WCD Case Study

Kariba Dam
Zambia and Zimbabwe

Final Report: November 2000

Prepared for the World Commission on Dams (WCD) by:

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Please cite this report as follows:
Soils Incorporated (Pty) Ltd and Chalo Environmental and Sustainable Development Consultants. 2000. *Kariba Dam Case Study*, prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

The WCD Knowledge Base

This report is one component of the World Commission on Dams knowledge base from which the WCD drew to finalize its report "Dams and Development-A New Framework for Decision Making". The knowledge base consists of seven case studies, two country studies, one briefing paper, seventeen thematic reviews of five sectors, a cross check survey of 125 dams, four regional consultations and nearly 1000 topic-related submissions. All the reports listed below, are available on CD-ROM or can be downloaded from www.dams.org

Case Studies (Focal Dams)

- Grand Coulee Dam, Columbia River Basin, USA
- Tarbela Dam, Indus River Basin, Pakistan
- Aslantas Dam, Ceyhan River Basin, Turkey
- Kariba Dam, Zambezi River, Zambia/Zimbabwe
- Tucurui Dam, Tocantins River, Brazil
- Pak Mun Dam, Mun-Mekong River Basin, Thailand
- Glomma and Laagen Basin, Norway
- *Pilot Study of the Gariep and Van der Kloof dams- Orange River South Africa*

Country Studies

- India
- China

Briefing Paper

- Russia and NIS countries

Thematic Reviews

- TR I.1: Social Impact of Large Dams: Equity and Distributional Issues
- TR I.2: Dams, Indigenous People and Vulnerable Ethnic Minorities
- TR I.3: Displacement, Resettlement, Rehabilitation, Reparation and Development
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- TR II.1: Dams, Ecosystem Functions and Environmental Restoration
- TRII.1: Dams, Ecosystem Functions and Environmental Restoration
- TR II.2: Dams and Global Change

- TR III.1: Economic, Financial and Distributional Analysis
- TR III.2: International Trends in Project Financing

- TR IV.1: Electricity Supply and Demand Management Options
- TR IV.2: Irrigation Options
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- TR IV.5: Operation, Monitoring and Decommissioning of Dams
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- TR V.1: Planning Approaches
- TR V.2: Environmental and Social Assessment for Large Dams
- TR V.3: River Basins – Institutional Frameworks and Management Options
- TR V.4: Regulation, Compliance and Implementation
- TR V.5: Participation, Negotiation and Conflict Management: Large Dam Projects

- **Regional Consultations – Hanoi, Colombo, Sao Paulo and Cairo**

- **Cross-check Survey of 125 dams**

Acknowledgements

The consultants in this assignment are grateful for the assistance that they received from a wide spectrum of individuals and institutions during the course of this study. This enormous task would have been impossible to accomplish without this assistance.

The WCD secretariat provided guidance to the study team, especially with respect to selection of and the amount of material to be presented in the report. Being an old dam, there is a tremendous amount of information and data available on Kariba. Guidance provided by WCD staff, especially Drs Madiodio Niasse, Bruce Aylward, and Englebertus Oud was valuable in the preparation of a concise report for a broad subject such as the Kariba project.

Most of the material relating to Kariba Dam is held in the libraries of the Zambezi River Authority in Lusaka, Kariba and Harare. The consultants are grateful to the Zambezi River Authority (ZRA), through its Chief Executive, Eng. Tumbare, for allowing the consultants free access to their libraries. Their librarians at these three locations, especially Ms Huxtable of Kariba, went out of their way to point out some obscure documents that the consultants would, otherwise, have found difficult to locate. The other source of information on Kariba was the National Archives in both Zimbabwe and Zambia. At both archives, the librarians gladly assisted consultants in accessing critical historical documents.

A large amount of historical data on power generated at Kariba and the financial costs thereof, were compiled in this study from records maintained by the Zimbabwe Electricity Supply Authority (ZESA), and the Zambia Electricity Supply Company (ZESCO). The consultants are grateful for the assistance rendered by these two power companies.

Most of the literature and debate with respect to Kariba centres on the fate of the 57 000 Tonga people who were displaced by the dam some 40 years ago; and the history of the dam is not complete without the accurate and balanced discussion of this issue. In the course of this study, the sociology consultants spent weeks in discussions with the Tonga people of the Zambezi valley, recording their experiences and their views of Kariba Dam. To these great people, the consultants are grateful. It is hoped that the record of their experiences will provide valuable lessons for similar dam developments in the future, to replicate the good lessons from Kariba and to avoid any negative impacts that Kariba may have had.

The draft final version of this report was presented at a meeting of stakeholders at Kariba, 20–22 February 2000, and comments were received on the report from the stakeholders who attended the workshop. In addition, the report was circulated widely to other individuals, NGOs, and other international organisations with interest in the large dam debate. The consultants are grateful to all these organisations and individuals for their comments.

Lastly, the consultants are grateful to two reviewers, Professor Saassa, of the University of Zambia and Professor Magadza of the University of Zimbabwe, for editing the first draft of this report. These two learned colleagues have tremendous first hand research experience on Lake Kariba. Their experience greatly improved the content and presentation of the report. However, any outstanding errors and weaknesses in the report are entirely attributable to the consultants.

A. Hungwe

Team Leader

Financial and in-kind Contributors:

Financial and in-kind support was received from 54 contributors including governments, international agencies, the private sector, NGOs and various foundations. According to the mandate of the Commission, all funds received were 'untied'-i.e. these funds were provided with no conditions attached to them.

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Executive Summary

The World Commission on Dams (WCD) selected Kariba Dam as 1 of 10 dams worldwide that would be studied to contribute to the current debate on the development effectiveness of large dams. The WCD developed common methodology that was followed in all case studies. This methodology comprised two phases, where Phase 1 was a scoping phase. The purpose of Phase 1 was to identify all the critical environmental, economic, social, and any other issues relating to the dam. The issues identified in Phase 1 were then examined in detail in the subsequent Phase 2 of the case study.

In the Kariba case study, the scoping phase was completed in August 1999, and was immediately followed by Phase 2 in the following September. This report addresses the issues raised in the scoping document and presents findings of Phase 2 for the Kariba case study.

Kariba Dam, constructed in 1955–59, with a storage capacity of 180km^3, extending over a length of about 300km, and having a surface area of some 5500km^2 at full supply level, is one of the largest dams in the world. The dam was constructed on the Zambezi river, at grid reference 28.74778^o E and 16.51222^o S, along the border between the countries of Zimbabwe and Zambia and is jointly owned by the two countries. The main purpose for the Kariba Dam at the time of its construction, and to this day, is to provide hydropower to the two countries that own the dam. Two power stations with a combined generation capacity of 1320MW have been installed at the dam.

The scoping report for the Kariba case study identified a large number of issues for detailed study in Phase 2. These can be classified into the subject areas summarised below:

- an analysis of the history of Kariba Dam and the decision processes that were followed in the planning implementation and operation of the Kariba Dam project;
- an analysis of the impact of Kariba Dam on the supply of hydropower in the participating countries;
- an examination of the impacts of Kariba Dam on agriculture and irrigation in the area around the lake;
- an examination of the ecological impacts of Kariba Dam on surrounding areas, as well as on downstream areas;
- an examination of the impacts that Kariba Dam has had on the people, especially on those displaced by the lake;
- the impacts of Kariba Dam on wildlife;
- the impacts of the dam on the hydrology of the Zambezi river, especially downstream of the dam;
- the impacts of the dam on the economies of the participating countries;
- the impacts of the dam on fish and fisheries;
- the impacts of lake Kariba on the development of tourism around the dam;
- an examination of the impacts of the dam on public health and the spread of water borne diseases; and
- an analysis of the seismic impact of the dam. This issue arose from the observation that the frequency of earthquakes appeared to have increased in the Kariba area since the dam was built.

All the issues specified in the scoping report as critical to the Kariba case study were examined in Phase 2 and the results of these studies are presented in this report. By way of approach, this study relied mainly on the review of existing reports and publications. Fieldwork and original research was only carried out with respect to sociological impacts in which field visits were made to the communities that were displaced by Kariba Dam to record their experiences and views on the resettlement wrought by the dam.

The Project

Kariba Dam, constructed in the period 1955–59, is one of the largest dams in the world. The dam was constructed on the Zambezi River, at grid reference 28.74778° E and 16.51222° S, along the border between the countries of Zambia and Zimbabwe (called respectively Northern and Southern Rhodesia during the colonial times) and is jointly owned by the two countries. Kariba was designed as a single-purpose hydropower project, but as it turned out both fishery and tourism became important benefits. The main technical characteristics are as follows:

Type of Dam	Double Curvature Concrete Arch dam
Height	617m
Spillway Gates	6 gates, 8.8m wide and 9m high
Discharge Capacity of Spillway	$9500m^3/s$
Length of Reservoir	280km
Minimum Retention Level	488.50m
Minimum Operating Level	475.50m
Total Storage	$180.6km^3$
Live Storage	$64.8km^3$
Maximum Surface Area	$5577m^2$
Depth of Stilling Pool	78m
Volume of Stilling Pool	410×10^6 m^3
Kariba South Bank Power Cavern	6 x 117.5MW = 705MW max capacity
Kariba North Bank Power Cavern	4 x 153.5MW = 615MW max capacity
Total Generation Capacity	1320MW

Predicted versus Actual Development

2.1 Project Cost and Construction Schedule

The project was built in two stages, first the dam wall and the Kariba South power cavern, and then in the second stage, the Kariba North Power cavern.

Stage 1 was originally assumed to cost £72.2 million ($1230 million: all costs converted to constant 1998 US dollars). This was revised upward to £79.38 million ($1350 million) during the tender stage. The cost increase was largely because of raising the dam by 6m, and the addition of one 100MW turbine unit. The final expenditure was £77.61 million ($1320 million), or 97% of projected cost, in spite of the addition of two more spillway gates and extra work on the south abutment. Stage 1 was completed in 1960, on schedule, in spite of two record floods during the construction period.

In the 1955 planning document Stage 2 of the project would immediately follow Stage 1 and was then estimated to cost $57.1 million. However Zambia decided to implement the Kafue project first, which delayed Stage 2 by several years. In 1970 a World Bank loan for Stage 2 was negotiated. The World Bank appraisal report mentions that with Kafue in operation, most of the power of Kariba Stage 2 was to be exported to Zimbabwe. The new target date for commissioning was 1974, with costs estimated at $195 million.

Due to unforeseen geological difficulties (there was only one borehole drilled at the selected powerhouse location) and the lack of experience of the first civil works contractor, who went into receivership, the project was delayed. The second civil works contractor was directly appointed (it was the company that had just finished Kafue) and progress of the civil works portion of the project was from then on satisfactory. However there were political difficulties between Zambia and Zimbabwe, which led to closure of the border, which meant that the hydroelectric equipment had to be re-routed through Angola or Tanzania. The first two generator units came through Angola, but then war broke out in Angola. The last two generators came through Beira in Mozambique via Southern

Rhodesia, for which a special permit had to be negotiated. This all led to further delays and costs. Stage 2 was finally commissioned in 1976/77 and the final cost amounted to about $480 million.

The construction of Kariba caused a large number of fatal accidents, probably more than 100. Men were caught in machines, electrocuted, crushed by falling rock, killed on the road, plunged to death after scaffolding collapsed, and so forth.

2.2 Hydrology

- **Mean Flow**

During the planning process flows measured at Kariba were correlated with those of Livingstone, at Victoria Falls for which a much longer period of data was available. The 1907–1923 data were discarded because they were of dubious quality (but indicating the occurrence of a major multi-year drought), and therefore only the 1924–1955 data series were used. On average the mean flow of the 1960–1998 period of operation are 10% higher.

- **Design Flood**

Kariba was designed for the safe passage of a 1 in 10000-year flood. The original design was for a 3-month flood with a volume of $68km^3$, based on 1924–1955 data series. During construction, in 1957, a flood with a peak of $8200m^3/s$ occurred, the highest on record, which led to revision of the design flood value from 68 to $74km^3$. In the following year a flood with a peak of $16\,000m^3/s$ and a 3-month volume of $61km^3$ occurred, and again the spillway capacity was increased, this time to $92km^3$. Had the project been built a number of years earlier with the original design capacity of $68km^3$, the spillway would have been completely under-designed.

2.3 Hydropower Generation

In the original planning document of 1955, the full station output was expected to be 6720GWh per year. The average output for the period 1977–1996 was about 6400GWh per annum, in spite of a slightly higher than planned maximum capacity of the turbines (1320 instead of 1200MW) and a 10% higher than expected flow. This indicates that the scheme is generally operated at lower heads than expected, and therefore also with lower efficiency.

2.4 Power Economics

If Kariba had not been built, then – in an all-thermal scenario – coal-fired steam plant would have been built in Harare (then called Salisbury), Bulawayo, Umtali and at several copper mines. The 1955 Kariba project report gives details. The data were used to construct a cash flow of power benefits (investment, operation and maintenance, fuel), which constitute the predicted power benefits attributable to Kariba.

In this study a cash flow was constructed for actual conditions: the thermal plant offsetting Kariba Stage 2 were delayed to 1976, the actual energy production of Kariba rather than the planned value was taken into account. In a few of increased open pit mining, the high prices of coal were gradually reduced from $30 to $20 per ton over a period of 30 years, which was the adopted life time of the thermal alternative. Then, when reinvestments were due, it was assumed that the stations would be built in Hwange, with a further reduction in coal price to $10 per ton, and that station efficiencies would be greatly improved. Coal was generally assumed to have a lower calorific value of 28GJ per ton.

On the cost side, the predicted development takes into account the project cash flow (investment, operating and maintenance cost) as published in the 1955 Kariba project report, with implementation of Kariba Stage 2 completed by the end of the ’60s. In the actual case the real project cash flows are considered, with the delay of Kariba 2 to 1976.

The cash flow analysis resulted in an economic rate of return of 16.5% for the project as planned, and 14.5% for the project as built.

As a result of the relatively low construction cost of Kariba and Kafue the average electricity cost in the region dropped by about 30% in the period 1961–1977, while the average price for other commodities and services rose by more than 75%.

2.5 Resettlement

The pre-project planning document (1951) estimated the number of people to be resettled at 29 000. In the Kariba 1955 project document, there is little detail on the resettlement programme, except for a budget allocation of £4 million that was to be spent on this programme. A decision was made that each of the governments in Zambia and Zimbabwe would have responsibility for managing resettlement in their country. This decision meant that the resettlement programme was removed from the main project. The actual number of people to be resettled increased from 29 000 to 57 000. The budget for resettlement remained unchanged.

Unexpected Benefits, Costs and Impacts

3.1 Technical Aspects

- **Geological Problems**

The extra works at the southern abutment and part of the problems encountered during the construction of the Northern Kariba power cavern, which both led to cost increases, were unexpected, but most likely the result of the drilling of an insufficient number of boreholes during the planning phase.

- **Problems with the Civil Works Contractor during Stage 2**

There are diverging opinions on the construction delays and cost overruns regarding the north bank powerhouse, but the most plausible view is that the contractor submitted a low bid to secure the works. The second and third ranked contractor was about 80% more expensive. When unexpected geological problems occurred, which were not surprising as only a single borehole was drilled in the power cavern area, and the methods of excavation and rock securing had to be changed, the contractor could not fulfil his obligations and went into receivership. The time lost and the extra cost in recruiting a new contractor were substantial.

- **Earthquakes caused by Kariba Reservoir**

The water storage volume of Kariba reservoir of 180km^3 translates into a mass of 180 billion metric tons. The reservoir is located in a tectonically active area, at the southern end of the African Rift Valley. Since its construction and filling in the early 1960s, Kariba has caused numerous earthquakes in the area, 20 of them in excess of magnitude 5 on the Richter scale. This is of significance for dam safety.

The project documents for Kariba did not discuss the possibility of reservoir-induced seismicity and the need to take this into account in the design of the dam.

3.2 Environmental Impacts

As already stated, there was no Environmental Impact Assessment (EIA) done for Kariba and therefore baseline studies on any of the environmental parameters are not available. Here only a few of the impacts can be dealt with. For more information see the main report.

- **Drowned Vegetation**

Almost 1000km^2 of the reservoir area were cleared as preparation to gillnet fishery. This constitutes about half the area of the top 20m of the reservoir, the depth occupied by most indigenous types of fish. The remaining 4500km^2 were not cleared. With respect to biodiversity it is unlikely that Kariba caused a serious extinction of species since most of the vegetation types in the flooded area are abundant elsewhere within the Zambezi valley.

The rotting vegetation caused the formation of H_2S, which when released caused severe corrosion of copper works, both in the powerhouse and downstream.

The eutrophication of the reservoir led to a boom in fish in the first years of its existence. Also various waterweeds, including the water hyacinth, were prolific. The situation normalised after a few years.

- **Operation Noah and the Creation of Wildlife Sanctuaries**

"Operation Noah" began in response to concerns about the fate of animals that would get drowned when the reservoir would start to fill. A wide variety of 4 000–6 000 large animals and numerous small ones were rescued. Mammals were initially released to the nearest shore, but after 1961 most animals were translocated to other parts of the country. Of particular note was the translocation of 40 black rhinoceros to Hwange National Park.

How many of the rescued animals survived and found a new habitat is unknown.

This project led to the creation of wildlife sanctuaries along the southern lake embankment, which was one of the factors that stimulated tourism.

- **Increased Habitat for Some Species**

The Kariba lake environment has been beneficial to some species such as crocodiles and aquatic birds. The number of crocodiles on the southern shore was around 10 000 in 1985. In the early stages of the lake the number of hippos and buffaloes may have declined, but it has since risen considerably as a result of the development of *Panicum* grassland on the shore.

- **Change from Riverine to Lacustrine Environment and Effect on Fish**

Pre-impoundment studies on the mid-Zambezi identified 28 species in the area upstream of Kariba. The number of species now is 42, including those in the reservoir.

In the reservoir, cyprinids, which need flowing water, have almost completely disappeared, whereas Cichlids have become the main fish in the littoral zones of the lake. Pelagic zone fish were absent before impoundment, but *Limnotrissa miodon* was introduced in 1976/77. Fish yield in Kariba reservoir rose from 5.6 kg/ha per annum to about 33kg/ha per annum in 1986.

Fishery and fish farming have become one of the most important secondary benefits of the Kariba project.

- **Downstream Effects on Fish**

Eels were found in the mid-Zambezi. Adult eels live in fresh water for 20 years before migrating to the sea to spawn. The Kariba Dam has created a barrier for eels and their numbers have declined in the mid-Zambezi.

The African lungfish, which lives in tropical vleis, pans and swamps has perished, and this may be the direct result of building Kariba. It inundated some swamps in the area now covered by the reservoir, and it regulated releases to the downstream area so that Mana Pools downstream of Lake Kariba is no longer swampy.

- **High DDT Concentrations**

Among the persistent pollutants in Lake Kariba, DDT has been found to be the most dominant. DDT was extensively used during and after construction of the dam to eradicate the tsetse fly in the region, but also upstream in Namibia’s Caprivi Strip and from agricultural areas upstream of the reservoir.

- **Resettlement of People into Wildlife Habitats**

Some of the resettlement areas had prolific wildlife before resettlement took place. The resettlement of an essentially farming community caused a conflict with the wildlife in the area. In the Binga district for example, 64 elephants were killed in 1956, and 31 in 1957. In 1964 more land was made available for resettlement and 120 elephants were killed. Altogether 17 rhinos were captured and translocated to Hwange National Park.

- **Downstream Effects**

As Kariba regulates most of the incoming floods, the number of times that the downstream Mana Pools are inundated is less than in the pre-dam period. This reduces the deposit of fresh alluvial material, which has led to a decline in grazer density. At the same time the occurrence of the dominant canopy tree *Faidherbia albida* declined and the occurrence of termites *Macrotermes* increased.

The downstream impacts of Kariba Dam extend all the way to the Indian Ocean. Because of the dam the natural rhythm of flow of the Zambezi has been changed and evened out. The seasonal high and low floods do not occur as much as they did before Kariba. As a result, the Zambezi River does not break its banks as it used to, and the delta floodplain ecology has been negatively affected. Shrimp catches have decreased, floodplains have been invaded by upland vegetation because of the absence of annual flooding, mangrove are dying off because of poor flooding of coastal areas, productivity of artesianal fisheries in the delta area has decreased. And wildlife populations in the delta areas have been negatively impacted upon.

3.3 Social Impact

Resettlement

- **Population affected by the Dam**

Before resettlement the Tonga inhabited both banks of the middle Zambezi Valley from Kariba Dam to Mlibizi. Villages were situated along the Zambezi and around the deltas of the tributaries. The main occupation of the people consisted of riverine and upland farming, livestock rearing, hunting, fishing and manufacturing. Riverine farming was based on recession agriculture, which depended on the flood regime of the river. Away from the flood plains, on the poorer soils of the upland valley area, shifting cultivation was practised. Typical crops were maize, bulrush millet, sorghum, sweet potatoes, groundnuts, a variety of cucurbits, tobacco and cotton. Of these, tobacco was primarily a commercial crop.

Due to the annual flooding of the Zambezi that fertilised the riverine gardens and deposited alluvial soils the Valley Tonga could harvest twice a year and were seldom victims of hunger and famine.

Livestock rearing was important although the tsetse fly invasion of the 1830s and the rinderpest epidemic of the 1890s reduced the cattle population. Goats, sheep and fowls became important instead. The restrictive game laws introduced in Zimbabwe in 1906 and Zambia in 1925, led to an increase in game and tsetse fly. Prior to the enactment of these laws, hunting was one of the Tonga's main economic activities and a major source of animal protein. Fishing was regarded as secondary economic undertaking, in spite of their proximity to the river.

That said, the pre-dam livelihood conditions should not be overly idealised. Health care was virtually absent and the Tonga suffered from many diseases, including leprosy, hookworm, malaria, bilharzia, dysentery, and sleeping sickness. Communication and transport were virtually non-existent, although there were relatively limited needs for such facilities. There were no roads, only footpaths, so no vehicles could reach the valley. The presence of wide animals made travel by foot rather dangerous and men and women often went in groups whenever they had to make long journeys.

- **Resettlement Process**

The 1955 Kariba project report, the 1956 World Bank appraisal report and the annual reports of the Central African Power Corporation (CAPCO) include a one-line cost estimate for resettlement, and offer no further discussion. The racist attitude of the time did not consider the resettlement of Africans as a problem.

The Central African Council on the Kariba/Kafue Hydroelectric Power Committee in its 1951 annual report estimated that in Northern Rhodesia 14 300 and in Southern Rhodesia 15 000 Africans "would be affected by inundation" and that "no provision has been made in the estimates for the establishment of these persons, but it is understood that suitable land is available in local territories for this purpose". As it turned out, the actual number of people to be resettled was 57 000 and suitable land was not sufficiently available in the direct vicinity.

The cost of resettlement had to be borne by the developer, the Federal Power Board, but the responsibility to actually undertake resettlement was left to the territorial governments. In Southern Rhodesia 23 000 people had to be moved; food would be provided during the resettlement period; adult males would be exempted from the annual poll tax of £2 for two years. In Northern Rhodesia compensation would cover: 34 000 people to be moved; resettlement costs; compensation to the individuals moved; tribal compensation for hardship, inconvenience and loss of tribal lands and customary rights; compensation in respect of loss of earnings while clearing new lands at the rate of £5 per acre, allowing one acre per person; compensation for the lost earning while building new huts at the rate of £10 per hut; and compensation for the loss of crops. In both countries, the Tonga were neither well informed nor consulted. When they heard that they had to abandon their ancestral land and move to new areas that were barren and hilly, and not situated at the river, they at first thought that the white men tricked them to take over the fertile lands at the river.

The resettlement plan aroused the Tongas' anger and caused strong anti-government feelings. Some were prepared to fight and even die for their land. In June 1958 for example, a group of people in the Chiefdom of Chipepo stoned a district commissioner. Three months later, in the same area, anti-resettlement protests culminated in violence when a group of men armed with spears, pangas, knobkerries and shields attacked a police party. In return, the police opened fire, killing 8 people and injuring 32.

Actual resettlement took place in 1957 and 1958. It was reported that the people to be resettled "were treated like animals or things rounded up and packed in lorries" to be moved to their new destination.

Most of the new land was of poor quality and easily erodable. Also, as no recession agriculture was possible due to the far distance to the river, only one crop per year could be produced. Resettling too many people to areas too small aggravated the problem. It is therefore not surprising that food production decreased and famine occurred in the first years after resettlement.

In later years many more problems occurred, caused by lack of water, breakdown of wells and other basic infrastructure provided as part of the resettlement programme, as well as influx of commercial fishermen.

There are a few things, which are certainly better than in pre-Kariba times, such as the access roads to the area, schools and medical facilities. But not all promises made during the resettlement campaign have been met. Most villages are still without electricity.

During the first years after resettlement, the Tongas were allowed to cross the lake and meet relatives and friends at the other side. However, the frequency of visits was no longer the same given the long distances involved, as some were located more than 100km from the lake. Furthermore, when the Federation of Rhodesia and Nyasaland broke up in 1963 and Zambia became independent in 1964, free movement ceased to exist and border posts were established at Chirundu and Kariba. From that time, the Tonga could no longer afford the long journey through the newly established border posts. This meant that relatives and friends on the opposite side of the border lost contact with each other.

- **Reparation and Rehabilitation Programmes**

Currently several programmes are underway to make up for the mistakes of the past and to uplift the living conditions and employment opportunities of the population affected. The Zambezi River Authority (ZRA), the Zambia Electricity Supply Company (ZESCO), the Southern Africa Development Bank (SADB) and the World Bank play an active role in this effort.

- **Health Aspects**

Health issues were not included in the original Kariba Project Report. However the Kariba Lake Coordinating Committee, formed after the decision to build Kariba, surveyed the incidence of diseases prior to impoundment and instituted programmes for disease control after the establishment of the dam.

Schistosomiasis

Prior to construction intermediate host snails were not found at the dam site, but they were present north of the gorge where Kariba Dam site is located. The possibility for an outbreak of schistosomiasis once the reservoir filled up was forecast.

Construction workers, who came from all over Zimbabwe and Zambia were treated. About 45% of them were infected.

Intermediate host snails were discovered in the lake, most frequently at places used by humans for domestic, recreational or occupational purposes. Dispersion of the snails seemed to be facilitated by drifting *Salvinia auriculata*.
The control programme consisted of spraying infected areas with nuclosamid and keeping shorelines free of the *Salvinia auriculata*. This programme lasted until the 1980s when the incidence of schistosomiasis was on the decline. From then on the number of people infected seems to have gradually grown until about 1990. Then there is a slight decline, but numbers are on the increase again

due to a general drug shortage, coupled with low staff levels at the health centres, particularly in Zimbabwe.

In Kariba town the incidence of Schistosomiasis in the area is about 20%, with about equal shares of *Schistosoma haematobium* and *S. mansoni.*

The treatment of an infected patient costs about $0.10.

Malaria

Malaria was prevalent in the area before dam construction. The construction workers were required to take prophylactic drugs. The contribution of Kariba to the disease was restricted to the construction phase due to the creation of borrow pits, poor living conditions, lack of understanding the importance of prophylaxis and a high susceptibility among the immigrants.

The reservoir does not in any way worsen the malaria situation, as the vector mosquito does not breed in large water bodies.

Other Diseases

During the construction period, a high number of sexually transmitted infections were observed. Of late, there is a steep increase in the number of HIV/AIDS cases in Kariba, as a result of tourism and the fishery industry (transport).

3.4. Other unpredicted impacts

Tourism

A thriving tourism industry has developed around lake Kariba since the dam was built, based on water sport, wildlife resources of the area and infrastructure (eg, airport and paved roads) provided by the Kariba project. 17 hotels have been constructed, 9 of them in Zimbabwe. They have a total of 933 beds, 706 of them in Zimbabwe. The positive and negative impacts of this tourism development should have been recognised in the project document.

Irrigation

The potential use of Kariba water for irrigation was not investigated as part of the project. A number of irrigation schemes have been established around the lake, and are drawing water from this lake. Fortunately, the amount of water being extracted by these irrigation schemes is too low to have any impact on power generation. In addition, analysis carried out in this study showed that more irrigation development than has been established to date, could have been carried out for the benefit of the people of both countries without significantly affecting the power generation capacity of the dam.

Fishing

One major impact of Kariba Dam that was not mentioned in the project document is the fisheries industry that has developed on the lake. A large kapenta fishing industry developed, mainly in Zimbabwe, following the introduction of the fish from Lake Tanganyika in the 1960s. Unfortunately, the capital intensive nature of the kapenta fishing business makes it difficult for most of the local displaced people to easily participate, and the industry has therefore not significantly benefited the local people who were displaced by the dam.

Distribution of Costs and Benefits

It is clear that the main losers of the project were the Tonga people who had to be resettled, although a few of them – who used the compensation money wisely – actually became better off. But for most of them the resettlement was a traumatic event, in which they lost access to their ancestral grounds, areas suitable for recession agriculture and easy access to their friends and relatives across the river. Losses were all encompassing: monetary, psychological, cultural and social.

Those who gained were millions of electricity consumers, the copper mines and other industries, who could enjoy low prices for electricity. Other beneficiaries include employees of the national parks created as a result of Kariba, fishermen and workers in the fish industry, and those who found employment in the tourist industry. People living in the area also benefit from improved access roads to the area. Most of these opportunities (fisheries, tourism, irrigation and wildlife development) benefited people from outside the dam basin. The local people, especially those displaced by the dam generally failed to compete for these economic benefits for a number of reasons which include lack of capital or professional skills or education. Thus, although the Tonga bore most of the social costs associated with Kariba Dam, people from outside the dam basin took up most of the benefits.

The people living in areas where, without Kariba, coal plants would have been built, enjoy cleaner air and less acid rain, and are indirect beneficiaries. The global population and environment gained from the project also, as Kariba offset coal-fired generation which has very high greenhouse gas (GHG) emissions.

Decision-making

Intense debate about the need to construct Kariba Dam began with the end of the Second World War in 1945 and the drive for industrial development that followed. At that time, both Southern and Northern Rhodesia were colonies of Britain, and the governments of the two countries were closely linked. In fact, plans were already afoot to form the Federation of Rhodesia and Nyasaland, consisting of the three territories of present day Malawi (then called Nyasaland), Northern Rhodesia and Southern Rhodesia.

The intensification of copper mining activities in Northern Rhodesia between 1920 and 1945 and the rapid expansion of the manufacturing sector in Southern Rhodesia brought about a need for a cheap and stable source of electric power in the two countries. The copper mines of northern Zambia were developing fast in response to a strong demand for the mineral worldwide and high copper prices on the international market. At that time, the copper mines were being supplied with electricity by a number of small coal-fired power stations on the Copperbelt of Zambia.

Investigations prior to 1946 had identified two suitable sites for the establishment of a hydroelectric power station to meet the demand for power being shown by the Copperbelt of Zambia. The first major step towards the establishment of a large hydropower plant was made in 1946 when the governments of Northern and Southern Rhodesia formed the Inter-territorial Hydroelectric Power Commission. The commission was composed of representatives from the two countries and responsible for investigating the most efficient way of solving the power shortages that were being experienced. In 1948 the commission appointed an advisory panel to decide upon the relative merits of the construction of the Kariba and Kafue dams as power generating schemes. The panel initially recommended Kariba, particularly in light of the inadequate hydrological information available for Kafue. The irrigation potential of the Zambezi downstream of Kariba and the possibilities of fishery and other developments related to the lake were pointed out, but also with the recognition that the larger and more costly Kariba scheme would take longer to construct. As the power needs on the Copperbelt were becoming critical, the Northern Rhodesian Government was keen to see development at Kafue and accordingly invited the panel to make a detailed assessment of that scheme.

When the Federation was formed in August 1953, the support of Southern Rhodesia for initial development at Kafue had apparently been gained, largely on grounds of reduced costs and speed with which it could be constructed. This was seen as essential for the well being of the Copperbelt as well as the Federation. However, in spite of the debate and application for a World Bank loan for Kafue, Kariba was still considered by some in the Federation as a more favourable site, whilst the potential at Kafue was seen to have been overestimated.

Following the formation of the Federation in 1953, the Inter-Territorial Power Commission was replaced by the Federal-Hydroelectric Board which was established in May 1954 to further the development of both schemes, the Kafue then being seen as a precursor to the larger project at Kariba. To resolve the argument for Kariba versus Kafue, a panel of experts was sought to examine the two projects and to advise on which the board should implement first. Once again the panel advised in favour of the larger Kariba scheme and the Federal Government accepted that advice in March 1955. Construction at Kariba started later that year. Predictably there was a major outcry in Northern Rhodesia, especially in Lusaka, but to no avail.

In 1956 the World Bank concluded its appraisal of the project and stepped in with finance. It is interesting to note that a substantial share of the funding came from the copper mines, which were in dire need of cheap power.

When it commenced operation in December 1959, Kariba fell under the Federal Power Board. In 1963 the Central African Power Corporation was established, and this organisation was replaced by the ZRA in 1987.

The ZRA was responsible for all matters concerning Kariba. Furthermore it was to collect hydrological and environmental data for the Zambezi River, and subject to the approval of the council of ministers operate and maintain any other dams on the Zambezi. In 1987 ZRA's responsibility for generation and transmission was handed over to the two utilities, the Zimbabwe Electricity Supply Authority (ZESA) and ZESCO.

Compliance

In the 1950s there were not many laws and regulations in place for the construction of a major dam project in North and South Rhodesia. When rockfalls occurred during the excavation of the Kariba North Bank Cavern, Zambia was seeking to invoke its Mines and Minerals Act, which contained a number of safety measures. According to the World Bank this "made it virtually impossible for the contractor to implement its work programme". Zambia eventually agreed to lift the act for the rest of the construction work.

There were no internationally binding design conventions, but by hiring reputed consultants it was assumed that all works would be state-of-the-art.

In terms of environment there were no regulations whatsoever. Voluntarily Northern and Southern Rhodesia approached the government of Portuguese East Africa (now called Mozambique), to negotiate a minimum release from the dam. It was agreed that this mandatory release would be 10000cusec or 283m^3/s. This value is still being adhered to.

In 1957 the Kariba Lake Development Company (KLDC) was formed. KLDC was formed hurriedly, with a brief to cover a wide range of subjects, including transport, industries, fisheries, national parks, tourism, irrigation and forestry.

The formation of KLDC is significant in that the committee effectively took over the responsibilities for environmental protection and management on behalf of the project. KLDC commissioned a fish survey, carried out studies on water borne diseases, was involved in setting up wildlife sanctuaries, etc. KLDC thereby developed the beginnings of ad hoc environmental and social regulation.

Views on Development Effectiveness and Lessons Learnt

The ultimate objective of the WCD case study process is to make an assessment of the overall development effectiveness of large dam development and to derive lessons for other large dam projects worldwide.

- **Assessment of the Development Effectiveness of the Kariba Project**

The concept of development effectiveness is a subjective one. It represents the overall opinion, all things considered, that a person has of a dam project. In the WCD case study methodology, the development effectiveness of a dam was to be evaluated by the stakeholders of the particular dam. The stakeholder meetings were used for this assessment, with questionnaires being administered on the stakeholders.

During the second stakeholder meeting for the Kariba case study, the stakeholders were asked for their view on the general effectiveness of the dam and to explain what they believed to be useful parameters on development effectiveness of dams. The stakeholders engaged in intense debate on this issue. In the end they agreed on a set of questions that must be asked in order to evaluate the development effectiveness of large dams. The following are some of the questions that the stakeholders believed should be used in assessing the development effectiveness of large dams:

- Was every possible development option considered and exploited in the in the planning and implementation of the dam project? According to the stakeholders, the decision to implement an effective large dam project should be preceded by an analysis of all possible development options to ensure that these are incorporated into the project. In the case of Kariba, one of the main weaknesses of the project according to the stakeholders, was the failure by the project planners to look beyond the provision of hydropower to the two participating countries. The stakeholders were of the view that development options in fisheries, tourism, irrigation and rural electrification should have been considered at the planning stage and implemented as part of the project.
- Did the project increase regional co-operation? In the view of the stakeholders, a dam is more effective if it promotes regional co-operation. The stakeholders felt that large dams are best implemented in a regional rather than national context. In this regard, Kariba was viewed as being effective by the stakeholders because it became the nucleus for the development of the Southern African Power Pool and the power from the dam led to the industrial development of Zimbabwe and Zambia.
- If people were displaced by the dam project, did these displaced people benefit from the dam project? For a dam to be considered effective, the benefits from the dam must be enjoyed by those displaced by the dam. This is one area in which the stakeholders found Kariba to have failed the test of development effectiveness, because the Tongas who were displaced by the dam benefited little from the project.
- Did the project meet the required rate of return? This is a purely financial and economic consideration, whereby an effective dam project should meet the predicted economic performance targets.
- Did the project exceed original objectives? According to the Kariba stakeholders, an effective dam project should exceed original objectives. The stakeholders noted that Kariba did in fact exceed the original stated project objectives and that it can be viewed as having been effective.
- Was there an equitable distribution of benefits from the project? This was another one of the issues that were most hotly debated at the stakeholder workshop. The stakeholders were reacting to the fact that most of the benefits from Kariba were not being enjoyed by local people who had suffered most as a result of the lake. In the view of the stakeholders, an effective dam project is one in which an effort is made to ensure that the benefits are distributed as equitably as possible. This was one area in which the stakeholders believed that the Kariba Dam project had not been effective.

- Did the living standards of the people improve as a result of the project? An effective dam project should be associated with an improvement of the living standards of the people, especially those displaced by the dam. Again, the Kariba Dam project was viewed by the most of the stakeholders as not having been entirely effective because the living standards of the displaced people were prejudiced.
- Did the affected people participate in the decisions that related to the project? In an effective dam project, the local affected people must be allowed to participate in decisions that relate to them. In the case of Kariba, the people were not afforded the opportunity to participate in the decisions that related to them and the dam, and stakeholders were mainly of the view that the Kariba project was not effective here.
- Was an EIA carried out and was a costing of impacts carried out? An effective dam project should have an EIA and an environmental management plan. Since no EIA was carried out at Kariba, this was one area where the project failed. However, the stakeholders excused Kariba on this issue because at the time, environmental issues were not yet in vogue.
- Is the dam project multi-purpose? This question is linked to the one where the stakeholders believed that all development options must be investigated in the planning of a large dam project. The stakeholders felt that because the planners for Kariba confined themselves to hydropower issues, some opportunities for multi-purpose use were lost.
- Were efforts made to minimise the displacement of people? The decisions that were made on the size of Kariba were aimed at maximising the amount of power from the project through the construction of the largest dam possible. No analysis was carried out to reconcile the need for a large dam and power station; and the need to minimise the number of people to be displaced. In fact the Federal Power Board went on to increase the height of the dam wall by 20 feet resulting in the increase in the area inundation and a concomitant increase in the number of people to be displaced.

The stakeholders for Kariba Dam had divergent views on the different aspects of the development effectiveness of Kariba Dam. Views were mainly divergent with respect to technical and economic issues, but there was general consensus on issues relating to social impacts of the dam. This consensus is not surprising when one considers the high awareness of the stakeholders with respect to these social issues.

When the stakeholders were asked to give their overall assessment of the development effectiveness of Kariba Dam, 15.5% rated Kariba very highly effective, 56% high, 13% were neutral, while the remaining 15.5% rated Kariba poor. None of the stakeholders rated Kariba in the lowest category of very poor. Therefore overall, the negative social impacts notwithstanding, the Kariba stakeholders viewed Kariba Dam as having been effective. These figures need however to be considered with care, given the fact the group who attended the stakeholder meeting is far from being a perfect reflection or a statistically representative sample of the broader population affected by or interested in the Kariba Dam.

Lessons Learned

The information and data collected by consultants with respect to the Kariba Dam and the views expressed at the stakeholders meetings were carefully examined to isolate lessons that may be useful or inform large dam development in the future. The following is a list of lessons that were identified in the Kariba case study for the large dam debate. The consultants drew the list of lessons first and presented them at the second stakeholders meeting. The latter made their contributions and editions to the consultants’ list of lessons. The lessons are:

- The design of spillways for large dams should make allowance for hydrological uncertainty. For safety, the dam spillway should be designed for the Probable Maximum Flood (PMF), which would be the highest flood that can physically occur.

Kariba was designed for the safe passage of a 1 in10 000-year flood. In the original design of the dam, the spillway had been designed for a 3-month flood of volume 68km^3. During construction, in 1957, a peak flood of 8200m^3/s occurred, the highest on record. As a result, the dam engineers revised their spillway design to a 3-month flood of 74km^3. In the following season, 1958, a peak flood of 16000m^3/s was recorded and a 3-month flood of 61km^3 occurred. This led to a further revision of the spillway design to its present capacity of 92km^3. Had the project been completed before these two floods, the spillway would have been seriously under-designed, with equally serious safety implications.

- **Hydroelectric schemes may have far more positive implications than just the production of electricity.**

The Kariba project provided access roads to hitherto isolated area; led to the development of a thriving fishery industry; triggered the formation of important wildlife sanctuaries; became a major tourist attraction; and was the basis for an interconnected electricity network of two countries. These developments cannot all be predicted accurately, but in future studies the development potential of non-electricity benefits should to be accorded more attention.

- **Major hydropower projects can lead to continuously low tariffs, with major benefits for the residential, commercial and industrial consumers**.

As a result of the relatively low construction cost of Kariba and Kafue the average electricity cost in the region dropped by about 30% in the period 1961–1977, while the average price for other commodities and services rose by more than 75%. It must be said however that in Zimbabwe ZESA almost went bankrupt in this time, as prevailing tariffs, dictated by the government, did not reach adequate levels.

The study found that there is good anecdotal and non-quantitative evidence of a good correlation between GDP of Zambia and Zimbabwe and electricity consumption. The completion of Kariba resulted in growth of manufacturing and mining sectors in Zambia and Zimbabwe respectively. For example, following Kariba, Zimbabwe established high power consuming industries such as fertiliser and ferrochrome plants.

- Large man-made reservoirs can cause earthquakes, especially when they are constructed in a tectonically active area, as is the case of Kariba. The induced seismicity may affect dam safety and lead to other damages such as flooding of downstream areas and should therefore investigated in the planning stages of the dam to ensure dam safety.

The water storage volume of Lake Kariba of 180km^3 translates into a mass of 180 billion metric tons. It was further noted that the lake is located in a tectonically active area, at the southern end of he African Rift Valley. Since its construction and filling in the early 1960s, Kariba has caused numerous earthquakes in the area, 20 of them in excess of magnitude 5. This has significance on dam safety.

The project documents for Kariba did not discuss the seismicity of the Kariba area, and the need to take this into account in the design of the dam. The planning of any future dams that are of similar size to Kariba, and which are located in tectonically active areas will need to take account of the potential dam-induced seismicity in the design.

