated agriculture are estimated as follows.

River basin	Location	Estimated irrigation potential (ha)
Nzoia	Middle/lower reaches	65,000
Yala	Yala swamp	15,000
Sondu/Nyando	Kano Plain	60,000
Kuja/Migori	Lower reaches	25,000
Mara	Upper reaches	20,000
Other	Many small areas	15,000
	Total	200,000

Source: LBDA, Five-Year Development Plan, 1983-88

Some areas may be better irrigated by pumping, making use of secondary energy of the Sondu project. Expanded farm lands, with better irrigation and drainage and protection against floods will allow more intensive farming practices to take place, if combined with improved provision of infrastructure and extension services. Irrigated agriculture under the Sondu project may prove to be a model case for such new farming practices.

Another important effect of the project is foreseen on geographic distribution of population. If the lowlands in the region are developed so that they can sustain larger population and more economic activities, the people now living on highlands or hill slopes will be able to settle in the lowlands. This will in turn, prevent the encroachment of highlands and hill slopes by inappropriate farming practices such as shifting cultivations. Then a favourable effect is expected on the Sondu project being planned with improvement of its watersheds.

The Sondu multi-purpose development project with its outputs of electricity and agricultural products would significantly contribute to the improvement of financial and project implementing capability of LBDA. This will in turn help the Authority to embark upon other investment projects - major ones related to infrastructure as well as industrial projects listed in Table 2.1.

Chapter 3. ENVIRONMENTAL ASPECT

3.1 The Present Environment

3.1.1 Population

The Sondu basin is divided into nine sub-basins as shown in Figure 3.1. Population and population density of each sub-basin are shown in Table 3.1. The total population of the Sondu basin is 510,553 in 1979 and increased by some 50 percent in 17 years as shown in Table 3.2.

In population density per km2, the Upper Sondu basin has the highest number of residents, 353, followed by the Lower Sondu basin, 268 and the Kabianga basin, 221. The Upper Itare basin has the lowest population density of 53. The average over the basin is calculated to be 142 person in 1979 which is lower than that of 217 in Kisumu district but is higher than that in South Nyanza district, 136.

The Sondu basin has the annual growth rate of 2.64% from 1969 to 1979 which is lower than that in Kisumu district of 4.10% and of 4.33% in South Nyanza district. The Upper Sondu basin has also the highest annual growth rate, 3.72%.

3.1.2 Land Use

The present land use pattern in the Sondu basin is shown in Table 3.3 according to the four categories used in Integrated Land Use Survey; viz. Agriculture, Infrastructure, Natural Vegetation and Miscellaneous.

In the Sondu basin, natural vegetation (48%) and agricultural land (46%) occupy most part of the land. In sub-basins, the percentage of natural vegetation is high in Upper Itare, Lower Itare, Kitoi and Sondu/Miriu Delta, and the percentage of agricultural land is high in Kabianga, Sisei, Kipsonoi, Upper Sondu and Lower Sondu.

Sub-basins of high percentage of tree canopy among natural vegetation are Upper Itare, Lower Itare, Kitoi and Kipsonoi, where the South Western Mau Forest is located, and these sub-basins occupy 88% of all tree canopy in the Sondu basin.

Among agricultural lands, 53% of the area is cultivated actively and 37% is managed pasture in the Sondu basin.

3.1.3 Economic Activities

The economic structure of the study area can be categorized in three:

(1) the primary sector composed of agriculture, livestock production, forestry and fishing.

(2) the secondary sector composed of manufacturing and mining.

(3) the service sector composed of the public administration, business and commerce.

Agriculture

Identified crop fields are 66,257 ha (shown in Table 3.4); maize and sorghum take 41% and tea 39% followed by wheat/barley/oats, banana, sweet potato, and sukumawiki.

In the Lower Sondu basin, where a dam site is located, maize and sorghum takes 23%, the largest area of all the identical crop fields, followed by banana (22%), sweet potato (17%) and coffee (12%).

Livestock production

Numbers and distribution of grade cattle (improved cattle), local cattle (unimproved cattle), sheep and goats, and donkeys of the Sondu basin are shown in Table 3.5. Total livestock units were calculated using the following multipliers:

grade cattle	* 1.00
local cattle	* 0.65
sheep and goats	* 0.15
donkeys	* 0.45

The Sisei basin has the highest livestock units density per km^2, 137, followed by the Kabianga basin, 113 and the Kipsonoi basin, 95. The lower Sondu basin has 62 of the livestock unit density, mostly of local cattle.

Service centres

Service centres are classified into four ranks: viz. principal towns, urban centres, rural centres and market centres as shown in Table 3.6. There are two urban centres, four rural centres and eight market centres in the Sondu basin.

Market centres will serve approximately 15,000 rural people in the surrounding hinterland and support both primary schools and a junior secondary school and also a health centre with family planning service. Rural centres will serve an area populated by approximately 40,000 people and have a residential area of 2,000 to 10,000 inhabitants. Urban centres will serve a rural hinterland of 100,000 to 150,000 people and become core of commercial, industrial, administrative, recreational and social services required by the rural population.

3.1.4 Ethnicity

The main tribes in the Sondu basin are Kipsigis belonging to Southern Nilotes distributed in upper areas from Sondu village and Luo belonging to Western Nilotes distributed in lower areas. Kisii, belonging to Bantu Speakers is distributed in the highland areas among Kipsigis, Luo and Maasai, and constitutes south-western part of the Sondu basin (see Chapter 1 for more details).

The ethnic structure in Lake Victoria basin is such that Luo has the highest percentage, 33.1%, followed by Luhya 31.6%, Kisii 15.3% and

Kipsigis 10.2% (1969).

3.1.5 Public Health

Most of the diseases afflicting many Kenyans today are either communicable or due to poor nutrition. Out-patient morbidity in Kisumu and South Nyanza districts is indicated by Table 3.7. The most prevalent disease in both districts is malaria that accounts for 32.9% in Kisumu district and 34.8% in South Nyanza district of the total new cases. Besides malaria, acute respiratory infections and diarrhea diseases have high infection percentage.