- With the numerous unexpected impacts that arose since its completion, the Kariba Dam illustrates the importance of systematic impact assessment in the planning of large dam projects. Many of the negative impacts of Kariba could certainly have been avoided if some impact assessment had been applied in a systematic way at the time. The impact assessment **should as a minimum,** address the following components: environmental impact assessment (EIA), social impact assessment (SIA) and health impact assessment (HIA)

In the Kariba project, the project document and the World Bank project appraisal report did not consider any environmental impacts of the dam. These documents confined themselves to the issues of the construction of the dam wall, the power stations, associated civil works, and their costing. As a result, the Kariba Dam had numerous unexpected impacts, especially in the environmental fields of wildlife, water pollution, tourism, water borne diseases and fisheries, and in social sectors (displacement and resettlement in particular).

- A dam project is governed and guided by the prevailing laws of the country. In situations where the laws are unjust, it is difficult for the project to deliver benefits equitably, and to minimise social and economic costs. As a minimum, it is important for a dam to ensure that the land rights of the people (especially the tribal land rights) are not lost as a result of the project.

Because of the differences in the political settings in Zambia and Zimbabwe (Northern Rhodesia, an "indirect rule" colony, which became independent 5 years after the completion of the dam, and Southern Rhodesia, a white settlement colony until 1980), the resettlement procedures were different in the two countries. While still far from optimal, the resettlement of the Tonga in the North was less inhumane than what happened in the South. That said, in both countries, the laws were such that people who were displaced by the dam had little protection by the colonial authority of the time. According to the laws of both countries peasants did not have title to the land on which they were settled. They only had usufruct rights, and the land belonged to the state. Because of this legal situation, there was no need for the project to take the interests and land access rights of the local people into consideration. If the laws had been just, and the people had had some land access rights, the project developers would have been compelled to consult the people and to take their rights and interests into account.

- In dam projects, cases of involuntary resettlement require detailed planning and the full participation of the affected people in the planning process. In addition, the planning process must be carried out well ahead of resettlement process and must ensure adequate infrastructure in the new areas of settlement to minimise the trauma of resettlement for those displaced by the dam. As far as possible, the displaced people must be equally or more comfortable in their new settlement areas than their areas of settlement in the dam basin.

The Tonga people who were displaced by Lake Kariba were never involved in the planning of their resettlement. All evidence available shows that the government officers of the day did all the planning of the resettlement exercise and the general selection of the new settlement areas for the Tonga. The Tongas were not provided with an opportunity to explore alternative ways of resettlement and to state their preferences. Another weakness of the resettlement programme is the fact that it was hurried. Not enough time was allowed for the Tonga to be prepared for the relocation, with the result that some had to be rescued on islands as the waters of the lake rose.

On the same issue of the need to involve the affected people in the planning of their resettlement, dam project developers should involve the people and negotiate with them on the most appropriate manner of resettlement. In the Kariba case study, it is reported that displaced people were bundled into lorries and left at their new homes. Cattle were driven over long distances on the hoof and it is reported that some died in transit. Any materials of cultural value, such as clay pots, which could not be transported on the lorries, were left behind. These losses or some of them could have been avoided if the people had been involved in the planning of the move and allowed to participate in decisions on the best way of relocation.

- Where resettlement process leads to community fragmentation, one of its potential consequences can be a loss of cultural identity.

Some of the displaced Tonga people were settled in areas where they became minority groups. In these cases (examples of Tongas settled in Sambakarouma and Binga in Zimbabwe), they ended up speaking the languages of their host communities, and lost not only their native languages but also their cultural Tonga identity. This loss of identity has been accentuated by the fact that the frequency and feasibility of visits between groups settled in the South (Zimbabwe) and those settled in the north (Zambia) were practically eliminated after impoundment because of the long distances involved (some were located over 100km from the Lake), and because of the tightening of the conditions for crossing the border, especially after the Federation of Rhodesia and Nyasaland broke up in 1963. As time passed, relatives and friends on the opposite sides of the border lost contact with each other. It was during the stakeholder meeting organised to discuss the draft Kariba report that some of the representatives of these communities met for the first time since the displacement took place, 40 years ago. A 40–50 year old traditional Zimbabwean Tonga chief who attended the Kariba stakeholder meeting needed an interpreter in order to communicate in Tonga with other chiefs.

- The effectiveness of a dam project must be evaluated on the basis of the extent to which it provides meaningful development opportunities for the people who are affected by the dam.

In the Kariba case, it would be fair to say that the displaced Tongas were never viewed as stakeholders in the dam or potential owners of the dam. As a result, there was no attempt on the part of the dam developers and the governments of the day to investigate ways in which the Tonga could maximise their benefits from the dam. In Zimbabwe, for example, the settlement areas were located far from the new water body where they could not easily access the dam for fishing and/ or irrigation. Some of the communities were settled more than 120km from the dam, with most of them being about 50km away. It is not feasible, from these distances, for the displaced people to take advantage of the dam.

The Kariba Dam was established for the production of electricity, and yet very few of the Tonga settlement areas are connected to the national electricity grid. In Zimbabwe, the first Tonga area to be connected to the national grid was Binga in 1985, 25 years after the first generator went into operation at Kariba. Since 1985, no other areas have been connected in the Tonga areas of Zimbabwe. It therefore follows that the Tongas of Zimbabwe were never provided with an opportunity to benefit from the main product of Kariba Dam.

- In resettling people who are displaced by large dam projects, efforts must be made to ensure that the relocated people are familiar with the agro-ecology of the new areas of settlement, and that they have the necessary agricultural skills for their new settlement areas. If the new and old areas of settlement are agro-ecologically different, the project should make budgetary allocations and adequate plans for the provision of long term, appropriate agricultural training for the settlers, to ensure success. This recommendation applies to areas where agriculture is the main occupation for the displaced people. However, where the affected people are involved in non-agricultural activities, the project must ensure that the people receive skills training in their field of livelihood.

The people who were displaced by Kariba in Zimbabwe were settled in areas that were agro-ecologically different from their original home on the banks of the Zambezi River. The agricultural studies carried out showed that while the Tonga were able to grow two crops per year in some areas along the Zambezi River, their new areas of settlement are in dry areas of unreliable rainfall and generally infertile soils. As a result, the Tonga have not been able to become self-sufficient in food over the last 40 years.

One of the reasons why they failed to become self-sufficient in food is that they were never provided with the training to manage agriculture in the new areas. No investment was made into the training of these settlers to develop appropriate farming systems for their new area.

- Resettlement is not completed when the people affected are relocated. In addition to compensation aimed at enhancing livelihood conditions in a sustainable way, continuous support is necessary over many years to help them to get adapted to a new style of life.

Compensation packages offered to displaced people varied between the countries of Zimbabwe and Zambia. The Zambians were provided with cash compensation paid to each individual as well as funds for some development programmes in the new areas of settlement. On the other hand, the Zimbabweans did not receive any cash payments to individuals and there was little provision for development programmes in the new areas of settlement. The present study found that the displaced people in Zambia were unhappy with the compensation that was offered, considering it inadequate.

40 years after commissioning the project, the people resettled in both countries because of Kariba still need help. Part of the project revenues should become available for this purpose.

The lesson that can be learnt from this observation is that designing an appropriate compensation package for people displaced by a dam is a complex and difficult exercise, and that dam developers need to be creative and to go beyond the provision of cash handouts. Compensation needs to be aimed at providing the displaced people with an opportunity to achieve a sustained improvement in their livelihoods. Compensation is best given in a form that provides opportunity to the displaced people to become economically self-reliant and must be consistent with the noble aspirations of the community.

In the Kariba Dam project, the compensation that was offered to the displaced people, in Zambia, was on a *pari parsu* basis (ie, a hut for a hut). This approach misses the opportunity to develop a compensation profile that enables the displaced people a chance to participate in economic benefits arising from the transformation of their land resources.

The United Nations principles on habitat, which state that “whatever the original conditions of the displaced community habitat amenities, the new homes must meet the basic needs of comfort, health and dignity”. This United Nations dictate is exactly opposite to the “no worse no better” approach that was followed in the Kariba project by the Zambian territorial government in determining the situation of the displaced people after resettlement.

The Kariba study also shows that compensation alone does not suffice in many cases to guarantee improved livelihood conditions in a sustainable way.

- In large dam projects, the affected people (especially those who would be displaced) must enter into legally binding agreements with the dam project developers with respect to the obligations of the developer to the affected people. This approach minimises misunderstandings between the dam project and the people.

This lesson was proposed by Kariba stakeholders at their second meeting, and it arose from the observation that all the complaints and expectations that the Tonga have with respect to the Kariba Dam would be addressed through legal means if there had been a legally binding agreement between the people and the project. At the time that Kariba was constructed, some verbal promises are reported to have been made by the governments of Zambia and Zimbabwe with respect to what the project was going to do for the displaced persons. The local people claim that many or some of these promises were not fulfilled by the project. For that reason, the local people now wish that they had recourse to a legally binding agreement for redress.

- Effective institutional structures should be established to monitor and attend to all identified potential negative impacts after the implementation of the dam project. In projects such as Kariba, which are inter-country, it is important to ensure that these institutions can survive any changes in the political relations of the countries.

In the Kariba case study, the project did not carry out any impact assessment. However, if the project had done so, it would have been important to ensure that effective institutions were identified to address any negative impacts after the project has been implemented. This lesson arises from the observation that the Kariba Lake Coordination Committee (KLCC) ensured that some of the potential negative impacts of Kariba were addressed by institutions that they established. An example is the assignment of all issues pertaining to wildlife to the game department, and how the latter has managed the wildlife of the area effectively ever since the dam was constructed. Similarly, through the efforts that were initiated by the KLCC, the Lake Kariba Fisheries Research Institute was established to oversee all issues relating to fisheries on the lake.

The role played by Central African Power Company (CAPCO) in managing the dam and power stations during the 1965–1980 period when the relations between Zambia and Zimbabwe were at their lowest shows the importance of strong inter-country institutions. The recent (1987) establishment of he ZRA as an inter-country body with wide ranging responsibilities, which include studying and making recommendations on environmental and social impacts of the dam as lessons for future dam developers, is further testimony in favour of strong international institutions. It is interesting that the idea of the ZRA had been suggested as far back as 1948, by the Inter-Territorial Power Council, but it had to wait 30 years before it could be implemented.

The corollary of this lesson is that the implementation of large inter-country dam projects must be accompanied by the immediate establishment of strong, legally constituted institutions that have clearly defined responsibilities with respect to the addressing of negative impacts. Without effective institutions it is not possible to address negative impacts of dams.

- As shown in the case of the Kariba Dam, a number of initiatives (trust funds, targeted development projects) can be considered for addressing some of the unsettled issues inherited from the past.

Most old dam developments, such as Kariba Dam, which were implemented prior to the 1980s, did not have the benefit of thorough impact assessments, especially environmental and social impact assessment. As a result, these dams are likely to be associated with some negative social impacts. The current ZRA Trust Fund and ZESCO's Tonga rehabilitation projects, initiated 40 years after the construction of the dam, are promising ex-post reparation initiatives. Some of the representatives of the Tonga people who attended the stakeholder meeting are doubtful about the effectiveness of these programmes, which they consider as too top-down if not mere cosmetic interventions.

- Projects of the nature of Kariba not only require regional co-operation, but are also opportunities for fostering it. As a large international and inter-country hydroelectric project, Kariba facilitated the creation of regional power pools and ensured reliability of power supply to the participating countries. In turn, regional power pools can reduce the unit cost of power through the optimisation of use and economies of scale.

As an international dam, shared by the two countries of Zimbabwe and Zambia, the Kariba Dam project automatically involved the erection of power transmission lines to the two countries, thereby connecting the national electricity grids. It also meant that Kariba became connected to any other power stations within the two countries. When Kariba was built, the Zambian Copperbelt was already connected to power stations in the Congo, and therefore, Zimbabwe became connected to the Congo. Kariba enabled the formation of the Southern African Power Pool in which the electricity grids of the countries of Zimbabwe, Zambia, Congo, South Africa, Mozambique, Botswana, and Lesotho became connected.

Regional power pools have many advantages, which include the maintenance of reliable power supplies in the event of any one station breaking down, the reduction in cost of power through the optimisation of use of the different power stations in the pool, and more importantly the savings in investment that accrue in foregoing the expansion of individual country generation capacity.

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List of Acronyms and Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
BRDC	Binga Rural District Council
CAMPFIRE	Communal Areas Management Plan for Natural Resources
CAPCO	Central African Power Company
CPUE	Catch per Unit Effort
CV	Coefficient of Variation
DC	District Commissioner
DDT	Dichloro-diphenyl-trichloro ethane
EIA	Environmental Impact Assessment
EPP	Emergency Preparedness Plan
ESC	Electricity Supply Commission
FAO	Food and Agriculture Organisation
FG	Federal Government
GCM	Global Climate Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRZ	Government of the Republic of Zambia
GVDC	Gwembe Valley Development Company
GWh	Giga Watt hours
HEC	Hydrologic Engineering Centre
HEP	Hydroelectric Power
HIV	Human Immuno Virus
IBRD	International Bank for Reconstruction and Development
INESOR	Institute for Economic and Social Research
ITPC	Inter-Territorial Power Commission
KCC	Kariba Coordination Committee
KLCC	Kariba Lake Co-ordination Committee
KLDC	Kariba Lake Development Company
KLFC	Kariba Lake Fisheries Committee
KLNPTC	Kariba Lake National Parks and Tourism Committee
KN	Kariba North
kV	kilo Volts
kWh	kilo Watt hours
mb	Body Wave Magnitude
Ms	Surface Wave Magnitude
MW	Mega Watts
NAZ	National Archives of Zimbabwe
NE	North East
NRG	Northern Rhodesian Government
OPEC	Organisation of Petroleum Exporting Countries
PMF	Probable Maximum Flood
PRP	Power Rehabilitation Project
RDC	Rural District Council
SADC	Southern African Development Community
SADCC	Southern African Development Co-ordination Conference
SIA	Social Impact Assessment
SOP	Standing Operations Procedures
STD	Sexually Transmitted Disease
STI	Sexually Transmitted Infection
SW	South West
TWL	Top Water Level
UDI	Unilateral Declaration of Independence

UK	United Kingdom
VMC	Village Management Committee
WCD	World Commission on Dams
WHO	World Health Organisation
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Company
ZRA	Zambezi River Authority
ZTA	Zimbabwe Tourism Authority
ZZSFP	Zambia-Zimbabwe SADC Fisheries Project

1. Introduction

The Kariba case study was carried out on behalf of the World Commission on Dams (WCD). The purpose of the study was to determine the impacts that Kariba Dam has had on the economics, the people and the countries of Zimbabwe and Zambia and on the ecology of the affected riparian communities.

The case study was carried out in two phases. In Phase 1, the scoping study, a small carefully selected team of consultants was assembled and commissioned to examine all the issues that were important in order to understand Kariba and which would, hence, require detailed study in the subsequent Phase 2. The scoping report was completed in August 1999. A meeting of stakeholders related to Kariba Dam was held 5 – 6 September 1999 to discuss the scoping report and to make additional recommendations on issues that required attention in Phase 2. A copy of this scoping report is available from WCD for reference.

The scoping report for the Kariba case study became the terms of reference for Phase 2. The Kariba scoping report is a comprehensive document in which the consultants examined a wide range of environmental, ecological, social, political and engineering issues associated with Kariba Dam and recommended further studies in each of these subject areas.

In summary, the scoping or Phase 1 study identified the following 13 subject areas for study in Phase 2:

a) ***History and Decision Analysis:*** Kariba was built in the late 1950s. The dam has a history spanning over 40 years. The scoping document requested a detailed documentation of the events leading to the establishment of the dam as well as the events that occurred during the operation of the dam and hydroelectric plants over the last 40 years. The scoping document also requested that a detailed analysis be carried out of how decisions were made with respect to what development options to take and when to implement particular development alternatives. Since Kariba was constructed, the political situation in Southern Africa has gone through a long series of profound political changes. Regional politics, at any particular time, decisively influenced decisions that were made with regard to Kariba Dam. Thus, the scoping document requested an examination of all the factors that influenced the decisions that were made.

b) ***Hydrology Studies:*** Kariba Dam was the largest man-made lake in the world at the time of its construction. With a storage capacity in excess of 180km^3, the dam represents a large storage of water that should have flowed uninterrupted to the sea. Thus, the scoping study requested that Phase 2 studies should examine the extent to which the dam has affected the hydrology of the Zambezi River, all the way to the ocean. The impact of Kariba Dam on the downstream riverine communities and ecology was also associated with hydrology impacts, since the establishment of the dam curtailed seasonal flooding. An analysis of the impact of droughts on the Kariba Dam was also requested.

c) ***Hydropower Studies:*** Studies on hydropower were for the analysis of the growth in demand for hydropower in the two countries that participated in the Kariba Dam project, and how the shortage of power in the 1950s reinforced justification for the Kariba project. Further analysis was also requested with respect to the actual performance of the Kariba power station(s) compared to projections that were made at the time of planning for the project.

d) ***Seismology Studies:*** The volume of water held by Lake Kariba at full capacity, amounting to over 180km^3, translates into a mass of over 180 billion tons. This mass of the stored water would, therefore, be expected to cause some tectonic instability in the basin.

The potential for tectonic movement becomes even more likely when one considers that Kariba Dam is located at the southern end of the African Rift Valley, an areas of known, recent tectonic movement. Thus, the scoping exercise for the Kariba case study recommended that a study be carried out to determine the seismic impact of Kariba Dam and to make an assessment of the general safety of the dam.

e) ***Economic Impacts of Lake Kariba:*** Phase 2 studies were expected to examine the impact that Kariba Dam had on the economies of the two riparian countries of Zimbabwe and Zambia. The analysis was expected to start with an examination of the economic considerations and analysis that were used to justify the Kariba Dam project, before proceeding to analyse the economic performance of the project during its operation. The economic analysis was to examine how the criteria that were used to make decisions to implement Kariba compared with criteria that would need to be followed in making decisions on a similar project today.

f) ***Legal Issues Associated with Kariba Dam:*** The Phase 2 Study was tasked with examining the laws that prevailed in Zambia and Zimbabwe during the planning, and implementation of the project. *Inter alia*, legal consultants were required to examine the extent to which the rights of the people of the area were respected in decisions relating to the implementation of the project. Lastly, the legal studies examined the institutions that have been established over time to manage Kariba Dam and their legal responsibilities.

g) ***Sociological Impacts of Lake Kariba:*** A large number of publications on lake Kariba exist and give prominence to the reportedly insensitive manner in which the inhabitants of the Zambezi basin were displaced by the lake (Colson, 1960; 1971; Scudder 1960; 1962; 1971). It is therefore pertinent that the scoping document specifically requested the examination of how Kariba Dam affected displaced people and the nature of these social impacts, including, an examination of the extent to which the inhabitants of the valley were consulted by the dam planners and project implementers. What did the valley residents understand about the dam and its effects on them and did they benefit or suffer by being displaced?

h) ***Ecological Impact Analysis:*** The scoping study recommended an examination of the impacts of Kariba Dam on the ecology of the Zambezi basin, inclusive of upstream and downstream areas. Ecological impact studies were also expected to examine the impacts that the dam had on terrestrial and aquatic habitats, biodiversity, and any pollution issues associated with the lake.

i) ***Agriculture and Resettlement Studies:*** an examination of the impacts of lake Kariba on the agriculture of the area around the lake and on irrigation development in the neighbouring and downstream areas. The study was expected to examine any plans that were made for irrigation and agriculture at the planning stage for Kariba and how these were implemented. In addition, the agriculture studies were expected to discuss any other unexpected agricultural development associated with Kariba Dam.

j) ***Impacts on Fish and Fisheries:*** With a surface area in excess of 5 500km^2, a shoreline which is about 2000km in linear length, and being located in a warm tropical environment, the Kariba Dam created a great opportunity for the development of a large fisheries industry for the two landlocked riparian countries. The scoping document instructed Phase 2 to examine the development of the fisheries industry on Lake Kariba and to analyse the impact of this industry on the displaced people and the economies of the two countries.

k) ***Public Health and Water Borne Diseases Impacts:*** As a fresh water body, Kariba was likely to be associated with some risk of water borne diseases. Accordingly, the scoping document requested that an examination be made of the impact that the dam has had on the incidence of water borne diseases in the basin. Although HIV/AIDS is not a water-borne disease, the scoping report requested that this disease be considered as an indirect impact of the dam, and in relation to the development of the tourism industry and the urban populations around the lake.

l) ***Impacts of Kariba Dam on Wildlife:*** The Zambezi basin is world famous for its wildlife, which includes large game such as elephant, rhino, lion, buffalo and many others. One of the historical highlights of Lake Kariba was 'Operation Noah' in which a few dedicated game rangers rescued large numbers of wildlife that were marooned and threatened with drowning on islands in the lake as the waters of the dam began to rise. A large wildlife estate was created on the Zimbabwe side which pre-empted lakeside land for resettlement. Accordingly, the scoping document requested that Phase 2 of the Kariba case study should examine the impact that the dam had on the wildlife resources of the area, as well as the relationship between human land use and wildlife.

m) ***Impacts of Lake Kariba on Tourism:*** the Kariba case study was tasked to examine the development of tourism around the lake and to determine how much of this tourism development was anticipated at the project planning stage. In addition, the tourism studies were to determine the participation of local people in this industry, especially the participation of those who were displaced by the dam.

Specialists in each of these 13 subject areas were recruited into the Phase 2 study team and detailed studies were carried out for each of these subject areas.

The draft final report for the Kariba case study was produced in February 2000 and presented at a meeting of some 70 stakeholders at Kariba, 20-22 February 2000. In addition, the first draft report was distributed widely to interested parties such as international Non-governmental Organisations (NGOs), and international organisations with interest in the large dam debate. Comments received from stakeholders who attended the second stakeholder workshop at Kariba and written comments received from other interested individuals and organisations were incorporated in the preparation of this final draft report.

1.1 Why the Kariba Dam as a Case Study?

The WCD chose to study Kariba for three reasons:

- It is one of the older of the large dams, worldwide;
- It is shared by two sovereign countries, Zambia and Zimbabwe, and therefore provides lessons on the implementation of inter-country dam projects; and
- It is on a river, the Zambezi, the catchment and basin of which involves nine countries; ie, it is on an international river.

Kariba is the only dam chosen for study by the WCD that is located in Africa.

As an old dam, Kariba provides lessons on how projects of that magnitude were conceived and planned in the 1950s. A number of new considerations, especially on the environmental, human rights, and economic fronts, have emerged since the 1950s. As a result, current large dam projects are assessed according to different criteria compared to the situation of the 1950s. Kariba therefore provides an excellent opportunity to understand the changes that have occurred in the assessment of large dam projects in the last 40–50 years.

The construction of Kariba was associated with the displacement of large numbers of people, under conditions that have enlisted the revulsion of many social analysts. Large volumes of literature have been produced on this subject, and Kariba Dam has the longest running uninterrupted study of the social impacts of a large dam. The existence of this long-term study on Kariba provides an excellent opportunity for lessons for WCD.

1.2 The Location and Features of Kariba Dam and Hydropower Stations

The location of Kariba Dam is shown in Figure 1, with the dam wall at grid reference 28.74778 ^{o} East and 16.51222^{o} South. The following are the design features of Kariba Dam and hydropower stations:

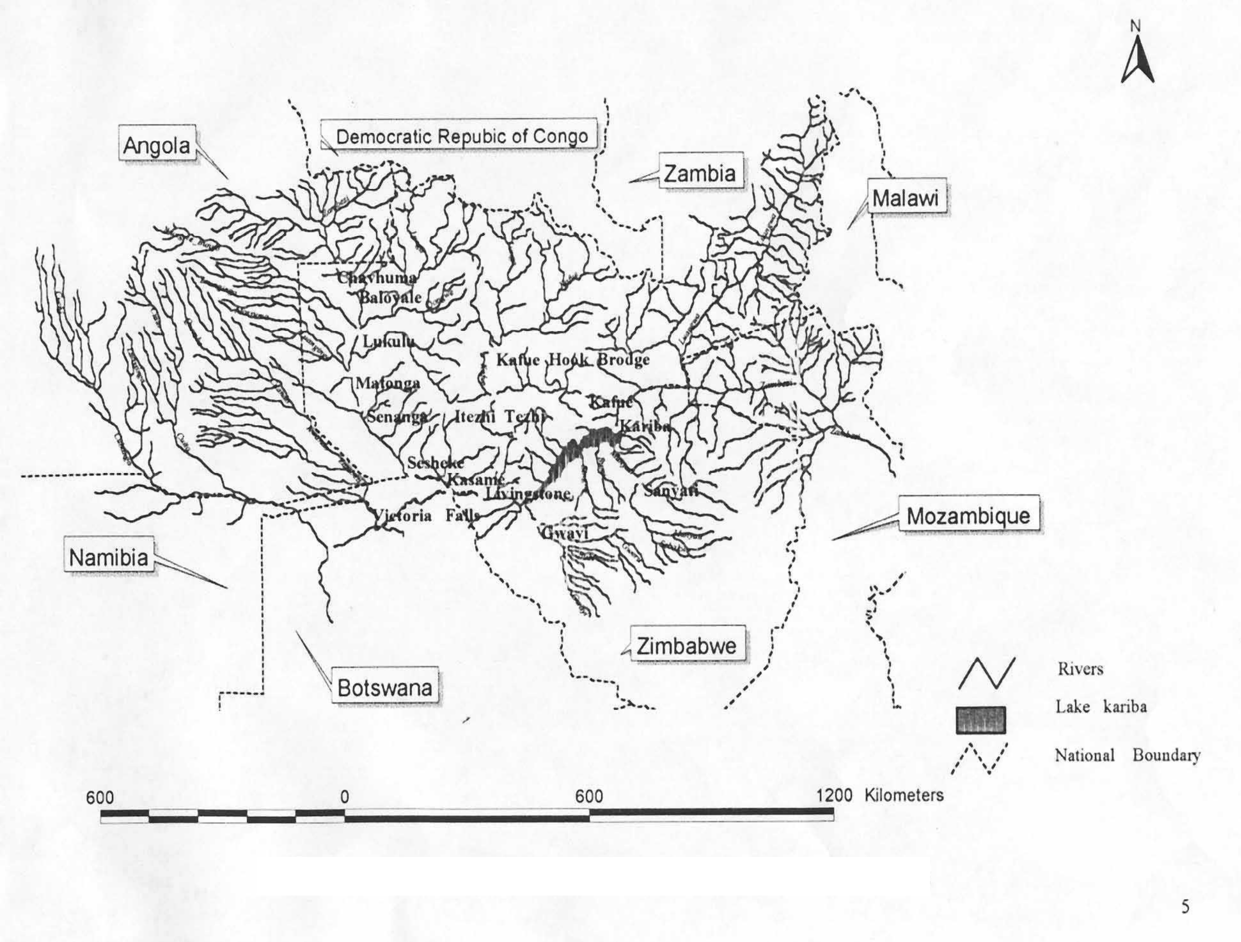
Type of Dam	Double Curvature Concrete Arch dam
Height	128m
Crest Length	617m
Flood Gates	6 gates of dimensions 8.8m width and 9m height
Discharge Capacity of flood gates	9500m^3/s
Length of Reservoir	280km
Minimum Retention Level	488.50m
Minimum Operating Level	475.50m
Total Storage	180.6km^3
Live Storage	64.8km^3
Maximum Surface Area	5577km^2
Depth of Stilling Pool	78m
Volume of Stilling Pool	410 x 10^{6}m^3
Generation Capacity:	a total capacity of 1320MW from both power stations as:
Kariba South Bank Power Station:	6 by 117.5MW generation units giving a total of 705MW
Kariba North Bank Power Station:	4 by 153.5MW generation units, giving a total of 615MW

1.3 Structure of this Report

The main purpose of this report is to enable the Commission to determine the development effectiveness of large dams through an analysis of the predicted and actual impacts of the large dams selected as case studies. To assist in this process, this report comprises seven chapters. Chapter 1 presents background material on the Kariba case study and the WCD case study process while Chapter 2 summarises the context and scope of the case study, including the history of Kariba Dam. In Chapter 3, the projected and actual impacts of Kariba Dam are presented. These are classified according to the subject areas identified in the scoping report and which were listed earlier as hydropower, ecological impacts, agricultural impacts etc. In Chapter 4 the distribution of the costs and benefits from Kariba Dam are analysed and presented as a summary of the main impacts that the dam has had in its 40 years of existence. This is followed by Chapter 5, which presents an options analysis for the Kariba Dam project and a discussion of the decision-making process that led to the project. In Chapter 6, the compliance of Kariba Dam with guidelines of the day is discussed. Lastly, in Chapter 7, the development effectiveness of Kariba Dam and the lessons that can be learnt from the Kariba Dam case study are presented.

Because of its long history, there are large volumes of data that may need to be presented with respect to Kariba, to support conclusions that will be made. Some of these will be presented in the Annexes.

Figure 1.1: Location Map of Lake Kariba and Surrounding Territories



1.4 Overview of the World Commission on Dams Global Case Study

The Commission at its inception in 1997 was given a challenging mandate by its reference group. The mandate includes, among other things, an assessment of the "development effectiveness" of dams, which the Commission has decided to address through thematic studies, a cross-check survey, and a series of case studies of dam projects worldwide, with a view of learning lessons from these experiences.

This report is one of 10 case studies being undertaken worldwide, with a common methodology and approach that seeks to inform the Commission on development effectiveness with respect to a wide range of issues associated with the planning, design, construction, operation, and decommissioning of large dams. Kariba was the largest man-made lake in the world at the time of its construction in the mid-1950s. The project was planned and implemented primarily for the provision of hydroelectric power to the southern African countries of Southern Rhodesia (now Zimbabwe) and Northern Rhodesia (now Zambia). The dam was established in a remote location, far from any existing urban settlements and was never intended to meet any existing urban water requirements.

According to WCD guidelines for case study reports, emphasis is placed on comparing the outcome anticipated by the project with the results that were finally achieved. Throughout the studies, key distinctions are therefore drawn between that which was predicted and that which was not. This "predicted versus actual" approach is important because the purpose of case studies is not to answer the question of "should the dam project have been implemented?", but rather to ask what its effect has been. In addition, the study seeks to document how effective the planning and implementation process has been in delivering the anticipated benefits, and how the decision-making process has addressed changing circumstances and unexpected consequences since the project was completed. The focus on the planning and decision-making process is essential, as lessons learnt in this area will directly inform the Commission’s findings and its proposals for future decision-making frameworks as well as criteria and guidelines.

The concept of “development effectiveness” is taken in its broadest sense. It includes not only the relevance and appropriateness of large dams as a response to the needs that motivated their construction (eg, irrigation, electricity generation, flood management, water supply, navigation, and other multi-purpose benefits) but also the projected versus actual services and benefits delivered. It further assesses the costs and impacts associated with the results obtained, the distribution of gains and losses among groups, and the general conditions under which the dams were built and have operated.

The case study uses existing data sources and reports to inform its assessment, as time does not permit additional research to be undertaken. In this respect, data availability from previous studies may limit the findings of case studies.

The Commission’s approach recognises that there cannot always be unanimity in the interpretation of the available data, or in the perceptions of different interest groups, and that these convergent and divergent views are a key aspect of differing perceptions of development effectiveness.

Assessing development effectiveness thus entails taking account of the views and perspectives of different stakeholders and project affected groups. A WCD case study does not take up a particular “position”, but simply reports on the views of different groups.

Equally, a case study will not pass judgement, with the benefit of hindsight, on whether or not a project should have been implemented, or how things could or should have been done differently. Nor will it comment on the future evolution and management of the project.

The purpose of a case study is to learn lessons from the past, focussing on those that are especially relevant to the planning, implementation and operations of large dams worldwide. A case study is intended to provide an analysis of performance, an assessment of how the decision-makers planned and implemented the different phases of the project, and the way in which decision-making has responded to an evolving social, economic and political context over the period since project completion. The category “unexpected” includes all features and consequences not included in the original project design. At times, this will refer to issues genuinely unknown to the planners, while at other times, this will refer to issues known at the time but unaccounted for or neglected in the planning process.

The case study methodology for WCD case studies is based around six key questions that provide the foundations for the assessment of performance and decision-making as:

- What were the projected versus actual benefits, costs and impacts?
- What were the unexpected benefits, costs and impacts?
- What was the distribution of costs and benefits – who gained and who lost?
- How were decisions made?
- Did the project comply with the criteria and guidelines of the day?
- What lessons can be learned for today’s context?

2. The Context and Scope of The Kariba Case Study

2.1 The Zambezi River and the Zambezi River Basin

The Zambezi River is one of the longest rivers in Africa. It flows over a distance of some 2650km from its source in north-western Zambia to its delta into the Indian Ocean in central Mozambique. Although this report is about the Kariba Dam on the Zambezi River, on the boundary between Zimbabwe and Zambia, it must be appreciated that there are six countries that are riparian on the Zambezi River along its length. From its source the river flows westwards into eastern Angola, and then south to re-enter Zambia at Caripande. Within western Zambia, the river then flows through a relatively flat stretch of country, called the Barotse Plains, before becoming the border between Zambia and Namibia along the Caprivi Strip. The Zambezi also becomes a border between Zambia and Botswana for a short distance and then changes its course from a southern to an easterly direction, as it becomes bounded by Zimbabwe and Zambia at Kazungula. About 70km past Kazungula, the Zambezi River flows over Victoria Falls, and then enters a stretch of dissected country where it has cut magnificent and picturesque gorges in the landscape. Notable gorges are Batoka, Devil’s, Kariba and Mupata gorges. These gorges have been investigated and identified as good dam sites for hydropower generation. The Kariba Dam wall is sited at one of these gorges.

Past Kariba, the Zambezi River enters relatively flat country and loses little altitude until it passes the Cahora Bassa dam. From the gorge at which the Cahora Bassa dam was constructed, the river drops to the low altitude coastal areas.

In general discussions about the Zambezi River, reference is made to the upper, middle and lower Zambezi. The upper Zambezi refers to the stretch of the river from its source to the Victoria Falls. The middle Zambezi extends from the Victoria Falls to Cahora Bassa Dam, while the lower Zambezi covers the remainder of the river to the sea.

In documents relating to the Zambezi River, distinction is made between the Zambezi River and the Zambezi basin. The former refers to the river, while the latter refers to the whole catchment of the Zambezi River. Thus, while there are six countries that border on the Zambezi River, the basin includes two more countries, Malawi and Tanzania. The Shire River, one of the main tributaries of the Zambezi River, flows through the latter two countries.

2.2 Brief History of Kariba Dam

The history of the planning for Kariba Dam dates back to the last decade of the 19th century when the Kariba gorge – where the Kariba Dam wall is today – was visited and examined to assess its suitability for the construction of a railway bridge across the Zambezi to the north. Since that time several colonial officers visited the site and interest switched from the construction of a bridge to the construction of a dam and hydropower plant. The first river flow measurements were taken at Kariba gorge in 1907.

A full description of the long history of Kariba Dam and all the events that occurred subsequent to the planning of the dam is beyond the scope of this report, and only a summary of the major historical events associated with the dam will be given here.

Of interest is the series of events that occurred in the 10-year period between 1946 and 1955 when the final decision to construct Kariba was made.

Intense debate about the need to construct Kariba Dam began with the end of the Second World War in 1945 and the drive for industrial development, which followed the end of the war. At that time, both Southern and Northern Rhodesia were colonies of Britain, and the governments of the two countries were closely linked. In fact, plans were already afoot to form the Federation of Rhodesia and Nyasaland, consisting of the three territories of present day Malawi (then called Nyasaland), Northern Rhodesia and Southern Rhodesia.

The intensification of copper mining activities in Northern Rhodesia between 1920 and 1945 and the rapid expansion of the manufacturing sector in Southern Rhodesia brought out a need for a cheap and stable source of electric power in the two countries. The copper mines of northern Zambia were developing fast in response to a strong demand for the mineral worldwide and high copper prices on the international market. At that time, the copper mines were being supplied with electricity by a number of small coal-fired power stations on the Copperbelt of Zambia.

The coal for the power stations was being supplied from the Wankie coal fields in north-western Southern Rhodesia and from South Africa. The large amounts of coal that were needed for these power stations were transported by rail, over distances exceeding 750km. The largely single-track railway line linking the Copperbelt with the Hwange Colliery proved incapable of coping with the increasing tonnages of coal, which were required to supply the power stations.[1]

Between 1948 and 1956 “Operation Cardwood” was mounted to supply wood to make good the shortfall in fuel for the Copperbelt power stations, and resulted in the clearance of 917km^2 of forest (Williams, G.J. 1985:48).[2] This ended in 1956 when electricity imports from the Le Marine hydroelectric power station in the Belgian Congo were started. However, this was seen, in the light of political disturbances in the Congo at that time, as essentially a short-term measure to make good the deficit in the supply during the construction of the Kariba, which had already commenced (Ibid). Although consideration had been given to a major improvement in the rail system, coupled with the expansion of the Hwange colliery mine, the Copperbelt was to provide a most compelling reason for a major investment in a hydropower installation: a large and consistent bulk demand for power. (Ibid.)

Despite the long recognised hydroelectric potential of the Zambezi and its main tributaries, the first move towards its use was in 1946, through the formation of the Inter-territorial hydroelectric Power Commission. This was followed in 1948 by the appointment of an advisory panel to decide upon the relative merits of the construction of the Kariba and Kafue dams as power generating schemes. The panel initially recommended Kariba, particularly in light of the inadequate hydrological information available for Kafue. The irrigation potential of the Zambezi downstream of Kariba and the possibilities of fishery and other developments related to the lake were pointed out, but also with the recognition that the larger and more costly Kariba scheme would take longer to construct. As the power needs on the Copperbelt were becoming critical, the Northern Rhodesian Government was keen to see development at Kafue and accordingly invited the panel to make a detailed assessment of that scheme.

The panel confirmed Kafue viability, that it would be cheaper, and estimated that it could be constructed in two to three years, less time than Kariba. This was sufficient for the Northern Rhodesian legislature to decide, in February 1953, to proceed with Kafue and subsequently the Kafue River Hydroelectric Authority was formed to carry it forward.

[1] The location of the principal thermal power stations hundreds of miles away from their coal supplies had now become a major problem. With low electricity consumption the load on the railways in carrying powerhouse coal was very limited. In 1951 the Rhodesia railways carried 460,000 tonnes to power stations in Southern Rhodesia alone and by 1956 this figure was expected to double thus calling for a corresponding increase in railway capacity. Due to the fact that coal was placed low on the railway rates classification, the likely direct return from such railway development was very limited. (Thompson and Woodruff: 15)

[2] By today’s environmental standards and concerns, this was clearly unsustainable. Even then, the cost of clearing forest has had negative impact on the future generation, though this is not quantifiable as in the present report.

When the Federation was formed in August 1953, the support of Southern Rhodesia for initial development at Kafue had apparently been gained, largely on grounds of reduced costs and speed with which it could be constructed. This development was seen as essential for the well being of the Copperbelt as well as the Federation. However, in spite of the debate and application for a World Bank loan for Kafue, Kariba was considered a favourable site, whilst the potential at Kafue was seen to have been overestimated. (In 1950 the advisory panel estimated that the maximum capacity that could be developed at Kafue was only 380MW as compared to 1000MW at Kariba). An interim 200MW scheme was later developed for Kafue pending the construction of Kariba. However, in 1953, the Kafue Hydroelectric Authority's consulting engineers revised the figure upwards to 690MW. Present installed capacity at Kafue is 900MW whilst the potential for a further 450MW is available in the lower section of the gorge.

The Federal-Hydroelectric Board was established in May 1954 to further the development of both schemes (the Kafue was seen as a precursor to the larger project at Kariba at the time) and the advice of external experts was sought. Once again they advised in favour of the larger Kariba scheme and the Federal Government accepted that advice in March 1955. Construction at Kariba started later that year. Predictably there was a major outcry in Northern Rhodesia, especially in Lusaka, but to no avail.

Federal protagonists at that time saw the Kariba Dam and its associated lake as a prestigious symbol of the political and economic links that they were attempting to forge between the two territories (Williams, G.J. 1985:49). Construction on the Zambezi also enabled a larger portion of the investment to be directed to the South, especially as the power station was sited on the south bank of the river. In retrospect it can be suggested that it was fortuitous for both countries that the Kariba and not Kafue was built at that time, for development on the Zambezi would not have been possible in the two politically tumultuous decades that followed. Zambia would instead have used much more of its internal hydropower potential while industrial growth in Zimbabwe would have been disadvantaged by the use of more expensive thermal power.

The Kariba Dam project was financed from a number of local and international sources, including the World Bank, which provided a sum of $80 million in 1956. A World Bank team visited the project site in March 1956 and prepared their report, dated 14 June 1956, recommending the provision of the loan to the Federal Government of Rhodesia and Nyasaland. It is interesting to note that construction work at Kariba had started late in 1955, while the application for the World Bank loan was still being processed.

The Kariba Dam was constructed from 1955–1960. Most of the civil works for the dam wall, the housing and town development was completed in 1959. The installation of the first generation units on the south bank was completed late in 1959 and the first electricity was generated in January 1960.

Annex 1 presents landmark dates and events associated with the Kariba Dam project.

2.3 Objectives and Components of the Kariba Dam Project

As can be deduced from the brief historical account presented in Section 2.2, the Kariba Dam project was designed and implemented primarily for electricity generation in response to a broad regional decision to move from thermal to hydropower. The need to choose between Kafue and Kariba and to raise finance resulted in a crisis: a race to meet burgeoning power demand. Other costs and benefits that could be derived from the dam were not considered in the justification of the dam to financiers such as the World Bank, nor were they factored into the financial and economic analysis of the project.

Thus, the Kariba Dam project can be considered to comprise the following components:

- a concrete arch dam at Kariba gorge (detailed specifications of the wall as presented in Section 1.1 above);
- two power stations on each bank of the river, with a combined planned capacity of 1320MW, but to be implemented in phases, beginning with the south bank station, 600MW in size. Completion of the second phase, by 1971,was planned for the north bank (Zambia), also with a capacity of 600MW;
- the construction of the residential town of Kariba, mainly for workers on the dam project;
- the construction of a paved road connecting the remote project site with the rest of the country;
- the erection of power lines to connect the hydropower station at Kariba with the copper mines in Zambia and the major centres of Zimbabwe; and
- the resettlement of Africans who would be displaced by the dam. The number of people who were likely to be displaced was initially underestimated as less than 30 000, but later revised to 57 000.

The project at Kariba was appraised and financed purely as a dam hydropower project with associated resettlement costs. There was no consideration made with regard to any other benefits that could arise from the dam such as fisheries, tourism, irrigation and others. Consequently the Kariba project document makes no mention of any of these additional benefits from the dam.

While those who were at the centre of the planning for Kariba did not consider the other opportunities that Kariba presented besides hydropower, there were others in the Northern and Southern Rhodesia governments who noticed the other additional economic opportunities that Kariba presented. To plan for and to implement projects that would take advantage of those additional opportunities, the two governments formed the Kariba Development Coordination Committee (KDCC) in December 1957. The objectives of this committee were to carry out development projects on Lake Kariba such as fisheries, tourism, wildlife management industries, forestry, irrigation and transport among others.

2.4 The Kariba Feasibility Studies and Reports

As can be seen from the summary history of Kariba presented in Section 2.2, the Kariba Dam project was implemented after a long period of intensive study, political negotiations, and economic and engineering analysis. The main documents for the Kariba project are outlined below. These are the documents in which the projected benefits and impacts of the Kariba project can be found.

The first main report with respect to Kariba was produced by the Inter–Territorial Hydroelectric Power Commission (1951). The report compared Kafue and Kariba and concluded that Kariba should be developed before Kafue. All reports prior to this one can be considered exploratory, and therefore not directly focused on Kariba as a project to be implemented.

By 1954, the decision on whether to build Kafue or Kariba was still not settled, and the Northern Rhodesians, desperate for power, were increasing their attention on the Kafue project. It is instructive to point out here that by this time the Federation of Rhodesia and Nyasaland had been formed, placing the two countries of Northern and Southern Rhodesia under one federal government.

To settle the Kariba-Kafue debate, the Federal government decided to appoint a neutral party to give an objective assessment of the two projects and to make a recommendation on which of the two should proceed first. A group of French engineers was appointed who visited the Kafue and Kariba Dam sites in 1954. They carried out thorough engineering and power supply and demand investigations and concluded that the Kariba Dam project should proceed first. The French Mission, whose report was produced in September/October 1954, was immediately followed by a further assessment by a renowned dam engineer, Monsieur André Coyne in November/ December 1954. The Coyne report of December 1954 convinced the Federal government that the Kariba project should precede Kafue.

Following the André Coyne report which gave Kariba the green light, the Federal Power Board appointed consulting engineers to prepare project documents for Kariba, with the first draft of the Kariba project report being produced in September 1955. The final revised Kariba project report was then produced in December 1955, shortly ahead of the beginning of implementation of the project. The preliminary report on the Kariba Hydroelectric scheme in September 1955 may be taken as the Feasibility Study report, with the final Project Report being completed in December 1955 (Federal Power Board, 1955).

Part of the finance for the Kariba Dam project was provided by the International Bank for Reconstruction and Development (IBRD–World Bank), which sent an appraisal mission to the Kariba Dam site in March 1956. The mission produced a report dated 14 June 1956 (IBRD, 1956). This report is also a reference document for the Kariba Dam project.

3. Projected Versus Actual Impacts of The Kariba Dam Project

In this chapter, the projected and actual impacts of Kariba Dam are presented. The objective of this analysis is to assess what the actual impacts of Kariba Dam have been in relation to what was anticipated during the planning for the dam. A sectoral approach will be followed in the presentation of these projected and actual impacts of Kariba Dam for two reasons. Firstly, the issues identified by the scoping report are quite diverse in nature, ranging from engineering, economics and environmental to social and political considerations and seismology. It would therefore be difficult to do justice to all the issues raised outside a sectoral approach. The second reason arises from the long history of Kariba Dam and all the data that exists on Kariba. It would be difficult to present the data associated with each of the issues raised in the scoping report coherently outside a sectoral approach.

3.1 Time Schedule for Implementation

Table 1 presents the major activities in the implementation of the Kariba project, the scheduled time of completion, the actual time of completion and related comments. The purpose of this table is to show whether or not Kariba was implemented according to schedule. One criticism that is levelled against large dams is that they tend to suffer time delays in their implementation and are rarely constructed on time and within budget. The data in Table 3.1 shows that the Kariba project was implemented on time and below budget for Phase 1. Time and cost overruns where however experienced with respect to Phase 2. The efficient implementation of Phase 1 may be attributed to the desperate shortage for power that was prevailing at the time and hence a possible strict monitoring programme for the project to ensure timely satisfaction of this serious need.

Table 3.1: Kariba Dam Implementation Milestones

Activity	Schedule	Actual	Comments
Preparatory Earth Works	1956	Early 1956	Brought forward to complete before floods of 2nd quarter of 1956
Construction of housing in Kariba	1958	8 months ahead of schedule	Estimated to take 2 years but done in 16 months within budget.
Construction of access roads	1957	On schedule	48mile road completed in March 1956 and a 42mile road from the Lusaka-Chirundu highway completed in 1957 on schedule
Construction of airstrips	1955	On Schedule but done in 3 stages	Airstrip for light aircraft completed in 1955 and upgraded in 1956. Permanent aerodrome built and commissioned in 1958.
Construction of dam wall	1960	Despite delays on south bank the dam was completed 10 months ahead of schedule	Ground condition problems at the south bank necessitated redesign and additional work worth £8 million
Installation of generation units	300MW by December 1959. Additional 300MW by 1962	On schedule 1st generation, 26 December 1959. Reached 600MW in 1962	No cost overruns. On schedule.
Installation of transformers	June 1958	On schedule	Done on schedule with completion of Kariba switchyard and substations
Resettlement of people	1956–1958	Behind schedule. Completed 1959 for Zimbabwe and 1960 for Zambia	Slow movement and delays due to resistance, lorry breakdowns and physical barriers to movement.
Transmission lines to Copperbelt and cities in Zimbabwe	1959	On schedule	
End of Kariba Dam hydropower Phase 1: south bank.	1962	On schedule	Ended after commissioning the 6th 100MW plant with the total cost being lower than estimated by £2 million

North bank Power Station Construction	Planned to in start 1965 for commissioning in 1971	Delayed. Started in 1972 for completion in 1974, and due to further delay, was only commissioned in 1976	Delay caused by political events, & by contractor problems resulting in a 2.5 times overrun on costs to US$147 million.

3.2 Project Costs

In this section, the projected and actual costs of all aspects of the Kariba project are reviewed and analysed. These include capital investment as well as operation and maintenance costs.

Since the Kariba project spans several political administrations, over a period of nearly 50 years, the project costs are reported in nominal terms and in five currencies as British pounds, Zambian Kwacha, Rhodesia dollar, Zimbabwe dollar and US dollars. To provide a correct perspective of cost figures, salient figures have been converted to 1998 US dollars. Exchange rate tables for these currencies to the 1998 US dollars are presented in Annex 3 for the 1955–1998 project period.

Where conversions have been made to 1998 US dollars the exchange rate for the year in which the figures were reported is used. For example, the final cost of the Kariba Phase 1 project was reported in 1961 as £77.61 million. In this case, the exchange rate for 1961 was applied. However, it must be borne in mind that this conversion is simplistic and does not take account of the fact that the figure of £77.61 million represents a sum of expenditures made in the years 1956–1961. Ideally the exchange rates for each of the years must be applied to the costs of that particular year, and summed up to derive the true 1998 US dollar cost.

3.2.1 Projected Versus Actual Capital/Investment Expenditure

As mentioned earlier, the Kariba Dam Project was defined by the Federal Hydroelectric Power Board (set up by the Hydroelectric Power Act of 1954) within the context of a hydropower development programme, and was to consist of 2 stages:

- Kariba Stage 1, comprising an arch dam, an underground 6 x 100MW Power Station on the south bank; and a 330kV transmission network
- Kariba Stage 2, comprising an underground 600MW Power Station on the north bank; and further strengthening of the 330kV transmission network.

3.2.2 Evolution of Cost Estimates for Stage 1

As the planning for Kariba Phase 1 proceeded, estimates of the cost of the project were constantly revised according to the latest cost information available. Phase 1 of the Kariba Project with a 500MW power station installed (for a top-water-level of 1 590ft (485.6m)) was originally assumed to cost £72.2 million ($1230 million in constant 1998 US dollars). This was revised upward to £79.38 million ($1350 million in 1998 US dollars) at the tender stage. In February 1956, before the receipt of the tenders for the principal contracts and the conclusion of the loan negotiations for the finance required, the cost estimate of Stage 1 was again (slightly) revised to £79.414 million. The cost adjustments were largely because of raising the dam by 6m, and the addition of one 100MW turbine unit. The final expenditure was $1320 million, with the addition of two more spillway gates and extra work on the south abutment. Stage 1 was completed in 1960, on schedule, in spite of two record floods during the construction period.

Table 3.2 presents a breakdown of the cost of Phase 1 according to the project document of December 1955. At this time, the size of the power station was planned to be 500MW, and with a top-water-level of 1590ft (485.6m).

Following the decision in July 1956 to increase the height of the dam wall by 20ft (6.1m), and after some savings were made in the original project budget, the Federal Power Board decided, in early

1958, to include the 6th 100MW generator in this phase of the works. This additional generation unit was easily accommodated because the power station hall had been designed and already excavated for six generators.

Unprecedented floods of 1957 and 1958 led to a redesign of the spillway to increase its capacity. The original design consisted of four floodgates. Two more gates were added to the dam to make the present six gates. In addition, some problems were experienced with the ground conditions on the south bank, necessitating some additional engineering work at an additional cost of some 8 million pounds.

In spite of these changes in the spillway design, the raising of the dam wall, and the inclusion of the extra 100MW generation unit, estimates of the cost of Kariba Phase 1, in June 1958, were only £73.3 million (1998 $1156.67 million) – still lower than the 1956 estimate.

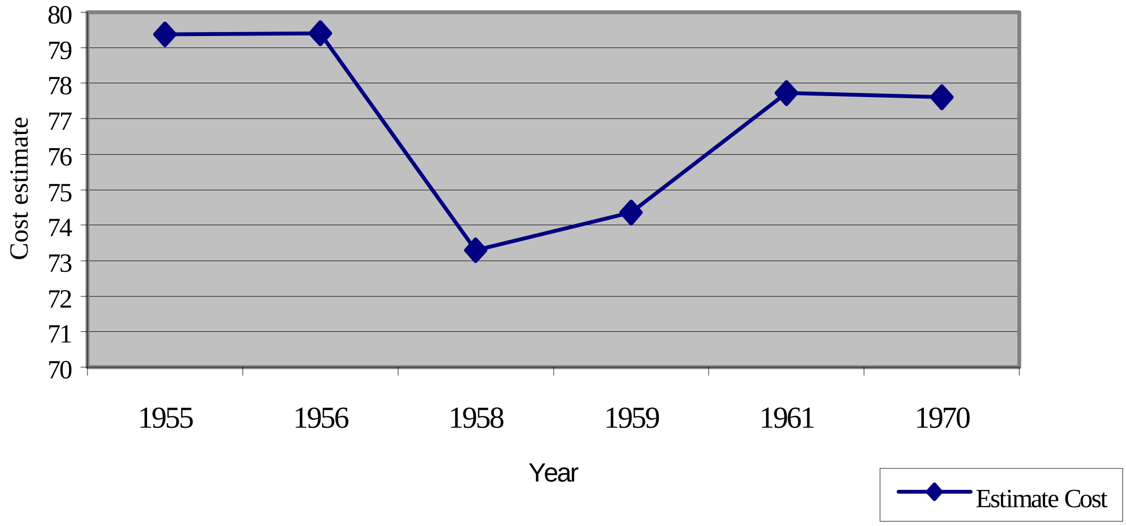
Table 3.2: Projected Investment/Capital Costs for Stage 1 as of December 1955 (in million Pounds)

At Kariba, including Switching Station	**£ (million)**
Civil Engineering Works	33.90
Contingent Works and Engineering @ 20%	6.75
Mechanical and Electrical Plant	6.53
Contingent Works and Engineering @ 20%	1.31
Sub-Total	48.49
Transmission System	
Transmission Lines	12.60
Substations	3.62
Contingent Works and Engineering @ 20%	3.24
Sub-Total	19.46
Federal Hydroelectric Board's Costs	
Resettlement of displaced Africans, payments in respect of water rights, wayleaves and mineral rights and administrative expenses of the Board	4.00
Preliminary expenses incurred up to 30 June 1955	0.28
Sub-Total	4.28
Interest during construction up to 31 December 1959	**7.15**
TOTAL ESTIMATED CAPITAL COST	**79.38 (1998 $1351.05 million)**

As of 30 June 1959, the water behind the wall had reached 1473.6 ft (450.6m) level, just under the gates, and the project cost estimate had risen to £74.4 million. In September 1961, the final cost of the project reached £77.6 million (1998 $1183.4 million), mainly because of the extra work on the south abutment. This was still lower than the estimate of £79.4 million made in February 1956. If it had not been for the expenditure of 8 million pounds on the south abutment, the final project cost would have been much lower.

Figure 3.1 indicates that despite the geological problems experienced at the south abutment, the floods of 1957 and the large number of people who where resettled, the revised costs at each stage kept within the original estimated figure.

Figure 3.1: Evolution of Cost Estimates for Kariba Stage 1



3.2.2 Actual Capital Investment Expenditure – Stage 1 of the Kariba Project

The final cost of Stage 1 of the project, calculated as of 30 June 1962, was £77.6 million. This is indicated in column A of Table 3.3. The table also indicates the initial estimates that were used as the basis for project planning, and the overrun/underrun has been calculated.

Table 3.3 shows that the Kariba Hydropower Stage 1 project was completed for 97% of the initial/projected estimated cost of £79.38 million. The result also indicates that despite the initial underestimate of the number of people to be resettled, the actual expenditure on this activity remained unchanged. This may indicate that although the project planners anticipated the need to move people, they did not appreciate the full social and economic impacts of the exercise. The High Commission for Rhodesia and Nyasaland, Mr Balneaves described the Tonga in the following way: " The valley Tonga lived simple, stagnant and precarious lives along the Zambezi river. Moving to new sites would open them to the wider world whilst they would also benefit from the larger fishery of the lake". This may be interpreted to mean that the authorities treated resettlement as a benefit to the Tonga people.

Table 3.3 : Comparison of Actual and Projected Costs for Kariba Stage 1
(Costs in £ millions)

	Actual £ million	**Initial Cost Estimate £million**	**Overrun /Underrun (%)**[3]
Civil Engineering Works			
Access roads	2.16	-	
Township	3.45	-	
Dam wall, south bank power station and associated works	34.97	-	
Engineering fees and expenses	2.26	-	

[3] Overrun/underrun calculated as actual divided by project.

Sub Total	**42.84**	**48.49**	88
Electrical and Mechanical Works			
Generation plant and equipment	5.23	-	
Transmission system	15.99	-	
Engineering fees and expenses	1.14	-	
Sub Total	**22.36**	**19.46**	115
Resettlement of Africans	3.98	4.00	-
Administration and Medical Services	0.685	0.28	245
Finance Charges	7.75	7.15	108
TOTAL	**77.61**	**79.38**	**97**

3.2.3 Projected versus Actual Capital Investment – Stage 2 of the Kariba Project

Implementation of Stage 2 of the Kariba project was estimated in 1970 to cost $57.1 million (Zambian Kwacha 40.8 million and 1998 $228.4 million)[4] as shown in the Tables 4 and 5.

The original estimates for the development of Kariba north included a figure of $4.2 million or 7.4% of the total cost to take into consideration of inflationary trends and other contingencies, on the assumption that the work would be completed in 3.25 years. This proved to be totally inadequate, as the actual sum for the price escalation was $23.8 million.

The work had extended over another 2 years from the scheduled completion date of 1974 to 1976 mainly due to the change in contractors and logistical problems experienced in he procurement of generation plant after the closure of the border between Zambia and Zimbabwe. The effect of the delay worsened as a result of the Organisation of Petroleum Exporting Countries (OPEC) oil price increases, which started in November 1973. The 1970 World Bank project appraisal report had noted the rapidly escalating prices for heavy machinery internationally. Although the appraisal estimates included an estimate (9.4%) for price escalation, this figure turned out to be lower than the average rate (42%) that prevailed over the duration of the project implementation.

The World Bank performance audit report[5] indicates that the final financial cost of the project was $147 million, which was 2.5 times the projected estimate of $57.1 million. The above figures are in nominal values. If deflated to constant 1970 Kwacha (K), the final cost would be K45.6 million ($63.8 million). The final over-expenditure of $90 million[6] only included $2.14 million attributable to additions or alterations to the spillway channel along the north bank. Over-expenditure on the original project was therefore $84.4. The main components of the over-expenditure are summarised in Table 5.

Commercial operation of the first unit at Kariba north bank started on May 14, 1976, 28 months after the original schedule date and 8 months after the revised date following the change of civil contractors. The key observation from the above discussion is that in an inflationary environment, a

[4] "Project Performance Audit Report, Zambia, Kariba North Hydroelectric Project", World Bank
[5] "The World Bank Audit Report: Kariba North Bank Hydroelectric Project
[6] " At the exchange rate of k1=US$1.4 used in the appraisal report

very significant component of over-expenditure for a large hydropower project such as the Kariba north bank is due to price escalation.

Table 3.4: Kariba Stage 2 Capital Investment Costs in US dollars

	Appraisal Estimate June-1970 US$ (millions)	**Actual Cost Dec-1976 US$** (millions)	**Actual versus Appraisal Estimate (%)**
Civil Engineering Works			
Preliminary works	0.68156	1.72472	253.05
Housing	2.01529	4.72191	234.30
Main Civil Works	16.29029	67.43680	413.97
North bank Spillway Channel	0.00	4.08989	
Engineering	1.26236	3.58427	283.93
Site Supervision	57380	1.61236	281.00
Contingencies and Escalation	3.79687	-	-
Total	24,62017	83.16994	337.81
Electrical and Mechanical Works			
Generating Plant & Equipment	16.81791	43.08006	256.16
Engineering	880.29	1,617.98	183.80
Site supervision	0.24911	550.56	221.01
Contingencies and Escalation	1.00765	0.00	0.00
Sub-Total	18.95496	45.24860	238.72
Administration	0.00	814.61	
Total Project Cost	**43.57513**	**129.23315**	**296.58**
Interest During Construction	9.34872	18.06039	193.19
Total Project Cost including Interest during Construction but excluding escalation allowance (Nominal values)	**52.92386**	**147.29354**	**278.31**
Total Project Cost in 1998 $	**$220.5**	**$420.83**	**190.85**

Table 3.5: Main Components of the Over-expenditure

Kariba North Bank Power Station		
Component of over-expenditure	**Million K**	**Million $**
Change in civil contractor	14.9	20.8
Price escalation	17.0	23.8
Interest during construction	6.2	8.7
Rerouting and delays	6.4	9.0
Changes in currency exchange rates	12.5	17.5
Miscellaneous	3.3	4.6
Total	**60.3**	**84.4**

3.2.4 Projected Versus Actual Recurrent Costs on Stage 1

The estimated recurrent financial costs on Stage 1 were made of interest on capital, amortisation, operation and maintenance and administration. The estimates were based on previous experience of similar hydroelectric undertakings in other parts of the world, and the anticipated power plant capacity installation programme**.** The total annual operation costs are directly related to the power generated and therefore, on load capacity installed. Annual operating costs would increase with the greater power plant capacity installed. Table 3.6 shows Kariba's projected estimates and actual annual costs.

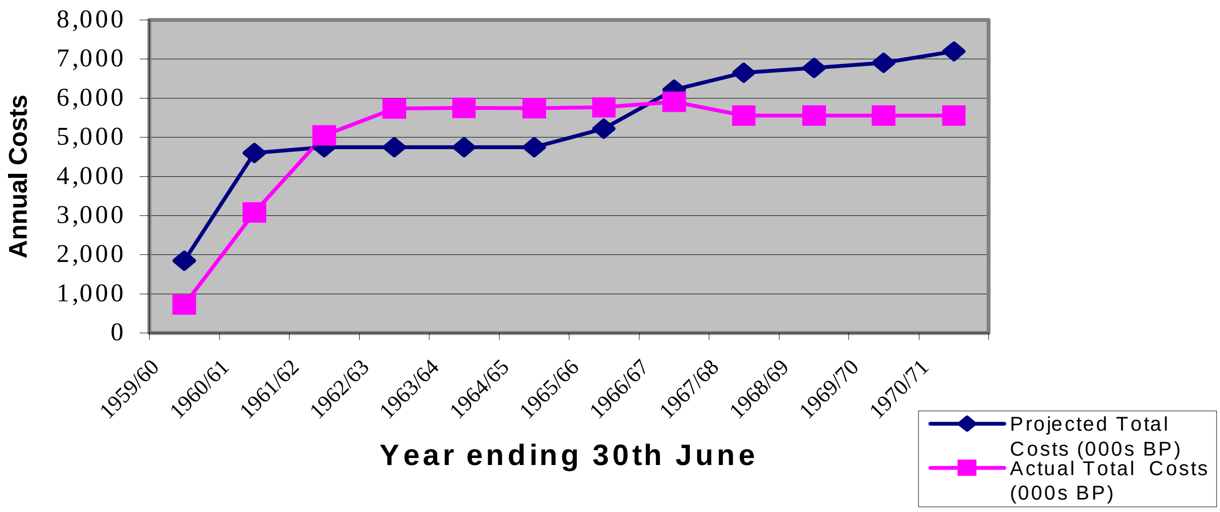
Table 3.6: Projected versus Actual Annual Costs in UK pounds (x 1000) on Stage 1

Year Ending	**Projected Total Annual Costs**	**Actual Total Annual Costs**	**Overrun/ Underrun (%)**
30th June			
1959/60	1.854	729	39.32
1960/61	4.600	3.084	67.04
1961/62	4.753	5.047	106.19
1962/63	4.753	5.733	120.62
1963/64	4.753	5.755	121.08
1964/65	4.753	5.746	120.89
1965/66	5.222	5.771	110.51
1966/67	6.223	5.902	94.84
1967/68	6.650	5.554	83.52
1968/69	6.774	5.558	82.05
1969/70	6.901	5.556	80.51
1970/71	7.194	5.557	77.24

Source: Kariba project document and Kariba annual reports.

Figure 3.2 is a graphic representation of data presented in Table 3.6 on projected and actual annual operation and maintenance costs. The data shows that, for most of the period under consideration, the actual annual costs were below the projected estimates.

Figure 3.2: Projected versus Actual Annual Costs for Stage 1



3.2.5 Sources of Finance for the Kariba Dam Project

The estimate of the cost of the first stage of the Kariba project made in February 1956 was £79.414 million. In order to finance this, the Federal Power Board entered into seven agreements with different lenders. The terms were different in each case. The longest was for a period of 40 years and the shortest 20 years. Interest payable ranged from 4.5 to 6.75%. Table 3.7 shows the different sources of finances

Table 3.7: Sources of Finance for the Kariba Project

Financier	**Amount (£ million)**	**Interest Rate (%)**	**Other charges%**
International Bank (IBRD)	28.6	5	0.75% on underdrawn loan amounts
Colonial Development Corporation	15.0	1 more than the rate obtaining in the UK	0.75% on underdrawn loan amounts
Copper Companies	20.0	4.5	0.75% on underdrawn loan amounts
Banks	4.0	5	0.75% on underdrawn loan amounts
British South African Company	4.0	5	0.75% on underdrawn loan amounts
Federal Government	5.4	5	0.75% on underdrawn loan amounts
Commonwealth Development Finance Company	3.0	6	Commitment fee of £20 000 and 0.75% on underdrawn loan amounts.
TOTAL	**80.0**		

Source: World Bank Audit Report: Kariba North Bank Project

3.2.6 Projected Versus Actual Annual Costs on Stage 2

The projected and actual annual costs for Kariba Phase 2 are presented in Table 3.8. They were derived similarly to the cost for Phase 1 as discussed in Section 3.2.5

Table 3.8: Projected versus Actual Annual Costs (in $ 000s) on Stage 2

Year Ending	**Projected Total [7]Annual Costs**	**Actual Total Annual Costs**	**Overrun/ Underrun (%)**
30th June			
1970	3.21994	2.79434	115.23
1971	3.35993	3.28293	102.35
1972	3.63993	3.78412	96.19
1973	4.29185	4.47118	95.99
1974	4.66200	4.38073	106.42
1975	5.59441	5.49650	101.78
1976	5.26462	6.65974	79.05

Because of the Unilateral Declaration of Independence (UDI) by Southern Rhodesia and international sanctions against that country, the Central African Power Company (CAPCO) could not proceed with the progressive development of Kariba Stage 2 (Kariba North Power Project). Kariba North Bank Company, a company wholly owned by the Zambian government was formed in 1970. The operational and maintenance cost, therefore, included the operational costs of the company even

[7] Average exchange rate obtained in each year isused to convert from kwacha

before the development investments were made. The appraisal forecast of operational and maintenance cost extended only up to 1976 when the power generation station was commissioned.

The data in Table 3.8 shows that in US dollar terms and on average, the actual annual costs kept within the projected estimates. This is in contrast with the investment capital costs, where significant price escalation was observed. This could be explained by the fact that the much of the operation costs financed by the local currency component, which was subject to devaluation between 1975 and 1976.

3.3 Hydropower Impacts

3.3.1 Projected and Actual Power Capacity and Generation

The project document for the Kariba Hydroelectric scheme was submitted in its preliminary form by the consultants in September 1955 and the final project report in December 1955. The report was based on two alternative top water levels (TWL) of 1570ft (480.1m)and 1590ft (486.2m). Table 3.9 gives the projected and actual generation by the scheme for the second alternative for the first 12 years of Kariba operation as the 1590ft TWL alternative was adopted.

Table 3.9 Projected versus Actual Power Output for the Kariba Project

Case	**Planned**			**Actual**		
	Installed Capacity	**Energy Generation**	**Plant Factor**	**Installed Capacity**	**Energy Generation**	**Plant Factor**
Year	(MW)	(GWh)	(%)	(MW)	(GWh)	(%)
1960	200	257	0.15	100	378	0.43
1961	400	1352	0.39	382	1637	0.49
1962	500	2550	0.58	630	2524	0.46
1963	500	2985	0.68	705	2949	0.48
1964	500	3215	0.73	705	3398	0.55
1965	500	3345	0.76	705	3708	0.60
1966	600	3690	0.70	705	3911	0.63
1967	800	4410	0.63	705	4105	0.66
1968	900	5250	0.67	705	4692	0.76
1969	1000	5740	0.66	705	4996	0.81
1970	1100	6230	0.65	705	5169	0.84
1971	1200	6720	0.64	705	5499	0.89
1972	1200	6720	0.64	705	5404	0.88
1973	1200	6720	0.64	705	5379	0.87
1974	1200	6720	0.64	705	5479	0.89
1975	1200	6720	0.64	705	5355	0.87
1976	1200	6720	0.64	1320	5500	0.48
1977	1200	6720	0.64	1320	6294	0.54
1978	1200	6720	0.64	1320	6834	0.59
1979	1200	6720	0.64	1320	6964	0.60
1980	1200	6720	0.64	1320	7688	0.66
1981	1200	6720	0.64	1320	7945	0.69
1982	1200	6720	0.64	1320	7726	0.67
1983	1200	6720	0.64	1320	7769	0.67
1984	1200	6720	0.64	1320	7148	0.62
1985	1200	6720	0.64	1320	7250	0.63
1986	1200	6720	0.64	1320	6582	0.57
1987	1200	6720	0.64	1320	6045	0.52
1988	1200	6720	0.64	1320	5250	0.45

1989	1200	6720	0.64	1320	7884	0.68
1990	1200	6720	0.64	1320	7236	0.63
1991	1200	6720	0.64	1320	6494	0.56
1992	1200	6720	0.64	1320	5701	0.49
1993	1200	6720	0.64	1320	4386	0.38
1994	1200	6720	0.64	1320	4096	0.35
1995	1200	6720	0.64	1320	4745	0.41
1996	1200	6720	0.64	1320	3859	0.33

As shown in Table 3.9 the second stage of the project was commissioned in 1976, and not in 1971 as planned.

The installed capacity in both powerhouses is somewhat higher than planned. Under maximum head conditions the output can be as high as 1320MW, 120MW higher than originally planned

The units in Kariba 1 can produce 117.5MW instead of 100MW. The total station capacity is 705MW. Kariba 2 has four turbines, which can produce 153.7MW instead of 150MW. The total station capacity is therefore 615MW. Kariba 2 has the provision for installation of two more units.

The average output of the project for the period 1977 – 1996 was 6400GWh per annum, slightly less than the predicted value of 6720GWh. This is within the limits of the natural fluctuation of dry and wet year cycles. If the values of the year 2000 are added to the statistics, it may well be that the average is close to 6700GWh.

3.3.2 Power Benefits and Costs

If Kariba had not been built, then – in an all-thermal scenario – coal-fired steam plant would have been built in Harare (then called Salisbury), Bulawayo, Umtali and at several copper mines. The 1955 Kariba Project Report (Federal Power Board 1955) gives details. The data in this report were used to construct a cash flow of power benefits (investment, operation and maintenance, fuel), which constitute the predicted power benefits attributable to Kariba.

Subsequently, a cash flow was constructed for actual conditions: the thermal plant offsetting Kariba Stage 2 were delayed to 1976, the actual energy production of Kariba rather than the planned value was taken into account, and the high prices of coal were gradually reduced from $30 (all costs in constant 1998 US dollars) to $20 per ton over a period of 30 years, which was the adopted life time of the thermal alternative. Then, when reinvestments were due, it was assumed that the stations would be built in Hwange, with a further reduction in coal price to $10 per ton and that station efficiencies would be greatly improved. Coal was generally assumed to have a lower calorific value of 28GJ per ton.

On the cost side, the predicted development takes into account the project cash flow (investment, operating and maintenance cost) as published in the 1955 Kariba project report, with implementation of Kariba Stage 2 completed by the end of the sixties.

In the actual case the real project cash flows are considered, with the delay of Kariba 2 to 1976.

The cash flow analysis resulted in an economic rate of return of 16.5% for the project as planned, and 14.5% for the project as built. The project cash flow calculations are presented in the Annex 2.

3.3.3 Unpredicted Power Benefits

Hydropower plants not only offset thermal generation, they also are well suited for a range of ancillary services (dynamic benefits): voltage and frequency control, load following, system black start, etc. The magnitude of these dynamic benefits cannot be predicted accurately, but range from about $20/kW/year to $50/kW/year. If the lower value is taken, and credited to Kariba, then the economic rate of return increases to 15.9%.

In the year ending 30 June 1960[8], the energy produced by the Kariba (South) power station was 378404140kWh. This output was reported as being equivalent to a saving of coal consumption at a thermal power station of approximately 190 000 tons. On that basis, Table 10 indicates the output of the Kariba power stations and the equivalent savings in coal consumption.

By offsetting coal-fired generation, hydropower plants help to combat global warming. In this analysis, it is normal to assume that during the first 3 full years of operation the savings of CO_2 of the thermal plant are used to offset the CO_2 production associated with the construction of the project (cement, steel, diesel oil, etc.) and the decay of biomass in the reservoir. If after these first 3 years, the savings in thermal plant CO_2 are fully credited to Kariba at a rate of $7 per avoided ton of CO_2 emission then the economic analysis for the project would yield an increase in the economic rate of return to 18.7%. Since the reduction of greenhouse gas (GHG) emissions does not reach the targets set by the Kyoto protocol, it could also be assumed that the marginal value is actually equivalent to the damage (rather than mitigation or avoidance) cost. The damage value is several hundred dollars per ton of CO_2 emission.

The message is that the Kariba project has been an important factor in the combat of global warming.

Table 3.10 Actual Power Generation and Actual Savings in Coal Consumption

Year ending 30 June	**Generation, million kWh**			**Equivalent coal Tons**
	Kariba South	**Kariba North**	**Total**	
1960	378.400	0.000	378.400	190 000
1961	1 637.270	0.000	1 637.270	822 096
1962	2 523.802	0.000	2 523.802	1 267 237
1963	2 949.102	0.000	2 949.102	1 480 786
1964	3 397.849	0.000	3 397.849	1 706 108
1965	3 707.874	0.000	3 707.874	1 861 776
1966	3 910.666	0.000	3 910.666	1 963 601
1967	4 104.986	0.000	4 104.986	2 061 172
1968	4 691.782	0.000	4 691.782	2 355 810
1969	4 995.683	0.000	4 995.683	2 508 403
1970	5 169.021	0.000	5 169.021	2 595 439
1971	5 499.079	0.000	5 499.079	2 761 165
1972	5 403.862	0.000	5 403.862	2 713 356
1973	5 378.985	0.000	5 378.985	2 700 865
1974	5 479.973	0.000	5 479.973	2 751 572
1975	5 355.142	0.000	5 355.142	2 688 893
1976	5 383.212	117.058	5 500.270	2 761 763
1977	3 916.719	2 378.233	6 294.952	3 160 785
1978	3 725.200	3 109.600	6 834.800	3 431 850
1979	3 563.500	3 400.500	6 964.000	3 496 723
1980	3 743.300	3 944.700	7 688.000	3 860 254
1981	4 098.500	3 846.200	7 944.700	3 989 146
1982	3 768.300	3 957.500	7 725.800	3 879 234
1983	3 884.900	3 883.800	7 768.700	3 900 774
1984	3 324.600	3 823.500	7 148.100	3 589 162

[8]Annual Report and accounts No 5 for year ended 30th June 1960, Federal Power Board *generation data for Kariba North power station is difficult to obtain from ZESCO

	Generation, million kWh			
1985	3 477.400	3 772.600	7 250.000	3 640 328
1986	3 128.700	3 453.900	6 582.600	3 305 217
1987	2 700.700	3 344.800	6 045.500	3 035 531
1988	2 666.000	2 584.000	5 250.000	2 636 099
1989	3 196.000	4 688.000	7 884.000	3 958 668
1990	4 369.000	2 867.000	7 236.000	3 633 298
1991	3 152.000	3 342.000	6 494.000	3 260 729
1992	3 161.000	2 540.000	5 701.000	2 862 553
1993	2 062.000	2 324.000	4 386.000	2 202 273
1994	2 096.000	2 000.000	4 096.000	2 056 660
1995	2 285.000	2 460.000	4 745.000	2 382 532
1996	2 163.000	1 696.000	3 859.000	1 937 659
1997	2 122.300	*	2 122.300	1 065 637
1998	1 879.500	*	1 879.500	943 724
Total	**138 450.307**	**63 533.391**	**201 983.698**	**101 418 876**

3.3.4 Other Benefits

Besides hydropower, Kariba yielded many other benefits that were not taken into account in the project justification. These include fisheries, tourism, irrigation development and wildlife conservation.

3.3.5 The Impact of Kariba on Cost of Power

Table 11 reflects the changes in monetary terms of the average bulk price per unit (kWh) of electricity from 1961 to 1977 – a reduction of 30%. Over this period of 16 years the average price of other commodities and services rose by more than 75%.

Table 3.11 Average Price of Electricity Per Unit (kWh) (1961–1977)

Rhodesia				Zambia		
	Units (millions)	**Rhod. $ 000**	**Average price/unit (Cents)**	**Units (Millions)**	**ZK 000**	**Average Price/unit (ngwee)**
1961	1126	7412	0.658	928	5572	0.600
1962	1480	9092	0.614	1159	6844	0.591
1963	1558	9427	0.605	1383	8024	0.580
1964	1688	9816	0.582	1658	8298	0.500
1965	1792	9985	0.557	1872	8665	0.463
1966	1870	10126	0.541	1981	8951	0.452
1967	1884	10416	0.553	2422	12244	0.505
1968	2212	11088	0.501	2990	15430	0.516
1969	2429	11814	0.486	3237	16148	0.499
1970	2812	12900	0.459	3607	16945	0.470
1971	3080	14090	0.457	3809	17248	0.453
1972	3490	15171	0.435	4212	18120	0.430
1973	4563	17793	0.390	4567	18427	0.403
1974	5066	19473	0.384	5108	20653	0.404
1975	5600	22128	0.395	5333	22302	0.418
1976	6151	25487	0.414	5420	23011	0.425
1977	6420	30057	0.468	5217	20576	0.394

Source: Central African Power Co-operation Annual Report and Accounts: 1977

generation data for Kariba North power station is difficult to obtain from ZESCO

3.4 Social Impacts

Although large dam development has been around since the turn of the 20th century, most of the dams that were constructed prior to the 1970s were implemented with very little consideration of the social and environmental impacts of the dam. The early dams were easily justified on the grounds of technical feasibility and on the argument that they were vehicles for industrial, and hence, economic growth. Social costs were never internalised in the appraisal of large dam projects. (Oud & Muir, 1997).

In the last 20–30 years (ie 1970s–1990s), large dam projects have been placed under more intense scrutiny and the debate on the effectiveness of large dam developments have began to insist on the internalising of external factors such as social impacts.

In this section, the social impacts of Kariba Dam are discussed. The scoping report for the Kariba case study listed the following, under social impacts as requiring attention in Phase 2:

- The Kariba Dam project is notable for its displacement of people and the manner in which the resettlement of displaced people was carried out. Carry out a detailed, unemotional and balanced analysis of the manner in which sociological issues were handled in the project. Analyse decision-making processes from historical records;
- In this study, you are encouraged to seek individuals who lived through the resettlement process and to interview them for their experiences. In addition, you will interview chiefs and local leaders for their views and experiences on this matter;
- Analyse the decision-making process with respect to compensation for displaced people;
- Determine which levels of society were consulted with respect to sociological issues, particularly resettled people;
- How were the social river basin issues understood at the time of Kariba;
- What were the planned and actual numbers of displaced people in Zimbabwe;
- What were the planned and actual numbers of Tonga who were resettled;
- Cultural loss caused by water submerging individual and communal places (eg, how valley people came to terms with their ancestors' graves or their ancestral shrines being submerged);
- Local people's perception of the " second resettlement"; outsiders taking up the lakeshore area in the name of development. Determine if other different tribal groupings have settled in the Tonga resettlement areas and determine the views of the Tonga on these new settlers;
- Change in land tenure and water resource use rights occasioned by the lake as individuals and organisations clamoured for lakeshore land and water space;
- Assess patterns of "voluntary" relocation occasioned by land pressure. Determine the extent to which some of the Tongas have had to resettle themselves for the second time after Kariba in response to land pressure;
- Compensation of relocated people by government; how was compensation carried out, was it adequate in relation to the loss, morally, socially and economically incurred because of resettlement programme;
- What do those relocated think about the compensation package they received. Do they have any suggestions on how it could be done differently now with hindsight;
- Provision of social amenities such as adequate water supply in the resettlement areas, school, health facilities etc;
- Were there any serious considerations of population dynamics in relation to the available arable land in resettlement areas;
- What do the relocated people and their descendants think of Kariba then and now;
- What are the perceptions of benefits and losses;
- In light of the way identified benefits and costs are shared, who are the beneficiaries and victims of the Kariba Dam? Are resettled people and their descendants better or worse off? How did the project affect the livelihoods of people living downstream and upstream river (fisherman,

traditional owners of farmlands in the floodplain)? Who are those that gain from fishing, tourism and recreational benefits of the dams? Who benefited from the electricity generated by the dam;
- From available data and knowledge, analyse the equity and ethical aspects associated with the way costs and benefits of the dams are distributed between riverine communities on the one hand, and national and regional scales on the other hand. Discuss the sharing of benefits and costs of the farms between past, present and future generations;
- What are the problems posed by attempts to redress past dams-induced grievances? What are the lessons from current rehabilitation initiatives targeting communities resettled because of Kariba;
- What are the factors leading to the decision to launch these programmes? In this activity, examine the programmes being proposed by the Zambezi River Authority (ZRA) for the rehabilitation of Tonga areas as well as the programme being run by the Zambia Electricity Supply Company (ZESCO) in Zambia for electrifying areas occupied by people displaced by Kariba; and
- Does Kariba have anything from 40 years of operation that is of use today when looking at rivers and big dams?

Two consultants were involved in the social impact studies for Kariba Dam. These consultants were selected for their previous research experience working amongst the Zambezi valley Tonga. Dr B. Siamwiza has worked for many years amongst the Tonga of Zambia and he also belongs to the Tonga tribe. He therefore can speak the local language. Dr. F. Nangati, who has had extensive previous research experience amongst Zimbabwean Tonga carried out thee social impact studies in Zimbabwe. In addition, Dr. Nangati also has a keen interest in labour relations issues and he applied this experience to the Kariba project, analysing the labour issues associated with the construction of Kariba Dam. So, besides referring to available publications on the social impacts of Kariba Dam, the two consultants brought in their rich experience from previous work amongst the valley Tonga.

3.4.1 Background: Profile of Basin Population

Future Dam-Reservoir and Upstream Areas

The area on both sides of the Mid-Zambezi Valley – from the present dam wall to Mlibizi ,– was inhabited by the riverine Tonga people by the 19th century. On the Zambian side of the river, they occupied the area up to the Victoria Falls. On the Zimbabwean side, the Tonga stretched upstream to Mlibizi and further to the present Hwange district.

Before the 19th century, very little was known of the history of the Tonga people. Reynolds & Cousins (1993), observed that the Zambezi Valley had been inhabited by the Tonga since the early Stone Age period, half a million years ago. Until the 15th century, they are believed to have settled over a large area on both sides of the river. Between the 16th and 19th centuries, the Tonga were invaded by new dynasties such as the Mutapas (16th–19th centuries), Rozvi (1700–1830), Ndebele (1838–1893) and the white settlers in 1894. All these invasions forced the Tonga to where they were by the time of the resettlements beginning in the 1950s.

By the 19th century, further upstream on the Zambian side, to the west lived the Lozi. To the west upstream on the Zimbabwean side lived the Nambia people, in the present Hwange district. The Nambia, who are of Shona origins, were displaced into Hwange during the Rozvi Empire (1700–1830) and by the Ndebele between 1838 and1893 (Beach, D. 1980).

By the time of resettlement, the total population of the Tonga who lived in the Zambezi Valley, and were subsequently relocated, was estimated at 57 000, (Colson, 1971; Scudder, 1962).

Downstream Areas

On the Zimbabwean side close to the present dam wall lived a “few” Korekore under their Chief Nyamhunga who were known to have moved from the Hurungwe district in about 1950 and were, during resettlement, simply told to relocate themselves back to Hurungwe, their original homeland (Hostes, W.W.H. 1959). The vast stretches of land downstream of the dam wall on the Zimbabwean side were uninhabited. Matthew (1976:22) suggests that it was mainly due to inclement climate, the inhabitable environment, and the isolation imposed by physical geography of the Zambezi escarpment that the Tonga people preferred to live in the valley, and hence their isolation from the rest of other peoples in Zimbabwe. For the same reasons, the Tongas on the Zambian side were effectively excluded from incorporation into the Lozi Empire to the west.

Downstream of the dam wall on the Zambia side also lived the Tonga who stretched down the valley beyond the Chirundu border post. Because of the large Tonga population on the Zambian side, some of them were forced to live on the plateau well before resettlement.

Available historical records do not indicate population estimates of the peoples who lived upstream (Nambia, Korekore and Lozi) on both the Zambian and Zimbabwean sides. The only population estimates given were of the Tonga within the dam basin. According to Matthews (1976:71), the population estimates available in the mid-1950s were only those of the Tonga and this was because of the impending resettlement, which made it necessary to know the number of people to be displaced. Population estimates of the Tonga were given at the time as 86 000 (including those who lived on the plateau) and those who were to be later displaced as 34 000 in Zambia and 23 000 in Zimbabwe (Mathews, 1976:17).