The most probable and suspected endemic diseases in study area for the hydro-electric and irrigation projects are:

(1) Malaria
(2) Schistosomiasis (S. haematobium and S. mansoni)

Malaria

Malaria is a disease transmitted from person to person by certain species of mosquito of the genus Anopheles as shown below and causes acute bouts of fever which recur at intervals. Malaria in man is caused by four species of protozoal parasite:[6/]

		Reproductive potential			
Disease	Vector or intermediate host	Number of eggs	Egg-to-egg cycle	Number of broods	Life-span
Malaria	Anopheles	200	10-14 days	6-10	20 weeks

Preferred behaviour			
Feeding time	Resting place	Source of blood	Flight of dispersal range
Night	Indoors and outdoors	Man and animals	1.5 km

Plasmodium falciparum - causing falciparum malaria especially in the humid tropics where transmission is possible all year round. This is the most serious form, and may be fatal.

Plasmodium vivax - causing vivax malaria especially where due to a pronounced dry or cool season, transmission is seasonal.

Plasmodium malaria - causing quartan malaria. It has a patchy distribution in the tropics and subtropics.

Plasmodium ovale - causing ovale malaria; uncommon and found mainly in West Africa.

By far the most common and serious malarial infections are caused by P. falciparun and P. vivax.

WHO reports that the spreading area of malaria should be divided into Endemic area, Epidemic area, and No-Epidemic area, and that Endemic area should be graded into four ranks.

The most spreading area is called "holoendemic". In such an area, the spleen of more than 75% of children who are 2 - 9 years old are swollen due to malaria (it is "spleen rate"), and the suffering period by mosquitoes is through almost the year round, at least more than six months, and though children there may suffer from malaria, adults suffer from it so frequently and are in so much semi-immune condition, that they seldom suffer even if there is parasite in their blood.

The secondary spreading area is called "hyperendemic" and spleen rate is 50-74%. The spreading period is influenced by rainy season and lasts about 3-6 months.

In the mesoendemic, spleen rate is 10-49% and the spreading period is less than three months. In the hypoendemic, the spreading period is less than 10% and spreading seldom occurs except near rivers. Epidemic is the area where malaria not always occurs but spreads through mosquitoes coming from other areas.

Table 3.8 and Figure 3.2 show that the area along Lake Victoria has the highest incidence in Kenya. Table 3.9 shows out-patient morbidity of malaria and schistosomiasis per 100,000 of population in Kisumu and South Nyanza districts and surrounding Provinces. Nyanza Province has many out-patients especially in Kisumu district, compared with surrounding Western and Rift Valley Provinces. According to annual reports, the number of deaths by malaria in Nyanza Province was 100 in 1981, 71 in 1982 and 141 in 1983.

Under sponsorship of the WHO, a survey of the A. gambiae complex at Kisumu was conducted during November 1970. Figure 3.3 and Table 3.10 show the status of differential geographical distribution of A. gambiae sibling species in South Nyanza. Hut indices of A. gambiae females averaged 1.0 along the lakeshore, 3.2 in general parts of the valley, 71.0 in irrigated areas, 2.8 along the lower foothills and 4.6 in the highlands.

Schistosomiasis

Schistosomiasis, also known as bilharzia, is an important disease whose vector is not an arthropod, but an aquatic snail. Schistosomiasis in man is mainly caused by one of four species of trematode worms.[6/]

Schistosoma japonicum - found in East Asia and the Philippines and infecting domestic and wild animals as well as man.

Schistosoma mansoni - found in Africa, the Middle East, South America, and the Caribbean and infecting man and some animals.

Schistosoma haematobium - found in Africa and the Middle East and rarely infecting animals.

Schistosoma intercalatum - found in Cameroon, Congo, Gabon, and Zaire.

Among these kinds, schistosoma mansoni and schistosoma haematobium are distributed in the study area (Figure 3.4). Man excretes schistosoma egg in his faeces (s. mansoni) or in his urine (s. haematobium). These eggs must find water where they will hatch into miracidia. These tiny swimming organisms will locate and infect an aquatic snail of a particular species as follows:[6/]

Schistosoma mansoni mainly infecting snails of the genus Biomphalaria, and

Schistosoma haematobium mainly infecting snails of the genus Bulinus.

The different snail species prefer different habitats, but very roughly speaking Bulinus species prefer still or very slowly moving water and are often found in small pools and water holes, whereas Biomphalaria can live in gently flowing water and tend to occur in streams and irrigation systems.

Some time after infection, the snail will shed many cercariae which will re-infect man through his skin when he is in water or, less commonly, when he drinks infected water.

The percentage which schistosomiasis occupies in the out-patient morbidity are 0.2% in Kisumu district and 0.4% in South Nyanza district (Table 3.7). These percentages are small in number, but compared to Western and Rift valley Province, they are comparatively large.

According to annual reports, no people died of schistosomiasis both in 1982 and in 1983.

3.1.6 Climate

A wide range of difference in elevation of the Sondu basin is also reflected in the pattern of rainfall as shown in Figure 3.5. Rainfall is marked by a variation from under 1,000 mm in the warmer and low lying areas around the lake shore to well over 1800 mm in the higher areas. Average annual rainfall in the Sondu basin is about 1,540 mm and geographic distribution of annual rainfall is as shown in Table 3.11. The monthly and annual rainfall at typical stations is as shown in Table 3.12.

3.1.7 Soils

Soils in the Study area are broadly classified into two categories according to physiographic conditions; one extending over volcanic footridges and upper middle-level upland, and the other extending over lacustrine plains.

The soils in the former category are developed on tertiary or older basic igneous rocks such as basalts, olivine basalts and nepheline phonolites. Main types of soils are humic nitosols, ando-humic nitosols and humic cambisols based on the FAO-Unesco soil classification system. Humic and ando-humic nitosols have characteristics of well drained, extremely deep, dark reddish brown to dark red, friable or friable and smeary clay. Humic cambisols have properties of well drained, shallow to moderately deep, friable, clay loam to clay. These soils are with an acid humic top soils.

The soils in the latter are developed on sediments from lacustrine mudstones. Main soil types are pellic vertisols and chromic vertisols. Pellic vertisols are poorly drained, very deep, very dark grey to black, very firm, slightly sodic, cracking clay with a calcareous deeper subsoil. Chromic vertisols are poorly drained, shallow to deep, very dark brown to very dark grey, firm to very firm, slightly sodic, cracking clay. The soil map mentioned above is shown in Figure 3.6.

3.1.8 Water Quality

Water quality data on Nzoia and Nyando River are available up to 1957 from Monitoring Programme of the Water Quality and Pollution Control Section in the Ministry of Water Development. As there were no existing data on the Sondu River, a survey was carried out at this time at the points as shown in Figure 3.7. The results of the analysis are presented in Table 3.13.