3.4.2 Economic Activities of the Valley Tonga Before Resettlement

The Tonga lived in small independent political units, and their villages were fewer, although larger than they are today. Chief Siansali of Zimbabwe, for example, claimed, during fieldwork for this study, that in the valley he had only two village headmen under him compared to seven he has today. This is true of Zambia as well. Prior to the introduction of the policy of indirect rule, after 1924, there were numerous small chiefdoms with very few and scattered villages. The human population was fairly small on both Zambian and Zimbabwean sides of the valley. At the time of resettlement in 1956, for example, each Zambian chiefdom in the valley had an average of 7 000 people. In Zimbabwe, each resettled chiefdom had an average of about 1 500 people. On both sides of the valley, the population has increased since resettlement, despite chronic famines, food shortages and diseases.

In the years before resettlement, settlement patterns were such that villages clustered or were situated along the Zambezi and around the deltas of the tributaries of the Zambezi River. Here people cultivated the alluvial soils of Zambezi and its tributaries.

Pre-Kariba Tonga life primarily revolved around riverine and upland farming, livestock rearing, hunting, fishing and manufacturing. The riverine farming was based on recession agriculture, which depended on the flood regime of the river.

Away from the floodplains, on the poorer soils of the upland valley area, shifting cultivation was practised. The fields were cultivated in October/November just before the rainy season, with typical crops being maize, sorghum, sweet potatoes, groundnuts, a variety of cucurbits and tobacco. Tobacco was a major commercial crop even in the pre-colonial period.

Livestock rearing was important although the tsetse fly invasion of the 1830s and the rinderpest epidemic of the 1890s reduced cattle population. Goats, sheep and fowls, instead, became important.

The enactment of restrictive game laws in Zimbabwe in 1906 and in Zambia in 1925 led to an increase in game and tsetse fly. Prior to the enactment of these laws, hunting was one of the Tonga people’s main economic activity and a major source of animal protein. Fishing was regarded as a secondary economic undertaking, despite their proximity to the river.

Due to the annual flooding of the Zambezi, which fertilised the riverine gardens and deposited alluvial soils, the Valley Tonga could harvest twice a year and were very seldom victims of hunger and famine. In one of the group interviews, it was pointed out that “by the river we could eat some fruits just for the joy of it, but now we have to eat to survive”. The abundant flora of the valley provided many types of wild foods, which were an alternative during periodic food shortages.

The basic principle was that the farmer had rights over any land that he or she had brought into cultivation. Such land could change hands upon the death of the owner through inheritance. A stranger could acquire land without any problem from kikatongo (the headman). Grown-up children were trained in the skills they needed to provide for themselves and their children.

One of the common issues that people mentioned when we talked to them about life before resettlement was that water was never a problem. Both in Zambia and Zimbabwe, the majority of the people used the waters of the Zambezi for drinking, bathing, swimming and washing clothes as well as irrigating their gardens in the dry season. Another advantage of living by the river as described by the people, was the ease of access to fish in the river.

Prior to the establishment of colonial rule, children were taught at home. Aunts and maternal grandmothers taught young women, and young men were taught by their uncles and fathers. They taught their children about morals, customs, traditions, skills, family life and ancestry.

In some discussion groups, people indicated that even though they did not have any hospital, people were generally strong and fit. This however should not be accepted at face value. The Zambezi Valley occupied by the Tonga was not free of debilitating malaria and sleeping sickness.

Both land and aquatic wild animals were a menace and a nuisance. Hippos and elephants destroyed people’s crops, crocodiles and lions maimed and killed people. Several groups, however, mentioned that these animals could easily be killed or controlled, especially before the enactment of game laws in 1906 and 1925, and, as such, they did not refer to them as a great threat to human life.

Groups talked to during fieldwork indicated that while in the valley they exchanged or bartered their fish and tobacco for beads. The Zambian Tonga bartered their tobacco mainly for grain with the Tonga of the plateau during famine times. With the development of the coal mining industry at Hwange in Zimbabwe and of the copper industry in Zambia, tobacco was sold to the miners for money. Some fish and even green maize cobs were transported in baskets and sold at Hwange Colliery. Dagga or Indian hemp also entered the circle of trade.

Labour migration drew some ambitious young men to urban centres of Zimbabwe and South Africa. As early as the 1880s, the valley Tonga in both the Zambia and Zimbabwe were already migrating to the South African mines where they were called “Zambezi boys”. Some of the money earned was remitted back home and used to pay tax. Some money was used to buy beads, agricultural implements such as hoes, axes, ploughs and cattle.

Communication and transport systems were a major problem at the time. There were no roads, apart from footpaths, and hence no vehicles of any kind could reach the valley from the escarpment. They too were able to cross the river and mix with their friends and relatives on either side of the river.

Although the Tongas remember and recall their lifestyles before resettlement, they also talked about the difficulties they faced. They bemoaned the lack of school and health facilities and development in general. In respect of health, for instance, Clements (1959) observed that the Tonga suffered from many diseases, which included leprosy, hookworm, bilharzia, dysentery, malaria yaws and sleeping sickness. These diseases were reported to have maimed, weakened and killed people. In addition to diseases, children and the aged suffered and even died from hunger, especially in years of extreme droughts and low floods when both rain fed crops and recession agriculture failed.

On balance, the Tongas appear to have enjoyed the relative freedom of their isolation from the rest of Zambia and Zimbabwe until the resettlement. However, it is this isolation and freedom that contributed to their historical marginalisation and under-development. It may also be pointed out that their "splendid isolation" before resettlement was, in the long term, a temporary phenomenon since population growth in time would have led to an inevitable strain on their resources.

3.4.3 The Displacement and Resettlement Processes: General Conditions

The Kariba Dam Project Document (Federal Power Board, 1955) does not discuss the issue of displacement and resettlement. It is only at the end of the report where the resettlement and displacement of Africans is indicated as one of the expenditure items under estimated administrative expenses (p.44).

Similarly, The World Bank Project Appraisal Report of June 14, 1956, does not deal with or consider the issue of resettlement. Instead, "Resettlement of Africans" is mentioned as one of the items under "Federal Hydroelectric Boards Costs", which included, among other things, water rights, wayleave and mineral rights.

All the Central African Power Corporation (CAPCO) annual reports from 1956 to 12961 maintained the same trend of mentioning the displacement and resettlement of Africans as an annual administrative expenditure sub-item (CAPCO annual Reports, ZRA Library, Kariba), without any discussion or details on how the resettlement was progressing and any problems that were being encountered.

The conclusion that can be drawn from this evidence is that the displacement and resettlement of Africans was not an issue at the time. For example, the Kariba/Kafue Gorges debate of the early 1950s did not take account of the fact that building a hydroelectric power station at Kafue had the advantage that the area was uninhabited and the scheme, if located at Kafue, would not have had the problem of displacement, resettlement and related compensation.

The Central African Council Report on Kariba/Kafue Hydroelectric Power Committee (Annual Report 1951:5) shows a gross underestimation of the population to be displaced. It estimated that in Northern Rhodesia 14 300 and in Southern Rhodesia 15 000 Africans "would be affected by inundation". Further, the report adds that, "no provision has been made in the estimates for the establishment of these persons, but it is understood that suitable land is available in local territories for this purpose". In retrospect, it is known that both the population estimates for displacement and relocation and the assumption of suitable land were far from the then-existing situation.

It is therefore clear that what was at stake at any cost was the construction of the hydroelectric scheme at Kariba as dictated by the powerful Southern Rhodesia settler interests of the time.

Furthermore, up to this point the issue of compensation was not discussed openly. In a correspondence of 26 November 1949 between the District Native Commissioner of Gokwe to the Provincial Native Commissioner, Midlands, Gweru, it was only indicated that "the fate of the people (to be displaced) needed to be investigated before waiting until the rising waters deposited a starving people on official hands, to be fed during the first few years of adjustment" (National Archives of Zimbabwe (NAZ)/Official Correspondences, Gokwe). In this correspondence, two options were given.

The first was "that the displaced persons be moved below the dam onto land which has already been prepared for irrigation from the dam, to carry a larger population. The success of such a scheme would necessitate years of planning and development, the natives would have to be fed until the floodwaters were available for irrigation. As an alternative, the population would have to be moved to inland areas where adequate water supplies would have to be developed."

However, it was observed that, “such a move would mean locating people at a higher altitude, away from the river on which their life was centred for generations. An immediate effect would be the deterioration in health, which would be expected".

However, the (PNC) for Gweru, Mr A G Yardley, was less sympathetic. In a correspondence to his senior, Chief Native Commissioner in Salisbury (Harare) dated 3/12/49 (NAZ, PNC/1974 Gokwe10/49), he commented, “I do not share the view that resettlement of the Bantonka (Tonga) will have any serious repercussions. They will be brought into close contact with civilisation for their benefit and for that of the Colony.”

On the Zambian side, the Economic Secretary for the government of Northern Rhodesia wrote to the Inter-Territorial Commission (10/02/51) acknowledging that the displacement of the Tonga would lead to loss of good alluvial soils and expressed doubt that there would be adequate land suitable for the displaced people, “the area available is covered with Mopani Forests, which are useless from an agricultural point of view. A detailed survey would have to be done by an agricultural officer before it can definitely be stated whether there would be sufficient land suitable for resettlement for this large number of Africans” (NAZ, Ref. E1712/7).

In August 1955, the Federal Ministry of Power sent a letter to the two governments detailing the framework of how resettlement would be carried out and what items would be subject to compensation. The framework included the following:

- that the territorial governments would be in absolute control of the movement of people and resettlement;
- the Hydroelectric Board’s interests would be confined to total financial liability in terms of payment and the timing of removal;
- that compensation should not include betterment and would be confined to provision of land transportation, compensation and supervision; and,
- territorial governments to support their claims with detailed schedules.

3.4.4 Two Approaches to Resettlement

After the end of the British South African Administration in 1923, the Southern Rhodesia government followed its own tradition of direct rule, while the Northern Rhodesia government operated on the basis of indirect rule. Within the general displacement/resettlement framework described above, separate arrangements were made by the two territories.

In respect of the resettlement in Southern Rhodesia, compensation covered 23 000 people who were to be moved; food was provided during the resettlement period; adult males were exempted from annual payment of £2 poll tax for two years. The Southern Rhodesia government was to be refunded the revenue lost because of the resettlement exercise by the project.

In respect of resettlement on the Northern Rhodesian side, compensation covered 34 000 people, and included: resettlement costs; compensation to the individuals moved; tribal compensation in respect of hardship, inconvenience and loss of tribal lands and customary rights; compensation in respect of loss of earnings while clearing new lands at the rate of £5 per acre, allowing one acre per person; compensation in respect of loss of earnings while building new huts at the rate of £10 per hut; and, compensation in respect of loss of crops. The cost of tribal compensation was not calculated at the time, but was estimated to be between £644 000 and £800 000.

3.4.4.1 Displacement and Resettlement processes in Zambia

a. Planning process

When the Valley Tonga were told that they should abandon their ancestral land and move to new lands that they knew were barren and hilly, many did not believe that the waters of the mighty Zambezi river, many miles away from their fields (other than *zilili* – riparian land – which were close to the river) and villages, would force them to move. The general thinking and belief was that the white man was merely tricking them to take over their land, especially their prized riverine land, which they had cherished for the many thousands of years they had inhabited the area. The Valley Tongas thus were simply not enthusiastic about abandoning their land and homes.

Elsewhere in the valley, stories of individual protests abound. In Sinazongwe some old men such as Muvundo and Ndilenge individually protested to the colonial officials responsible for resettlement and refused to move. They remained in submerging islands only to be forcefully removed by their relatives who had to reach the islands in their dug-out canoes. Muluti, also an old man from Sinazongwe, was rescued with his 10 dogs in the same manner. Muluti protested because he did not want to leave behind his *musika (Tamarindus indica)* tree because it provided very sweet fruit. He challenged the colonial authorities to resettle him with his *Tamarindus indica* tree.

Although the official agents of the colonial government and those of the Federal Power Board were aware of how the Valley Tonga were attached to their dead, there were no attempts to consider the effects upon them of the loss of shrines and ancestral graves, which were so dear to them.

Although the colonial government made a concession that neighbourhood shrines could be transferred to resettlement areas, it was made without full knowledge of what really shrines were and stood for. Shrines could not be transferred because they did not represent the communities that were to be resettled but rather the relationship of these communities to particular known physical environment; the shrines were the media through which the communities tried to influence the natural forces impinging on their particular locality. Nowhere in the colonial documents were these issues seriously raised.

The moral emotions the Gwembe Valley Tonga attached to resettlement became manifest when 50 people died a mysterious and sudden death in 1959 in the Lusitu area – medical inquiries could not establish the cause of death. The people relocated attributed these deaths, together with deaths from dysentery and measles that occurred earlier in the year, to “bad spirits” or their own “good spirits” who had been left behind at their old areas and could no longer protect them.

In Zambia, chiefs and their village headmen spread information about resettlement. The District Commissioner for Gwembe and his District Officers called for meetings at Siavonga and Manyumbe for chiefs and village headmen, at which the latter were told and directed to inform their people about resettlement.

The Valley Tongas were scornful at the idea of moving to poor barren lands lacking water. The resettlement programme aroused people’s anger that could not be suppressed. The programme caused strong anti-resettlement feelings. Some people were ready to fight and even die for their land. In June 1958, for example, a group of people in the chiefdom of Chipepo stoned a District Commissioner. Three months later in the neighbourhood of Chisamu, in the same chiefdom, anti-resettlement protests culminated in violence when a group of men armed with spears, pangas, knobkerries and shields attacked a police party. In return, the police opened fire, killing 8 people and injuring over 32 (Colson, E.F. 1971).

In addition to group resistance to resettlement, individual protests also took place. During fieldwork, Chief Sinazongwe narrated how some old men in his chiefdom individually protested against the whole idea of resettling them.

The above illustrations of opposition to resettlement suggest two major issues: firstly, they suggest how attached the Valley Tonga were to their land and environment; secondly, and probably more importantly, they suggest lack of serious consultations and involvement of the people to be resettled in the decision-making and planning process.

In the Legislative Council, Robinson Nabulyato voiced against the resettlement of the Valley Tonga arguing that the policy would bring about hardships among the people because of sudden movement they were to be subjected to; Nabulyato's sentiments came to nothing and the Valley Tonga had to "accept" the white man's decision to leave their old homesteads.

b. The Displacement Process

The population of the Gwembe Valley had been increasing fairly rapidly in the two decades preceding the forced resettlement due to the penetration in the area of at least rudimentary medical facilities and services, which helped to check mortality caused by endemic diseases such as malaria and diarrhoea-related ailments. The population estimates for the area was about 33 770 in 1932, after a devastating famine. The famines of 1941–42 and 1947–49 may have undermined population increase in the area, but evidence suggests that there was still an upward trend in the population growth.

Since all the land below the 480m contour was to be flooded and eventually did, the main victims were the population of the chiefdoms nearer the Zambezi. The people on the upland areas above the 480m contour were only affected because they had to receive and accommodate the newcomers. Three chiefdoms of Chipepo, Mweemba and Sinazongwe were particularly affected and large numbers of their people had to be resettled.

c. The New Settlements

Serious attempts were made to provide social amenities in the area of resettlement in Zambia. In 1956 a deliberate 4-year "development plan" was drawn up. In 1957 four new lower primary schools and two upper primary schools were opened. One of these upper primary schools became the first girl's school of its kind in the Gwembe Valley. By 1959 22 prefabricated schools were built to replace those that were or would be flooded. Six of these were extra schools that became necessary because of village groups being split up. In 1964 Chipepo Secondary School was opened and became the first and only school offering post-primary education in the Valley and remained so until the 1980s. In addition to building schools, water wells and boreholes were sunk. By 1958 77 wells and 27 boreholes were sunk. In 1959 17 additional boreholes were drilled throughout the resettlement area. The boreholes drilled in the Lusitu area of the Valley proved unsuccessful because the water was found to be brackish.

Despite the splitting up of villages and population, no health centres or clinics were built in the resettlement areas besides the few that had existed before resettlement.

Notwithstanding the provision of water and schools, resettlement continued to present problems to the people of the Gwembe Valley as will be illustrated in the subsequent sections.

d. Actual Compensation Packages

As explained earlier, the basic planning documents – the 1955 Project Document and the 1956 World Bank Appraisal Report – did not address resettlement issues, although their budget made provisions for a line item on "Resettlement of Africans".

The governments of Northern and Southern Rhodesia were well aware that resettlement would lead to numerous problems and losses among the relocated people. As a face-saver, the officials concerned worked out a compensation package. Although in Northern Rhodesia the government dealt with the Africans through the Gwembe Tonga Native Authority on issues surrounding the Kariba Scheme, which had direct bearing on them, the compensation package was decided upon with very minimum consultations with this local institution, and without consulting the villagers who were to be removed.

According to the *Report of the Commission Appointed to Inquire into the Circumstances Leading up to and Surrounding the Recent Deaths and Injuries caused by the Use of Firearms in the Gwembe District and Matters Relating Thereto* of 1958, a number of compensatory and other demands were made to the governor of Northern Rhodesia in 1955, as well as demands that included that compensation should be paid to the Local Authority to cover general losses and to individuals to cover personal losses.

In other words, the government agreed upon two types of monetary compensation packages. In October 1960, Sir Malcolm Barrow presented a cheque to the Local Authority to the sum of £200 000 at a symbolic ceremony held at Gwembe Boma, which was attended by all chiefs and councillors from the Valley. Individual compensations were in three forms of payment. The first was compensation for huts, which had to be abandoned, and amounted to £10 per hut. In the chiefdom of Mweemba, in the south-western end of present-day Sinazongwe district, people built both regular living huts and *ngazi* (huts on raised platforms), which were used, as granaries and as sleeping quarters. People received compensation for both types of huts. Some families in this chiefdom received as much as £170 as opposed to £100 in those areas of the Gwembe Valley where compensation was given for dwelling huts. The second and third payments of £5 and £2.10 per head were compensation for loss of production due to the move. These payments were actually made per person for every man, woman, and child who appeared on the village census register that was compiled by the district officers shortly before the people were removed. The Gwembe Tonga called this “body money” (“mali ya mubili”).

The compensation payments were made from late 1958 through 1960 and the cost was met by the Federal Power Board and not by the Northern Rhodesia government. The government merely executed the distribution. In total, the Board paid the Northern Rhodesian Government £372 000 in individual compensation in addition to the £200 000 “tribal” compensation payment.

There was also indirect compensation called the “Fund for Gwembe Rehabilitation”, which amounted to £1 115 000. It is not very clear regarding how this fund was used; probably this was the money used to provide social amenities and other infrastructures. “Mali ya Kariba”, as this compensation was often referred to, was gender insensitive for there were no clear guidelines as to who should really benefit; in most cases women never received money, as their men folk claimed all that was allocated to all members of households who depended on them. As a result much hostility was generated as to who really had rights over the money. Fathers or male guardians also obtained “body money” on behalf of their unmarried daughters and sons still under their custody.

Besides the conflicts it generated, compensation in relation to the losses incurred as a result of resettlement cannot be said to have been adequate. In any case, it is really difficult to accept that it could ever be adequate. The compensation policy did not take into consideration the unforeseen losses that would be incurred by the relocated people, or the obvious losses. For example, the loss of the prized alluvial soils was more traumatic because those who possessed riverine gardens did not only lose forever their chance of cultivating dry-season crops, but also many of them lost the opportunity to grow tobacco, which was their age-old commercial and cash crop. Unforeseen losses, which the compensation package did not take into consideration included losses in livestock, which were very serious: somewhere in the range of £48 000 worth of cattle, goats and sheep were lost in accidents while in transit to the areas of resettlement.[9] Some were lost through predators, poisonous plants, lack of suitable and palatable browse, water shortages and epidemics that characterised the

[9] Thayer Scudder and Elizabeth F. Colson, ‘The Kariba Dam Project: Resettlement and Local Iniative’ in H. Russell Bernard and Pertti J. Pelto (eds.) *Technology and Social Change* (New York: Macmillian, 1972), 48.

new areas. There was also loss in household items resulting from breakage while in transit. Because of this, the relocated people have always thought the compensation package inadequate.

Their current perception of compensation is that the people should jointly own the Kariba generated resources so that some money obtained go towards the overall development of the Gwembe Valley.

e. Consequences of Displacement and Resettlement

The Early Years

In Zambia, the programme of resettlement was carried out from 1957 through 1958. But, according to the Provincial Commissioner, Southern Province, Mr. A. St. J. Sugg the programme symbolically came to an end only in 1963 when he officially opened the new building for the Gwembe Tonga Native Authority Headquarters at Munyumbwe. Sugg saw this event as “a start to the more prosperous times that lay ahead.” Sugg’s perception of the whole Kariba scenario at this point seem to represent the official attitude, which was optimistic, that the resettled people would quickly fit well in their new environment. For example, it was recorded in that year that relocated people had “shown admirable powers of recovery from the shock of resettlement”. In 1963, *Nshila*, a popular magazine, became a propaganda tool to cover up the relocated people’s trauma of resettlement by publishing stories that painted a positive picture of the post-resettlement period.

The Department of Agriculture report for 1960, estimated that prior to the construction of the dam and subsequent formation of the lake, there were 2230ha of riverbank gardens, 13 000ha of floodplain and alluvium gardens and 11 300ha of gardens in the upland parts of the Valley.[10] All the riverbank and floodplain and alluvium gardens are now “wastelands” under the floodwater. Only the higher parts of the Valley survived and it is this area that now constitutes the Gwembe Valley between Lake Kariba and the Zambezi escarpment. This means that 57.41% of the arable land was lost. It is noteworthy that the remaining 11 300ha of higher parts of the Valley was the area to which the riverine population was relocated.

In addition to the types of land discussed above, other land was also flooded. For example, in the Mweemba chiefdom alone, more than 172743ha of land was flooded. Cases of overcrowding in some new areas were reported hardly a year after the move. The land problem must be seen as a reflection of lack of commitment on the part of colonial government to serious pre-resettlement planning. The government officials were well aware that much of the land was poor quality and easily erodable. In spite of knowledge of the situation in the area, they went ahead to resettle people. For example, in the Mweemba chiefdom about 7500 people were resettled in an area whose arable land’s carrying capacity was estimated at only 2300.[11] The land population equation was thus highly unbalanced, with densities ranging from 100 to more than 300 people per square mile in some resettlement areas. In the mid–1960s for example, William Allan observed that the Gwembe Valley’s cultivable soils had been “much over-cultivated under pressure of population” because “populations had increased at an alarming rate ”.[12]

It is therefore not surprising that in the immediate years following resettlement food production decreased on a large scale and famine ensued.

Although famine was not unknown in the valley and did occur from time to time, the famine of 1958–1960 largely resulted from resettlement-associated factors because the relocated people had not yet cleared sufficient land for farming and because of debilitating illnesses people suffered in the new

[10] Northern Rhodesia, Department of Agriculture. *Annual Report for 1960* (Lusaka: Government Printer, 1961), 51.
[11] NAZ, SEC 5/454. H.A.D’Avray, District Commissioner, Gwembe Kariba Resettlement Tour Report, 1960.
[12] William Allan, *African Husbandman* (Edniburgh: Oliver and Boyd, 1965), 148-49.

areas; the Lusitu deaths are a good example of the latter. Because of the ensuing famine the administration found it necessary to distribute large amounts of maize as famine relief: 38 000 bags of maize were distributed in the region between 1958 and 1960. This maize was not given free; instead the administration demanded that it be purchased using compensation money. As a result, the resettled people felt the money given was not adequate.

Although the general prevailing view regarding the compensation package among the people resettled is that the money was not adequate nor commensurate with the losses incurred due to resettlement, many people talked to during fieldwork still felt that “those with heads” (enterprising and industrious men) made very good use of the compensation money. Many, especially in the Chiefdoms of Mweemba and Sinazongwe invested their money in cattle and some in fishing; they bought fishing nets and even ‘Seagull’ engine boats.

Yet others bought bicycles. Anderson Muleya Simwami of Munzuma Village in Sinazongwe chiefdom says his father bought two cows and his uncle bought a boat and a Seagull engine. Some bought guns, especially the Grinner makes. Some of the money was used to pay outstanding debts of lobola (bride price) and yet others used it to marry their second or third wives, as they were now in a position to pay the bride price. Yet others were able to send their children to school and pay their boarding and other school fees. To a large degree, therefore, compensation contributed to the betterment of some individuals in the Gwembe Valley and to the general development of the area in the long-run.

The Subsequent Years

By 1965 resettlement was a thing of the past. People still reminisced about the “Chisamu war” and the fears it engendered; the horrors of the move, the fears of the first days in the new strange land (Colson 1971: 61). If by 1965 resettlement was a thing of the past, it was so in the short-term perspective of the programme. It is true that initial shocks caused by trauma of resettlement were over, but the period ushered in some long-tem problems whose roots can be traced to the resettlement programme.

It was made very clear, during fieldwork interviews and group discussions, that the people affected by the Kariba Dam Project have not lost their sense of the history of resettlement. They were able to differentiate the problems that confronted them during their immediate years of settlement in the new areas from those that became perennial after the initial years in the new areas.

One of the major consequences and problems associated with the construction of the Kariba Dam has been the shortage of arable land. The shortage of land has been ever-growing and was exacerbated by the loss of riverine gardens and other types of fields. For example, there were 2 230ha of riverbank gardens, 13ha of floodplain and alluvium gardens and 11 300ha of gardens in the upland parts of the valley (Northern Rhodesia, Department of Agriculture, 1961:51). The riverbank, floodplain and alluvium gardens are now “waterlands” under the floodwater. This means that 57.41% of the arable land was lost. It is noteworthy that the remaining 11 300ha of higher parts of the valley was the area that the riverine population was relocated. In addition to the types of land discussed above, other lands were also flooded. In the Mweemba chiefdom alone, more than 172–743ha of land were flooded.

As a result, cases of overcrowding in some new areas were reported hardly a year after the move. The government officials involved in the resettlement programme were well aware that much of the land was poor quality and easily erodable, but in spite of this knowledge of the situation in the area, they went ahead to resettle people.

The land population equation was thus highly unbalanced, with densities ranging from 100 to more than 300 persons per square mile in some resettlement areas. In the mid-1960s, for example, Allan observed that the Gwembe Valley's cultivable soils had been "much over-cultivated under pressure of population" because "population had increased at an alarming rate". (Allan, W. 1965:148–149).

By the late 1960s Scudder was able to identify over cultivation as a cause of soil degradation in many parts of the valley. (Scudder, T. 1971:24). During the dry season, Siameja and Lusitu resemble the Sahara desert.

The inevitable consequence of inadequate land has been the chronic food shortages and in some years famine conditions have prevailed. This has been due to the fact that because of scarcity of land, the traditional Tonga system of land use, which requires that the land lies fallow for some years, has not been possible. As a result, soil nutrients have been quickly depleted, resulting in poor yield returns even in a good rainfall season. The situation became worse in the 1980s through the 1990s because of chronic droughts that ravaged the southern African region. The situation was worse in the valley, because the area is naturally semi-arid.

These decades of droughts and food shortages revived people's memories of the valley. During fieldwork, interviews and group discussions conducted in Chipepo, people complained that during the recent food shortages relief agents humiliated them by forcing them to work for food. They were quick to point out that in the valley, drought had been a temporary set-back because they cultivated their riverine gardens and managed, even though with difficulty, to pull through stressful periods (Group discussions held at Mpambazana village, Lusitu).

Many people interviewed, during fieldwork for this study – including Chiefs Chipepo and Sinazongwe – complained that they have been reduced to wanderers; they are no longer the proud men and women of the river that they used to be before the Kariba Dam Project. This was probably in reference to the evident and apparent wave of recent steams of migrations out of the valley that have been taking place. Many families from Chipepo in Lusitu have moved to the Mazabuka district while those from old Chipepo have moved to Chikanda in Kalomo and some to Mumbwa and other parts of the Central Province.

In the equally land-hungry Siameja area in the Mweemba chiefdom many have migrated to Njabalombe and other parts of the Kalomo district. These voluntary relocations have been largely necessitated by the poverty and degradation of land, which – as already outlined above – has caused severe food shortages that have become chronic even in good rainfall years.

It is, however, important to accept the fact that the good memories given of the pre-Kariba Gwembe Valley were not going to be perpetuated forever. Both human and livestock population was certainly destined, soon or later, to outstrip the region's resources. However, it must also be seen from the perspective that the situation was hastened by the Kariba project.

Chief Chipepo was insistent during our interview with him that the crisis the people of the Gwembe Valley have undergone since resettlement would not have occurred despite population increase simply because people would have been responding to the problems as they arose, without the panic and rush that was the case during forced relocation. Lack of adequate water is a particularly significant problem in resettled areas.

In recent years, the water problem has become even more serious. Most wells and boreholes sunk during resettlement programme have since dried up or broken down. The situation has been worsened by the fact that most, if not all, the rivers in the Gwembe Valley, which were perennial in the 1960s and the 1970s became sandbeds during the droughts of the 1980s and 1990s. People living in those areas where water is a particularly serious problem, such as Lusitu, complained that they were "chased by water", and now have no access to it; referring to the water in the lake. In many parts of the valley, especially in the Chipepo Chiefdom, Tonga women and children walk long distances to draw water. The situation is particularly bad during the dry season when the sinking of wells in river sandbeds does not help the situation, as these wells quickly dry up.

The years subsequent to resettlement saw the emergence of development-related activities that set the local people on a seemingly endless path of marginalisation. Following the end of Zimbabwe's guerrilla war and the subsequent independence of the country, there was a sudden influx of commercial Kapenta fishermen using big fishing rigs, and of foreign investors taking up the northern lakeshore line, displacing the local people. Currently, there are over 30 "foreign" investors along this shoreline involved in a number of activities including crocodile farming, game ranching and Kapenta fishing. This second time around, land alienation has caused many problems among the local people. Recently, some 4 600ha of land was alienated to about 40 foreign investors in Siavonga's chiefdom of Simamba. In Sinazongwe, more than 1 600 people were dispossessed of their land to pave way for a huge irrigation farm in 1985. These developments are directly associated with the construction of Lake Kariba.

Group discussions and interviews revealed that the co-use of the aquatic resources of the lake between the commercial and artisanal fishermen has not been balanced. Artisanal fishermen complained that their gillnets have sometimes been damaged by Kapenta rigs and are not compensated for the losses they incur, but should the rig be damaged, they are forced by the rig owner to pay for the damage. Instances where a commercial fisherman confiscated and sometimes destroyed artisanal fishermen's canoes or boats and nets were reported as having been common and has generated bitterness against commercial fishermen.

Some people have been able to send their children to school and pay their boarding and other school fees. Once the adjustment process was over, many children were able to enrol themselves in school because of improved access to education, compared to the pre-resettlement situation. This was indicated during fieldwork and group discussions as one of the benefits of resettlement. John Kadakwa proudly said that education facilities improved greatly after resettlement and many schools were built after this period. Education facilities, to some degree, led to the breaking up of the isolation of the Gwembe Valley, as gifted Valley Tonga children began to leave the valley to attend secondary schools, which were not in existence in the valley until 1962 when Chipepo Secondary School was built.

Conclusions and Key Findings

The Gwembe Tonga generally perceive the experience of displacement as a negative experience, which was forced upon them. To this extent, the displaced communities feel the victims of the project from which they stood to lose, since they had no control or say in the project.

The resettlement process was hastily undertaken with little preparation and limited resources on the part of those implementing the project: the Federal Power Board and the parent Federal Ministry of Power. Besides the question of limited resources for resettlement, the political and economic priorities of the time were regional and national with little or no consideration for the future well being of the displaced communities.

Although the Local Authority – the Gwembe District Council – with the assistance of lower level colonial officials made relatively strong claims based on loss of good agricultural land in the valley, loss of water (riverine gardens crops), and the inability of resettlement areas to carry additional populations, meant that compensation was inadequate to make up for the losses incurred through displacement. For instance, in the claim made to the Federal Power Board by the Northern Rhodesia government, the contribution of the winter crop or riverine gardens in the valley to the total annual crop for households was estimated to be only 30–50% and yet the percentage contribution increases in seasons with poor summer rainfall (Economic Secretary of the government of Northern Rhodesia, Correspondence to the Secretary of Inter-Territorial HEP Commissioner, 10/02/51, NAZ Ref. EA12/7).

3.4.4.2 Displacement and Resettlement Processes in Zimbabwe

a. Planning Process

The Southern Rhodesia government assigned the responsibility for resettlement to its Ministry of Native Affairs, later to be renamed Ministry of Internal Affairs. Sir Patrick Fletcher was the Minister of Native Affairs at the time and his ministry was responsible for all the decisions that had bearing on resettlement and compensation. The key person on the ground was I.G. Cockcroft, the District Native Affairs Commissioner referred to by the nickname "Sikanyana" by the Tonga. He was initially based at Gokwe, then the administrative centre for the Sebungwe region/district that included the present Gokwe, Binga and Kariba districts.

In 1957, Sebungwe was divided into three administrative districts of Gokwe, Binga and Kariba. It was at this point that Cockcroft moved to Binga as its first District Commissioner (DC).

In August 1955, Sir Patrick was accompanied by DC Cockcroft and visited all the Tonga chiefs in the valley to inform them about the dam and resettlement plans. They were given the opportunity to go and choose where they would like to settle on the escarpment. The Rhodesian government, according to Clements (1959), did not intend to pay any monetary compensation to those who had to be moved. It further intended that commercial fishing on the lake or other enterprises along the shores would be largely in European hands.

It was also the intention of government "to place them well away from the shores of the future lake where they would not interfere with its developments" (Clements, F. 1959). This decision is lamentable since it represents a deliberate denial of access to water for the Tonga who had for centuries managed their lives around water.

Interview respondents gave different answers with respect to the time when they were informed about plans for resettlement and their actual relocation. The responses given varied between 6 months and 2 years. Since the Tonga were resettled in stages, notification is likely to have varied from about 1 to 2 years. However, it was often mentioned that even though people were told about the dam and that people had to be resettled, many did not believe that this would happen. Many thought that it was just a joke when they were first informed of future displacement (group discussions).

The Tonga could not quite comprehend that humans could possibly change nature, and that the mighty Zambezi guarded by the revered river God Nyaminyami would disappear and be replaced by an extensive man-made lake.

In more than half of the 20 group interviews conducted, the respondents said that the person who came to inform them about the resettlement was I.G. Cockcroft. He was generally remembered as a "good man". Some even said he was a "good and rough man" (group discussions).

Individuals remembered different things about what they were told concerning resettlement. Most remembered that the chiefs were told to go onto the escarpment and look for new areas to settle. In one group interview, it was pointed out that the government gave the chiefs several options on where to settle. While the chiefs and the people were forced to move, they were not permitted to resettle near to where the edge of the lake would be, as this area was reserved for national parks and future tourism development. Because of this prohibition, the chiefs tried to find new places with some kind of water source, often located 50 to more than 100km away.

Opposition to both the Kariba Dam Project and resettlement came from the African nationalist movements: the African National Congress Party of Zambia led by Harry Nkumbula and the Malawi Congress Party of Malawi led by Wellington Chirwa.

Chirwa was temporarily successful in stopping the recruitment of contract labour from the Southern Province of Malawi in 1956. He campaigned against the Rhodesia Native Labour Supply Commission (RNLSC), which was recruiting contract labour in the Southern Province to provide work during the construction of the Kariba Dam. In March 1956, Chirwa campaigned against the Dam, which he described as a scheme for depopulating southern Malawi by forcing people to work under conditions similar to slavery. Reports of poor working conditions, sickness and death during dam construction at Kariba, strengthened his campaign although the real bone of contention was the existence of the Federation itself, which was associated with white rule in Southern Rhodesia, and the fact that the latter government was opposed to nationalists fighting for independence in Zambia and Malawi. Chirwa's criticism of the poor working and sanitary conditions at Kariba led to the cessation of contract labour recruitment and shortage of labour at Kariba. The RNLSC had to source labour from non-traditional sources – Angola, Congo, Mozambique, and Bechuanaland and Tanganyika.

Nkumbula, leader of the Africa National Congress Party of Zambia mounted a similar campaign against Kariba and resettlement. Nkumbula sent his agents to the Tonga on the southern bank to politicise people against resettlement and the Kariba project generally. Nkumbula had petitioned the Queen of England and the United Nations (UN) against the Federal project and resettlement. His agents carried leaflets of the petition, which were distributed among the Tonga on both sides of the river. Nkumbula, like Chirwa, was against the Federation, which was opposed to the struggle for African political independence in the three Federal territories.

From the group interviews conducted in Binga, the discussions indicated that the people and chiefs on both sides of the river were not in favour of resettlement. Weinrich's study of the mid-1970s supports this view. "The move of the people was far from voluntary and many, like the people of Sinakatenge, moved only at the very last moment when the water level was already rising and their homes became inundated." (Weinrich, A.K.K. 1977).

b. The Displacement Processes

The resettlement was a tension ridden programme to move people before the river flooded the people's homes in the valley. As a result, "people were moved before the resettlement areas could support them" (Colson, E. 1971). When people in the group discussions talked about the time of resettlement, they remembered it as being a traumatic experience.

At the time of resettlement, the Tongas were worried about how they were going to be able to carry all their belongings. It was a "rough time" and it was also mentioned that some elderly people "died of sorrow". Time and time again in the group discussions, it was pointed out that "we were treated like animals or things – rounded up and packed in lorries". Some, at the time, heard others call out, "they are taking us to live in the bush like animals" (group discussions). The physical displacement was effected in lorries. The Tonga had to be prepared for the lorries to come and take them away with their belongings.

Generally, little attention or care was paid to the Tonga; "the animals seemed to be more important". Probably this was also in reference to "Operation Noah" mounted at the time to rescue animals and snakes from the flooding river. Clements (1959) noted that "scores of animals were saved – baboons, monkeys, civet cats, porcupines, snakes and a variety of bucks trapped on temporary islands by the rising waters of the new lake. It was the biggest animal rescue operation since Noah". "Operation Noah" was highly publicised overseas, which completely overshadowed the resettlement of the Tonga. One of the concerns the Tonga frequently expressed was grief due to the separation between the Tonga on both sides of the River. It was mentioned in the group discussions that many wanted to join their relatives in Zambia but were refused.

It appears that people did not show open resistance on removal mainly because of the fear of "Sikanyana" (DC Cockcroft) and his armed police, and lack of options. Despite this, it was sometimes said that resistance occurred and that those who resisted lost their belongings when the flood came. The general opinion, however, was that no one died during the move in Zimbabwe.

Even though most of the respondents indicated that at the time of resettlement the location of their new villages had already been decided upon, more than three groups mentioned that people climbing into the lorries did not know where they were going. This, however, was probably the case, because it was only chiefs who had been asked earlier by Sikanyana to find suitable places on the escarpment. When asked if people were able to bring all their belongings to the new homes, some said time did not allow the retrieval of all their items (group discussions). However, due to the fear of leaving behind their ancestors and sacred places, some were reported to have brought the gravestones to the new homes. What appears to have been a particular problem was the transportation of livestock. It was pointed out that although Sikanyana decided that people could bring their goats in the lorries, the other livestock had to be brought to the new places on hoof. The result of bringing the goats on lorries was that many of the animals died before reaching their destinations.

Altogether, 23 000 Tonga were relocated on the escarpment plus a “few” Korekore under Chief Nyamhunga who were moved back to where they had come from – Hurungwe reserve (Clements, F. 1959).

c. Actual Compensation Packages

The Senior Information Officer of the Native Affairs Department, W.T. Nesham produced an information sheet – NADFORM Service Information Sheet, No. 18 of 1955 (NAZ, NAT 36) which contained details on, “Kariba Resettlement: Southern Rhodesia”.

It is clear that there was no cash compensation in Southern Rhodesia, and people were moved in stages as follows:

- movement of the two Korekore Chiefs and one Tonga Chief, possibly Chief Msampakaruma and their people in 1956 –50 miles off Lake Kariba;
- movement of the main Tonga group of 11 Chiefs and their people located in Sebungwe District, 1957;
- movement of the two Tonga Chiefs and their people located in the Wankie District, 1958;
- the construction of 962 miles of access roads to serve the resettlement area;
- the cutting of hundreds of miles of rough track to serve as extraction routes from existing villages;
- numerous boreholes and wells were sunk and fitted with pumps.
- Numerous earth dams and weirs were built;
- people were transported by lorries including their belongings, grain and stock to resettlement areas;
- clinics were built and provisions made for the necessary medical facilities;
- a complete new administration centre at Binga, with police post and hospital was built; and
- grain was provided to supplement the food supplies of the resettled people.

Adult males were exempted from taxation for two years. In the resettlement areas, people were provided with cut and bundled thatching grass, grain rations to meet their family needs for two seasons, powdered milk and vitamin enriched food concentrates. Regular medical attention and drugs was provided as required. Inoculation of stock against trypanosomiasis was conducted. All these were supplied free of charge. The absence of cash compensation payment was in sharp contrast to the resettlement process in Zambia as described earlier.

By the end of the resettlement exercise, a total of £3.98 million had been spent on resettlement on both sides of the river out of the total project cost of £77.61 million (CAPCO Annual Report, 1961). The average expenditure was £134 per person moved in Northern Rhodesia as compared to £59 per person moved in Southern Rhodesia (CAPCO Annual Report, 1961).

d. Consequences of Displacement and Resettlement

The Early Years

Settling down on the escarpment was no easy task since homes had to be built and new fields cleared of bush and trees. The surroundings were totally different from the ones by the river. There were only bush and trees, and when the Tonga arrived, they had to put all their belongings under trees and sleep in the open. They had to establish new routines, building new homes and farming in generally non-fertile dry lands. Respondents indicated that "life was very hard from the beginning". It took most people at least a year to settle down. No longer able to rely on riverine gardens, which supplemented the harvest from the fields, villages became more spread out and larger fields were needed.

Wild animals became a more serious problem; they threatened people's lives, preyed on livestock and wiped out crops in the fields and green vegetables in the winter gardens. Another problem connected with the livestock was the tsetse fly, which constantly reduced the numbers of goats, sheep and cattle. Soon after resettlement, the Tongas were not permitted to kill wild animals under the newly established game laws.

Although the Tongas were promised water, it came to be one of their biggest problems. In one group interview, one elderly woman remembered that "they said that the water will follow you". Water from dug-out wells and boreholes sunk during resettlement provided water, but the water was either dirty or brackish. More than 60% of the boreholes drilled failed to provide water and others dried up in the dry season (Nesham, ? 1955). Water was no longer available to the Tonga like it had been along the Zambezi River.

Other factors mentioned during fieldwork, which changed their lives after resettlement was that they began to wear more clothing and use money. This was facilitated by migrant labour, which became important in their lives. Further, it was not easy to find new religious and sacred places in unknown lands. Many things could not be replaced, especially the lost sacred places.

During the first few years after resettlement, the Tonga were allowed to cross the Lake and meet with relatives and friends on the other side. However, the frequency of visits was no longer the same given the long distances involved; some were relocated over 100km away from the Lake. Furthermore, when the Federation of Rhodesia and Nyasaland broke up in 1963 and Zambia became independent in 1964, free movement ceased and border posts were established at Chirundu and Kariba. From that time, the Tongas were transported in lorries and could not bring most of their belongings. Many felt they were treated like animals and were dropped at new sites, which had not been cleared before arrival.