The Sondu River shows red brown colour with high turbidity. Concentration of dissolved oxygen is found at almost saturation level. Concentration of nitrate-N is comparatively high.

The analysis of chemical property indicates water quality in the Sondu River is suited for irrigation.

3.1.9 Vegetation

Natural vegetation covers 48% of the Sondu basin as shown in Table 3.14. The main subdivisions of natural vegetation are trees (occupying 22% of the Sondu basin), bushes (9%) and herbaceous (17%).

The area with high natural vegetation cover extend around Mau Forest in Upper Itare, Lower Itare and Kitoi as shown in Figure 3.8 and Table 3.15. This represents the best virgin forest remaining in the whole of Kenya, of which the conservation is of utmost importance. The central portion of Kericho District have low natural vegetation cover, as it consists of areas of high agricultural intensity. The Sondu delta has high natural vegetation cover, but have low woody cover (trees and bushes) as shown in Figure 3.9.

Figure 3.10 shows sectional illustration of vegetation in Gari and dam site. Figure 3.11 shows trees known to grow in each climate type in Kenya.

The Vegetation Assessment of Kisii District (elevations: 1,500 - 1,980 m) which constitutes a part of the Sondu basin, describes herbaceous, bushes and trees there as follows.

Herbaceous plants

Several species appeared to be selectively and continuously used to mark boundaries or to make hedges: Plectranthus sp., Solanum sp., Tithonia diversifolia, Acacia sp. (recurved thorns), Lantana camara, among others. T. diversifolia and L. camara are introduced species and in some areas are becoming dominant and undesirable.

The most common herbaceous weed was Tagetes minuta (Mexican marigold) and was found in cultivated fields. Nicandra physalodes was only seen in one field situation; however, in this instance it was a thick stand and appeared very aggressive. This too is an introduced species. Other herbaceous weeds, other than grasses, fairly common in areas left for grazing were: Conyza floribunda, Crassocephalum Vitellnum, Datura stramonium, and Solanum incanum. The last two species tended to be more common in drier areas.

Species that were less common but occurred throughout the District included: Gutenbergia cordifolia, Leonotis nepetifolia, Crassocephalum montuosum, and Aspilia mossabicensis.

Two species that were herbaceous woody perennials and used for rope and firewood were: Pavoria urens and Triumfetta villosa. The latter is usually found only in wet or swampy areas whereas the former is found in a wider range of environments.

Two species were collected that were of food value: Amaranthus dubius, whose leaves are eaten and Eleucine coracana, whose grain is eaten. The latter is finger millet or wimbi (Swahili) and is locally ground and made into a porridge. Seeds are supplied and distributed locally as well.

Imperata cylindica was originally a native species and now is cultivated in small areas as a source of thatch. It grows well in various environments, i.e. low and high altitude and low and high rainfall. Several Cyperus spp., that are used for thatching as well as grazing, occurred commonly in wet, swampy areas. Loudetia kagerensis grew only on hilltops and in higher areas along roadsides.

Shrubs (Bush)

Most shrub and tree specimens were found along roadsides and boundaries between fields. Less frequently they were found in unmanaged areas or areas left for grazing. There were no large areas of 'virgin vegetation' found. At first glance, the relative abundance of these shrubs appears to be low; however, the actual amount of space devoted to hedgerows may be substantial.

Shrubs that were found occasionally in all environments were: Vanqueria acutiloba, Bridelia micrantha, Bridelia tensisfolia, Parinari curatellifolia, Ficus valle-choudae (also along rivers), Sida cunefolia, Ocimum suave, Cassia didymobotrra. Four shrubs with coppicing ability were: V. acutiloba, B. micrantha, B. tensisfolia, and P. curatellifolia.

There were several shrubs primarily seen only in the drier areas. Four of these species are used in basket making (winnowing, carrying, and grain stores): Sida sp., Indiofera sp., Sida cunefolia, Lantana camara. Four other species found occassionally in the drier areas were: Pittosporum mannii, Sesbania sesban, Vernonica auricilalifera, and V. amygdalina. Bovetta ternifolia was found only along stream beds.

Trees

The relative abundance of trees compared to shrubs is low. Specimens were gathered from roadsides, along streams and from fields. Several species were relatively rare: Kigelia africana, Sapium ellipticum, Ficus campensis, and Vitex doniana.

Several shade or ornamental trees were solitary but planted over many environmental conditions: Grevillea robusta, Markhamia platycalyx, Spathodea campanulata, Croton macrostachyus, Acacia mearnsii (more abundant), and Erythtina abyssinica. Other trees seen only occassionally in several environments were: Abizia grandibracteata, Cordia abyssinica, Combretum molle.

Trees providing edible fruit included: Psidium guajara, Ficus campensis, Kigelia africana, Vitex doniana, Vangueria acutiloba. Because these trees were found so infreqently, it was difficult to get an adequate feeling for their preferred habitat.

The Settlement area was ecologically different. Several species found only here were: Acacia lahai, Acacia sp., Catha edulis, Clerodendrum cordifolium and Ficus campensis.

3.1.10 Wildlife

There exist no data available on wildlife of the Sondu basin. Hearings from the local people around dam site indicate, the principal wildlife include the following.

Mammals		Reptiles	
ENGLISH	LUO	ENGLISH	LUO
Bushbuck	Ngao	Lizard	Ogwe
Antelope	Mwanda	Monitor	N'gech
Monkey	Onger	Crocodile	Nyan'g
Rabbit	Apvoyo	Cobra	Rai
Sacred Baboon		Python	Ngielo
Squirrel		Blackmamba	Rachier
Rat		Brownmamba	Olueru

3.1.11 Fishes and Fisheries

Physical features

The Winam Gulf is a shallow bay that lies at an altitude of 1,134 m on the northeast shore of Lake Victoria as shown in Figure 3.12. It extends 60 km into the Nyanza Province, covers an area of approximately 1,920 km^2, has a mean depth of 6 m, and an average secchi disc reading of 1.0 - 1.5 m. The Gulf reaches up to 30 km in width but is joined to the main lake by a narrow (6 km) strait. It developed on a mid-Pleistocene lacustrine bed and the bottom consists of mud, sand, gravel and rock. It may once have been detached from Lake Victoria, but later joined the lake through vulcanism, faulting, and tilting. The northern shore is generally rocky and steep, while the southern shore is flat and swampy. The Nyando and Sondu rivers are the major sources of water to the Gulf, but subsidiary inflows come from smaller rivers that drain the Nandi and Kisii Highlands.

Aquatic fauna

Lake Victoria has representatives of five orders, thirteen families, twenty-eight genera, and over 200 species. Since fishes do not recognize political or administrative boundaries, all the species of fish present in Lake Victoria are also present in the Winam Gulf. The species are too many to list by name. It is sufficient here to indicate as per Table 3.16 representing the most important groups giving the scientific names as well as the English and local names where applicable. All the species of fish present in Lake Victoria are edible.

The Lake has a Nilotic fish fauna with a degree of endemism. During 1951/54 four non-endemic Tilapia species were introduced in Lake Victoria. Tilapia niloticus and Tilapia leucosticus were from Lake Edward in Uganda. Tilapia zillii a native of Lake Albert in Uganda was also introduced during the same period. Tilapia rendalli a fish found in Lake Malawi and other southern African waters and a close relative of Tilapia zillii also escaped into Lake Victoria from fish ponds near Kisumu.

For Lake Victoria, another development of considerable significance was during the period 1962/63 when the predator fish Lates niloticus, the Nile perch was introduced in Lake Victoria from both Lake Albert, Uganda and Lake Turkana, Kenya (the first introduction in May 1962 at Entebbe). Nile perch is the largest of all African freshwater fish. The heaviest recorded weight is 160 kg, but fish of 50 kg are common.

Fisheries

The Winam Gulf has 200 species of fish some of which have only recently been introduced into Lake Victoria from other waters. The fishing industry currently supports a fishery of 4,000 fishing canoes with about 25,000 fishermen. The fisheries are mainly exploited by traditional and artisanal fishing methods:[7/]

- gillnets usually set overnight as a wall of netting in which the fish become entangled,

- beach seine "nets" which surround the fish and pulled into sandy beaches.

- mosquito seine nets (acting as ring nets) which encircle the fishes and pulled into a boat,

- hooks on long lines with live or artificial baits for catching fish.

- Barriers set across river mouths fitted with non-return basket traps to catch migrating fishes which go up the rivers to spawn,

- a whole host of traps using ingenious devices for catching fish.

Table 3.17 supplied by the Fisheries Department indicates that fish catches from Kenya waters of Lake Victoria have increased year by year. On the other hand qualitative overfishing has occurred continuously in the Winam Gulf as shown in Table 3.18.

Two indigenous species of Tilapia namely Tilapia esculentus and Tilapia variabilis, previously the mainstay of the fishing industry and the fishes of greatest commercial importance, have virtually disappeared from the Winam Gulf. Numerous other fish species have also declined drastically, especially Haplochromis, Labeo, Barbus, Mormyrus, Schilbe, Synodontis, Bagrus, Clarias, Alestes and Protopterus.

Lates and Engraulicypris recorded the highest landing of 68.9% and 21.6% respectively whereas Tilapia species accounted for only 5.6% in 1983.

The riverine fishery is based on the species of fish that travel upstream to spawn during the rainy season especially when the rivers are in flood. During the rains, the rivers bring a flush of rich nutrient materials into the lake providing more food resources in the sublittoral zone.

Some of the fishes in the Winam Gulf especially Barbus, Labeo, Alestes, Clarias and Schilbe migrate upstreams when the rivers are in flood, and *breed in them and return with the young fish to the lake as* the water level of the rivers drop. The breeding seasons of these fishes are determined by the rainy season and more clearly marked than those fishes that live permanently in the lake where conditions are more static or uniform.

In addition, there are other numerous small rivers that drain into the Lake and contain fish especially during the rainy seasons. At the moment there are no reliable statistical data on the annual harvest from all the rivers, but it is estimated that about 1,000 tons of fish per annum are caught, and an understanding of the biology of these anadromous fishes is of considerable practical importance.

3.1.12 <u>Nature Conservation</u>

Gazetted and Ungazetted Forest areas in the Sondu basin are as shown in Figure 3.12. Gazetted Forests are South-Western Mau, Western Mau and Trans-Mara, in the upper reach areas of the Sondu basin as shown in Table 3.19. Ungazetted Forests are Koguta and Miriu near the dam site as shown in Table 3.20.

3.2 Assessment of Environmental Impact

An environmental impact assessment was carried out in and around the project area of the Sondu River Multipurpose Development Project.

The objective of the assessment was to predict on a preliminary level possible effects of implementing the Project to indicate if they would be beneficial, neutral or harmful to natural and human surroundings. As it is only a preliminary assessment, the possible effects were classified into the following five ranks.

+H : high positive
+L : low positive
0 : no or negligible effects
-L : low negative
-H : high negative

In this classification, the following criteria are used. "Low positive (negative)" means same positive (negative) effect is likely to be involved but is socio-economic impact is not likely to be significant. "High positive (negative)" implies that the socio-economic impact may also be significant.

Assessment results are summarized in Table 3.21.

3.3 Recommendations

As shown in Table 3.21, environmental effects of the Project in the aspects of recreation, sedimentation, vegetation and fish and fisheries were evaluated low negative (-L), and public health high negative (-H). These effects evaluated low negative at this time, however, may turn out to be negligible, if more detailed investigations are made into the existing conditions and a careful approach is to be taken accordingly to project implementation. For instance, the provision for some maintenance flow may minimize the negative effect on fish and fisheries downstreams of the intake weir.

Possible effects on public health evaluated high negative, especially prevalence of malaria and schistosomiasis, may be more serious and thus call for follow-up studies. Precedents of the other similar projects and control measures on malaria and schistosomiasis are described below for reference of the further studies.

(1) Precedents

Assessment of environmental impact on public health may be aided by referring to findings in other similar projects in tropical Africa and elsewhere. Studies of the impact on health by man-made lakes for the purposes of hydro-electric production, irrigation or both observe the following.

Malaria: It is apparent that this disease increases in prevalence and stability although in many of the project areas the endemicity of malaria is often found to be so high already in the pre-construction period that the difference following inundation may be minimal.

(a) Kariba dam: the increase in malaria is not clearly reported.

(b) Aswan High Dam: the construction of this dam re-introduced Anopheles gambiae to the area which increased malaria prevalence. Super reports more than 1300 deaths due to malaria in two years only (1970) but the vector has been brought under control (Grilles 1972).