The separation from their friends and relatives was mentioned as one of the most painful experiences connected with resettlement. People were given food during the first years of resettlement as "compensation". Besides this compensation in kind, the Tonga were promised water and access to Lake Kariba. To this day these promises have not been fulfilled.

The Subsequent Years

40 years have passed since the Tonga were resettled from the Zambezi River. While most of them accept that they are now accustomed to their areas of resettlement, they continue to express ongoing concerns and needs. During group discussions, respondents frequently highlighted the differences between now and then and pointed out the problems they are facing today. Lack of water in particular is a significant problem that they have to deal with. In the group discussions, it was frequently remarked, "the lake is there but we cannot use the water". Since the people cannot use the water from the lake today, boreholes and small- and medium-sized dams have been constructed. However, these boreholes and dams are not adequate since there are too few and the water dirty. Tonga women have

to walk long distances to obtain water, and when the pumps are not working, "we do not have any water".

The soils on the escarpment are generally poor for farming and this was mentioned at all group meetings. One respondent pointed out that there had been further movement of people after the initial resettlement who were searching for better farming land (shifting cultivation) because of poor soils. It was further pointed out that during the drought of 1992, some people went down to the lake to grow crops on the banks, even though this was illegal. Lack of farming equipment like tractors and ploughs contributes to the difficulties with farming today, since most of the cultivation is still done by hand.

Furthermore, the Tonga are entirely dependent on the rains for their crops to grow and mature, something which was indicated as being a major problem since the rains are not reliable. Although their land is rich in wildlife, the game laws do not allow them to hunt, even though animals are a threat to their livelihood and existence. Elephants are mentioned as being the biggest problem, although baboons and birds are also mentioned along with the felines. One elderly woman vividly expressed the problem of the elephants. She said that "today if an elephant kills you or destroys your field people are not allowed to kill it and nothing happens to it, but if you kill an elephant you are sent to prison." The implied criticism in this statement is that government is more concerned with wildlife than people and this puzzles the Tonga. Another woman remarked that "government should get rid of wildlife, especially the elephant." In addition to insufficient rains and the poor soils, wildlife is a factor that contributes in no small measure to poor harvest and starvation in Binga and other surrounding districts.

People still grow the same crops they did by the river; maize and sorghum. Their first preference is maize, but since there is not enough rain, they do not try hard with maize anymore. Livestock are not as common as they used to be, especially since the drought of 1992 when many cattle were lost throughout the country. However, some still have cattle, goats and sheep.

One of the income generating activities that people mentioned is manufacturing or making crafts, which they try to sell from door-to-door, or at markets. Some even go as far as Harare and Victoria Falls to sell their wares. Those who do not have much to sell, are forced to sell their livestock to survive. Others, especially young men, go to the towns to look for work. This was mentioned in all group discussions as being frequent, but not a very successful solution to their problems. It is common for young men to go and look for work in Bulawayo or to cross the border to Zambia. There also exists the phenomenon of migration to South Africa.

The reason why labour migration is not a successful strategy is the generally high level of unemployment in the country, especially since the introduction of economic structural adjustment policies in the early 1990s.

When people are able to find work at all, it is often lowly paid, such as garden "boys", child-minders or housekeepers. In one group people pointed out that "employment goes together with relationship or favouritism". This was given as one reason why it is very hard to find work. However, those who do find work remit money home to their families.

Kapenta fishery co-operatives also generate income. However it is a difficult activity to participate in because the joining fee is $100 and the capital-intensive nature of the business.

Many changes have taken place in the lives of the Tonga over the last 40 years. Some of these pointed out in the group discussions relate to changes in religion and culture. The presence of churches has contributed to a mixture of traditional beliefs and Christianity. It was also indicated that changes have taken place in marriage. People are now free to marry/choose their partners and are holding wedding parties, without reference to their elders or some of their traditional marriage customs.

The provision of health services was indicated as one of the positive changes since resettlement, although it was observed that more people are now dying from many illnesses.

Some indicated that access to education had improved compared to when they were in the valley where there were no schools. Today, more Tonga children go to school although it is difficult for many parents to afford school fees for secondary education. People also mentioned the problem of language barrier between parents and children since the Tonga language is not taught in schools.

The Tonga in Zambia and Zimbabwe continue to wish for closer contact although there are restrictions on visits. The Zimbabwean Tongas prefer the Zambian side, partly because most of their relatives are there. Even though people were generally of the opinion that they had become accustomed to their new situation, recurrent in the discussions was their desire to go back to the river.

There is fear of being resettled again. The issue of resettlement and its perceived injustices is still present in the minds of the Tonga today, as one elderly man remarked, “old people still shed tears and are waiting for a solution.” Another added, “nothing good came out from the creation of the Lake.”

3.4.5 Impacts on Other Basin Communities

3.4.5.1 Impacts on Host Communities

Here again the contexts of the two countries were dissimilar. In the case of Zimbabwe, the settlers were relocated to uninhabited. In the case of Zambia, host communities had to share their available farm and grazing land with settlers, which resulted in the reduction of both its availability and quality, due to overcrowding. This situation has led in many cases to increased search of better land. On the other hand, the host communities enjoyed better access to services such as schools, clinics, and road infrastructure wrought by the settlement programme.

3.4.5.2 Impact on Downstream Communities

On the Zambian side, those originally near the dam wall area and upstream were affected more drastically by displacement and relocation onto the escarpment, which was of poorer quality in comparison with the alluvial soils in the valley. Those downstream of the dam wall, who were not relocated, suffered the effects of changes in reservoir behaviour, loss of land that could be planted – either because crops dry up when reservoir levels drop more rapidly than expected as happened in 1994 or because of inundation in cases of rapid rises in the levels in low-lying areas, as happened in 1995 in Zambia. Further, villagers are hesitant to plant in otherwise suitable areas because of the fears that the crops may not be harvested due to the unpredictable flow of water downstream.

On the Zimbabwean side, the downstream area was a wilderness and the project affected wildlife rather than people. With respect to upstream communities, the project led to loss of land and homes for the 23 000 people who had to be displaced

Other aspects of downstream impacts (with social ramifications) are analysed later in this chapter: as part of the analysis on the ecological aspects (Section 3.6.2.7); wildlife (Section 3.9.5) and hydrology (Section 3.11.6)

3.4.6 Employment Opportunities During Dam Construction

20 groups were interviewed among the displaced Tonga along the Lake in the three adjacent districts of Binga, Gokwe North and Nyaminyami. All the 10 groups of men indicated that large numbers of people were employed for clearing the lake bottom of trees prior to inundation. However, only 2 male groups under chiefs Sinakatenge and Sinamasanga indicated that some people obtained employment at Kariba, either at the dam site or with Richard Costain Construction Company which was given a contract of £3.5

million by the scheme authorities to build houses, shops, banks, schools, hospital, access roads, electricity and water supply and sewage systems in February, 1956.

Only 3 women groups under chiefs Siamupa, Sinamasanga and Sinakatenge indicated that they, and many others, were also employed for cutting trees and that they were paid with packs of salt and not money. Men who were employed at the dam site or by Costain were paid in money wages and the rate was variously indicated as 25-35 shillings per month. Project authorities contracted out the available work – such as the cutting of trees, the building of shops and access roads – to a Mr D.G. Vorster.

From the foregoing discussion, it can be seen that the Tonga – men and to a limited extent women – had the opportunity for employment and earned some income created or occasioned by dam construction. The employment was, however, temporary, and appears not to have benefited most people because preference was given to cheap foreign and contract migrant labour from other countries besides Zambia and Zimbabwe (Clarke, D.G. 1974).

3.4.7 Reparation and Rehabilitation Programmes Underway

The main dam-induced grievances mentioned by 20 groups interviewed in Binga (Zimbabwe), Kariba and Gokwe North districts, are as follows: poverty, lack of access to water, lack of access to fishing and game, human/animal conflict, transport problems, poor roads and services, and problems with water transport.

a. At the bi-national level

In 1995, the ZRA mounted one of the first reparation efforts by the Kariba project for the displaced Tonga. The authority initiated a programme to raise funds through golf tournaments, the sale of handbooks and videos on Kariba and similar activities. The funds raised in this way are used to finance development projects within the Tonga communities in the two countries. Details of this programme are presented in Tumbare (1998).

Unfortunately, the amount of funds that have been raised in this effort have small in relation to the development needs of the communities. As of mid-1999, the fund only had Z$500 000 (equivalent to about $15000). ZRA has provided grinding mills to some Tonga communities in Kariba and Binga district.

The ZRA’s initiative stems from its recognition of the fact that there was insufficient time allocated to the planning and implementation of the resettlement programme, and that insufficient resources were made available for the massive exercise. ZRA acknowledges that compensation was not provided (the case of those displaced in Zimbabwe) or grossly insufficient (the case of those displaced in Zambia). The reason given for such a policy is that individual/private property rights did not exist among the victims, and that the land they occupied was legally owned and controlled by the state. In such a context, ZRA’s view is that logically, the state could not compensate itself. (Tumbare, M.G. 1999; op cit.)

In any case, ZRA is now of the view that any major resettlement exercise should be accompanied with “sufficient” mitigation measures, which include compensation for all lost property and assistance to resettle and finding alternative gainful employment. Further, it is suggested that policies for minimum facilities in the new resettlement areas should be spelt out by both financiers and governments, so that the displaced are provided for and their needs and rights included within the project costs.

It is in the light of the above deficiencies on displacement and resettlement, exposed by both researchers and ZRA itself, that the latter has decided to launch the Zambezi Valley Development Fund to initiate self-sustaining projects aimed at improving the living conditions of those displaced by the Kariba Dam Project.

The funds for this initiative are being raised through donations, fund-raising activities by ZRA and a 1% levy on water bills for the water used for power generation. It is, of course, too early yet to examine the impacts of the ZRA initiative. It suffices to know, for the moment, and for the purpose of this study, that the fund and related projects have begun in earnest. What counts in this initiative perhaps is not so much the size of the fund, but the recognition of the need for reparation and the very act of initiating a reparation fund. One hopes that both the financier – the World Bank – and the governments of Zambia and Zimbabwe who were parties to the Kariba Hydroelectric Scheme, will follow suit with even more meaningful projects, which will have significant positive impacts on the lives of those displaced.

Future plans by ZRA to allocate a certain percentage of its annual revenue from Kariba water sales for development projects will hopefully lead to a sustainable and substantial reparation programme.

b. Initiatives at the national level

In Zambia

In Zambia, the government (through the national power utility, Zambia Electricity Supply Corporation – ZESCO) recently initiated a rehabilitation activity targeting the formerly displaced communities. This activity, known as the Gwembe-Tonga Rehabilitation and Development Programme is one of the components of the Power Rehabilitation Project (PRP). Limbwambwa (1999) in a paper presented at a recent WCD conference in Cairo, Egypt, in December 1999, gave a detailed description of the ZESCO Tonga Rehabilitation Programme.

The formation of this project followed the commissioning of a study by ZESCO Ltd. and the World Bank entitled, "*Development Strategies and Rehabilitation Programmes for the Peoples affected by the Construction of the Kariba Dam*". Following the results of this study, the World Bank suggested to ZESCO Ltd to carry out a transformation of ZESCO's generation, transmission and distribution systems. The Rehabilitation Project can therefore be viewed in the light of the World Bank's changes in policy regarding bank-financed projects. For instance, in 1980, the Bank formulated an explicit social policy aimed at improving the handling of unavoidable resettlement operations with the view to avoiding the social and economic dislocation of relocated people. This policy now provides the basic guidelines, which every project the Bank finances must meet.

The fundamental objective of the policy is the restoration of the income and livelihoods of the affected communities and, where feasible, to improve them. This policy requires the planners or borrowing agencies to consider the economic and cultural elements of the people to be resettled. It seems, therefore, that the Bank has in the recent past been examining the impacts of the projects it financed prior to the current policy and that it has encouraged organisations owning such schemes to redress whatever problems have been associated with them before any requested funding can be provided. The $26 million Gwembe-Tonga Development Project[13] seems to have its origins in this change in World Bank social policy. The programme was officially launched on 19 December, 1998, and is rehabilitating a number of infrastructures in the Gwembe Valley and in parts of Chikanta Chiefdom of Kalomo among the people displaced by the Kariba Dam Project. Despite its promises, it is too early to assess the project's effectiveness.

According to Limbwambwa (1999) the reparation programme is at the early stages of implementation and is proceeding well. However, during the second stakeholder meeting for the Kariba case study in Siavonga, February 2000, some of the local chiefs expressed disappointment in the project, especially the long delay in actual benefits for the communities. According to one chief "all the money is being used on project personnel and vehicles and the money may be finished before anything is done for the

[13] Of the this budget, about 50% (12.3 millions USD) was secured in December 1999. Source: Limbwamba (1999)

Tonga. Some of the vehicles bought for the project have already been written off in road accidents before any projects have been implemented on the ground".

In Zimbabwe

Interviews with key informants in government departments, council and parastatal staff in Zimbabwe, show that these development agents do not view the above list of development issues as dam-induced social grievances. Instead, they pointed out that they are implementing development programmes in general as directed by government and District Council policies on rural development. It was indicated that their main concern is effective implementation of programmes based on the available resources in the district. The services that are being provided in Binga are similar to those being provided elsewhere in other rural districts in the country.

In fact, all Rural District Councils (RDCs) operate on the basis of the provisions laid down in the Rural District Councils Act (1988), and as revised (1996). The main development programmes in Binga and Nyaminyami are the Communal Areas Management Plan for Indigenous Resources (CAMPFIRE) Programme and the Poverty Alleviation Programme. These are aimed at improving the population's standard of living and employment generation, since poverty is the biggest social problem faced by these districts.

In Binga, agricultural annual reports indicate that most families can produce only enough food to last them for 6 months in a year, and the very poor can only feed themselves for a period of 3–4 months in a year.

Interviews with the Department of Water Development and the Zimbabwe Electricity Supply Authority (ZESA) staff in Binga revealed that there are no plans for providing piped water to the Tonga from the Lake because neither the council nor the people will be able to pay the cost.

It seems, therefore, that there are no efforts and not enough resources to address the dam-induced grievances per se on the part of either government or RDCs.

However, the Binga Rural District Council (BRDC) has had discussions with the ZRA, which had shown some interest in assisting the Tonga who were displaced by the dam. However, the BRDC expressed its disappointment when it was offered a couple of grinding mills. The council, instead, suggested that the authority assist the people of Binga by upgrading the roads, which are in a poor state. The council is hoping that the authority will assist in upgrading the main Binga–Karoi road, which is the main road out of Binga to Harare.

Besides the ZRA, no other organisation is known to be interested in addressing dam-induced grievances. However, it was pointed out that since independence many donors have come to Binga to offer relief assistance in the form of food handouts and this was thought to be creating dependence together with government's "permanent annual assistance through the grain loan scheme". The scheme is however a misnomer because "the people will never be able to pay back the grain loaned annually because of chronic poor harvests."

The transport system on and along the lake is mainly in the hands of private entrepreneurs. The people can no longer cross freely to the Zambian side as was the case when they lived in the valley. There are designated cross border points at Chirundu and Kariba. It was pointed out by the Ministry of Transport and Energy Officials at Binga that there are plans to open up a third entry point at Photo Corner in Mola Ward 4 in the Nyaminyami District to slightly ease the movement of people on and across the Lake. Currently, people have to travel long distances from Binga to Kariba on private transport and this costs Z$560 return (about $16–17 in 1998). As a result, very few can afford such costly trips.

It is only at designated fishing villages that people can freely travel on the lake since most of the coastline is either under the Department of National Parks or state forest under the Forestry Commission. Further, the long distances to the lake from the areas of resettlement on the escarpment discourage many from using water transport. In cases of emergency, however, the police at Binga issue permits not lasting for more than 14 days and applicants can use a police ferry on specified days. The ferry costs Z$200 for a return journey across the lake. This means that the resettled communities have limited access to, and communication with, relatives on the Zambian side.

In summary, the two reparation programmes underway (in Zambia by ZESCO and in both Zambia and Zimbabwe by ZRA) are in their early stages, and, therefore, it would not be opportune to look for their impacts as yet. What is important is that the conscience of those behind the Kariba Dam Project, including the World Bank itself, has been pricked.

3.4.8 Conclusions and Key Findings Regarding the Social Aspects

- It is clear from the evidence of group discussions and related literature that displaced people were not willing to move and had to be forced to abandon their riverine life.
- There were no consultations with the affected people and the decision to move was a *fait accompli* on the part of chiefs and their respective peoples.
- Adequate preparations were not made with respect to removal and settlement in new areas. People were removed hastily and the resettlement areas were not prepared to accept the relocated people; eg, no temporary accommodation and basic services were provided.
- The removal itself was traumatic and led to losses of property and livestock on transit; eg, livestock carried on lorries such as goats and sheep were traumatised and this lead to losses. Some of those transported on hoof (cattle) were lost through tsetse infestation.
- Plans for resettlement were inadequate; eg, the actual numbers of people to be resettled kept changing over the resettlement period.
- Compensation in general was not provided (Zimbabwe) or was grossly inadequate (Zambia): £59 average per capita was supposed to cover all losses incurred by settlers.
- Resettlement as such had a very low priority in the project. There was no discussion of the issue in the project documents except as a sub-item of resettlement administrative expenditure.
- The settlers were not considered as potential beneficiaries of the scheme and did not feature in the project design.
- Those displaced thought that they were treated more or less like animals (group interviews, Binga).
- The whole resettlement exercise created conditions of seemingly endless food insecurity and poverty.
- Both host and resettled communities, despite the mitigation measures undertaken, have generally been negatively affected by the project. They have been disadvantaged mainly with respect to land and this has reduced agricultural productivity through either farming less productive land (settlers) or restricted access to more land on the part of the host communities.
- Generally, the losses experienced by displaced communities were all encompassing – economic (land), political (autonomy), social and psychological (the social fabric was torn apart and people were separated from relatives on the Zambian side) and cultural (loss of shrines or cultural property in general). The benefits (schools, clinics, infrastructure, etc) were by far outweighed by the losses indicated above. This was not a surprise, since the relocated communities were not meant to benefit from the project.

- The two reparation programmes currently being carried out by ZRA and ZESCO, though coming late (40 years after displacement), are important in the sense that they represent an acknowledgement of the fact that a degree of social injustice exists by the manner in which the Gwembe Tonga were displaced and resettled.
- Although it is too early to assess the effectiveness of the current reparation programmes, they represent promising initiatives, not only for the people displaced by Kariba, but also for other communities displaced by dams worldwide with no or inadequate compensation.

In summary, the Kariba Dam Project was designed for regional economic growth and development. The displaced communities where excluded from these macro-level goals. Therefore, the needs and benefits of the displaced were not on the agenda. In the absence of any guidelines on resettlement by the World Bank, the needs of the displaced communities could not be guaranteed. The most important lesson to be learnt is that any major project involving the displacement of people requires guidelines directed at achieving sustainable livelihoods for displaced communities. In the absence of such guidelines, as we have seen, the social consequences and impacts tend to become permanent, cumulative and difficult to reverse. The further lesson is that if the displaced communities are not allowed to have a say or to participate in the project, their interests cannot be guaranteed.

3.5 Agriculture and Irrigation

In this section, the impacts of Kariba Dam on agriculture and irrigation with respect to the resettled people in Zimbabwe and Zambia over the past 40 years will be described and analysed. The scoping document for the Kariba case study identified a number of issues relating to the impact of Kariba Dam on agriculture and irrigation and specifically listed the following for detailed examination in Phase 2:

- assess the land classification, land tenure and land use before and after resettlement in relation to food security;
- assess the area under irrigation and establish who owned it prior to the establishment of the
- irrigation schemes in Zimbabwe;
- determine who the beneficiaries of current schemes in Zimbabwe are;
- estimate the contribution of current irrigation activities on local and national economies in Zimbabwe;
- assess the irrigation potential around the lake in Zimbabwe; and
- evaluate the degree of impact on the lake if all the irrigation potential were to be exploited.

The six issues listed above were considered in relation to and in conjunction with the six basic questions that have been formulated for the WCD process.

In considering the six issues raised by the scoping document with regard to agriculture, and the six core questions that guide the WCD case study process, it emerges that the main question that needed to be answered by the current agriculture studies is:

> To what extent did Kariba Dam affect agriculture in the Zambezi basin, in the areas of settlement of displaced people and in the country as a whole? Where were gains and losses made? Was anybody prejudiced by the dam with respect to agriculture?

3.5.1 Agricultural and Irrigation Planning in Relation to the Kariba Project

The Kariba project document (Federal Hydroelectric Board, 1955) and the World Bank project appraisal report (World Bank 1956) make no mention of any agriculture or irrigation as parts of the Kariba Dam project.

Most large dam developments worldwide are either primarily for irrigation or, if the main use for the water is hydropower, then the water released from the power stations is used downstream for irrigation. Irrigation is therefore a very common benefit of these large dams, and, as a benefit, irrigation is usually included in the viability analysis of the dam project.

The Kariba Dam is an exception to this general trend. Irrigation development was never given prominence in the planning for Kariba Dam. All the feasibility study documents for Kariba are silent with respect to the benefits that can be derived from irrigation development at Kariba.

In their report on the Kariba gorge and Kafue River hydroelectric projects, the Inter-Territorial Hydroelectric Power Commission (1951) discussed the two projects in detail and concentrated on the hydropower issues. Only one paragraph on page 5 discussed the possibility of using Kariba water for irrigation where it is pointed out that the opportunities for using Kariba water would be investigated in future.

The French Mission (1954), which was commissioned to examine the Kariba Dam project on behalf of the government of Rhodesia and Nyasaland carried out a detailed analysis of the project and produced an equally detailed report. Nowhere in that report was the possibility of the Kariba water being used for irrigation discussed or used to justify the project. The analysis was confined to hydropower and civil engineering issues.

Similarly, in his justification of the Kariba project over the Kafue project, André Coyne (1954) did not use any potential benefits from irrigation to justify or compare the projects. He relied entirely on hydropower and civil engineering considerations for his analysis and his subsequent conclusion that Kariba should be constructed before Kafue.

It is however ironic that although irrigation was not considered in all the feasibility and design studies for Kariba Dam, the early work on river flow measurements was carried out by the Irrigation Department of Southern Rhodesia. Officers of the Irrigation Department carried out reconnaissance visits to the Kariba Gorge dam site beginning in 1924. They collected river flow data for a period of 30 years hence (Federal Hydroelectric Board, 1955).

3.5.2 Agriculture and Farming Systems in Kariba Dam Basin Prior to the Dam

Scudder (1960) in his book on the ecology of the Gwembe Valley Tonga presents a detailed account of the agricultural practices of the Tonga before Kariba Dam was built. In this book, the author shows the deep understanding that the Tonga had developed with respect to the hydrology of the Zambezi river and how much their crop production systems had been developed to take full advantage of the flood regimes of the river.

In the existing literature on the agriculture of the Zambezi Valley Tonga by Scudder and others after him, the discussion is confined to the high level of sophistication of the crop production system along the river valley. There was no attempt to determine how much land existed along the river for agriculture and how much of it had been opened up for agriculture before Kariba. It would have been interesting to know how much river valley land remained available for future use in agriculture or crop production. Answers to the above questions would have allowed an analysis of how sustainable this agricultural system was over time and, as the population of the Tonga increased.

In an effort to answer these questions, this study examined aerial photographs of all the areas that were submerged by Lake Kariba. An aerial photograph interpretation was carried out to delineate the following land use zones in the submerged areas: areas that were under active cultivation; areas that were, from a topographical standpoint, suitable for arable agriculture but which had not yet been opened up for agriculture, (these were referred to as potentially arable lands); and, upland areas away from the river valley that were very sparsely populated and generally of rugged topography. From a crop production or arable agriculture standpoint, most of these areas are unsuitable for agriculture. There was practically no human settlement in these areas.

Table 3.12 presents the extents of the three land use types in the areas that were submerged by the Kariba Dam.

Table 3.12: xtent of land use areas that were submerged by Kariba Dam

Land use	Area (Hectares)	% of total area
Cultivated	45 500.00	8.2
Potentially cultivated	5 609.84	1.0
Zambezi river	11 868.31	2.1
Rugged upland areas	492 201.85	88.0
TOTAL	555 000.00	100

The data in Table 3.12 shows that the extent of arable lands along the Zambezi River that was submerged by Kariba Dam amounted to 9.2% of the total area submerged. Most of the submerged areas, over 88%, comprised practically unsettled upland areas that are generally of rugged topography.

Figure 3.3 is a map showing the land use areas whose extents are presented in Table 3.13. From the map, it can be seen that the Tongas were all settled along the Zambezi River and its tributaries and that there was practically no settlement in the rugged areas above the river. A possible reason why there was little human settlement outside the river valley is the shortage of portable water in these areas. Boreholes (which did not exist in the Zambezi valley at the time) would have been needed to provide water to any community settled in these areas – hence the high density of settlement in the vicinity of the Zambezi River and its tributaries.

3.5.2.1 Crop Production

The pre-Kariba farming systems of the Zambezi River valley are described in detail in Scudder (1960). Most of the crops were produced on the alluvial soils on the banks of the Zambezi where, in addition to rainfall, the soils derived their moisture from the floods of the Zambezi River. Because of the large catchment of the Zambezi above Kariba Dam, wide variations in river level were experienced during the year with peak flows in the March–May period. As the river level dropped after May of every year the Tonga planted crops in the alluvial soils behind the receding flood level. It is thus reported that the Tonga grew crops throughout the year in some of their lands along the river. Their crops included local varieties of maize, different types of vegetables, pumpkins, other cucurbits, local varieties of sorghum and tobacco.

These crops were grown for subsistence and there are no reports of a crop trading system. In times of famine or food shortage some barter trade or exchange of food for other commodities such as livestock is likely to have occurred.

Existing reports on pre-Kariba agriculture do not present any yields for the crops that were grown. It is therefore difficult to discuss the productivity of this pre-Kariba crop production system. If the yields achieved in this farming system were known, and using the extent of arable land given in Table 3.13, it would have been possible to determine how much food was produced in the areas submerged by the dam. The analysis could also have extended to determining the carrying capacity of this land and hence, how much longer after Kariba that the system would have sustained the Tonga.

3.5.2.2 Livestock

According to Scudder (1960) the Zambezi River Valley Tonga kept some livestock, mainly goats. Cattle only existed in some of the areas that were not infested with tsetse fly.

3.5.3 Existing Irrigation Development Prior to Kariba Dam

There is no record of any irrigation scheme that was established in the areas that were submerged by the lake. Therefore, Lake Kariba did not submerge any irrigation scheme.

It is, however, instructive to report hereon the development of the Chirundu irrigation scheme along the Zambezi River, 65km downstream of Kariba gorge. This estate was established by the Chirundu Sugar Estates Ltd, a company that was incorporated in December 1953. A sugar cane estate and sugar mill were established and raw sugar was first produced in the late 1950s with the first significant quantity of 10 000 tons being produced in 1960 (Willsher, J.P. 1965). The company acquired about 2300ha of land on the south bank of the Zambezi river.

Reading through Chirundu Sugar Estates management reports, it is difficult to establish whether the development of this estate was in any way related to the establishment of Kariba Dam. Although its date of establishment is coincident with the times when Kariba was being designed, existing reports do not show any relationship between the two projects. Scudder (personal communication) however reports that the Chirundu sugar estate was first established on the Zambian bank of the Zambezi River, in the present day Lusitu area, but was moved to its present location in Zimbabwe when the sugar company failed to secure long-term access to the irrigation land in Zambia. Scudder (personal communication), however reports that Chirundu Sugar Estate was initially established on the Zambian bank of the river but was moved to its present location in Zimbabwe when the sugar company failed to secure long-term access to land from the chiefs in Zambia.

Figure 3.3: Land Use Areas of Basin Flooded by the Lake

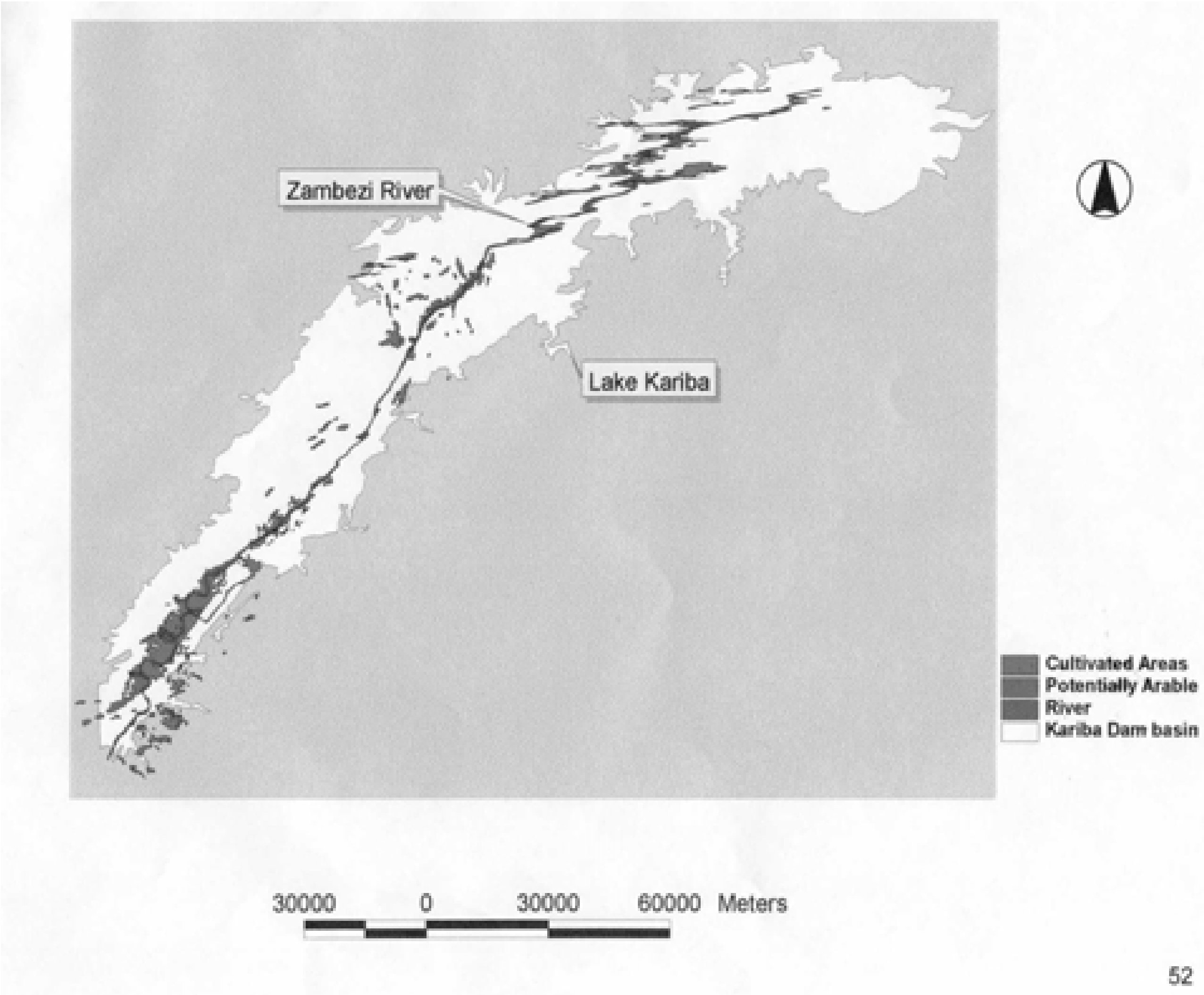


Figure 4 Landuse Areas of Basin Flooded by Lake Kariba

3.5.4 The Kariba Resettlement Programme in Relation to Agriculture

3.5.4.1 Selection of Settlement Areas in Zimbabwe

The Southern Rhodesian Government officers responsible for resettlement visited all the chiefs whose areas would be inundated by Lake Kariba to inform them of the dam project and to advise them that they would have to move. The chiefs were then advised or instructed to select areas where they would prefer to be resettled. Existing reports do not indicate how the chiefs chose their new settlement areas.

16 chiefs in all were affected by the dam and had to move. These are the following: Chief Saba; Chief Siachilaba; Chief Siansali; Chief Binga; Chief Sigalenke; Chief Sinakona; Chief Sinamagonde; Chief Sinasengwe; Chief Sinamupande; Chief Simuchembu; Chief Sinamwenda; Chief Siamupa; Chief Sinamasanga; Chief Sinagatenke; Chief Mola and Chief Msampakaruma.

These chiefs were displaced to varying distances from their original location in the dam basin. Figure 5 shows the original areas of settlement for each of these chiefs in the dam basin and their new area of settlement. Thus, for example, while chiefs Siachilaba, Saba and Sigalenke were displaced short distances, chiefs Simuchembu and Sinamagonde were moved over distances in excess of 120km from their original homes.

There is no evidence of the provision of agricultural support services to assist the new settlers in developing their agriculture in the new areas. For example, there is no evidence for the provision of extension support to assist the settlers in crop and animal husbandry in the new areas, since these areas were ecologically different from the original areas of settlement along the river.

The Southern Rhodesian territorial government which was responsible for resettlement in the south bank of the lake made a decision to designate the whole southern lake shore a protected national and recreational park. A zone, up to 5km wide and demarcated by the 490m contour, was designated as recreational land along the entire southern shoreline of the lake. This designation effectively meant that none of the tribes were allowed to settle within about 5km of the lake, thereby denying any of the displaced people access to the waters of Lake Kariba. Thus, the tribesmen would need permits to exploit the fishing resources of Lake Kariba. This is one area where the resettlement programmes in Zimbabwe and Zambia were significantly different because the Northern Rhodesian territorial government did not restrict the relocated people access to the lakeshore and the opportunity to exploit the water and fish resources of the lake.

In addition to the buffer zone along the lake which was designated as a recreational park, the Southern Rhodesian territorial government also demarcated a number of inland national parks and safari hunting areas. One problem associated with this proximity to wildlife areas is the threat to the crop production efforts of the farmers by the wildlife from these parks. This issue is discussed further in the wildlife and the sociology sections of this report.

Figure 3.4: Map Showing Areas of Settlement by Tonga Chiefs

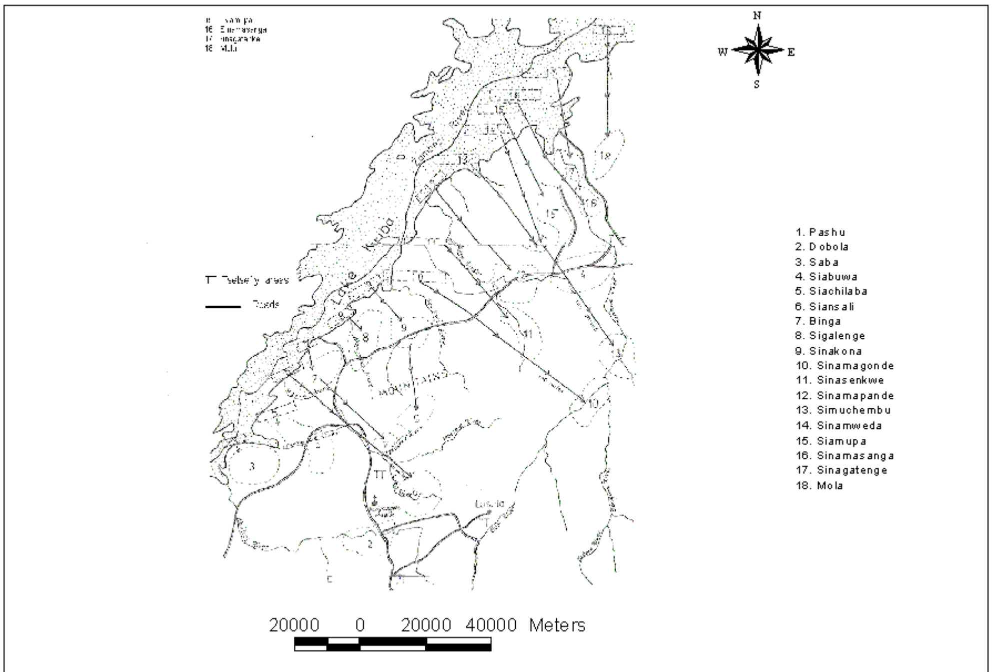


Figure 3.5.2 . Areas of Settlement by Tonga Chiefs

3.5.4.2 Selection of Settlement Areas in Zambia

Available literature with regard to agriculture and Kariba resettlement in Zambia shows that the consultative processes relating to agricultural livelihoods for people displaced by the Kariba Dam were at best inadequate. Where they existed, they tended to be largely confined to the federal and national levels. The lower level stakeholders were almost completely left out of the decision-making and other processes that led to the agricultural programmes and initiatives, which were implemented after the construction of the dam. The Federal government of Rhodesia and Nyasaland was essentially in the driver's seat.

The consultation made between the Northern Rhodesian government (NRG) and the Federal government (FG) on the agricultural livelihoods of the displaced people, was largely characterised by "take it or leave it" attitude and consequently made consensus difficult. Five levels of consultation relating to agricultural livelihoods of the Valley Tonga in Zambia with regard to the construction of Kariba Dam, have been identified, starting from intergovernmental level downwards, as: (i) intergovernmental level consultative process; (ii) national level consultative process; (iii) provincial level consultative process; (iv) district level consultative process; and (v) community level consultative process. These are briefly discussed below.

With regard to the agricultural livelihoods of the displaced people, the Federal government took the position that the underlying principle of the resettlement plan was a "no better no worse" situation, whereby the Valley Tonga would be expected to enjoy a standard of living that was on par with their pre-dam situation. The Northern Rhodesian government objected to this proposition, claiming that it represented an abrogation of responsibility by the Federal government. NRG felt that FG was being unfair and that it was dragging its feet to "remedy the disastrous situation inherited from resettlement at substantial cost to its own finances".[14] NRG strongly felt that FG and the Federal Power Board's initiated programme of resettlement had lamentably failed because it had made Valley Tonga worse off. NRG believed the situation could be corrected by urgently implementing an agricultural development programme.

Consequently NRG came up with an Agricultural Development Plan with respect to the resettlement of the displaced Valley Tonga contained in a letter it written to the FG. [15] The key elements of the proposed Agricultural Development Plan for the displaced Valley Tonga were: (i) agricultural methods of the displaced population would have to improve because the poor soils of the areas to which the Valley Tonga had been relocated would not sustain the population growth within a short time; (ii) related to the one above, the agricultural methods were to have fundamental changes effected on them in order to make more economical use of the soil and provide for cash crops in varying degrees; thus a deliberate emphasis on a local cash economy was to be pursued; (iii) peasant[16] and irrigated agriculture were to be introduced, involving the establishment of 1250 peasant farms feeding approximately 6000 inhabitants; 200 farm families (about 1000 people) were to be settled on irrigated agriculture; and (iv) for the remaining inhabitants, conservation farming measures were to be insisted on to ensure the subsistence methods of agriculture did not ruin the soil.

The above Agricultural Development Plan would entail a considerable increase in cattle population without which the agricultural improvement could not be effected. It was estimated that 8 000 head of cattle existed then. This was to be increased to 20 000 head of cattle for the peasant farms and a

[14] *Claim on the Federal Power Board for the Arbitrator*, 1956, Northern Rhodesian government.
[15] The letter was referenced *E.6130/3*, dated 22nd November, 1958 addressed to "The Secretary, Office of the Prime Minister and External Affairs", Box 1403, Salisbury. It was signed by H.L. Jones, Administrative Secretary to the government of Northern Rhodesia.
[16] Peasant agriculture was perceived to be more advanced compared to the "primitive subsistence farming" which had obtained before dam construction.

further 20 000 for the other displaced Valley Tonga farmers. This would involve an increase of 32000 head over a 20-year period, with an average of 1600 head per year.[17]

The Agricultural Development Plan targeted at the displaced Valley Tonga, and the costs of actual resettlement as well as individual compensation would cost a total of £3 889 728. This budget (made in 1958) exceeded by 56% the provisional estimate of £2.5 million made by NRG in 1955.

NRG hoped that the above Agricultural Development Plan would, in the long run, bring about sufficient progress towards achieving a viable economy for an expanding population, despite the inadequacy of the cultivatable land available at the time. The above was considered the minimum programme that would achieve the desired objective.

However, the Federal government was totally against the proposed Agricultural Development Plan by NRG. They were against a long-term development plan because of the "no better, no worse" policy. They felt that the above proposal was a responsibility that extended beyond the resettlement and hence they were unwilling to accept it.

3.5.4.3 Current Agriculture and Farming Systems in the Settlement Areas for Displaced Peoples

In this sub-section, the agricultural activities of the Tonga in their new settlement areas are described, in addition to a discussion of the agricultural potential of these areas. The objective of this discussion is to carry out a comparison of the old and new areas of settlement and to determine if the displaced people gained or lost (with respect to agriculture) when they were moved.

a. Agricultural Potential of the new settlement areas in Zimbabwe

- **Soils**

The soils of the districts of Binga, Kariba and Gokwe North are all derived from sedimentary Karoo deposits. Most of these are sandstone, with some areas being under shale and mudstone. A detailed description of these soils can be found in Thompson & Purves (1981). These soils in the Tonga settlement areas are generally sandy, infertile, shallow and have low water holding capacity. Where the soils have reasonable fertility and texture, crop production is hampered by the low rainfall regime of the Zambezi valley.

- **Rainfall and Natural Regions**

The Zambezi valley, including the areas on which the Tongas were settled is an area of low and unreliable rainfall.

Figure 3.5 is a map of the study area where natural regions are defined according to the amount of rainfall and reliability of the rainfall (Department of Conservation and Extension, 1983). Five natural regions have been defined as I - V where I denotes areas of high reliable rainfall and V represents areas of low and unreliable rainfall. Rainfall amount and reliability decrease from natural region I to V. Figure 3.5 shows that the Tonga chiefs were settled in areas that fall into natural region IV and V, with most of them in V.

The three natural regions III, IV and V, which occur in the study area, are defined as:

[17] The cattle would have to be protected from tsetse flies, wild animals, ignorance of their owners and disease. They would need to be supplied with adequate water points where natural ones - including Kariba Lake, were not available.

Natural Region III: Semi Intensive Farming Region: rainfall in this region is moderate in total amount (650–800mm), but because much of it is accounted for by infrequent heavy falls and temperatures are generally high, its effectiveness is reduced. This region will receive an average of 14–16 rainy pentads[18] per season. The region is also subject to fairly severe mid-season dry spells and therefore is marginal for maize, tobacco and cotton production, or for enterprises based on crop production alone.