(c) At Kainji: the endemicity of malaria was increased from hyperendemic to holoendemic and thus malaria became stable around the lake with high transmission rate throughout the year. The malaria control activities here were aimed only at the labour force and involving larviciding which reduced mosquitoes but did not reduce malaria prevalence (Walsh 1970). In fact the immediate project area became holoendemic - the highest endemicity level possible. Waddy states that Anopheles gambiae continued to thrive in 1972.

(d) Volta Lake: vectors of malaria parasites were abundant (A. gambiae and A. fenestus) but their breeding and population increased even further as the extensive shoreline provided more breeding sites.

(e) Some increase in malaria prevalence was also observed in the Ord River (Australia) as reported by Alphers et al in 1972.

(f) However malaria was not a serious problem following the construction of Ubolratana dam mainly because of the Malaria Eradication Programme that was going on in Thailand at the time (Harinsuter, 1970).

(g) Figure 3.14 shows the proportions of various mosquito species biting man in an unchanged and in an irrigated area a few miles apart near Kisumu. The increase in Anopheles gambiae is especially alarming since this mosquito is the major African vector of Malaria and also carries Bancroftian filariasis and arboviral infections (Surtees et al, 1970).

<u>Schistosomiasis</u>: It will increase in prevalence and intensity following impoundment of water. This conclusion was arrived at by Deom (1976) when he reviewed the health impact of several projects of this kind. The ecological changes affect the biological balance in such a way that the vectors of Schistosomiasis (particularly S. haematobium) increase in population around the shores of the dam (or lake) which was the reservoir. The documented cases are discussed below:

(a) Kariba dam (Zambia/Zimbabwe) the shores become heavily infested and even the inlets and back-waters previously free of the vector snails become heavily infested. The increase in vector snails was followed by an increase in both prevalence and intensity of schistosomal infection and disease.

(b) Aswan high dam (Egypt): the prevalence of schistosomiasis was increased by more than 50% - (Dawood - 1971). A malacological survey conducted in 1971 by Dazo and Biles also showed the establishment of Bulinus truncatus, the vector for S. haematobium and the same study showed a correlation between water contact and prevalence of schistosomiasis: Only 9% of temple workers were found to have schistosomiasis as compared to 63% of fishermen. The problem, as in the case of Kariba had been foreseen before water impoundment but the cost of a large scale control program was found economically and logistically infeasible.

(c) Kainji dam (Nigeria): Bulinus truncatus, B. globosus and Biomphalaria pfeifferi were present in the area before construction (Walsh and Millink 1970) but their population increased tremendously after impoundment. This was followed by a sharp increase in the prevalence of Schistosomiasis haematobium as described by Dazo and Biles (1972) who found an average prevalence rate of 31% (which was, however, lower than the rate predicted by Walsh and Mullink in 1970). They noted that the trend was upward and that the prevalence level would be higher still in the later years. They also found snail control an impossible undertaking and had to recommend health education as a major component of the control exercise.

(d) Volta Lake (Ghana): the ecological changes following construction reduced the population of Glossina spp. (Vector of trypanosomiasis) and of Simulium spp. (Vector of onchocerciasis), but increased the population of snail vectors of schistosomiasis - (L.E. Obeng 1975). These vectors established themselves soon after inundation and all parts of the lake shore were soon found to transmit the disease.

In general the parasitic diseases that are increased by dam construction seem to be schistosomiasis and malaria. Onchocerciasis and trypanosomiasis do not seem to increase. Rather they might decrease in the immediate vicinity of the lake. This phenomenon was shown by Dazo and Biles in 1972, and is explained by the fact that simulium prefers fast-flowing water. The above appears to have been true of dams in areas where either one or both of the two diseases were endemic prior to construction.

(2) Malaria and schistosomiasis control

Since malaria and schistosomiasis will increase in the area and will contribute the most to the increase in mortality and morbidity, a special effort should be made to counteract this impact.[6/], [8/] The following are outlines of available control technologies.

Malaria

(a) Chemoprophylaxis and chemotherapy

Control priority should be aimed at the control of mortality (by chemotherapy readily accessible and available) and of morbidity (by chemoprophylaxis). These activities should go together with health education and deliberate efforts to involve the community in the planning and implementation of the services.

(b) Vector control

The control of morbidity and mortality due to malaria, achievable by chemoprophylaxis and chemotherapy, should be backed up by the control of the vector which should impact on transmission of the malaria parasites and hence on the prevalence of the disease.

Mechanical control measures - this is the elimination of larval habitats by appropriate water management e.g. ditiling, draining or filling. This will reduce mosquito breeding but will not eliminate the problem given the nature of the project.

Screening of the houses from mosquitoes should be considered and chemical control measures encouraged (using wire mesh).

Residual Spray: this is an antiadult mosquito measure. The houses should be sprayed regularly with an appropriate insecticide chlorinated hydrocarbons or organophosphorus compounds.

Larvicides: All temporary or permanent water pools which cannot be eliminated mechanically should be covered regularly by larvicides. Possible material for use include: chlorinated hydrocarbons, organophosphorus compounds or various oils from the petroleum industry.

Biological methods: This is to use other living organisms that attack the vector, e.g. introducing fish into irrigation ponds, such as Tilapia nilotica that eat the mosquito larvae.

Schistosomiasis

(a) Chemotherapy

This is treatment by drugs of infected persons to reduce the number of viable eggs being released into the environment. The role of mass chemotherapy in schistosomiasis control is increasing due to the development of greatly improved drugs. In particular, oxamniquine (against S. mansoni) and praziquantel (against all three major schistosoma species) are likely to become key weapons in major control programmes of the future.

(b) Snail control

Appropriate channel design: with a certain combination of water velocity, channel lining, and vegetation regime, snails will be unable to colonize a stretch of water channel. That is, channel kept clear of vegetation, and with mean velocities of over 0.6 m/s (schistosomiasis cannot inhabit over 0.30 - 0.35 m/s velocity on the bottoms or sides of channels) have a good chance of being snail-free.

Adequate drainage: the drainage or filling-in of natural shallow pools and seepages helps to reduce the number of snail habitats. In irrigation schemes, drainage has similar effects.

Improved irrigation practices: efficient irrigation management is good for snail control. Regular maintenance of irrigation channels to prevent blockage by vegetation will also help to control snails.

Intermittent irrigation can also be remarkably effective in reducing snail populations.