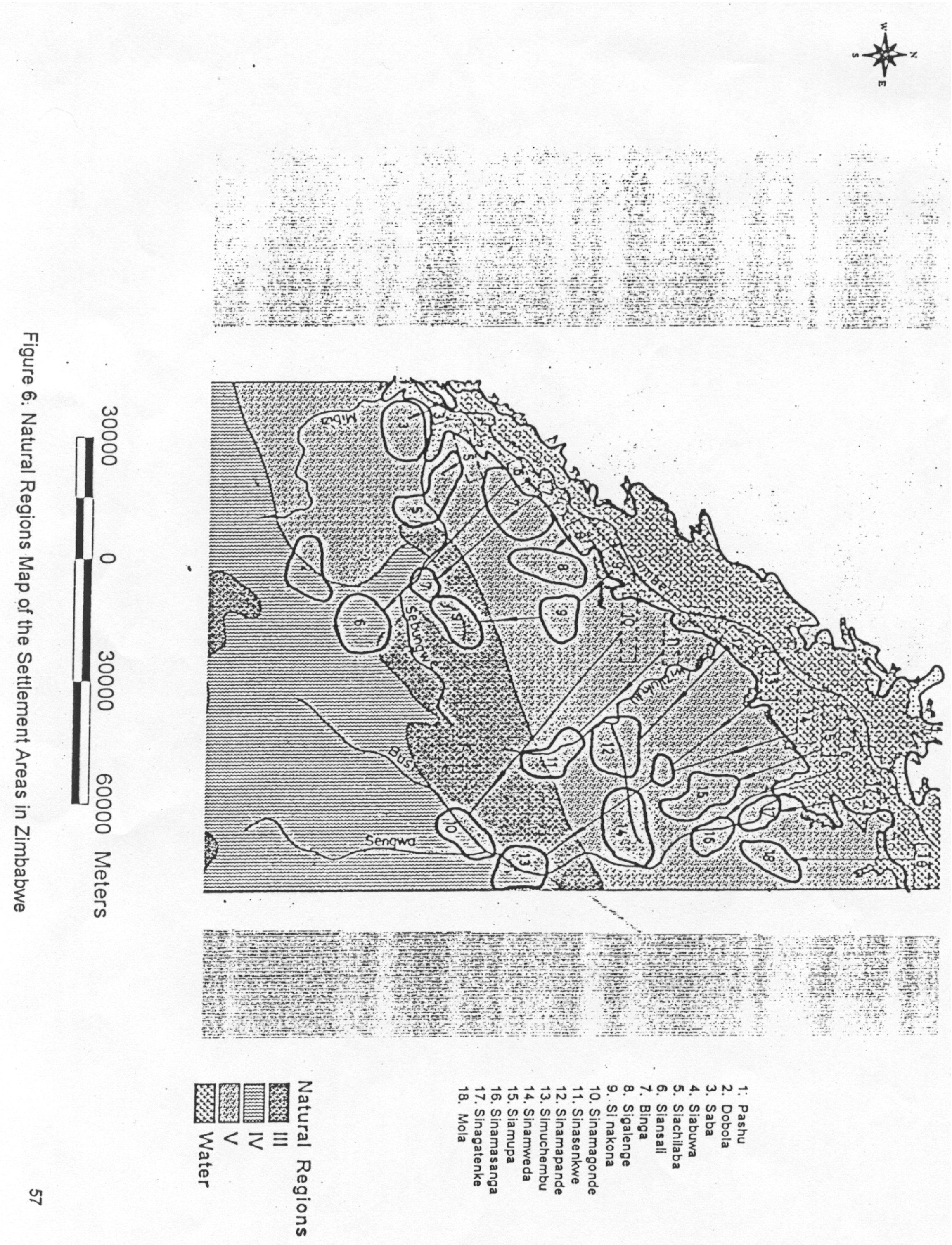
The farming systems, in conformity with the natural conditioning factors, should therefore be based on both livestock production (assisted by the production of fodder crops) and cash crops under good management on soils of high available moisture potential.

Natural Region IV: Semi Extensive Farming Region: this region experiences fairly low total rainfall (450–650mm) and is subject to periodic seasonal droughts and severe dry spells during the rainy season. The rainfall is too low and uncertain for cash cropping except in certain very favourable localities, where limited drought-resistant crops can afford a sideline. The farming system, in accord with natural factors, should be based on livestock production, but it can be intensified to some extent by the growing of drought-resistant fodder crops.

Natural Region V: the rainfall in this region is too low and erratic for the reliable production of even drought-resistant fodder and grain crops, and farming has to be based on the use of the veld alone. The extensive form of cattle ranching or game ranching is the only sound farming system for this region. Included in this region are areas of below 900m altitude, where the mean rainfall is below 650mm in the Zambezi Valley and below 600mm in the Sabi-Limpopo valleys.

[18] A rainy pented is defined as the centre one of three five-day periods (pentads) which together receive more than 40mm rainfall and two of which receive at least 8 mm of rainfall.

Figure 3.5: **Natural Regions Map of the Settlement Areas in Zimbabwe**



The foregoing definition of the natural regions and Figure 3.5 show that most of the Tonga people were settled in natural region V, an area of low and unreliable rainfall where crop production is a risk, even for drought resistant crops.

Similar analysis with respect to mean annual rainfall shows that most of the displaced people were settled in areas of low rainfall, less than 600mm per year. The foregoing discussion shows that the settlement areas for Kariba relocated people in Zimbabwe do not only receive low mean annual rainfall but that the rainfall is also unreliable. It therefore follows that the Tonga people who were moved to make way for Lake Kariba were settled in areas of low agricultural potential, where they were unlikely to ever be self-sufficient in food

- **Crop Production**

The information Sheet No 18 of 1955 (NAZ, NAT 36), which was prepared by the Native Affairs Department of Southern Rhodesia listed all the facilities and services that would be provided to settlers in their new homes. The list comprised 11 items, which included among others: the provision of health care services; the construction of 962 miles of access roads; the sinking of boreholes; the construction of earth dams and weirs; and, the transportation and storage of grain to supplement food supplies of resettlement people.

Conspicuously absent from this list is the provision of any services that would assist the settlers in growing their own food. It would have been expected that the settlers would be provided with improved seed that is suited to their new environment, extension services to improve crop husbandry and irrigation schemes where possible.

It is therefore not surprising that between 1958, when they were settled, and the early 1980s when the new independent Zimbabwe government promoted development activities in these remote areas, the Tonga were the most primitive and underdeveloped people of Zimbabwe. They were isolated from the rest of the country because of poor or non-existent road access to their areas and the limited provision of all social services.

With no government or other assistance to improve their agriculture, the Tonga continued to practise the crop husbandry that they could adapt from their experience along the Zambezi River. However, the agro-ecology of the river valley was significantly different from that of the new settlement areas. Not only were the soils different and less fertile in the new areas, but also the new areas were drier and did not have the benefit of river floods.

Chiduza (1989) studied the sorghum varieties that were being grown by Tonga farmers in the Sinampande and Siabuwa areas and found that these were traditional Tonga long-season varieties that required at least 5 months to mature. In an area of unreliable rainfall such as the study area, these varieties were not reaching maturity in most years. These long-season varieties had been brought by the Tongas from the Zambezi River 30 years earlier.

Since the early 1980s and through the provision of extension services by the government of Zimbabwe, the Tonga settlement areas have enjoyed some improvement in their agriculture. Short-season sorghum and maize varieties have been introduced into these low rainfall areas.

- **Livestock**

At the time of resettlement from the Zambezi River in 1957/58, all the new Tonga settlement areas were infested with the tsetse fly. Consequently, these areas could not support cattle and other sensitive livestock. In that time, goats and chickens were the only forms of livestock in the Tonga areas.

In the absence of cattle, all the Tonga farmers tilled the land by hand, a condition that was not only difficult for the farmers but which also limited the amount of land that a family would cultivate.

The fly was cleared from the Tonga Settlement areas in mid 1980s. This coincided with the establishment of cotton as a cash crop and the inflow of “cotton dollars”. As a result, some of the cotton earnings were used to obtain cattle, which were then used for drought power.

b. Agriculture in the new settlement areas in Zambia

After the construction of the dam the people who were resettled, as well as those in their original villages continued practising subsistence farming, but with some changes arising largely from improved communication. Consequently, agriculture after dam construction was characterised by cash crops and dry season cultivation.

- **Cash Crops**

Three important cash crops have been introduced in the farming system of the lakeshore districts. These are; cotton, sunflower and soybeans (in order of importance). The production of the cash crops has been necessitated because of the unreliability of maize, due to the inadequate rain and the recurrent droughts. Consequently, food shortages have been a common feature due to constant maize crop failure. Cotton, sunflower and soybeans are more drought-tolerant. The production of these crops has enabled farmers to raise cash to purchase food (maize or maize meal) from other districts.

- **Dry Season Cultivation**

This is being practised along the lake's drawdown areas. Some farmers who had no access to land along the riverbeds for dry season cultivation now have new areas along the lakeshore to cultivate.

Dry season gardens are a common feature along the lakeshore and the riverbanks. In Valley Tonga language, they are called "*zilili*" and are of two types; one type uses residual moisture for the entire growing period while in the case of the other type, the moisture is inadequate and has to be supplemented by irrigation. Traditionally, the first type is called "muliide" or "sikaliide", which literally means self-supporting. The dry season gardens, which depend entirely on irrigation to support crop production, are not classified under *zilili*.

Annual hectarage under *zilili* cultivation depends on three factors. Firstly, the extent of lake water recession has direct impact on the width of the drawdown areas; the higher the water level, the less the areas available for *zilili*. Secondly, the greater the cattle population, the less land is available for *zilili* and vice-versa. Thirdly, when the harvest is good, there is less need and demand for *zilili*, as farmers would have enough food to last them for almost the whole year. However, in areas with good markets, farmers still cultivate the dry season gardens on which they grow horticultural crops and green maize for cash.

The sizes of *zilili* gardens vary from area to area. However, they are in the range of 0.2–1.0ha per farm family. Although *zilili* gardens are generally small, they play a critical role in the agricultural system of the small-scale farmers of the lakeshore districts (Siavonga, Munyumbwe and Sinazongwe) as a source of food when food from rain fed agriculture is scarce. Furthermore, *zilili* gardens are an important source of cash for many households. Table 3.13 gives estimated hectarage for dry season gardens by lakeshore district.

Table 3.13 Available Area for *zilili* (Dry Season) Gardens by Lakeshore District

District	Total Arable Land (ha)	Total Land for *Zilili* (ha)	Land for *Zilili* as a % of Total Arable Land	Potential Areas for *Zilili*
Siavonga	28 000	800	2.9	Matinangala; Munduludulu; Manchavma; Munyama; Lufuwa; Gwena; Dambwe
Munyumbwe	19 400	350	1.8	Kayuni; Sinafala; Kota-Kota; Chiyabi; Kole; Chisanga

Sinazongwe	34 300	1300	3.8	Chiyabi to beyond Siatwinda; & along the following rivers: Maze, Zongwe, Sikalamba & Nang'ombe
Total	81 700	2450	3.0	

(Source: Derived from Lakeshore Development Planning, 1993.)

The number of households participating in dry season *zilili* gardening cultivation varies considerably from year to year. This depends on rainfall patterns. In drought years, household food insecurity becomes serious, causing more households to participate in *zilili*. The opposite is true in good rainy seasons. Villages along the lakeshore and along the rivers have more households participating in *zilili*.

3.5.5 Irrigation Development in Relation to the Kariba Project

3.5.5.1 Zimbabwe

Considering that irrigation was not given prominence in the feasibility and design studies for Kariba Dam, it is not surprising that little irrigation development has occurred in Zimbabwe using Kariba Dam water. To date, only two irrigation schemes have been established on Kariba Dam in Zimbabwe as:

- Charara Estates, a privately owned commercial irrigation scheme, with 50ha of irrigation for the production of bananas and horticultural crops;
- Gatshe-Gatshe community smallholder irrigation scheme, with an irrigated area of 18ha which is being managed by 39 smallholder farmers. Main crops being grown are maize and vegetables.

There are a number of reasons why there has been limited irrigation on the Zimbabwean shores of Lake Kariba. Firstly, the designation of the 5km buffer zone of recreational land along the whole shore restricts the use of the shoreline for agriculture and irrigation. The re-designation of recreational land into agricultural land requires special sanction, which can only be obtained through a long bureaucratic process. The second reason, which probably is more responsible for the limited irrigation development, is the topography of the land along the shoreline. The country along the shoreline in Zimbabwe is generally of rugged topography, which does not lend itself easily to arable agriculture. In most places, in fact, the land is unsuitable for arable farming.

3.5.5.2 Zambia

Irrigated agriculture in the lakeshore districts of Siavonga, Munyumbwe and Sinazongwe is undertaken at two levels: (i) large-scale schemes and, (ii) as organised small-scale schemes.

a) Large Scale Irrigation Schemes

One large commercial irrigation scheme was established at Sinazongwe in 1986. The scheme commonly referred to as the Buchi irrigation scheme was established mainly to compensate the Valley Tongas who had been resettled in this area from the Zambezi River basin. This was to be done through an outgrower scheme arrangement whereby the scheme consisted of a core commercial estate, and an outgrower scheme in which local people would participate. The irrigation scheme, 2500ha of irrigation land in size, was established in 1986, and initially operated successfully, based on cotton as the main crop. In the early 1990s, the scheme began to have serious performance problems mainly as a result of the poor macro-economic conditions in Zambia. At present, the scheme is almost moribund.

Employment creation and income distribution were the main benefits from the establishment of the large-scale irrigation scheme to the local people who had been resettled in this area following the construction of Kariba Dam. The scheme had 450 permanent employees, and up to 3 000 casual workers mainly during the cotton picking season.

However, these benefits were not without adverse social consequences. About 2 000 settlers lost their fields and houses in order to make way for the establishment of the farm. Compensation given to the displaced villagers by the Gwembe Valley Development Company (GVDC) included: (i) a daily bus service to Choma (formerly a provincial capital, about 100km from the irrigation scheme); (ii) participation in an outgrower scheme whereby local villagers were allocated small irrigation plots adjacent to the large estate and on which they grew crops similar to those grown on the large estate. In this situation, the outgrowers could source inputs through the GVDC and also market their crops through the large estate; and (iii) the construction of a health facility (clinic). It is a moot point whether this compensation can be viewed as having been adequate.

b) Organised Small-scale Irrigation Schemes

Only two of the lakeshore districts (Siavonga and Sinazongwe) have organised small-scale irrigation, with a total of 8 schemes. The schemes were chiefly set up to take advantage of the water of Lake Kariba for irrigation. Improvement of the livelihood of the displaced Valley Tonga due to the construction of the dam was another important factor behind the establishment of the irrigation schemes.

Table 3.14 presents data on the 8 small-scale irrigation schemes established along the Kariba lakeshore and which draw water from the lake.

Table 3.14 Small-scale Irrigation Schemes in Zambia

Name of Scheme	District	Year established	Area Irrigated	No. of Farmers	Annual H_20 Consumption (mm)	Annual Water Consumption x 10^3 m^3(megalitres)
Nkandabbwe	S/zongwe	1958	10	88	2000	200
Buleya Malima	S/zongwe	1970	24	98	2000	540
ZTF cooperative	Siavonga	1970	40	40	2000	800
Zambezi Training farm	Siavonga	1970	23	-	2000	460
Siatwinda	S/zongwe	1971	12	17	2000	640
Lusitu IS2	Siavonga	1971	14	11	2000	280
Gwena Training	Siavonga	1982	2	13	2000	40
Lusitu IS1	Siavonga	1983	13	20	2000	260
Total			**138**	**287**		**2760**

The performance of these schemes varies from very poor to good. In general, the performance of most of them has been unsatisfactory.

c) Water Consumption by existing Irrigation Schemes

The terms of reference for this study specifically requested an analysis of the impact of existing irrigation schemes on water availability for power generation. Table 3.15 presents these quantities.

Table 3.15 Water Consumption by Irrigation Schemes on Lake Kariba

Irrigation scheme	Charara	Gatshe-Gatshe	Zambia Large-scale	Zambia Small-scale	TOTAL
Irrigation area (ha)	50	18	2500	138	2706
Crops	Bananas & Horticultural users	Maize & Vegetables	Wheat & Cotton	Various	Various
Annual Water Consumption (mm)	2000	1500	1500	2000	7000
Volume of Water Consumed per year ($x10^3$ m^3)	1000	270	37500	2760	41530

The data presented in Table 3.15 shows that all the irrigation schemes that draw water from Lake Kariba consume a combined total of 41 530 megalitres.

Considering that the storage capacity of the lake Kariba is 180km^3 and that 64.5km^3 of this represents live storage, the amount of water that is consumed by Charara and Gatshe Gatshe irrigation schemes amounts to 2.3 x 10^{-3}% of the storage capacity and 6.4 x 10^{-3} % of the live storage, a very insignificant amount indeed. It can therefore be concluded that the existing irrigation schemes on Lake Kariba in Zimbabwe are of no consequence to the availability of water for electricity generation.

d) Potential Future Irrigation Development

It was pointed out earlier that the rugged terrain limits the potential for irrigation development on the southern shores of Lake Kariba. In addition, the sandy nature of the soils in north-western Zimbabwe reduces the potential for finding irrigable soils.

An area that is suitable for irrigation development was located in the upper reaches of Lake Kariba, in Chief Siachilaba's area, by a large Zimbabwean agribusiness conglomerate in 1990. An area of some 1500ha of irrigable soils was found and it was planned to plant cotton. In the course of the present study efforts were made to obtain the feasibility study reports from the private company, without success.

The soil maps of the study area were examined to determine if any other areas of irrigable soils existed. It was established that there is little scope for finding extensive areas of irrigable soils that can be irrigated with Kariba water. It would be safe to state that the maximum potential for developing irrigation in Zimbabwe using Kariba water is about 5000ha.

From past studies and aerial photographs, sites have been identified which have potential for irrigation schemes in Zambia. These are presented in Table 3.16 according to lakeshore district .

Table 3.16: Potential Irrigable Land by Lakeshore District

Lakeshore District	Potential Irrigable Area (ha)	Potential Irrigable Area as % of Total Area
Siavonga	285	3.1
Munyumbwe	305	3.3
Sinazongwe	8646	93.6
Total	**9236**	**100.0**

Taking into account the existing 68ha of irrigation in Zimbabwe, the existing 2700ha of irrigation in Zambia, and the potential irrigable areas of 5000 and 9300 ha in Zimbabwe and Zambia respectively, the total area that would be irrigated from Kariba Dam would be about 17 000ha. Assuming an annual average water consumption of 1750mm, this area of irrigation would consume about 300000megalitres of water per year, which represents 0.17 % and 0.47% of the total and live storage of Lake Kariba respectively – still an insignificant amount that is unlikely to affect power generation.

3.5.6 Conclusions

In this section, the impacts of Kariba Dam on agriculture and resettlement were discussed. From the foregoing discussion, a number of observations and conclusions can be made with regard to agriculture and resettlement as follows:

- the resettled people were peasants who were practising subsistence agriculture in isolation along the Zambezi river;
- the areas to which the displaced people were settled were of poor agricultural potential. The soils on the new settlement areas were of poor fertility compared to the alluvial soils that the Tongas were cultivating along the Zambezi River. The soils were also generally sandy and have low water holding capacity, and hence prone to droughts. In addition to sandy and infertile soils, the areas of new settlement also had large areas of extremely shallow soils which are not suitable for any form of crop production;
- the new settlements were all located in areas of low and unreliable rainfall, where crop production is a risky undertaking. This factor, in combination with the infertile, shallow and sandy nature of the soils rendered these settlement areas unsuitable for any meaningful crop production;
- the new settlers were not provided with any agricultural extension services to enable them to learn how to practice successful agriculture in their new settlements;
- the new settlement areas were infested with tsetse fly during the first 30 years following relocation. It was therefore not possible for the settlers to keep cattle for draught power. Cattle were only introduced into the settlement areas in the mid-1980s after the eradication of the fly. Following the eradication of the fly, some of the farmers obtained cattle and were able to use them for draught power;
- the Southern Rhodesian Government, which was responsible for all resettlement on the southern shore of lake Kariba decided to demarcate a 5km wide buffer zone along the lakeshore, which was designated recreation land, and therefore was out of bounds for the relocated Tonga. The existence of this buffer zone effectively denied the Tonga access to the water resources of the Zambezi River, which had been their birthright. The Tonga therefore not only lost their productive alluvial soils along the river, but also lost access to fisheries resources;
- aerial photo analysis that was carried out on the areas that were submerged by Lake Kariba showed that the Tonga had opened up most of the potentially arable lands along the Zambezi River and there was little room for opening further areas. If Kariba Dam had not been constructed, there was a possibility that the Tonga population would have expanded beyond the carrying capacity of the river valley. There is no way of telling when that would have occurred;
- the Southern Rhodesian Government provided food for two years to the settlers and expected them to be self-sufficient thereafter from their own agricultural production. This assumption seems to have been wrong because even 40 years after resettlement, the Tongas are still not self-sufficient. The conclusion from this observation is that it takes longer than two years for settlers to adapt to their new environment.

The conclusions listed above with respect to agriculture point to the following lessons for the large dam debate:

- in resettling people who are displaced by a dam, efforts must be made to ensure that the relocated people are familiar with the agro-ecology of their new areas of settlement, and that they have the appropriate agricultural skills for their new settlement areas;

  if the new and old areas of settlement are significantly different, the project must make budgetary provisions and plans for appropriate agricultural training for the settlers and this must be provided for a long period of time. In the Kariba case study, it was wrongly assumed that this would take only two years and that thereafter, the settlers would be self-sufficient. In the feasibility studies for a project, expertise must be allowed to analyse the need for this agricultural training;

- related to the above lesson, it was observed in the Kariba case study that the relocated Tonga people were barred from having access to the water resources of the lake. Considering that they had been a people whose life and culture evolved around water, this deprivation must have been painful indeed. In future dam projects, efforts must be made to ensure that, as far as possible, the displaced people are allowed access to the water resources of the lake.

- in the Kariba case study, little irrigation development has been carried out in Zimbabwe using the waters of the lake. What is even more striking is that the displaced persons were provided with little opportunity to participate in irrigation. As a lesson for WCD, it must be appreciated that irrigation is one effective way of providing employment and economic opportunity for peasant farmers. Irrigation is therefore an effective way of compensating displaced people; and finally

- it is not enough for a resettlement programme to leave people in the same economic state that they would have been before resettlement, There is need to design programmes that improve the conditions and standard of living of the settlers. In the case study described above, it would appear that the Southern Rhodesia government made no effort to improve the standard of living of the settlers from what it was in the valley.

3.6 Ecological Impacts of Lake Kariba

This section reviews information on the stretch of the Zambezi River that was inundated by Lake Kariba. Coslon (1960, cited in Coche, A.G. 1974) described four topographic zones in the Gwembe Valley prior to inundation, in the area extending from the Zambezi/Gwaai to the Zambezi/Kafue confluence. The zones are: (i) the Zambezi Plain; (ii) the Lower Hills; (iii) the High Upland Valleys; and (iv) the Escarpment Region. The distance between the lakeshore and the escarpment in Zambia is only about 30km. Since the escarpment is the source of all the rivers flowing into the lake in Zambia, it means that the drainage into Kariba, in Zambia, is characterised by short rivers. On the southern bank, in Zimbabwe, drainage into the Zambezi extends much further inland as far as the central watershed, which runs southwest to northeast from Bulawayo through to Harare. Most of the drainage into the Zambezi River (and now into Lake Kariba) is from the southern catchment. The major Zimbabwean rivers that drain into Lake Kariba, such as Munyati, and Gwaai, are generally in excess of 300km in length.

The analysis of ecological impacts of Lake Kariba that follows was carried within the framework of the 6 basic questions set by the WCD. The analysis was further guided by specific questions by the scoping document and listed below:

- What biodiversity changes occurred in the basin area as a result of the dam?
- What are the impacts of tourism and recreational activities on the environment?
- What is the level of siltation in the reservoir?
- What have been the ecological impacts of Kariba Dam on the downstream reaches of the Zambezi River with and throughout the Cahora Bassa dam?
- What are the major threats to wetlands in the Zambezi basin?
- Has Lake Kariba created a micro-climate of its own?
- What impacts will climate change have on the ecology of Lake Kariba and the Zambezi River?
- What are the sources and the levels of pollution on Lake Kariba?
- What are the risks of eutrophication on the Lake Kariba?
- What have the ecological effects of water level fluctuations in the reservoir?

3.6.1 Projected Impacts

At the time that Kariba Dam was conceived and built, in the mid-50s, ecological impacts or environmental impact assessments were largely unknown. There were no requirements for ecological studies and/or impact studies to precede major developments such as the Kariba Project. Thus in analysing what the ecological and environmental impacts of Kariba Dam and its lake have been, one has to take this debate in context. Hardly any of the observed ecological impacts were either anticipated or predicted.

According to the Kariba Scheme Time Schedule 1955–1957 (French Mission, 1955; Coyne, A. 1954), preliminary steps that were to be taken in 1955, prior to commencement, did not include any ecological surveys. Even the subsequent activities at the construction site, as well as the erection of transmission lines did not include any ecological assessment of potential impacts. The decision to build Kariba first before Kafue was not made with any reference to the relative merits and demerits of the two schemes on the ecology of the dam area. In Coyne's report to the Federal Power Board in November–December 1954, *"Comparison of Kariba and Kafue Projects"*, no mention was made of the ecological benefits, losses or costs of either scheme.

3.6.2 Actual Impacts

After the creation of Lake Kariba, the Zambezi Plain and the Lower Hills were drowned, a gross area of some $5500km^2$. Most of the flat alluvial plains, previously used for recession agriculture disappeared under the water. Thus in this regard an analysis of the actual ecological impacts can be best done by first considering the ecological aspects of these areas before inundation so as to reflect what was lost. Furthermore the impacts will be analysed with reference to the construction period and the post construction period with emphasis on human induced ecological impacts, climatic and downstream impacts.

3.6.2.1 The Pre Construction Phase

The ecological impacts in this section are studied with reference to aquatic habitat, terrestrial habitat and the impact on human activities. The focus is mainly on the ecological resource endowments that were lost as the lake filled up and inundated an extensive area of land that was formally a habitat for numerous plant and animal species.

a) Aquatic Habitat

Prior to Kariba Dam, the Zambezi River flowed "normally", exhibiting seasonal fluctuations from high and low water levels in summer to low water levels in winter. This hydrological regime dictated the nature of the flora and fauna that existed then. River flows were swift during: (i) the local flood period from December to February; and (ii) the main flood period from May to July. The former is due to rains falling in the Kariba basin in Zimbabwe and southern Zambia, while the latter is due to the arrival of floodwaters from the upper Zambezi in north-western Zambia and Angola. The local inhabitants would grow two crops in a year, one during the local rainy season and other as the river receded after the main flood.

Although it has been difficult to find literature on the aquatic vegetation of the river before the dam, much can be inferred from upstream reaches of the river of similar physiognomy. Not much aquatic vegetation would have been expected in fast-flowing sections of the river. In slow or gentle flowing sections, plant genera such as *Phragmites, Papyrus, Typha, Ludwigia, Nymphea, Trapa, Vallisneria, Potamogeton, Ceratophyllum, Lagarosiphon* and a few others that have been observed above Victoria Falls (Masundire, H.M. 1998) should also have occurred in the Gwembe Valley.

While studying shoreline vegetation in the early years of Lake Kariba, Magadza (1971) suggested that plant species in the zone exposed by rapid recession of the water line such as *Ludwigia stolonifera,* *Alternathera sessilis, Glinus lotoides, Vossia cuspidate, Paspalum commersoni, Polygonum salicifolium* and *Eclipta alba*, grew on the banks of the Zambezi River prior to Kariba Dam. The alien fern, *Savinia molesta /(auriculata),* already existed in the Zambezi River before the construction of Kariba Dam (McLachlan, A.J. 969). Very few phytoplankton species were expected. Thomasson (1965) also showed that there were few phytoplankton species prior to damming of the Zambezi River at Kariba. One of his sampling sites was in Devil's gorge, which is above Lake Kariba. This site had the poorest plankton species composition in the Zambezi River.

There are several studies on invertebrate fauna shortly after the creation of Lake Kariba (McLachlan, 1968; 1969; 1970; 1971). However, there appear to be no data on invertebrate fauna in the Zambezi River prior to the creation of Lake Kariba.

Jackson (1961) observed that the fish species of the middle and lower Zambezi were very similar. However, the middle Zambezi obviously lacked marine or estuarine-derived fauna.

These two sections of the river were very poor in species owing to the seasonal adverse conditions that prevail in the dry season, when flow is reduced to a trickle, thereby greatly diminishing the habitat for fish. During these times food is very scarce while predatory tendencies are highest, as there are few refuges for prey species from the voracious predators such as tiger fish (*Hydrocynus vitattus*).

The Joint Fisheries Research Organisation is said to have surveyed the middle Zambezi before the creation of Lake Kariba (Coche, A.G. 1974). Jackson (1961) recorded 14 species in the middle Zambezi prior to Kariba Dam.

b) Terrestrial Habitat

There is no detailed record of surveys of riparian vegetation in the middle Zambezi before Kariba Dam was built. However, the nature of the riparian vegetation can be deduced from unflooded sections of the river both upstream and downstream. Mapaure (1998) and Du Toit (1982) give descriptions of vegetation in the Batoka Gorge and Mupata Gorge areas respectively. These are likely to be similar to what the middle Zambezi must have been like in the present-day Lake Kariba area. The flatter sections are likely to have had vegetation similar to that found around Mana Pools and Mupata Gorge while the gorges such as Chete Gorge, Sebungwe narrows and Kota Kota narrows probably resembled the Batoka Gorge vegetation.

There were three extensive vegetation types and seven types of smaller real extent. The three types that had large and real coverage were: (i) riparian vegetation; (ii) mixed species layered dry forest (jesse bush); and (iii) *Colophospermum* woodland. Du Toit (1982) further subdivided the riparian vegetation into four subtypes: *Acacia albida* woodland; *Acacia albida*-dominated woodland; mixed *Acacia albida/Combretum imberbe/Kigelia africana/Loncocarpus capassa* woodland; and mixed riparian woodland.

The other seven vegetation types are: (iv) *Colophospermum mopane* woodland with understorey; (v) *Colophospermum mopane* scrub; (vi) *Combretum/Terminalia/Diospyros kirkii* woodland, *colophospemum/Kirkia/Terminalia* woodland on ridges; (vii) mixed species woodland on larger hills; (viii) *Acacia robusta/Terminalia* woodland; (ix) mixed *Acacia/Lonchocapus capassa* woodland; and (x) grassland. The species composition of each of these vegetation types is described in Du Toit (1982).

In the narrow gorges, such as at Kariba Gorge, it is likely that the vegetation described by Mapaure (1998) for Batoka Gorge would have been present. Indeed the vegetation in the Kariba Gorge immediately downstream of the dam is very similar to that described by Mapaure (1998). The scree slopes of the gorge have a *Commiphora-Sterculia africana* mixed woodland. Also present in this association are *Combretum maossamabicense, Hippcratea buchananii, Cordia pilossima, Stropathus kombe, Commiphora caerulea, C. mollis, C. mossambicensis, Aflezia quanzensis, Gyrocarpus* *americanus, Lannea schweinfurthaina, Acacia nigrescens, Kirkia acuminata, Diospyros quiloensis, Combretum apiculatum, Elephantorrhiza buchananii, Grewia flavescens, Ormocarpum kirkii, Croton menhartii, C. gratissimus.* Several xeric species including *Sansvieria pearsonii* and *Euphorbia fortissima* occur scattered on the gorge slopes.

Close thickets also occur in the gorge slopes and close to the valley floor. These thickets are composed of *Artabotyrs brachypetalus, Tiliacora funifera, Elachyptera parvifolia, Jasmium fluminense, Acacia schweifurthiana, Clematis brachiata, Diospyros quiloensis, Syzigium caudatum,* and a few shrubs and climbers.

3.6.2.2 The Construction Phase

The much-publicised "Operation Noah" began in response to concerns about the fate of animals that were being drowned in the swelling waters of Lake Kariba. There had been no anticipation of this problem as an issue in the project-planning phase. Estimates of numbers of animals saved during "Operation Noah" range from 4000 to 6000 although small sized species were not recorded (Main, M. 1990).

The success of "Operation Noah" lay perhaps not so much in the number of animals "saved" but the variety of species observed, as well as the raising of awareness among people in general, and among dam planners in particular, about issues such as how to deal with drowning of animals when a dam fills up. The project also led to the creation of wildlife sanctuaries in the form of game reserves, national parks and safari areas in Southern Rhodesia. It is interesting to note that all these wildlife protection or conservation areas were all set in Southern Rhodesia and none in Northern Rhodesia.

There are no documented records of ecological impacts of the Kariba project during the construction phase. The Federal Power Board (1961) reported on the establishment of a thermocline in the forming lake and the discharge of water with large quantities of hydrogen sulphide in the tailraces. This water was observed to be causing severe corrosion of copper works both in the powerhouse and in the gorge downstream; however, no ecological impacts of the issuing of this water with high concentration of hydrogen sulphide – known to be poisonous to animals – were reported.

In addition the construction phase saw plans being initiated for a "boom" in fish once the lake was completed. A Joint Fisheries Research Organisation was formed to plan for the eventual management of the fishery. Over 950km^2 of bush, 510km^2 of it on the Zambian side and the remainder on the Zimbabwe side were, cleared at a cost of $6 million in preparation for a gill-net fishery (Main, M. 1990). The cleared area is approximately half of the area submerged to a depth of 20m; the depth occupied by most of the indigenous fish species.

3.6.2.3 Post-Construction

The majority of the post-construction ecological impacts were neither planned nor anticipated. Changes have occurred over the 40 years that Lake Kariba has been in existence. Where possible, impacts discussed here will be placed in a chronological context.

In terms of Zambezi water quality, Masundire (1998), working on water samples collected at Kazungula, showed that, by and large, the quality of water in the Zambezi River above Victoria Falls has not changed significantly since the early 60s. However, the quality of water has changed significantly following inputs of effluents from Livingstone and Victoria Falls municipalities (Feresu & van Sickle, 1990; Masundire, 1992; 1998).

The impact on lake water quality can be deduced from the fact that the creation of Lake Kariba changed the section of the river that formed the Kariba basin from riverine to lacustrine. The water remains in the reservoir long enough to create conditions very similar to natural lakes. Thus the obvious impact of Kariba Dam upstream was to change the habitat from riverine to lacustrine. This has implications on the physical, chemical and biological attributes of the "new" habitat.

The quality of water in Lake Kariba has been the subject of numerous studies (Bowmaker, 1969; Begg, 1970; Coche, 1974; Magadza, et al, 1987; 1988; 1989; Masundire, 1992). Lake water has evolved from an initial high-medium nutrient (eutrophic/mesotrophic) status to the current poor nutrient (oligotrophic) status. There are signs of localised mesotrophic/eutrophic conditions in those receiving anthropogenic nutrient inputs. Magadza & Dhlomo (1996) demonstrated high amounts of faecal coliform bacteria along the Lake Kariba shoreline close to Kariba Town. Phosphorus appears to be the most limiting nutrient to biological productivity.

With reference to biodiversity, all the riparian vegetation was drowned during the filling phase. However, it is unlikely that Kariba caused serious extinction of species, since most of the vegetation types in the flooded area occur abundantly elsewhere within the Zambezi Valley. The land-water interface was pushed to the high ground of *Colophospermum mopane* woodland.

The creation of lake conditions favoured the development of phytoplankton communities. Following the closure of the dam in 1958, blooms of cyanobacteria, *Microsystis* species were observed in 1959 (Mitchell, 1969). Several studies have focussed on the phytoplankton ecology of Lake Kariba (Thomasson, 1981; Hancock, 1968; 1987; Ramberg, 1987). The number of phytoplankton species increased as the lake formed (Hancock, 1987, Thomasson, 1981).

However, Ramberg (1987) claims that it was not possible to draw any conclusions about long-term changes in phytoplankton from the analyses made by Thomasson (1981). A comparative analysis of the composition of the phytoplankton is summarised in Table 3.17 and 3.18.

Thomasson (1981) analysed samples collected between 1968 and 1970, while Ramberg (1987) sampled between 1982 and 1984. Thomasson (1981) recorded a total of 156 species from the entire lake while Ramberg (1987) recorded 82 species from the Sanyati basin only. In both studies, Chlorophyceae were the most dominant in terms of number of species.

Table 3.17: Number of species of Phytoplankton per Family in Lake Kariba

Family	**Thomasson, 1981**	**Ramberg, 1987**
Cyanophyceae	15	15
Haptophyceae	-	1
Chrysophyceae		4
Bacillariophyceae	20	12
Chlorophyceae	109	30
Xanthophyceae	2	-
Cryptophyceae		6
Euglenophyceae	5	3
Dinophyceae	5	11
Total	**156**	**82**

For the macrophyte species (floating, rooted and submerged), the alien fern, *Salvinia molesta* exhibited the most notable change in abundance in the early years of Kariba. This weed demonstrated a dramatic explosion in population during the early eutrophic/mesotrophic phase of the lake's productivity. Since 1963, the weed declined to its present state where it is no longer the menace that it used to be. In fact, some people would argue that the ecology of the lake could benefit from a few more weeds, as they offer shelter to fish fingerlings, and provides feed for the hippos.

During the peak *Salvinia* period, floating mats of the weed were colonised by a variety of species forming the sudd (Mitchell, 1969). Species that formed this sudd community included *Scirpus cubensis, Ludwigia stolonifera, L. leptocarpa, Polygonum senegalense, Panicum repens*. In 1961, Boughey (1963, cited in Mitchell, 1969) observed *Ludwigia, Polygonum, Cyperus, Scirpus cubensis, Typha latifolia and Pharagmites mauritianus* forming the sudd community. It was postulated that these plant species must have been present in the Zambezi River or its tributaries prior to the construction of Kariba Dam.

The ecological benefits of *Panicum ripens, a* grass which grows in the draw down areas of the lakeshore was studies by Taylor (1985). His studies showed that the population of buffalo in the lakeshore areas benefited from fluctuating levels of the lake, which in turn encouraged the growth of this grass. This issue will be discussed further in the wildlife section of this report.

Other floating weeds were *Pistia stratiotes, Azolla nilotica* and *Lemna minor*. These appear to have been out-competed by *Salvinia* at its peak. *Azolla nilotica* showed periodic resurgence in the late 80s and early 90s.

Masundire (unpublished) observed *Eichhornia crassipes* growing as an ornamental plant at Kariba Hospital in 1989. A follow up survey showed that the plant was been grown ornamentally by several families in Mahombekombe surburb, a stone's throw away from the shores of Lake Kariba. The weed existed in the Zambezi River below Kariba Dam but had hitherto not been observed in Lake Kariba. This floating weed has recently been subject to chemical spraying of 2-4-D to control its explosion on Lake Kariba.

Furthermore, the post-construction ecological impact of Kariba can be viewed by assessing the effect that the lake had on the drawdown vegetation and particularly the impacts that were exerted on the fauna.

a. Drawdown zone vegetation (also known as "soak zone")

Lake Kariba does not have a true littoral zone. This is because of the wide fluctuation in water levels due to the operation of the dam as well as to losses due to evaporation. The area of lake bottom that is periodically flooded and later exposed is called the drawdown or "soak" zone. Aquatic plant species that would normally occur in a littoral zone occur in the shallow water.

They face the danger of either being left high and dry if water level falls rapidly, or of being drowned if water levels rise rapidly. Within this zone are found *Ludwigia stolonifera, Phragmites, Typha, Vallisneria, Potamogeton, Alternathera sessilis, Glinus lotoides, Vossia cuspidate, Paspalum commersoni, Polygonum salicifolium* and *Eclipta alba*. All these grew on the banks of the Zambezi River prior to Kariba Dam. *Potamogeton sweinfurthii* was first observed in 1967 (Mitchell, 1969).

Other aquatic plant species that occur above Victoria Falls, such *Trapa natans, Nympheae* spp. and *Cyperus papyrus* (Masundire, 1998) have not established themselves in Lake Kariba. McLachlan (1968) reported that *Nymphaea* sp. and *Nymphoides indica* failed to survive after inundation.

The vegetation type described above is either only found in sandy shoreline or in gentle sloping floodplains. Steep sloping shorelines have remained bare of any shoreline vegetation.

Machena (1988) has studied the shoreline vegetation of Lake Kariba in detail. He showed that the change from a riverine to lacustrine habitat enabled submerged plant species such *Najas pectinata, Ceratophyllum dermesum, Lagarosiphon ilicifolius* and several species of *Potamogeton* to colonise the Kariba basin. According to Mitchell (1969), *Ceratophyllum demersum* was always present in Lake Kariba. *Lagarosiphon ilicifolius* began to appear in 1966. Comparing Machena (1988) and Mitchell (1968), it appears that the composition of aquatic plants in Lake Kariba has not changed much, if at all, since the mid-60s. Thus this part of the biodiversity of Lake Kariba has remained stable.

Because most, if not all the, macrophytes found in Kariba today occur in the Zambezi River, especially in the upper Zambezi, where it is often referred as a reservoir river, it does not appear that the creation of Lake Kariba has led to a significant change in aquatic plant diversity. Biodiversity changes occurred only with reference to the altered section of the river and not to the whole river ecosystem.

b. Fauna

As for the plant species, the changed habitat upstream of the dam also altered the composition of animal species composition. Some of the changes are summarised below.

Microinvertebrates (zooplankton)

The fast flowing river would not have offered favourable conditions for zooplankton. However, the creation of lacustrine conditions enabled planktonic species to thrive well in the lake. The number of zooplankton species recorded in Lake Kariba shows some wide variation as demonstrated in Table 18.

Table 3.18: Number of Zooplankton Species Recorded in Lake Kariba

Rotifera	Cladocera	Copepoda	Total	Reference
46	12	0	58	Thomasson, 1965
9	9	2	20	Begg, 1967
-	7	6	13	Mills, 1977
5	4	6	15	Magadza, 1980
26	4	1	31	Thomasson, 1980
30	9	9	48	Green, 1985
50	9	10	69	Masundire, 1992

From the above, it is difficult to discern any particular pattern in biodiversity trends among the microinvertebrates.

Variations in numbers of species may be real or maybe due to variation in intensity and temporal and spatial extent of the studies. Variations may also be due to differences in taxonomic competence of the researchers.

Macroinvertebrates (benthic fauna)

McLachlan studied the early colonisation or development of benthic fauna in Lake Kariba. As there were no pre-impoundment records of benthic organisms, and no records from either upstream or downstream unflooded areas, it is not possible to make comparisons that would shed light on the possible impact of Lake Kariba on these organisms. However, McLachlan (1970) demonstrated that the drowned tree trunks, mainly of *Colophospermum mopane*, significantly increased the habitat for colonisation by benthic invertebrates. He also showed that the presence of aquatic vegetation influenced the variety and abundance of benthic fauna (McLachlan, A.J. 1969).

Average biomass of benthic fauna was 206mg/m^2 in bottom mud, 1064mg/m^2 among aquatic vegetation and 60mg/m^2 on submerged tree trunks (Mclachlan, A.J. 1970). There were 46 species in sites with aquatic vegetation compared to 28 at sites without vegetation. 24 species were common to both sites, 3 only occurred where there was no vegetation while 21 occurred only where there was vegetation (McLachlan, A.J. 1969). The total number of macroinvertebrate species found are demonstrated in Table 3.19.