Barriers to prevent snail drifting: as snails often breed in an irrigation water reservoir or pond, barriers should be placed on the irrigation channels leading from it. Drifting snails in irrigation channels mostly travel very near the surface and nearer the banks than the centre. Therefore, mechanical barriers which extend down 0.5 m from the surface, and are especially designed to trap snails near the banks, may prevent snails from carrying infection downstream. The mesh should not be coarser than 3 mm in order to catch juvenile snails.

Fluctuation of water levels: this is the method of rapidly fluctuating water levels in order to strand snails on the banks where they may die through desiccation or be subsequently flushed downstream as water levels suddenly rise. Such measures may be applied to channels or lakes or to both together.

Assistance to chemical control of snails: good engineering design and efficient maintenance of channels will considerably reduce the costs of mollusciciding.

Miscellaneous measures: irrigation systems require periodic maintenance, to clear vegetation and accumulated silt, and to prevent seepage and leakage of water. This also helps to control snail infestation.

Biological methods: introduction of snail enemies can result in disappearance of vector snails, e.g. a certain large bug is an obligatory snail-eater and a single bug will kill about 125 snails in its life. The introduction of foreign species, however, is a sensitive issue, as it may result in adverse environmental impact such as disruption of local ecosystem.

(2) Final remarks

In controlling Malaria and Schistosomiasis, biological methods are in principle preferable to chemical ones, although a care has to be taken in introducing foreign species as mentioned above. For schistosomiasis, a biological agent called "otho" is already available and found effective. On the other hand, if chemical agents are to be used, effects of their widespread uses have to be investigated as a part of environmental impact assessment.

Annex to Chapter 3.: Socio-Cultural Aspect of Relocating People

General remarks

How to properly relocate people in the area to be innundated by a reservoir or otherwise used for a project is an essential question for successful implementation of the project. Although it is still at relatively early planning stage of the Sondu project, attention was directed to this important aspect. The following remarks on this issue are based on the discussions with Professor A. B. C. Ocholla-Ayayo and Dr. John O. Oucho of Population Studies and Research Institute, University of Nairobi. The remarks may apply to the case where the implementation of the Sondu project would induce the intra-region migration of people in the LBDA area, for instance, from highlands to lowlands as suggested in Chapter 2.

In many cases in the past, people were compensated in cash, according to proper laws, for their property sacrificed by project implementation, and they moved to wherever they wanted to at their own will. People around the Sondu project, if relocated this way, may move further up toward Kisii, resulting in excessive pressure on land in the area where population density is already very high. The similar case was observed with Awendo Sugar Development Project in South Nyanza, when relocated people moved to Sakwa area, that caused high population density there.

Alternatively, the relocated people can be brought to the Nyakach plain, if intensive irrigation is to be provided to support them, but this may result in socio-cultural problems. Generally, relocation within the Kabondo area will pose less serious problems due to better relationships among clans.

Census data indicate that the people on the Nyakach side were more mobile in the recent past, but this is largely labour mobility - i.e. migration for employment, often associated with specific projects. It should not be taken as the evidence that the people there are in general willing to move to make room for new immigrants.

Proposals

A lesson should be learned from past experiences that monetary compensation by itself would not be the best solution. People may just spend it rather than investing it into land and properties, or land prices around the project area will go up. It would be better to combine money payment and compensation in kind (e.g. in the form of land).,

Another possibility is to let the relocated people to invest a part of their compensation payments into the project and to enter into a sort of cooperative. This will reduce the land requirements for farming, but proper institutional arrangements have to be devised to realize such a scheme.

It is desirable to carry out at the next planning stage a detailed study to see relationships among tribes and clans in order to seek means to minimize socio-cultural problems. No easy generalization applies to such relationship, as they are tribe- or clan-specific - cultural inhibition (For instance, a man does not want to live in the land of his wife.), "Nyiego" relationship etc.

Also it would be suggestive to ask a small sample of people in the project area about their preference and attitude towards relocation and compensation. In this case, it is important to show them options; e.g. to relocate within the Kabondo area or to move to a distant place where government efforts are being made for development and settlement.

Chapter 4. PARAMETERS FOR ECONOMIC AND FINANCIAL ANALYSES

4.1 General

Project evaluation in a narrow sense consists of economic evaluation and financial analysis conducted respectively from a viewpoint of the nation's economy and the implementing agency. The economic evaluation corresponds to one of three "evaluation accounts" in the three-way evaluation system utilized here. For this evaluation, all the costs and benefits involved in the project have to be evaluated as real resource costs or opportunity costs.

The measurement of economic cost of a project input depends on how it is likely to be procured, when the project is implemented. Clearly it is impracticable to trace procurement sources for all the project inputs. Thus in this study, attempts were made to measure economic costs only for major project inputs. The results are presented in the subsequent sections.

Benefits associated with project outputs should also be measured from a viewpoint of nation's economy in economic evaluation. For agricultural products, these economic values are estimated as reported in Chapter 6 of Volume III. For electricity, calculation of long-run marginal cost of power supply as a measure of unit power benefit is included in Section 4.3 of this appendix.

Financial costs of the project inputs used in financial analysis are purchase costs either in domestic or international market as the case may be, and included in respective chapters on cost estimates for hydropower and irrigation components (Volumes II and IV). Compensation costs constitute an important cost element of the project, and their derivation is described in Section 4.4.

4.2 Economic Costs of Major Project Inputs

4.2.1 Labour Opportunity Costs or Shadow Wage

Common labour required for construction works of the project would most likely come from neighbouring rural areas. Thus the opportunity costs of common labour can be calculated based on the assumption that opportunities to be sacrificed by the project implementation be agricultural activities. However, since there generally exists excess in labor force (or under-employment) in rural areas, agricultural production would not be reduced in proportion to the labour drafted for construction works. Degree of reduction in agricultural production would depend on degree of under-employment.

The degree of employment in the rural areas around the project is estimated here based on the data for the Kano plain contained in a report of an on-going study , as no extensive effort could be made at this time to obtain better data. According to the report, labour requirement for the Kano plain is about 5.2 million working days per year, while the labour force available there is about 38,100 active working units. Thus the average working days per year per active working unit is calculated to be:

$$\frac{5.2 \times 10^6}{38,100} = 136 \text{ days/unit.}$$

Assuming the average working days per unit be 220 days per year, the degree of employment is calculated to be:

$$\frac{136}{220} = 0.618 \quad 60\%$$

On the other hand, a typical wage of hired farm workers in the area is 25 Shillings per man-day. Therefore, the shadow wage for common labour becomes as follows.

25 x 0.6 = 15 KShs./man-day
= KShs. 3,300 per year
= K£. 165 per year

4.2.2 Shadow Price of Cement

Production and marketing

Cement in Kenya is produced at two major factories, Bamburi and Athi River; in the latest year, the former contributed some 1 million tons and the latter about 0.2 million tons. Domestic consumption of cement is slightly decreasing in recent years, reflecting generally sluggish economic activities, but export is steadily increasing to share over 60% of the total production in 1983 (See Table 4.1).

A major distributor of cement in domestic market is Kenya Cement Marketing Limited (Kencem), which is a company limited with its director and 50% shareholders belonging to the cement industry. There also exist consumers who purchase cement directly from cement factories.

Cement prices in domestic markets are administered by Ministry of Finance and Planning and basically the same all over the country except surcharges for local transportation. As of November 1984, the local prices of cement are as follows.

Purchase price by Kencem from cement factories	1,292.60 KShs./ton
Price to distributors purchasing from Kencem	1,307.30 KShs./ton
Retail price set by the Government (Since 1981)	1,377.30 KShs./ton

Some domestic consumers, in particular associated with major development projects, purchase cement directly from producers at lower prices. For the Kiambere hydropower project, for instance, negotiation is going on to purchase cement directly from Athi River Cement Company at the price lower than the Kencem purchase price, deducting transportation rebate. In other cases, price to distributors or otherwise the lowest local price, or purchase in foreign currency at export prices may be applicable; the latter are much lower than the domestic market prices (See Table 4.2).

Demand/supply prospects

Cement has been an important foreign exchange earner in the past several years, and established export markets exist. It is therefore necessary to expand its production capacity, after meeting domestic demand and to produce sufficient surpluses for export. For the purpose of demand/supply projections and shadow pricing, it is assumed that the export demand will increase at 8% per annum in the next several years, which is lower than the average growth rate of 10.8% between 1979 and 1983.

Domestic demand is expected to start growing again as the Kenyan economy in general recovers slowly. It is assumed herein that the domestic demand for cement will increase in line with the growth target set by the current five-year development plan for the building and construction industry (i.e. 15.9% growth between 1983 and 1988).

Consequently, the demand for cement in 1988, the end of current five-year plan period, is calculated as follows.

Export demand	1,130 x 10^3 tons
Domestic demand	660 x 10^3 tons
Total demand	1,790 x 10^3 tons

Of the existing cement factories, one at Bamburi is operating already close to full production capacity, and Athi River plant has some excess capacity. In addition to these, expansion of supply capacity by 0.5 million tons per year is planned by the current five-year development plan. Thus the total supply capacity in 1988 will be about 1.8 million tons per year, barely sufficient to meet the growing demand.

Shadow pricing

As the demand/supply prospects indicate, a continuous increase in production capacity seems necessary to meet the growing requirements for export as well as domestic demand. Such an expansion is in accordance with the Government policy for export promotion, and seems to be supported by availability of indigenous raw materials. In this case, the most legitimate basis for estimating the economic or shadow price is either marginal production costs taking into account of supply capacity expansion or opportunity costs in alternative uses.

Since the quantity of cement required for the project is marginal (i.e. some 2% of total production or 3 - 4% of total export expected in early 1990's), it is assumed that no significant production increase be induced by the project. Thus the cement required by the project would be obtained basically by diverting from export and other domestic uses.

For the portion to be diverted from export, the shadow price or opportunity cost of cement is taken to be the f.o.b. price, i.e. 40 US Dollars or 600 Kenyan Shillings per ton. Added to this is the transportation costs to the project site, which is estimated to be 300 Shillings per ton, to make the total cost 900 Shillings per ton.

For the amount to be procured in domestic market, the production costs are taken as a basis for estimating the opportunity costs, since market prices cannot be used by themselves as they are administered by the Government. Since the production costs cannot be directly estimated at this time, the lowest purchase price or 1,227.30 Shillings per ton applicable to major development projects is taken as the basis and sales tax of 17% is deducted to obtain 1,049 Shillings per ton.

The shadow price of cement is calculated as the weighted average of the prices calculated above for different precurement sources - export and domestic markets. The weights are taken to be the shares of export and domestic demand in the total demand calculated above for the year 1988, assuming no change in the demand structure thereafter. Thus, the shadow price becomes:

$$900 \times \frac{1,130}{1,790} + 1,049 \times \frac{660}{1,790} = 955 \text{ KShs./ton.}$$

Assuming the indirect foreign costs included in the inland transportation costs and domestic production costs are 100 Shillings per ton and 20 percent of the total production costs respectively, the foreign currency portion of the cement cost is calculated to be about 54 percent. For the evaluation purpose in the present study, it suffices to take both the foreign and the domestic currency portions to be 50 percent each.

4.2.3 Foreign Exchange Rates

In order to make comparable the economic costs of the project expressed in both foreign and local currencies, an exchange rate has to be applied. The exchange rate used for this purpose has to reflect the real economic value of foreign exchange or the shadow exchange rate. There exist alternative ways to assess the real economic value of foreign exchange and in this study two simple methods were used to analyze its transition in the past decade as well as the current rate applicable to the project evaluation.

The first method to assess the shadow exchange rate makes uses of import/export statistics, based on the recognition that the divergence between the official and the shadow exchange rates arises from distortion of foreign exchange markets caused by the government intervention such as import/export duties and taxes. The other method is based on the measurement of divergence between general price levels in international and domestic markets.

Data used for the analysis are summarized in Table 4.3 and 4.4, and the transition of foreign exchange rates in the past decade is given in Table 4.5. From these data and simple calculations based on them, the following observations are in order.

Through the latter half of 1970's, Kenya shillings were consistency under-valued against U.S. dollars as compared with the official exchange rate, represented by the special drawing right (SDR). However, due to distortions of foreign exchange markets, there always existed forces to push price quotations of foreign exchange upward, which eventually forced to devalue Kenya shillings at the beginning of 1981.

This devaluation created temporarily a slight under-valuation of the domestic currency, but it was quickly offset by high rates of domestic inflation, which led to the over-valuation of Kenya shillings already in mid-1982. Consequently the shillings were devalued again at the end of 1982, and further in mid-1983.