Table 3.19: Number of species of macroinvertebrates

Group	# of species
Chironomidae	25
Trichoptera	5
Odonata	6
Ephemeroptera	4
Mollusca	5
Others[19]	4

Source: *McLachlan, 1969*

Machena & Kautsky (1987) showed that while the early years of Kariba were dominated by chironomids (McLachlan & McLachlan, 1971), by the early 80s, molluscs, snails and mussels, dominated benthic fauna biomass. Four species of mussels: *Mutella dubia, Caelatura mossambicus, Corbicula africana* and *Aspatharia wahlbergii* and two genera of snails, *Melanoides* and *Cleopatra* spp. are the dominant contributors to benthic fauna biomass. Other snails that now exist in Lake Kariba in appreciable quantities are *Blelamya* sp., *Bulinus globosus, Lymnaea natalensis*, and *Biomphalaria pfeifferi,* which are known to transmit bilharzia parasites (Moyo, N.A.G. 1994; King, 1994).[20]

Hutton (1991) and Games, (1992) showed that the population of crocodiles increased subsequent to the creation of Lake Kariba. Hippopotamus have also increased considerably since the lake was created. Increases have been due to increased habitat and more food availability for both species.

c. Upstream terrestrial

Jarman (1971) reported a reduction in population sizes of grazers such as hippo and waterbuck while browsers such as kudu were affected to a lesser extent. As the lake has evolved, especially following the establishment of littoral and drawdown zone vegetation, the population of most grazers has been increasing.

The terrestrial ecological impacts of Lake Kariba can be observed at varying distances from the project site. There are those impacts that can be observed in the immediate project area and there are those that can be observed far beyond the immediate environs of Kariba.

The latter include the ecological “benefits” that accrued to both Zambia and Zimbabwe by slowing down deforestation due to availability of hydropower from Kariba. That most major urban metropolitans were supplied with reliable power from Kariba should, definitely, have reduced the dependence on wood fuel by urban populations. This is, however, quite difficult to quantify.

The other alternative source of energy other than hydropower was thermal power from burning coal. It has been suggested that by generating power from Kariba instead of burning coal, there would have been 472 000 tonnes of carbon dioxide, sulphur dioxide and nitric oxides released into the atmosphere (Gersten-Briand, unpubl.). These would have added to the battery of GHGs that are largely responsible for global warming. Thus, generating hydropower at Kariba made positive contributions to averting global warming.

Initially the flooding of the Kariba basin displaced wildlife, as already discussed. It is not known what and how many species were actually lost due to habitat destruction. Most of the larger mammals that either escaped from drowning or were saved by human intervention have adapted to new homes or moved into more suitable areas. Since no baseline biodiversity assessment was carried out prior to

[19] Hirudinea & Oligochaeta
[20] Aspects of the effects of Lake Kariba on waterborne diseases are discussed elsewhere in this volume.

Kariba, it would appear that the full story regarding terrestrial biodiversity changes wrought by Kariba will not be fully understood.

3.6.2.4 Human-induced ecological impacts

Human-induced ecological impacts arising from the Kariba project are mainly land degradation subsequent to human resettlement. Although the problem should be viewed as complex, it is not an easy cause-and-effect phenomenon. Land degradation is discussed elsewhere in this study. The Lusitu valley in Zambia is a manifestation of some of the more serious cases of land degradation in resettlement areas. But did Kariba "cause" this degradation?

One of the consequences of land degradation is the increase in soil erosion leading to increase in silt-loading into rivers and streams that flow into Lake Kariba. Land degradation has also been taking place at high rates in areas that were not resettled by the people displaced from the Kariba basin.

While it has been estimated that one of the tributaries of the Zambezi River, the Gwaai River – which joins the Zambezi just above Lake Kariba – can transport as much as 1.8 million tonnes of silt in a year (Chikwanha & Ward, 1979), this cannot be solely attributed to the resettlement of communities from Kariba. The extent of impact of the threat from siltation on Lake Kariba should be assessed from the assertion by Olivier & Bolton (1978, cited in Du Toit, 1982), that "to silt up the dead storage in Lake Kariba – 116 $x10^9$ m^3 – would take about 1000 years, silting up at the rate of 116 x 10^6 m^3 per year". Considering the rate of land degradation over the last 20 years, the rate of siltation into Lake Kariba should have increased significantly. There is need to investigate and quantify the current rates of siltation into the lake. But this cannot be viewed as an ecological impact caused by Kariba. Tumbare (1998) reported loss of storage due to siltation to be minimal and hence not a serious issue.

The establishment of several population centres around Lake Kariba has occurred since the construction of the dam. The most notable ones are Kariba, Siavonga, Chalala, Sinazongwe, Binga and Mlibizi. Smaller centres are developing along the lakeshore, especially on the Zimbabwe side. Kariba is being viewed as an area of development opportunities. Such population centres pose serious ecological implications with respect to waste management and pollution.

Sanyanga & Masundire (1998) studied waste management practices in major population centres in the Zambezi Valley in Botswana, Zambia and Zimbabwe. Included in this study were Kariba and Siavonga. The two towns produce about $9000m^3$ and $6000m^3$ of wastewater per day, respectively. At the time of the investigation the sewage works in Kariba were overloaded beyond their design capacity. It is pertinent to note, however, that new sewage treatment ponds have already been constructed to deal with the problem.

Siavonga uses large communal septic tanks that were found to be full with sewage overflowing into the lake in some portions. For Kariba Town, the sewage effluent is supposed to be pumped to the Zambezi River below Kariba Dam. The impact of this practice has not been investigated but Sanyanga & Masundire (1998) showed that water samples collected at Chirundu had no evidence of sewage contamination.

Magadza & Dhlomo (1996) found high levels of coliform bacteria in inshore waters around Kariba Town. However, they did not confirm whether these coliforms were of human origin or not. Mammals, other than humans, and birds also harbour coliform bacteria in their alimentary canals. This notwithstanding, there is quite a serious potential of pollution from human waste in virtually all the population centres. Where there are no reticulated systems the most favoured waste treatment process is the septic tank and soak away. Developers take advantage of the slope to drain down towards the lake. Thus it can be projected that the volume of human waste entering the lake will increase in the near future. This poses a risk to human health as well as a risk to ecosystem health – increased loading with human waste increases the possibility of eutrophication. It is likely the recent invasion of the lake by *Eichhornia crassipes* is a response to increased nutrient availability in the eastern-most basin where there are highest human populations.

Heavy metals such as cadmium, copper, chromium, manganese, nickel and zinc were generally low in the water, as well as in various aquatic plant and fish species (Berg, 1996; Berg et al, 1995). These findings conform with those of Masundire (1998) who found similar low concentration of heavy metals upstream of Lake Kariba. However, concern has been expressed over lead concentrations that do appear to be rather higher than expected. A peculiar disease of elephants, known as elephant trunk paralysis, has been suspected by some wildlife scientists to be linked to lead poisoning, although there has not been any hard scientific evidence to support this suspicion. As will be discussed later in the wildlife chapter of this report, more recent research is linking the incidence of this paralysis to chemicals in certain plant species that are consumed by elephants. In Kariba, the source of lead is thought to be lead-laden fuels and oils. Some of this is thought to arise from fuel leakages, oil spillages and deliberate dumping of used oils into the lake.

Increase in boat traffic on the lake is likely to exacerbate oil/fuel pollution on the lake. On the Zimbabwe side alone, there were 616 boat-nights (nights spent by kapenta fishing boats out on the lake fishing) in 1974. The number of boat-nights increased to 31747 in 1980, 41403 in 1985, 59193 in 1990 and to 71066 in 1992. The number of luxury boats, houseboats and other commercial vessels have also increased over the years. Among the persistent pollutants, DDT has been found to be the most dominant (Matthiessen et al, 1984; Phelps et al, 1989; McCarton & Mhlanga, 1994; Berg et al, 1995; Berg, 1996). The concentrations of DDT in various components of the Lake Kariba ecosystem are summarised in Table 20.

Table 3.20: Mean SDDT levels in Lake Kariba in parts per billion (ppb)

Component	Mean DDT	Source
Water	<0.02	Matthiessen *et al.* (1984).
Sediment	390	Matthiessen, *et al.* (1984)
Algae	2500	Berg *et al* (1995)
Kapenta fish	1600	Berg *et al* (1995)
Labeo altivelis	5700	Berg *et al* (1995)
Tilapia rendalli	1900	Berg *et al* (1995)
Tiger fish	5000	Berg *et al* (1995)
Crocodile	34200	Phelps *et al*. (1989)
Reed cormorant	9500	Berg *et al* (1995)
Corbicula africana (a species of mussel)	10100	Berg *et al* (1995)

The main source of DDT is thought to be the tsetse fly eradication programme (Matthiessen, 1984; 1985). However, Phelps et al, (1989), found high total DDT concentrations in the fat of crocodiles caught near river mouths draining agricultural areas suggesting that DDT could have originated form agricultural uses. While Phelps et al, (1986) found the highest concentration of total DDT (25.91mg/kg) in eggs collected at Kariba Crocodile Farm – now called Kariba Crocodile Park – they also found relatively high total DDT concentrations in crocodile samples collected at Mpalangena River and Chundu Island, both upstream of Victoria Falls. They postulated these high levels of DDT could be due to use of DDT in Namibia’s Caprivi Strip.

Heavy metals: mercury, lead, selenium, cadmium, and zinc were analysed in crocodile egg samples collected from the Zambezi upstream of Victoria Falls as well as from the Sengwa River mouth and from Kariba Crocodile Farm in 1981 (Phelps et al, 1986). They did not give baseline data for comparisons but described the levels of the heavy metals to be low, with the exception of mercury at Sengwa River mouth and lead at all four sites. The concentration of zinc ranged from about 27 mg/kg to about 48 mg/kg but were also described as low.

3.6.2.5 Ecological impacts of tourism

Tourism is a form of land use that might lead to less negative ecological impacts compared to other land use forms, such as agriculture and livestock production. The fact that the area around Kariba, on the Zimbabwe side, has been a wilderness area has made Kariba an important tourist destination. The eradication of tsetse fly from the Zambezi Valley, including Kariba, opens opportunities for human immigration with livestock. This poses ecological risks, which tourism, as the prime land use practice, has helped to stave off for decades (Magadza, 1986). Eco-based tourism, if implemented, would have fewer negative ecological impacts.

A possible negative impact from tourism results from the proliferation of lodges along the lake frontage. Because the majority of developers want to have a lake view, this has led or is leading to “ribbon” development along the lakeshore. As more of these developments continue to be constructed, routes followed by wild animals on their way to drink from the lake are becoming blocked. This kind of ribbon development is self-defeating since wild animals form one of the major tourist attractions to Kariba.

There have been notable differences in tourism-related infrastructure developments and investments on the north and south bank of the lake due to the absence of wildlife on the northern shoreline, which has been mostly devoted to agriculture. In addition, tourism may contribute to the problem of littering and wild bush fires, though these have not been assessed in the case of Kariba.

3.6.2.6 Climate impacts

In terms of climatic impacts, while the lake does have a cooling effect, this effect appears to be felt only in the immediate vicinity of the lake. Thus it is only a microclimatic impact. Main (1990) quotes unconfirmed/undocumented sources, claiming increases in rainfall in the Hwange area and an increase of as much as 50mm annually over the Zambian Lake shore. Main (1990) also mentions two other sites with very limited data where increases in rainfall are said to be in the order of 500mm per year! The other climate impact already mentioned, is the saving in GHG emissions that would have occurred had the power produced at Kariba been produced from burning coal.

Magadza (1994) has projected some likely impacts of global climate change in southern Africa. Most Global Climate Models (GCMs) predict a reduction in precipitation in southern Africa and/or increased frequency of extreme events such as droughts and floods. The effects on Lake Kariba and its environs will include ecological, social as well as economic losses. Power generation could be reduced or become unreliable. Either way economic losses form either or both scenarios are likely to be significant.

3.6.2.7 Downstream Impacts

The downstream impacts of Kariba were felt to varying degrees, all the way from Kariba Dam to the Zambezi delta. The effects on the delta region have since been exacerbated by the construction of Cahora Bassa dam. Thus the downstream ecological impact can be analysed as: (i) Kariba without Cahora Bassa; (ii) Kariba with Cahora Bassa; and (iii) Kariba with Cahora Bassa and Kafue. In this analysis only the first two scenarios will be considered.

a. Kariba without Cahora Bassa

The downstream ecological impacts arise from the hydrological operation of the dam. The following true account illustrates some of the downstream impacts arising from the hydrological operation of Kariba Dam.

“At Christmas in 1993, the author observed very little or no flow out of the tailraces of both the south and north bank power stations. Upon inquiring from ZESA engineers, the response was that there had been so little demand for power, that they were only allowing the minimum flow out of the dam. This minimal flow is apparently what would have been the normal river flow. A few days later, an insurance firm in Harare was asking for advice on a claim from a fish farmer at Chirundu, downstream of Kariba. All the fish on the farm had died.

"The farmer had dug out canals to divert water from the banks of the Zambezi into his farm. But because of the low flow from the power stations, the level of water in the river had fallen below his intake canals".

Downstream flows are dictated by power generation. Natural flow patterns have been altered. The flows are more regulated, with generally higher flows than normal when natural flow would have been lowest and lower flows than normal when natural flow would have been highest. One of the most cited ecological impacts is the reduction of the floodplain downstream of Kariba, especially at Mana Pools (Attwell, R.J.G. 1970). This appears to be refuted by Du Toit (1983) who claimed there appear to have been only four floods in the Mana Pools this century: 1916, 1934, 1957/58 and 1975. If Du Toit is correct, then the assertion that the Zambezi used to break its banks every year and flood the Mana Pools becomes doubtful. The main downstream hydrological impacts with ecological implications were thought to be: (i) the unnatural flow patterns – explained above; (ii) reduction in silt load in discharge waters that would be "silt-hungry" and ore erosive; and (iii) increased and untimely riverbank erosion that changes channel positions.

The regulated and generally slower flows have allowed for the establishment of aquatic vegetation, both floating and submerged. There are no records on impact of regulated flows on riparian vegetation.

An obvious ecological impact of dams is to block upstream and downstream fish migrations. Some of these fish movements were spawning runs. The one much-debated fish in the Zambezi is the Africa mottled eel. This fish is "born" in the sea and enters freshwater when juvenile. The young fish, called elvers, migrate upstream to grow and mature in freshwater after about 7 years (Balon, E.K. 1974). When mature, the adults then return to the sea to breed, after which they die. It was thought that the young fish would not be able to overcome the dam wall at Kariba. Balon (1974) and more recently Moyo (1998) have recorded young eels that have gone upstream of Kariba alone as well as upstream of Kariba together with Cahora Bassa

The direct impact of Kariba Dam on the lower Zambezi valley area, stretching between the present day Cahora Bassa dam and the delta of the river in the Indian Ocean only occurred between the completion of Kariba Dam in 1959 and the construction of the Cahora Bassa dam in 1975. This is the only period during which the impact of Kariba extended to the sea. After the completion of Cahora Bassa, the hydrology of the river between this dam and the sea was more under the control of the Mozambican dam.

There is no scientific record of any assessment of the actual impact of Kariba Dam on the lower Zambezi area. However, since Kariba Dam controls about 50% of the catchment area of the Zambezi basin, it would be expected that Kariba Dam led to some change in the flow regime of the Zambezi River right through to the delta. Despite the existence of some fairly large tributaries that flow into the Zambezi river below the dam, such as the Kafue, the Luangwa and the Shire, the barrier imposed by the Kariba Dam would be expected to have evened out the flow of the river considerably – reducing the wet season flow and raising the dry season flow. In qualitative terms, Kariba Dam can be considered to have had the following impacts in the delta area:

- reduced frequency and intensity of flooding of the delta area, such that some low-lying areas around the delta, which normally experienced annual flooding, did not flood at all or flooded less frequently;
- a reduction in the amount of silt that the flood waters would deposit in the flood plains of the delta area, thereby reducing the fertility and biotic productivity of this areas;

- an invasion of the old floodplain by upland vegetation species, which survive in the absence of flooding;
- reduced artisanal fish productivity. Prior to the dam, when the Zambezi River seasonally broke its banks, there was good opportunity for the increased productivity of fish in the shallow water of the floodplain. With the failure of the river to break its banks and to flood these plains, the productivity of fish also declined;
- die-back of mangroves of the coastal areas can be expected to have occurred as a result of the reduced flooding of the delta areas; and
- reduction in the wildlife population of the delta plains, which thrived on the grazing created by the seasonal flooding.

The above list is confined to the impacts of the dam on the ecology of downstream areas. However, the change in the hydrology of the Zambezi River as a result of Kariba Dam also had a profound impact on the people of the Zambezi valley, including the Zambezi delta area. Like the Tonga of the Kariba Dam basin, the people of the Zambezi valley below Kariba had developed an understanding of the rhythm of the flow of the river. They knew when the river would normally be low and when the river would be high and overflowing its banks. With this knowledge, they devised land management practices that took advantage of these peaks and troughs in the flow, especially recessional agriculture. Similarly, the people of the valley also settled at elevations that were safe from these floods.

With the construction of Kariba and the disruption in the rhythm of the river, the people had to adapt to the new situation. One of the adaptations was the movement of human settlement closer to the river, since the dam removed most of the peak floods. In so doing, these people exposed themselves to risk of flooding in years when the dam managers needed to release water from the dam for some reason, such as high rainfall seasons. This was the case in February 2000, when, following a season of unusually high rainfall, Kariba Dam filled faster than expected and there was need to open the floodgates. In excess of 12000 people were displaced in south-eastern Zambia by the floods that were caused by this release. Riverine fields were flooded and homes destroyed, and cases of drowning were reported; and all this devastation because the flow-pattern of the river has been changed by the dam.

b. Kariba with Cahora Bassa

The negative impacts caused by Kariba Dam in the downstream areas were undoubtedly magnified when Cahora Bassa Dam was completed in 1975. With a generation capacity of about 2000MW, this dam led to a further evening of flow of the river in the Zambezi delta area, and an almost total elimination of flooding of the flood plains below the dam. All the negative impacts of the Kariba Dam in the delta area that were listed earlier were made exacerbated by Cahora Bassa. Shrimp catches declined, artisanal fish productivity declined, mangrove forests suffered die-back, and the plains were invaded by upland vegetation. In addition, the communities moved to the former floodplain areas and exposed themselves to a great risk of flooding in wet years, as happened in 1978 when unusually high rainfall led to the Zambezi breaking its banks in the delta area. This led to the death of about 45 people and the displacement of thousands who had settled in the floodplain.

In the inception report of the Zambezi Basin Wetlands Conservation and Resource Utilization Project, Hiscock et al (1996) highlighted priority issues in the Zambezi delta wetlands ecosystem. They included: alteration of flow regimes due to hydroelectric dams (Kariba, Cahora Bassa); loss of siltation and shoreline erosion; decline in prawn fishery offshore from the delta; receding mangroves; and insufficient knowledge of the impacts of the hydroelectric dams on the Zambezi River.

Catch per unit effort (CPUE) of the shrimp, *Penaeus indicus*, at the Sofala Bank, a shallow shelf outside the mouth of the Zambezi River is very highly correlated with flows in the Zambezi River, (r=0.983, Gammelsrod, T. 1992a; 1992b). Analyses of shrimp catches and year-to-year fluctuation in river flow were carried from 1974 to 1988. Cahora Bassa dam was completed in 1975.

There is, however, not enough data on the relationship between the river flow and the shrimp catches before Cahora Bassa dam. Gammelsrod (1992b) demonstrated that by simulating flows in the Zambezi River without the flow regulation caused by Cahora Bassa dam, the CPUE of shrimp could be increased by as much as 24.7 ∓ 11.87 kg/hr.

Other possible impacts of flow reduction and/or regulation have yet to be qualified and quantified. The Zambezi Basin Wetlands Conservation and Resource Utilisation Project holds promise in this regard. The extent to which delta wetlands have been or are being lost is yet to be quantified.

3.6.2.8 Ecological impacts of transmission system

Transmission pylons distributing power from the Kariba Scheme cover thousands of kilometres. Each year, trees and bushes below the power lines are cleared so that they do not interfere with the power lines. The ecological effects of this management practice have not been assessed. Electric power lines have also been known to cause mortality among birds, especially migratory species that flock and fly at night. How much the Kariba power lines have affected birds is largely not documented. However, around Kariba Town, several baboons have been observed to have been electrocuted or had limbs amputated after contact with transmission lines.

It is conceivable that the laying out and management of the power lines has inevitable affected the quantity, and possibly the quality, of biodiversity. The extent of this phenomenon has not been assessed.

3.6.3 Conclusions

The ecological impacts caused by the construction of Kariba Dam and the creation of Lake Kariba have been discussed above. Some of the impacts have not been thoroughly covered, or have been completely excluded, mainly due to paucity of data. The majority of the impacts were not, and, perhaps could not, have been anticipated at the time when the project was implemented. The major conclusions are that:

- it is inevitable that dam construction will disrupt the ecology of the impoundment area as well as downstream of the impoundment;
- it is possible to minimise some of the negative ecological impacts from dams, based on current ecological knowledge. If an Environmental Impact Assessment (EIA) had been carried out as part of the Kariba project, most of the negative ecological impacts discussed above would either not have occurred, or appropriate mitigation measures would have been devised for them. It is therefore imperative to carry out comprehensive EIAs prior to major projects such as the Kariba Dam;
- static water in reservoirs acts as a sink for materials including pollutants, nutrients and silt from the reservoir’s catchment;
- catchment management should be an integral part of dam and reservoir management;
- dam and reservoir management should include ecological management as well;
- dams create new habitats which may increase biological diversity, especially upstream of the dam;
- Lake Kariba has had both positive and negative ecological impacts with the balance in favour of the positive upstream of the dam and the balance in favour of the negative downstream; and
- the success of the kapenta fishery at Lake Kariba and its potential at Cahora Bassa suggest that not all species introductions have adverse ecological consequences.

3.7 Seismic Impacts of the Lake Kariba Dam

The scoping report for the Kariba case study identified seismology as one area of significant impact of the Kariba Dam. The scoping studies had gathered reports of increased seismic activity in the Kariba area following the construction and filling of the dam.

The dam has a storage capacity of 180km^3 of water when at a level of 484.6m above sea level (Gough & Gough, 1970b). This volume of water in Kariba translates into a mass of water of about 180 billion metric tons. The sudden imposition of this mass on the underlying geology of the basin would be expected to lead to some tectonic readjustment and some subterranean movement. The mass of the stored water notwithstanding, the Kariba basin is located in the southern extremity of the African Rift Valley system, a longitudinal zone of faulting and recent earth movement.

Thus it can be stated that the Kariba basin was an area prone to tectonic movement well before the establishment of the Kariba Dam.

Because of the existing reports of seismic activity in and around the Kariba Dam area, the scoping report for the Kariba Dam study recommended an examination of a number of issues relating to seismicity in the area. The issues were stated with regard to:

- whether any trends can be discerned in the historical data before and after Kariba so as to ascertain and probably predict the magnitude of future earthquakes;
- whether fluctuations in water levels are likely to cause significant weight changes. What would be seismic consequences of these water volume/weight changes on the seismicity of the area;
- how this seismicity affects the safety of the dam and other installations;
- the fact that a great deal of investment has been made in infrastructure such as hotels, lodges, residential housing etc. subsequent to the creation of Kariba Dam. It is assumed that Kariba will persist “forever”. Is this the case;
- the risks to the dam wall associated with earth movement; and
- the analysis of the risk of dam failure as considered in the original dam design and as can be derived from seismic activity since the dam was constructed. In addition, to determine if the measures put in place for dam failure are consistent with the level of risk determined.

This section of the Kariba case study report seeks to provide answers to the above questions or concerns.

3.7.1 Approach

In carrying out the series of studies presented here, the following investigations were carried out:

- an examination of the original engineering design document for the Kariba Dam to determine the extent to which seismicity was taken into account in this design;

- an examination of seismic data for the Kariba area as far back as permitted by records, in order to determine trends in the data and hence to determine the likelihood (if possible) of seismic activity in the future. This data was obtained from Goetz Observatory (Zimbabwe), which holds all seismic records of the Kariba area back in time to 1959. This data was collected and analysed in the course of studies presented here; and lastly

- a thorough literature search was carried out on all reports, journal publications, and any other relevant documents.

In the studies presented here, only the seismic data was analysed. The data was studied for spatial and temporal distribution. The temporal distribution of earthquakes of larger magnitude helps us to see how far away from the dam wall they occur. From the temporal distribution of the earthquakes, it will be easy for us to tell whether the reservoir area has stabilised or not.

At this point it is important to say something concerning the magnitude of earthquakes as presented in this document. Earthquakes are measured with the aid of a number of scales, which include the commonly known Richter scale. In addition, there are the surface wave magnitude (Ms) and the body wave magnitude (mb).

The surface wave magnitude (Gutenberg & Richter, 1936) is a scale based on the amplitude of Rayleigh waves with a period of about 20 seconds. Rayleigh waves are seismic waves that propagate along the earth's surface: hence the name "surface wave" magnitude. This scale is most commonly used to describe the size of shallow (occurring at a depth of less than 70km) or distant (more than 1000km) earthquakes. Shallow earthquakes have large surface waves that propagate along the earth's surface for long distances. Surface wave amplitudes get smaller as the earthquake source depth increases. Thus in the case of earthquakes with deep-focus, surface waves are usually too small to give a reliable value of the surface wave magnitude. In such a case the body wave magnitude (Gutenberg, 1945) that is based on the amplitude of the P-waves is used. P-waves propagate inside the earth and are referred to as body waves (mb) giving rise to the name body wave magnitude. The P-waves are not seriously affected by the focal depth, as is the case with the surface waves.

Magnitudes of the seismic data obtained from Goetz Observatory for Kariba are equivalent to the body wave magnitude, mb, (Chow et al, 1980).

3.7.2 General Appraisal of the Tectonics of the Kariba Area

The Lake Kariba area lies in the mid-Zambezi basin, assumed to be the dormant southern extension of the east Africa Rift system (Gough & Gough, 1970b; Pavlin & Langston, 1983b; Rosendahl, 1987; Hlatywayo, 1995). The rift system is considered by many to be the best example of continental rifting in the world (eg, Fairhead & Stewart, 1982; Kebede, 1989). The Kariba basin was formed due to rifting during the Late Carboniferous (Karoo period) to Early Jurassic (Campbell et al, 1991).

The Lake Kariba area is highly faulted with normal faults. Faults in the area under study continue in a north-easterly direction into Zambia to join the Luangwa Rift zone (Rosendahl, 1987). The map in Annex 4 shows the high density of faults in the Kariba area.

According to Bozovic (1974), the dam wall is situated in very old rocks belonging to Precambrian times (gneisses and quartzites). The rock is densely folded, with the old faulting still evident. Pavlin & Langston (1983b) noted that the reservoir is in direct contact with Upper Palaeozoic to Mesozoic units of the Karoo rocks and these are about 1.9km thick immediately below the reservoir.

3.7.3 Seismicity of Kariba

3.7.3.1 Prior to impoundment

Detailed information on pre-impoundment seismicity is lacking because there were no seismic stations around or close enough to the reservoir area prior to the dam. It was not until 1959 that a seismic network was installed to detect earthquakes. As a result it is not possible to fully establish the exact nature of the changes in the seismic regime caused by the reservoir.

The reservoir area, as discussed earlier, is located in an area in which tectonic processes associated with rifting are and have taken place. Such processes are associated with earthquake occurrence. According to Ambraseys & Adams (1991) an earthquake of magnitude 6.0Ms occurred on the 28th of May 1910, in the southern part of Lake Kariba. Seismic instruments that are at great distances from the source can detect earthquakes of such large magnitudes. The smaller earthquakes will usually go unnoticed if there is no seismic station close to or around the area at which they occur. This report is evidence that the reservoir area was seismically active before impoundment. Also, in July 1956 (Gough & Gough, 1970b), a tremor was felt near Binga by Professor G. Bond (a well known geologist who worked in present day Zimbabwe in that era), who noted that the local people did not seem disturbed at all by this tremor. This seems to suggest that the local people were familiar with such occurrences.

Despite there being no seismograph equipment within or close to the reservoir area before impoundment, the tectonic set up of the area and the anecdotal reports of earthquake occurrence prove that Lake Kariba is located in an area that was seismically active prior to impoundment.

3.7.3.2 After impoundment

Below is an extract taken from a document by Tumbare & Sakala (1997). The document shows how the Tonga people interpret the occurrence of earth tremors after impoundment;

"...the Tonga people living in the Zambezi valley associate the tremors with the presence of the Nyaminyami River God, a Tonga spirit believed to be half snake and half fish. The Tongas believe when the snake moves it vibrates the walls of the Kariba Dam showing its presence to the people of the valley. Their explanation of the tremors is that at the time of closing the dam, Nyaminyami's wife had gone downstream of the Kariva, now Kariba gorge to answer prayers of her people and bless them. When it was time for her to return to her husband, she could not cross because of the dam wall and this angered Nyaminyami. From then until today, Nyaminyami is still upset and the occasional tremors felt in the lake area are caused by the spirit. The tremors occur when Nyaminyami, it is believed, tries to break up the wall and cross to the other side where his wife is and at the same time show his people that he still exists and is powerful."

The above would suggest that the frequency of tremors after impoundment increased to a level higher than that which the local people were used to.

A number of studies on the seismicity of the Lake Kariba area have been carried out by several researchers (eg, Gough & Gough, 1970a,b; Lane, 1974; Gupta & Rastogi (1974), Gough & Gough, 1976; Pavlin & Langston, 1983a,b; Guha & Patil, 1992; Jonathan, 1996). Despite lack of pre-impoundment data and the fact that the reservoir is located in an area that is naturally earthquake-prone, these studies concluded that seismic activity at and around the Lake Kariba was mainly due to impoundment. Many earthquakes have occurred in the area of study since 1959. There is a high density of earthquakes in the vicinity of the dam wall that is also the area of the highest mass of water, as shown in Annex 5

When the impoundment was completed in 1959, recorded seismic activity in the area increased and peaked in 1963 (Annex 6). The 1963 activity was concentrated in two areas along the dam wall: the neck area, and in the Matusadona sub-basin (Pavlin & Langston, 1983b). These two areas constitute a region that was found to have high incremental stress (Gough & Gough, 1970a). All earthquakes of magnitude 5.0 and above have occurred in this area (shown in Annex 7). The largest earthquake, of magnitude 6.1, was recorded in 1963. This earthquake caused damage to the dam structure and some property in nearby settlements. However, no casualties were reported (Pavlin & Langston, 1983b).

The temporal distribution of the earthquakes (Annex 8) shows a general decline in the number of earthquakes per year that have been occurring at Kariba since 1963. 20 earthquakes of magnitude 5.0 and greater have occurred, the last one having been in 1984 (Annex 6). The present day seismic activity shows that the NE - SW trending faults are active (Shudofsky, 1985; Hlatywayo, 1995).

The Kariba area has continued to display seismic activity to this day. However, the available data – pre- and post-impoundment – shows no definite trends that can be used to ascertain or predict the magnitude of future earthquakes at Kariba.

Earthquake prediction entails giving the time and place as well as the magnitude of the future earthquake. Main (1993) states that the “ultimate goal of the prediction of the place, size and time of an individual major earthquake remains as elusive as ever”. Earthquake prediction is currently a subject of intense research worldwide.

3.7.3.3 Dam Level Fluctuations and their Influence on the Seismicity

In a study focusing on the mechanism causing the earthquakes at Kariba reservoir, Gough & Gough (1970b) suggested the following as causes of the earthquakes occurring at Kariba:

- that near the western end of the lake, failure of pre-stressed, previously active faults were triggered by the addition of stress or due to fluid pressure or both; and

- that near and under the Sanyati basin failure of the pre-stressed faults were triggered by shear stresses of 1–2 bars resulting from the lake load. It was concluded that the increase of fluid pore-pressure due to the flow of water from the reservoir to the surrounding rocks played an insignificant role in the triggering of the earthquakes.

The above points show that the weight of the water as well as changes in the weight resulting from the water level changes, play an important role in generating earthquakes at Kariba.

The observed initial seismic activity at Kariba has been correlated to the water level fluctuations (Gough & Gough, 1970a). Recently, Tumbare & Sakala (1997) also showed that there was a correlation between seismicity and dam water level. However, it is not always the case that fluctuations in dam water level can be correlated to the observed seismicity. This was shown to be so in a study by Gough & Gough (1976). In this study, they analysed Kariba data for the period 1968–1974 and observed that the correlation between the seismicity and incremental stress no longer existed as had been observed in earlier studies. Thus they concluded that the triggering mechanism for the earthquakes was the increase of pressure in pores and rock fractures.

Apart from the additional stress and strain that occurs in the surrounding rock of the reservoir area and its vicinity due to static pressure of the water load, dam level fluctuation is one of the factors that affects the frequency of earthquake occurrence at reservoir sites. The dam water level fluctuations imply fluctuations of the weight of water on the underlying geology. Earth movements along faults in the reservoir area will accompany these fluctuations in the dam water level.

3.7.3.4 Seismic Hazard at Kariba

Earthquakes with magnitudes greater than 4.9 have occurred in the Lake Kariba area; earthquakes of such magnitudes can pose hazards to life and property of nearby populations.

3.7.3.5 Kariba Dam Wall Design and Seismic Loading

The available literature indicates that seismic loading was not considered during the design stage of the Kariba Dam. In their review of the design and construction methods of the underground works of Kariba Hydropower scheme, Lane & Roff (1961) state that, “The works are sited within a stable zone where significant movement is unlikely to occur and it is not a seismic area”.

This is further confirmed by the following extract taken from the Standing Operations Procedure for the Kariba Dam and Reservoir (1999), “Because of the tectonic stability of the area of location no seismic considerations were taken into consideration in the design of Kariba”.

Apart from the non-availability of adequate information on the seismicity of the Kariba area during the design stages, Mazvidza (1994) notes that the dam was designed "at the time when rock mechanics was not fully understood and not considered in design calculations".

Nowadays it is almost mandatory that the developments of major engineering activities, especially in areas of known seismicity require that the seismic hazard be assessed and that proper seismic criteria be incorporated into the designs. In the case of large reservoirs such as Kariba, which have a tendency to significantly modify the seismicity in their vicinity, such anticipated changes have to be taken into account when doing the hazard analysis.

This is especially so in areas of relatively low seismicity. In areas of relatively high seismicity the designs usually takes seismicity into considerations anyway.

3.7.3.6 Effect of Seismicity to the Dam Wall and Other Installations

The danger to the dam wall and other installations posed by the earth movements resulting from earthquakes at Kariba emanate from the fact that seismic load was not considered during the design stages. Hence in the event that a "large enough" earthquake occurs, structural damage can result. Though it has been documented that the 6.1 magnitude of 23 September 1963 caused some damage to the dam structure and some property in nearby settlements, no elaboration on the damages could be found. The occurrence of surface rupturing accompanying a triggered earthquake on a fault passing through the dam itself is the greatest risk. The accuracy of the epicentres as determined by the Zimbabwean seismological network is not high enough to enable association of earthquakes with a particular fault. Hence it is not possible to know which fault is active or to know the position of the fault relative to the dam wall. It is possible that the earth movements could weaken the dam structure over a long time. Also at risk is the Kariba south bank. It has already been noted that the September 1963 burst in seismic activity may have induced some slope failure and may have had an effect on the south bank (Knight Piesold, 1991).

3.7.3.7 Will the Kariba Dam be there Forever?

The largest accepted reservoir-induced earthquake to date is of magnitude 6.5, which occurred at Koyna dam in India in 1967. Kariba has had a magnitude 6.1 as the largest. This situation begs the following question "Is the magnitude of 6.5 the maximum that can be expected from reservoir induced earthquakes?" as a partial answer to whether the Kariba Dam will be there forever. It should be remembered that there are two processes at play in generating earthquakes at Kariba; those related to the reservoir and those related to the tectonic processes associated with the rifting process. A detailed study needs to be undertaken to answer this question. It should be remembered that earthquakes will occur as long as the tectonic activity triggering them exists and always in close proximity to this subterranean activity.

3.7.3.8 Level of Preparedness for Dam Failure

In the event that dam failure occurs as a result of an earthquake or any other cause, the Cahora Bassa could be destroyed by the floodwaters from Kariba. Apart from this there are several settlements downstream that could be affected. The area that would be affected is approximately 3000km^2 in both Zambia and Zimbabwe from the Kariba all the way to the Indian Ocean. In addition, the whole civilisation for the two countries would be at stake through the loss of electric generation capacity and the destruction of infrastructure.

Since the time of construction, the hazard potential of the dam has never been of concern. For more than 36 years, no measures for dam failure were put in place (ie, the dam had been operating without an Emergency Preparedness Plan (EPP) (Mazvidza et al, 1997).

An internal report by Mazvidza (1994) laments the need to have a hazard potential classification for the Kariba Dam. The hazard potential classification has three categories namely: low, moderate or significant, and high. Low hazard classification refers to those dams whose failure would cause little property damage and no loss of life; moderate or significant hazard is for dams whose failure could cause moderate property damage and the loss of a few lives, whilst high hazard refers to those dams whose failure would cause large loss of life and extensive property damage. Thus the hazard potential classification would give information on the possible damages economically, environmentally and the cost in terms of human lives.

It is only recently that measures have been put in place for dam failure at Kariba. Currently an EPP is in place. The EPP is well documented in the "Standing Operations Procedures (SOP) for Kariba Dam and Reservoir" (1999). This document details the emergency action plan and / or procedures that have to be taken in case of dam failure. Several agencies with whom to co-operate during an emergency are given. These include the Civil Protection Unit, Local government Zambia and Zimbabwe, Police Cahora Bassa Authority etc. An emergency situation is simulated at least once per year to ensure that staff know what they should do. At the same time the Dam Safety Engineer checks the communications network at least quarterly to verify phone numbers and names of those officials key to the emergency action plan.

Despite the fact that seismic loading was not taken into consideration for decades after impoundment, the SOP document does take into account the fact that the reservoir area is seismically active. Procedures are laid down on what to do when an earthquake has been felt or reported to have occurred. Earthquake prediction is not yet possible. Continued earthquake monitoring is one of the way to mitigate hazards due to earthquakes. Currently ZRA has plans to have a seismic network around the reservoir.

ZRA designed measures for dam failure. The measures and level of preparedness are consistent with the risks expected.

3.7.4 Conclusions

Lake Kariba is situated in the mid-Zambezi basin, an extension of the East Africa rift system. The reservoir area is highly faulted. This area displayed seismic activity prior to impoundment. The seismic activity was a result of tectonic processes associated with rifting.

Despite lack of pre-impoundment seismic data, all studies have concluded that the observed seismic activity at and around Lake Kariba was mainly due to impoundment.

The available pre- and post-impoundment seismic data do not show any trends that can be used to ascertain or predict the magnitude of future earthquakes and tremors.

The fluctuations of the dam water level play a significant role in determining the frequency of occurrence of earthquakes in the reservoir area. The fluctuations translate to changes in the weight being exerted on the underlying rocks. As a result the earth will always move in order to accommodate the weight change, hence the occurrence of earthquakes.

Seismic loads were not considered in the design of the Kariba Dam. The reservoir area was considered to be seismically inactive. The danger posed to the dam as a result of this non-consideration of seismic data in the design could have led to a dam wall design that was not sufficiently robust to stand the type of earthquakes that have occurred at Kariba, leading to a danger of dam failure. Also over a long period of time, continued earth movements could have the cumulative effect of weakening the dam structure. The risk is higher for the Kariba south bank, which could be affected by large earthquakes, as was the case during the burst of seismic activity in 1963. A much more detailed study is needed to find out whether the Kariba Dam will persist forever.

Measures have now been put in place for dam failure and are consistent with the expected risks. An Emergency Preparedness Plan is well documented in the Standing Operations Procedure for the Kariba Dam and Reservoir. An emergency situation is simulated at least once per year to ensure that staff knows what they should do. In recognition of the fact that the reservoir area is seismically active, procedures are also laid down detailing what to do when an earthquake occurs or has been reported to have been felt. Also there are plans to install a seismic network around the reservoir area, since continued earthquake monitoring is one way to mitigate earthquake hazards.

In future it is advisable to have a network of seismic stations close to and in the reservoir area prior to building a dam the size of Kariba in any seismically active area.

3.8 Impacts of Lake Kariba on Fisheries

In the scoping report fisheries' benefits from Kariba Dam were recognised and the following issues were identified for further study in Phase 2:

- What was the importance and significance of fishing in the pre-dam period?
- How bound up is fisheries management on the lake with the general need for a common authority that can bring all the elements of the lake and of the river together? And how are the two parts of the industry to be regulated so that it produces optimal activity in ways that are acceptable to all, local and outsider?
- How has fishing benefited traditional fishermen and local communities?
- How are fishing rights allocated?
- Assess the overall contribution of the large-scale fishing industry to the economy of the Gwembe Valley, the river basin, and the two nations.
- How many jobs have been created? Who are the beneficiaries?
- How much has fisheries management benefited from research; and are concurrent offtake levels sustainable?
- Kapenta is supposed to be a cheap source of protein. Is kapenta really affordable to its target market?
- The establishment of a new giant company, Lake Harvest, is likely to cause or have caused changes in the socio-economic dynamics of the fisheries. This should be assessed in the medium- and long-term.
- Examine the potential and current impact of aquaculture on fisheries in Lake Kariba.
- How sustainable are fisheries on Lake Kariba?
- What are the main impacts on downstream fish species and fisheries yields on the Zambezi River? Investigate mechanisms to help fish migrations; can this option be applied on the Zambezi dams?
- What has been the impact, if any, on silt free discharges from Kariba on downstream fish and other natural phenomena?

3.8.1 The Fish Ecology of the Zambezi River Prior to Kariba

Little was known about the fish and fisheries of the mid-Zambezi. The Joint Fisheries Research Organisation commissioned a study in 1956/1957 to gather preliminary data on the biology of the fish in the middle Zambezi River, which was going to be flooded with the creation of Lake Kariba. Very little work had been done on the fishes of the middle Zambezi prior to this because it was relatively inaccessible. It was hoped that the preliminary fisheries data would form a guide to the later management of Lake Kariba fisheries.

Pre-impoundment studies showed that the mid-Zambezi where Lake Kariba was going to be built, had only 28 species compared to 83 species in the upper Zambezi (Jackson, 1960; 1961). The fish families found in the survey are listed in Annex 9.

The Fish of the Riverine Environments

Important riverine environments of the mid-Zambezi include: sections of the Zambezi between the Victoria Falls and the western end of Lake Kariba; and the area below the Kariba Dam wall to the Luangwa confluence. There has been very limited fish sampling for scientific investigations in these areas, as the Lake Kariba area has been the major fishery focus since its creation.