The Kenyan government has been pursuing a relatively active exchange rate policy as represented by frequent re-valuation of Kenya shillings and trying to reflect the real economic value of foreign exchange into the official rate. Since the last devaluation of shillings in May 1983, however, the real rate has been slowly diverging from the official rate. From the behavior of U.S. dollars and their relationships with SDR in the past decade, it may be concluded that the floating price quotations of U.S. dollars well represent the real value of foreign exchanges in Kenya. Thus for the project evaluation, the foreign currency costs expressed in U.S. dollars are to be converted to Kenya shillings at the rate of 1 U.S. dollar = 15.00 Kenya shillings, the rate effective at the end of field investigation period (November 1984).

4.2.4 Transfer Payments in Local Currency Costs

In addition to shadow pricing of major project inputs, internal transfer portions have to be excluded from local currency costs of other project inputs. These internal transfer costs in general include various taxes and subsidies. In some cases, indirect taxes on commodities in competitive markets should not be excluded, as consumers express their willingness-to-pay by the market prices including taxes, but such possibilities are neglected in this study.

Data used for the assessment of internal transfer portions are summarized in Table 4.6. Some indirect taxes such as import duties have been treated separately in estimating economic costs and already excluded. By inspection of other indirect taxes and the gross domestic products (GDP) at market prices, the internal transfer portions are estimated to be about 10%.

4.3 Unit Power Benefit and Long-Run Marginal Cost of Power Supply

For preliminary assessment of economic viability of the Sondu hydropower development, the project costs are compared with the costs of alternative thermal generating facilities having equivalent supply performance. This in essence is to define the unit power benefit based on the unit generation cost of alternative thermal that would be saved, should the Sondu project be implemented.

Specifically, the following two alternatives were considered,

(1) Combination of geothermal and a gas turbine (composite thermal)
(2) Coal thermal

The unit generation cost by each alternative is calculated as follows.

(1) Alternative 1: composite thermal

Geothermal

Capital costs

Unit construction cost	30,800 KShs/kW
(KP&L estimate at January '84 price)	
Escalation to November '84	34,000 KShs/kW (about 10% up)
Annual energy generation	7,446 kWh/kW (85% plant factor)
Capital recovery factor	0.100859 (10%, 50 years)
Unit capital cost	0.461 KShs/kWh

O & M costs

Unit O & M cost	0.024 KShs/kWh
Unit cost	0.485 KShs/kWh

Gas turbine

Capital costs

Unit construction cost	10,800 KShs/kW
(estimated at Nov. '84 price)	
Annual energy	4,380 kWh/kW (50% plant factor)
Capital recovery factor	0.117460 (10%, 20 years)
Unit capital cost	0.290 KShs/kWh

O & M costs

Fuel cost	3,500 KShs/ton
Fuel rate	280 g/kWh
Unit fuel cost	0.980 KShs/kWh
Fixed O & M cost	756 KShs/kW (7% of construction costs)
Unit O & M cost	1.128 KShs/kWh
Unit cost	1.418 KShs/kWh

Composite thermal

The supply performance to meet the 60% load factor at sales end can be obtained by combining the 30 MW (15 MW x 2 units) geothermal and the 20 MW gas turbine. The unit generation cost of this composite thermal can be calculated as follows.

0.485 x 0.6 + 1.418 x 0.4 = 0.858 KShs/kWh

(2) Alternative 2: coal thermal

Coal

Capital costs	
Unit construction cost	24,000 KShs/kW
Annual energy	6,184 kWh/KW (about 70% plant factor)
Capital recovery factor	0.100859 (10%, 50 years)
Unit capital cost	0.391 KShs/kWh
O & M costs	
Fuel price	785 KShs/ton
Calorific value	6,000 kcal/kg
Thermal efficiency	0.37
Unit fuel cost	0.304 KShs/kWh
Fixed O & M cost	1,200 KShs/kW (5% of construction costs)
Unit O & M cost	0.498 KShs/kWh
Unit cost	0.889 KShs/kWh

The smaller one of two figures calculated above is taken to be the average incremental cost of power generation.

The average incremental cost of transmission and distribution is estimated in the following.

	KShs/kWh	Sales weighting factor
Transmission (EHV)	Included in generation cost	0.02
Subtransmission (HV)	0.06	0.28
Distribution (LV)	0.07	0.70

The weighted average cost to final consumers, according to sales shares and cumulative costs at each voltage level, is estimated to be 0.11 KShs/kWh.

Including other costs, the long-run marginal cost (LRMC) of power supply is estimated to be as follows.

Generation	0.86 KShs/kWh
Transmission & distribution	0.09
Commercial & management	0.04
Metering	0.02
Engineering	0.11
Total	1.12 KShs/kWh

The estimated LRMC is 60% higher than the average electricity tariff that was effective at the time of field investigation.

4.4 Compensation Costs

Objective

Compensation costs constitute an important cost element of the hydropower project. The objective of estimating the compensation costs in the present study was to determine on a consistent basis reasonable rates applicable to different kinds of land and other objects in the project area so that they can be used for the purpose of project evaluation (financial analysis). Needless to say, no such intention has been involved as to provide any guideline whatsoever for setting compensation rates to be used at the time of project implementation. In practice, compensation payments would be determined in accordance with Kenyan laws[9/] and customs, taking much longer time for negotiation among those concerned and other procedures.

Data

During the field investigation period, data were collected for estimating the compensation costs related to the project. Main sources of the data are hearings from the Land Valuer in Kisumu and Land Evaluation Division, Ministry of Land and Settlement in Nairobi. Other miscellaneous data and information have also been referred to.

The data thus collected consist of land prices for different areas around the project, ranges of compensation payments applicable to trees, houses and other facilities of different types. Based on these data, unit cost of compensation was determined for each kind of object and the compensation costs were calculated for the range of elevation subject to analysis, combined with information on objects for compensation identified by an aerophoto study. the results are summarized below and also plotted in Figure 4.1.

Calculation of compensation costs

The calculation of compensation costs is summarized as follows.

(1) Unit costs

Cultivated land	11,000 KShs/ha
Non-cultivated land	7,500 KShs/ha
House yard	18,500 KShs/ha
Houses	2,500 KShs/house

(2) Compensation objects by elevation

Elevation(m)	Cultivated land(ha)	Non-cultivated land(ha)	House yard(ha)	Number of houses
1,390	30	70	5	25
1,400	85	120	13	60
1,410	175	230	20	100
1,420	285	415	30	190
1,430	435	635	80	400
1,440	650	850	145	730

(3) Compensation costs by elevation

Elevation	Total compensation costs (10^3 KShs)
1,390	948
1,400	2,226
1,410	4,270
1,420	7,278
1,430	12,028
1,440	18,033