The fish of the Batoka Gorge area approximately 50km down the Victoria were sampled by Moyo in 1997 and 1998 during the studies for the environmental impact of the Batoka Gorge Dam. The results obtained indicate presence of Cyprinids, Characids, and Cichlids. Fish sampling for this study was mainly confined to the low water period in isolated pools.

It is therefore very likely that the sampled catch did not provide a good representation of the ichthyofauna of the area. A notable surprise however was the recording of a seventeen-year-old eel.

The Fish Ecology of Kariba Dam in the Past 40 years

The fish species composition of a particular reservoir is primarily dependent on the riverine fish fauna of its watershed. When riverine fish communities are trapped in a reservoir, most of the fish stay close to the shore, the mouth tributaries and in the shallows. Rivers are a normal and universal component of freshwater; reservoirs are anomalous and accidental and their duration is most often ephemeral. Pre-impoundment studies in the mid-Zambezi identified 28 species and there are 42 species in the 1990s. Rivers are older than lakes and reservoirs and consequently have higher species diversity (Fernando & Holick, 1991). In the case of Lake Kariba, where the reservoir has a higher species diversity than the river this is attributed to undersampling during the pre-impoundment fish studies.

Species that thrive in fast flowing water are threatened when a reservoir created. The cyprinids, *Labeo congoro* and *L. altivelis* dominated the fish catches soon after impoundment but the cyprinids catches have declined significantly. Cyprinids are riverine fish and are not preadapted to lacustrine conditions. They are potamodramous fish making upstream migrations to breed and clearly the creation of reservoirs compromises their breeding. Some *Barbus* species (which are also cyprinids) require fast flowing water. *Barbus marequensis* and *B. poechii* were found in parts of the mid-Zambezi that was not flooded. They have almost disappeared from Lake Kariba.

Cichlids are the mainstay of the Kariba inshore fishery. They are pre-adapted lacustrine fish and their biomass increased substantially soon after water impoundment (Balon, E.K. 1974). The shallow littoral zone, which is usually the most biologically productive part of a reservoir, may not be fully used if suitable fishes are not present in the watershed. Cichlids were present in the mid-Zambezi and when the reservoir was flooded they gradually occupied the littoral zone. In other African reservoirs such as Lake Nasser, Lake Kainji and Lake Volta cichlids dominate the littoral fish fauna. Cichlids could have been highly abundant if Lake Kariba were a shallow reservoir. Parakrama Samudra is a shallow reservoir (mean depth 5m) in Sri Lanka whose fish yield increased from 1kg/ha before introduction of *Orechromis mossambicus* to 1300kg/h after introduction (Fernando & Holick, 1991). However Lake Kariba is a deep reservoir, with a mean depth of 29m, and only 30% of the bottom of was inhabited by indigenous fishes (Coke, 1968).

The Development of Fishing Industry on Lake Kariba

The pelagic zone of a reservoir with a riverine fish fauna not adapted to lacustrine conditions represents a vacant habitat zone. Natural colonisation of the pelagic occurs only if the river basin is inhabited by species pre-adapted to lacustrine conditions.

Although various families are able to inhabit the pelagic zone, Clupeidae are of particular interest. Observations made in various parts of the world show clupeids to be extremely successful in this respect. It was against this background that the clupeid, *Limnothrissa miodon* was introduced in Lake Kariba, in 1967/1968. With introduction of *Limnothrissa miodon* the fish yield in Lake Kariba rose from 5.6kg/ha in 1968–1969 to 31.7– 342kg/ha in 1986 (Fernando & Holick, 1991). Table 3.21 shows the growth of the pelagic fishery based on *Limnothrissa miodon.* The maximum sustainable yield of the *L. miodon* fishery is however not known. Attempts have been made to estimate the potential yield (Lindem, 1988; Mudenda, 1989; Munyandorero, in press) but all these amount to guess work because single species models were used on a multi-species fishery. In the light of this, adaptive management is highly recommended.

Lake Kariba is a deep reservoir and its inshore fish potential is low. Moyo (1994) demonstrated the importance of depth in fish production. Early after impoundment, fish production increased because of the eutrophic state of the water. As the lake matured, fish production declined and the present yields are <3 000 tonnes from both Zambia and Zimbabwe. Catch statistics from the inshore fishery are difficult to obtain. No common management strategy between Zambia and Zimbabwe was adopted. It is only in recent years that this is being discussed. The catch statistics from Zambia and Zimbabwe are usually not comparable.

The development of the inshore fishery on the Zimbabwean shore is shown in Table 3.22 and that on the Zambian side in Table 3.23. The inshore fisheries on both shores are essentially small-scale operations characterised by use of low levels of technology.

A number of fish management regulations were introduced in Zimbabwe soon after impoundment that effectively limited the access to fishing.

Management of fisheries in Zambia is largely confined by measures such as a closed fishing season and prohibition of certain fishing methods. Fishing licensing for the artisanal sector was only introduced in 1986 in Zambia. There is no limit on the number of fishing licences that can be issued and this is largely because the capacity of the resource base is unknown. As in the case of the pelagic fishery an adaptive management strategy would be helpful.

The Participation of Local People in the Fishing Industry

Before Lake Kariba was built, the Tonga people fished for subsistence purposes. Their villages were in remote isolated areas and there was no commercial market available to them. However, accessibility increased when Lake Kariba was created and a market for the fish developed. Once fishing starts being carried out on a commercial basis, the resource potentially becomes threatened. In Zambia efforts were made to accommodate the local people in the fishing industry. In Zimbabwe no special dispensation was made for the local Tonga people who had been displaced. Fishing co-operatives have been formed on the Zimbabwean side and no special preference was given to the local people. Clearly, the local Tonga people did not benefit from the creation of Lake Kariba from a fisheries perspective in Zimbabwe. The Zambian government on the other hand was always conscious of the need to compensate the local people. In 1994, the department of fisheries developed and introduced the community approach to fisheries management. The Zambian side of the lake was divided into four zones based on chiefdoms found along the shores. In each fishing village, a Village Management Committee (VMC.) was formed by the fishermen of a particular village. The newly introduced system has proved to be popular with the local people as it brings a sense of resource ownership to them.

The Impact of Kariba on Downstream Fisheries

Eels were found in the mid-Zambezi. Adult eels live in freshwater for 20 years before migrating to the sea to spawn. The Kariba Dam wall created a barrier for the eels and their numbers have declined in the mid-Zambezi.

The building of Lake Kariba probably negatively affected the African lungfish, which lives in tropical vleis, pans and swamps. It is most probable that when Lake Kariba was built some of the swampy areas downstream dried up and the African lungfish also perished; for example, Mana Pools downstream of Lake Kariba is no longer swampy.

Limnothrissa miodon (kapenta) was intentionally introduced to Lake Kariba. A decade after its introduction the fish colonised the downstream dam, Cahora Bassa. This was an accidental introduction, which has had a positive influence on fish yield in the downstream reservoir. Table 3.21 presents data on kapenta harvests in Kariba since the beginning of Kapenta fishing in 1974.

Expected and Unexpected Impacts of Lake Kariba

No EIA that carried out when Lake Kariba was built. The expected and unexpected impacts are therefore poorly documented. However, it appears that fish production was expected to increase; but this only happened during the filling years. The local people were supposed to benefit from this but that did not happen. The introduction of *L. miodon* was an after-thought, which had a positive influence. The failure of the inshore fishery to give high yields has led to the introduction of fish cage culture on Lake Kariba in an effort to boost yields. However, if more cages are established on the lake, Lake Kariba could become eutrophic.

Table 3.21: Kapenta Fishery Catch and Effort Trends, 1974–1998 (tons)

	Zambia		**Zimbabwe**				
Year	**Catch**	**Effort**	**Catch**	**Effort**	**Total Catch**	**Total Effort**	**CPUE Combined**
1974			488	616	488	616	0.79
1975			656	1298	656	1298	0.51
1976			1050	1833	1050	1833	0.57
1977			1172	3114	1172	3114	0.38
1978			2805	5973	2805	5973	0.47
1979			5732	15108	5732	15108	0.38
1980			7952	31747	7952	31747	0.25
1981			11137	37972	11137	37972	0.29
1982	4136	18874	8350	56650	12586	56650	0.22
1983	4965	16670	8548	55535	13513	55535	0.24
1984	5959	27832	10394	69066	16353	69066	0.24
1985	7422	30304	14586	71707	22008	71707	0.31
1986	8226	32163	15747	77953	23973	77953	0.31
1987	5858	31755	15823	84169	21681	84169	0.26
1988	6319	33218	18366	86621	24685	86621	0.28
1989	7753	34897	20112	89816	27865	89816	0.31
1990	6948	37413	21758	96606	28706	96606	0.30
1991	7284	39284	19306	101492	26590	101492	0.26
1992	7672	45004	18931	116070	26603	116070	0.23
1993	8526	46416	19957	114571	28483	114571	0.25
1994	7178	36402	19232	107651	26410	107651	0.25
1995	6736	44797	15280	120240	22016	120240	0.18
1996	5728	36033	15423	109557	21151	109557	0.19
1997	5927	37170	17034	112803	22961	112803	0.20
1998	7960	43695	17034	118735	23248	118735	0.20

Source: Department of National Parks and Wildlife Management, Zimbabwe, and Department of Fisheries, Zambia

Table 3.22: Inshore Fishery Estimated Catch, 1974–1998 (Zimbabwe)

Year	Catch in tonnes	CPUE (kg/100mm net)
1974	786	
1975	772	
1976	620	
1977	656	
1978	767	3.9
1979	627	5.1
1980	876	2.4
1981	807	3.8
1982	614	3.5
1983	637	3.8
1984	837	2.1
1985	544	2.0
1986	2170	5.1
1987	2140	7.9
1988	2875	9.8
1989	1530	7.3
1990	1116	11.0
1991	1747	8.2
1992	877	6.3
1993	1280	6.1
1994	987	5.4
1995	1175	4.8
1996	958	4.7
1997	111	6.7
1998	1083	7.9

Source: Department of National Parks and Wildlife Management.

The 1998 catch estimate decreased by 2.9% (32 tonnes) compared to the 1997 estimate. There was, however, an increase in CPUE.

Table 3.23: Artisanal fish Catches from Lake Kariba, Zambia since 1983 in tonnes.

Year	Catch in tonnes
1983	1262
1984	1743
1985	1938
1986	2223
1987	3136
1988	2588
1989	2651
1990	2237
1991	1974
1992	986
1993	1196
1994	1732
1995	1938
1996	1748
1997	1886
1998	1857

Source: Department of Fisheries, Zambia

From 1966 to 1981, there are no records of catches and other activities that were taking place on the Zambian side due to raids by the Rhodesian Armies. Regular fishery activities on the lake resumed in 1980 when Zimbabwe became independent.

Key Issues with Respect to Fisheries at Kariba

Large and deep reservoirs have low fish yields. To maximise fish production, shallow reservoirs are preferable. Cichlid production, which is the mainstay of the artisanal fishery in Africa, is enhanced where there are gentle slopes, sandy soils and shallow waters.

Large reservoirs like Kariba create a large pelagic zone. Most fish found in the river where the dam is constructed are not able to inhabit the pelagic zone. The clupeids are well adapted to colonising the pelagic zone. If they are present in the river, natural colonisation will take place. However, in the case of Kariba, clupeids were not in the mid-Zambezi and introducing clupeids in large reservoirs boosts fish production, as they will fill, a vacant niche.

In Africa cichlids tend to dominate the littoral zone of a reservoir. Littoral fish production can be enhanced through cage culture. Cage culture in Kariba has been highly successful.

High fish yields will be recorded during the first few years after dam construction. The high fish yields will drop as the dam matures.

The foregoing analysis and discussion shows that successful fisheries industries can be developed on large man-made lakes. To maximise the benefits from fisheries the possible fisheries opportunities must be studied at the project design stage and fisheries must be part of the dam project document.

Fishing is one industry in which local people can participate. In large dam projects consideration must be made to encourage the participation of local people in fisheries as a way of compensating them for displacement by the dam.

3.9 Impacts of Lake Kariba on Wildlife

In this section, the impacts of Kariba Dam on the wildlife of surrounding areas are discussed. The scoping report identified the following issues with respect to wildlife:

- Was there any planning put in place to manage the wildlife?
- How effective has it been?
- And to whose benefit?
- How has the wildlife habitat fared over the last 40 years and how is it likely to fare in future?
- Are there positive links to the growth of tourism and to community interest in wildlife that might portend major land use and regional economic changes?
- What lessons have been learnt from the long conflict between wildlife and humans for space and how can the management of both humans and wildlife adapt to the situation?
- Tsetse fly has almost been eradicated from the Kariba environs. What have been the benefits of tsetse eradication? What negative factors arose or may arise as a result of the removal of tsetse fly?
- In light of the way identified benefits and costs are shared, who are the beneficiaries and victims of the Kariba Dam? Are resettled people and their descendents better or worse off? How did the project affect the livelihoods of people living in the downstream and upstream river (fishermen, traditional owners of farmlands in the floodplain)? Who are the gainers from the fishing, tourism and recreational benefits of the dam? Who benefited from the electricity generated by the dam?
- From available data and knowledge, analyse the equity and ethical aspects associated with the way costs and benefits of the dam are distributed between riverine communities on the one hand, and national and regional scales on the other hand. Discuss the sharing of benefits and costs of the dam between past, present and future generations.

- "Operation Noah" was more a case of crisis management, than an integral part of planning and implementation. Could it have been done differently?

3.9.1 The Wildlife of The Kariba Dam Basin Prior to Dam Construction

Information available on the presence of wildlife in the Zambezi Valley prior to inundation by the waters of Lake Kariba is very limited and entirely qualitative. The earliest travellers to comment on wildlife abundance in the area gave mixed reports. Selous, in 1877 and 1887 said there was little game present except in the vicinity of Kariba Gorge in 1877, while Depelchin & Croonenberghs reported that game was abundant in 1880 (Scudder, T. 1962). These impressions were probably influenced by differences in game distribution seasonally and between years.

Child (1968), who collected scientific information during the game rescue operations, listed 56 mammal species including 10 mice and shrews (Annex 11) but noted that the smaller species were not well known and his list did not include bats. Two species, blue wildebeest (*Connochaetes taurinus)* and giraffe (*Giraffa camelopardis)*, that are widespread in southern Africa were absent from the mid-Zambezi valley.

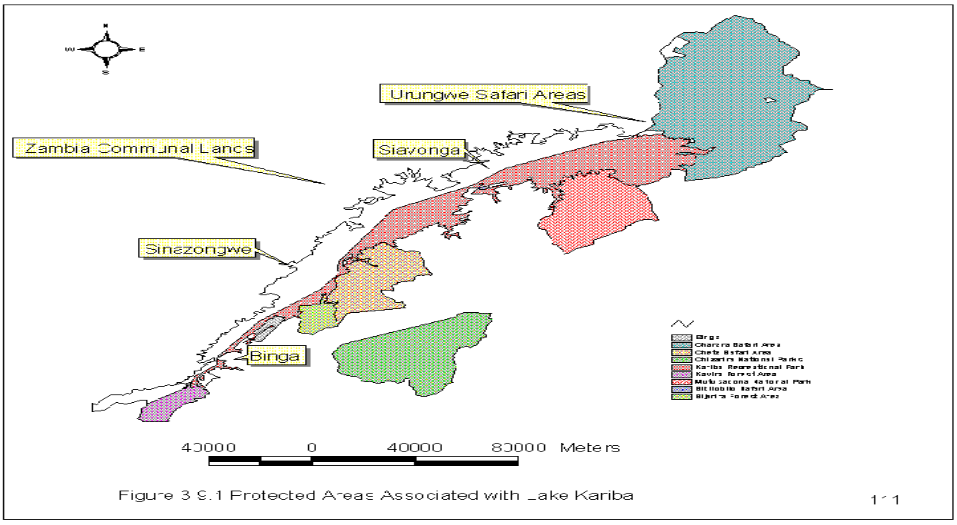
Wildlife abundance and distribution in the Lake Kariba basin was influenced by human populations; wildlife was more plentiful where human population density was low. There was more wildlife south of the river than north because human population density was higher on the north bank (Child, G. 1968).

Hunting is known to have been an important part of the way of life of the Valley Tonga but most species were reported to be still present north of the river in 1957, including elephant, hippopotamus, buffalo, zebra and smaller species (Scudder, T. 1962). There were no game reserves in the mid-Zambezi Valley on either the north or south sides of the Zambezi River.

Child (1968) gave a detailed description of game distribution on the south side of the river before impoundment. Game was generally scarce in the densely populated meander zone of the river below the Binga escarpment where the river wound through a flat, fertile, alluvial plain up to 8km wide) and became more plentiful to the east of this plain. Elephants were widespread and numerous but rare on the alluvium near Binga until 1960, after the people were moved, when they became as common as elsewhere. Conversely, hippopotamus and duiker were most common in the meander zone. Hippos favour alluvial habitats because of the availability of food and people prefer to cultivate alluvial plains, which leads to conflict when hippos eat crops, while duiker thrive in habitats modified by cultivation. Baboon and klipspringer were fairly evenly distributed while hyaena, leopard and bushpig were also widespread; but their density was difficult to estimate because of their secretive habits. Buffalo, impala, warthog and waterbuck were more numerous east of the Mwenda River. Black rhino were found between the Mwenda and the Umniati rivers and were more common away from the river where they were less accessible to hunters from Zambia with firearms, while roan, sable and zebra did not reach as far west as the Mwenda. Eland and lion were not found west of Chete. Hunting for control of tsetse fly between 1946 and 1956 in the eastern half of the Umniati basin probably resulted in less game in that area.

There was certainly seasonal movement of various wildlife species, with an increase in the concentration of animals along the Zambezi and around more permanent sources of water in pools in the larger tributaries and springs as the dry season progressed. Davison (1958, cited by Jarman, P.J. 1968) in a visit to the area some 35 miles (55km) downstream of Binga in August/September of 1958 noted that there was no concentration of game along the Zambezi, there being sufficient water away from the river, where elephant, buffalo, rhino, impala and kudu were plentiful. In an inspection of three hills that would become islands in the lake he recorded the presence of klipspringer, bushbuck, grysbok, porcupine, squirrel, night ape, wild cat, genet, mongoose (unspecified) and rodents.

Figure 3.6: Protected Areas Associated with Lake Kariba



3.9.2 Wildlife considerations in the planning for Kariba Dam

When construction of the dam was being planned it is clear that wildlife was not an important consideration. The priority was obviously the generation of power, and the potential for fish production was recognised; tourism and wildlife were not given much attention initially. In an appraisal of the project by the International Bank for Reconstruction and Development (IBRD, 1956) that was stated to consider all factors having a bearing on the suitability of the project for Bank financing, there was no mention of wildlife or the environment. This sort of approach was typical of planning during that era, when it was possible to plan a single-purpose dam and justify the project solely on economic grounds, with little concern for other aspects, even in a country as relatively advanced as the USA (Trefethen, 1973).

Although the decision to construct Kariba Dam was taken by the government of the then Federation of Rhodesia and Nyasaland, wildlife conservation outside the National Parks was the responsibility of the territorial governments, meaning that the governments of Southern Rhodesia and Northern Rhodesia were each responsible for wildlife considerations on their sides of the future lake.

The Game Department in Southern Rhodesia began in 1952 as the Game Section in the Division of Agriculture and Lands, with one game officer (Fraser, A.D. 1953) whose main duty was elephant control (G. Child, pers. comm.). In 1953, the Game Section, consisting of the game officer, one clerk and a vacant post of vermin officer was transferred to the Department of Research and Specialist Services and in 1954, the Game Section was transferred to the Department of Mines, Lands and Surveys. By the time construction of the dam was complete in 1957, the Game Section had become the Game Department.

The first mention of Kariba Dam in the annual reports of the Game Section are in 1955, when it was noted that the decision to build the dam, taken that year, offered splendid opportunities for the creation of one or more game reserves, which would be a considerable attraction to tourists. At that time various committees were set up to examine and report to the government on the exploitation of the waters and surrounding areas, including the possibility of game reserves. The game officer was appointed a member of the Kariba Lake Fisheries Committee and the Kariba Lake National Parks and Tourism Committee (KLNPTC).

The Game Department was associated with the construction process from the beginning. Activities included law enforcement, control of animals interfering with ground insecticide spraying against tsetse fly and the supply of meat for labourers. In 1955, consideration was given to the possible effect of flooding on the wildlife and it was thought that sport hunting in that part of the valley might have the effect of pushing the larger animals back to the escarpment foothills.

The necessary regulations were promulgated and hunting under permit commenced in August 1955, but it soon became apparent that the animals relied on the riverine vegetation for much of their feeding in the dry season and would not move away without a major hunting campaign. After it was agreed that two game reserves would be developed, hunting was stopped. Before closure it was realised that wildlife could be endangered by the rising water and plans were made for game rescue, but there was no precedent from which to draw experience and neither the pattern of flooding nor the reactions of the animals was anticipated (Fraser, A.D. 1958). For example, it was commonly thought that animals would just move away from the rising water and the extent to which animals would congregate and become trapped on islands was not realised.

3.9.3 Operation Noah and Wildlife Relocation during Construction of Kariba Dam

Operation Noah was the name given to the game rescue activities carried out separately on the south and north sides of the expanding lake. The dam was closed in December 1958 and for the first two weeks the rising waters were contained within the riverbeds and there was little spill-over. After that the water spread out and islands started to form. The game rescue operation started in the south and in the north four months later in March 1959.

Data are available for Southern Rhodesia where over 5 000 animals were rescued from drowning, ranging in size from squirrel to elephant. A full list with total numbers is given in Annex 12.

The first animals to be cut off from the mainland were species that inhabited the riverine habitats and included bushbuck, baboons, monkeys, genets, hyraxes, lizards, snakes and rodents, and rescue workers developed techniques to capture these species. It was then realised that the rescue operations would need to be on a scale much larger than originally anticipated. Live snakes were taken for the Salisbury Snake Park and others collected as specimens. By the end of February 1959, satisfactory techniques had been developed for capturing a range of species and more staff were committed to the operation. Six temporary game rangers were appointed and other support staff recruited. To capture animals on large islands game nets were used, up to 3m high and 200m long and drugs were used to combat the effects of shock. The larger animals that could not be physically captured were guided by boats towards the mainland and sometimes physically supported in the water. Some animals died during capture and it was found necessary in a few cases to kill animals. Later in the operation large animals such as rhino were immobilised with drugs and removed from islands on makeshift rafts.

In Southern Rhodesia larger animals were initially moved to the closest shore and released, particularly into Matusadona Reserve and many of the animals were ear-tagged in the hope of tracing their movements after release, over 800 in 1959 alone. After 1961 most animals were translocated to other parts of the country. Of particular note was the translocation of over 40 black rhinoceros to Hwange National Park. In Northern Rhodesia animals were also moved to the nearest shore and some were moved to Livingstone Game Park.

The peak rescue period was from May to July each year when the water rose the most rapidly. From September onwards the water level became more or less static and physical rescue was less necessary.

There was a lack of local knowledge of what to expect when the lake started to flood and lack of experience in dealing with the situation that arose. The governments were criticised for not doing enough and not being more aware of the requirements (Lagus, C. 1959). Soon after closure of the dam it became apparent that preparations were inadequate and in Southern Rhodesia the government increased efforts, but in Northern Rhodesia there was a shortage of funds because of a fall in the price of copper and there had been retrenchment in the Game Department. When it became apparent that the government was unable or unwilling to mount a rescue operation, funds were raised privately to start rescue and later the government also gave assistance. Although it was also suggested that the entire game rescue operation was futile (Balon, E.K. 1975), the operation caught the imagination of people all over the world and helped to trigger interest in wildlife conservation within Zimbabwe and Zambia (G. Child, pers. comm.). Experience gained in game capture was also the beginning of much larger scale capture and translocation in later years. With more resources the operation could certainly have been carried out better. For example, use of an aircraft to locate islands and trapped animals would have saved much time (G. Child, pers. comm.).

3.9.4 The Designation of Wildlife Areas as a Result of Kariba Dam

The first meeting of the KLNPTC was held in January 1956 "to examine and report on the potential value of the lake, lake shore and islands as a tourist attraction, and to consider the establishment of national parks, game sanctuaries etc". This committee concluded that the interests of resettlement of the displaced people must be of paramount importance and only areas not required for resettlement could be considered for the game reserves. Further investigations were necessary to determine whether game reserves could be created in the areas north of the Sijarira and Matusadona Range, both of which would have lake frontage, had little agricultural potential, were of no value for resettlement and were virtually unpopulated. The establishment of these two non-hunting reserves as they were known, was agreed in principle in 1957 and they were proclaimed in November 1958. There were no plans for similar wildlife conservation areas north of the Zambezi close to the future lake.

In Zimbabwe, Matusadona Non-hunting Reserve eventually became Matusadona National Park, while Chizarira Non-hunting Reserve was split in 1961 into what would become Chizarira National Park and Chete Safari Area with settlements between them. On the western side of Chete, Sijarira Forest Area is also now used exclusively for wildlife. An additional area of wildlife land, Charara Safari Area was also designated, adjacent to Kariba town, and the main access road and a group of islands and a portion of mainland near Bumi Hills was designated as Sibilobilo Safari Area. North of the access road to Kariba, designated wildlife land extends along the Zambezi downstream for about 200km. Most of the islands and a strip of land along the lakeshore became Kariba Recreational Park. national parks, recreational parks and safari areas in Zimbabwe all fall under the Department of National Parks and Wild Life Management.

In Zambia, no wildlife areas were created bordering the lake, but Chete Island, the largest island in the Lake and Kennies Island were declared bird sanctuaries. There was a proposal for the development of wildlife-based tourism on Chete Island and nearby Capstan Island in the 1990s, including the possible relocation of large mammals to Chete Island (Zambia-Zimbabwe SADC Fisheries Project (ZZSFP), 1996).

3.9.5 Expected and unexpected Impacts of Kariba Dam on the Wildlife of the Basin and Downstream areas

It is difficult to separate expected and unexpected impacts because, although the issue of wildlife was not discussed in the project documents (Federal Power Board, 1955; World Bank, 1956), the Kariba Lake Development Committee appears to have considered these issues prior to and during the construction of the dam.

3.9.5.1 Negative Impacts of the Dam on Wildlife

- **Loss of Wildlife Habitat**

There was a loss of habitat for all classes of terrestrial animals, birds, mammals, reptiles, amphibians and insects. All animals that lived in the area that was flooded, lost habitat and were forced to move. They either drowned or moved to new areas outside their previous home ranges, where they would have come into contact, and frequently conflict, with existing residents. In addition, the habitats available to animals that reached the mainland were in the relatively unproductive foothills of the escarpment rather than the more fertile valley floor. Jarman (1968) studied the changes to animal species composition and abundance associated with these changes. He compared the vegetation and wildlife present in an area on the shores of the lake with the situation in an unflooded area of the Zambezi Valley 100km downstream of Kariba.

He concluded that the loss of riverine habitats led to reductions in the numbers of hippo, waterbuck and vervet monkeys. Some birds associated with flowing water such as the African skimmer and others associated with riverine vegetation (eg, green pigeon, purple-crested lourie and trumpeter hornbill) were all reduced in abundance compared to unflooded habitats. Water dikkop and bronze-winged courser, both associated with riverbanks were also affected by loss of habitat. The breeding habitat of the rock pratincole, rocky outcrops in flowing water, was also lost.

- **Terrestrial Animals Killed by the Rising Water**

In spite of the efforts of personnel involved in game rescue on the southern and northern sides of the growing lake, many terrestrial animals perished. Animals moved away from the rising water but retreated to higher ground, which frequently became cut off from the mainland and formed islands. These animals were then restricted as the islands shrank in size until they disappeared and the animals took to remaining trees until they were forced to swim. Large numbers drowned. This process continued as the lake rose in stages each year for 5 years until full supply level was reached in 1963.

- **Animals Killed during Construction**

During construction an unknown number of animals were killed for a number of reasons. For example, in 1955, the game officer's annual report noted that 18 elephant were killed in the vicinity of the dam site to chase other elephants away from the area and to supply meat for the construction workers. In addition, 1 lion, 1 leopard, 1 hyaena and 1 rhino that caused problems were also killed.

- **Resettlement of People into Wildlife Habitats**

In 1955, it was noted in the game officer's annual report that there would be resettlement into the Kariangwe-Lubu areas of Binga District, an area where good game concentrations had been reported in the annual report for 1954. This resettlement predictably brought conflict with the wildlife resident in those areas and 64 elephants were killed in 1956, and 31 in 1957 in Sebungwe, the area between Binga, Gokwe and the Sanyati river. The problems continued, with a large number of elephants killed annually. In 1964, more land was made available for resettlement in the Binga District and 120 elephants were killed. In the same district, 17 rhino were captured and translocated to Hwange National Park to make way for resettlement.

These numbers however pale into insignificance compared to 10 000 animals killed in Sebungwe in anti-tsetse operations in 1955 alone.

- **Accumulation of DDT in the Lake**

The measures taken to eradicate tsetse fly had incalculable adverse effects on wildlife and wildlife habitats. They included the elimination of game animals from large areas by hunting, destruction of riverine vegetation, spraying with DDT, annual burning of vegetation and clearing of a vast network of tracks and roads. These effects will not be considered here, only the effects of eradication and eradication measures on wildlife in the context of Lake Kariba.

Indirect negative effects specific to Kariba have been the accumulation of DDT and DDT-metabolites washed down rivers into the lake (Matthiessen, 1984, 1985, cited in Phelps et al, 1986). In a study in 1990, Berg et al (1992) found residues in fish, both algal feeders and the predatory tigerfish, with the highest levels in the fresh water mussel (*Corbicula africana)* and bottom feeding fish.

Residue levels were, however, lower than FAO/WHO maximum levels for human consumption. DDT residues have also been found in pre-reproductive crocodiles (Phelps et al, 1989) and in crocodile eggs (Phelps et al, 1986). The effect of DDT on crocodile physiology was not known and there was no evidence that levels found were harmful to crocodiles. The levels found in eggs from Lake Kariba were not higher than in eggs other places with more agriculture.

Effects of DDT accumulation on birds were more serious and eggshell-thinning of fish eagle eggs was recorded. The effects on wildlife of DDT used in ground spraying generally, was studied by a number of workers and consolidated by Douthwaite & Tingle (1994).

- **Downstream Effects**

The changes in river flow that followed the closure of Kariba Dam adversely affected some downstream wildlife habitats. These effects were probably relatively minor in the sections where the river is confined within steep banks but much more significant in alluvial areas such as the Mana Pools flood plain and at the Zambezi Delta where the river meets the Indian Ocean.

After the lake filled in 1963, an artificial flood regime was maintained by opening flood gates in the wall, but the timing of this release was different to the natural flood regime of the river, taking place later in the dry season from about July, when temperatures are lower and the response of plants probably less. Apart from stopping the flooding that formerly occurred and stabilising the flow generally, the effect of Kariba was to impoverish the alluvia by removing the silt deposits from the river before they reached the floodplain. Attwell (1970) felt that these changes reduced the ecological dynamism, reproductive success and behaviour patterns of the fauna of the riverbanks and plains areas. Attwell (1970) predicted an invasion of the floodplain by dry woodland species but that does not seem to have happened and Timberlake (1998) concluded that although knowledge of the downstream impacts of Kariba Dam is poor even after 40 years, no significant changes in the ecology of Mana Pools have been detected since soon after Kariba Dam was closed.

The ecology of the alluvia at Mana Pools was also studied in detail by Dunham (1989; 1994). After 1958, tree density of *Faidherbia albida*, the dominant canopy tree declined, as a result of low recruitment and loss of canopy trees, but the role of flooding in woodland establishment in the past and the effect of cessation of flooding was unknown. At the same time, the density of *Macrotermes* sp. mounds increased, indicating an expanding termite population. The flood regime altered again in 1981, the last time that floodwater was released from Kariba Dam. The densities of most grazing mammals on the flood plain declined after 1981 and Dunham (1994) concluded that the long-term decline in grazer density was probably due primarily to a reduction in grass production during the dry season following cessation of flooding.

3.9.5.2 Positive Impacts of the Dam on Wildlife

- **Increased habitat for some species**

The lake environment was beneficial to some species such as crocodiles and some aquatic birds. There are no estimates of crocodile numbers in the Zambezi River prior to Kariba Dam but crocodiles were heavily hunted along the river in the 1950s. They certainly increased in number after the lake filled and in 1985 there were estimated to be around 10 000 along the southern shore (Taylor et al, 1993). There are no similar data for the north shore.

A number of bird species increased soon after the formation of the lake (Jarman, 1968). The lake environment was particularly beneficial to the white-winged black tern, reed cormorant, and darter while the jacanas used the large areas of floating weed (*Salvinia molesta* and later, water hyacinth , *Eichhornia crassipes*).

In the early stages of the lake there may have been a reduction in hippos, as discussed earlier but the development of the *Panicum* grassland on the shore led to increases in their numbers. Buffalo, that probably dropped in numbers after impoundment also increased in number when the *Panicum* grassland developed (Taylor, R.D. 1985).

- **Sustainable Wildlife Use in Communal Lands**

During the resettlement phase there was conflict between people who were moving into uninhabited wildlife habitat and the resident animals as described above. The conflict continued as settlement expanded and wildlife was compressed. Smaller species that could be easily killed were reduced in number by illegal hunting for local consumption and commercial gain but elephants and the large predators were problems and they were killed in "control" work by government officers. Apart from "problem" animals that were resident in the communal lands the existing protected areas (parks and wildlife land and forestry land) were refuges for wildlife that could enter the communal land, cause problems by crop raiding or stock killing and then return to safety. These conflict situations were often exacerbated by settlement next to the protected area boundary.

There was no benefit to the communal land residents in having wildlife, and a common attitude was that wildlife areas should be fenced and animals prevented from leaving these "islands".

The eradication of tsetse fly allowed cattle to be kept in many areas for the first time and growing numbers of domestic stock caused degradation of the former wildlife habitat outside the protected areas.

In response to these pressures, during the 1970s a new philosophy developed, of better planned settlement with integrated wildlife and agriculture (R. Taylor, pers. comm.). A way was seen of using wildlife in the communal lands that would benefit the people and take the pressure off the protected areas; this idea led to the Sebungwe Regional Plan (Martin & Taylor, 1983) and the development of the Communal Areas Management Plan for Indigenous Resources (CAMPFIRE). Although this philosophy may have developed anyway, its genesis was linked to the areas into which displaced people from Kariba were settled and protected areas that were created when Kariba Dam was built. One of the first districts to develop a wildlife-use programme was Nyaminyami, which borders on Lake Kariba and is home to communities that originally lived in areas now inundated.

- **Conclusions**

- Detailed consideration must be given to wildlife issues along with other dam development issues as early as possible in the planning stage, particularly the possibility of animals being trapped by rising waters.
- EIAs need to be carried out before the final decision to construct the dam, and should include a full investigation of all classes of animals, which is time-consuming and therefore expensive. This would require the services of a number of specialists in different fields (eg, mammals, birds, reptiles, amphibians, insects). Although an EIA is now considered obligatory for dam development projects, the inventory component of the EIA must be done in detail for large dams, since the fauna and flora of large areas of the underdeveloped world are poorly known.
- There is a need for the incorporation of mitigatory measures for adverse impacts into the Project Management Plan.

- In addition to mitigation, efforts need to be made to identify measures that would contribute positive impacts to the project (eg, opportunities to develop wildlife refuges adjacent to the impoundment).
- Thorough investigations are needed of areas to be used for resettlement of displaced people and measures taken to minimise the conflict with any resident wildlife.
- It must be ensured that a comprehensive monitoring programme is followed after completion of the dam.

3.10 Tourism Impacts of Kariba Dam

The tourism studies of the Kariba case study analyse the development of the tourism industry in and around the Kariba area resulting directly or indirectly from the construction of the reservoir. The scoping study identified tourism as one development option that was not anticipated in the original concept, yet this sector has become the pillar on which the twin towns of Kariba and Siavonga are supported. The tourism study is therefore intended to carry out a detailed analysis of the tourism impact of the Kariba Dam.

The following issues were raised in the scoping report with respect to tourism:

- What is the contribution of tourism and recreational activities around Kariba on the economies of Zambia and Zimbabwe?
- Assess employment generated by tourism and recreational activities around Kariba.
- What are the economic and social impacts of tourism and recreation on riverine communities?
- Does tourism and recreational activities have impacts on the environment?
- What is the role of Victoria Falls in the success or failure of Kariba as a tourist attraction?
- What were the year-by-year capital expenditures for the development of tourism, split into costs borne by the project, by the government and by the private sector?
- The increase in human traffic between Harare and Kariba as well as between Kariba and Lusaka and between Kariba and Bulawayo suggests an increased interest in Kariba. What opportunities are perceived to exist in Kariba? In this process, analyse the role of Kariba as a transit point between Zimbabwe and Zambia, and the benefits in trade between the two countries.
- To what market segment (socially, economically, etc) does Kariba have an appeal?
- Analyse the distribution of benefits from tourism.

Problems were experienced in of tourism studies conducted in Zambia, as there was a general paucity of data with respect to the Zambian side of the lake.

3.10.1 Kariba Town

The tourism industry in Kariba can be well attributed to the development of the infrastructure and the eventual growth of the town that was to support the successful completion and operation of the Kariba hydroelectric power station. Thus to ensure all-weather access to the construction site of the dam, first class gravel surfaced roads 100 miles long were built by April 1957.The road along the crest of the dam wall was opened to traffic and pedestrians on May 28 1959.

The first airstrip for light aircraft was in service in September 1955 and then extended to an all-weather airstrip capable of handling aircraft up to DC-3 standard. Hunting-Clan African Airways Private Limited operated this temporary aerodrome. A permanent aerodrome, on a higher ground closer to south access road, (its present site), about 10 miles from Kariba was built and opened on November 20 1958.

Kariba residential township, roughly 15 square miles in extent, was built in 16 months at a cost of £3.5 million, with a population of 10 000. Amenities were provided through the African Beer Hall Fund, and a Club for senior (white) employees. Conducted tours were introduced in March 1962 attracting 10 000 visitors and by 1965 there were over 35 000 people visited the power station per year.

VIPs were brought to see the project whenever they visited the country and were accommodated in a guesthouse and hostel controlled by the Federal Power Board. The potential for tourism was unmistakable and had been a talking point in the Kariba Lake Coordination Committee (Chapter 6).

However, the limitations to the development of tourism were the heavily wooded bush around the town of Kariba and the lakeshore, and the fact that there was no ready-made organisation to take responsibility of such a broad field. The Federal government in conjunction with the governments of Northern and Southern Rhodesia created a Lake Kariba Committee to consider the uses to which the lake might be put, other than for power generation.

From the mid-1960s, soon after Kariba's commissioning, the Zambezi Basin and the Kariba Lake became the focal point for considerable destabilisation efforts of Rhodesia and then South Africa, until 1990. In addition to the trauma of political developments the area was also affected by the collapse of mineral prices in the late 1960s, the latter leading to a serious slowing down of the Zambian economy.

Tourism facilities on the Zambian side of the lake developed later than in Zimbabwe. This is because, when Phase 1 of the Kariba Dam project was implemented, all the professional worker and labourers housing was located in Zimbabwe. Similarly all settlement infrastructure, such as sewage works, hospitals, schools, airport and guest houses were sited in Zimbabwe. One of the few main infrastructural developments that was built in Zambia was the tarred road from Lusaka. It is therefore not surprising that more large hotels were established in Zimbabwe than Zambia.

The tense political situation between Zimbabwe and Zambia that followed the completion of Phase 1 and which led to the delay in the implementation of Kariba Phase 2 also had the effect of retarding the development of tourism facilities in Zambia. The town of Siavonga was only fully developed to its present size as part of the establishment of the Kariba north bank power station in 1976.

3.10.2 Projected Impacts of Tourism in Kariba

The Federal, Zambian and Zimbabwean governments in December 1957 created the Kariba Lake Coordination Committee, whose mandate included giving advice to the three governments on the coordinated development of the Lake. Though part of this objective involved the promotion and exploration of investment activities, the impacts of the potential development of the tourism industry in the region did not feature much in its activities. Furthermore an analysis of the minutes of the Federal Hydroelectric Board indicates that the likely impacts of tourism in Kariba were not taken into account. This has been attributed to the fact that the responsible boards, namely the Federal Hydroelectric Board, established in June 1954 and later reconstituted as the Federal Power Board in 1956 paid more attention to the development of hydroelectric power supply infrastructure and thus little was devoted to tourism. It was however these infrastructural developments, which included the construction of an airstrip to enable quick access to the site, the construction of the access road to the site; the development of the Kariba township and the social amenities that came with it and the dam itself that have lead to the extensive development of tourism in Kariba.

3.10.3 Actual Impacts of Tourism

3.10.3.1 Development of Tourism

In the tourism context, Kariba is among the five airports within the basin serving as regional airports (ie, airports that serve airlines from within Southern Africa). Kariba's visitor profile is illustrated in Table 24 showing the proportion of regional and overseas visitors arriving at Kariba's selected entry points by source of markets. The table shows that approximately 20% of the visitors were regional while 80% were from overseas. Kariba is a "hub" of flights serving small airstrips in the Kariba Dam basin region. These flights make it possible to reach the lodges along the lake and in the national parks of the dam basin.

Attention still needs to be given to the development of new secondary airports to provide direct access to some of the more remote, but high potential destinations. In Zambia, the tourism facilities associated with the lake can only be accessed by road.

Table 3.24: Visitor Arrivals at Selected Entry Points by Source Markets

Entry Point	Regional Visitors	Overseas Visitors
Harare airport	41%	59%
Victoria Falls airport	34%	66%
Victoria Falls border post	62%	38%
Chirundu border post	92%	8%
Kariba border post	20%	80%
Charles Prince	50%	50%
Kanyemba border post	100%	

Source: ZTA Passenger Exit Survey (January-June 1999)

Most visitors are between the ages of 20 and 30 and can be divided into two main categories. The 20–30 year olds are mainly interested in game viewing and adventure tourism while the over 30 year olds are largely into game viewing and specialised activities like bird watching.

The main source markets of tourists for the area are from Europe, the Americas, Asia, etc, and are long-haul travellers who use mainly air transport. Regional tourists coming from neighbouring countries, and countries within the southern African region mainly use road transport. Domestic tourists travelling within their country also mainly use road transport.

The preferred activities are illustrated in Table 3.25. The total carrying capacity of Kariba area is estimated at 485 000 visitors per annum (OUZIT, 1999).

In terms of capital expenditure on tourism there was no readily available data to indicate year-by-year capital expenditures for the development of tourism. The only information available related to recent works that had been carried out, such as water augmentation and sewage refurbishment, which had amounted to some Z$50 million. With regard to housing development no information was available, except for the initial housing development undertaken to provide accommodation for staff and labour on the dam project. Attempts were made to obtain data on property values for Zambia without success.

Table 3.25: Activities by Main Source of Tourists

Activity	International Tourists	Regional Tourists	Domestic Tourists
Game viewing	X	X	X
Hunting Safaris	X	X	
Fishing	X	X	
Adventure activities	X	X	X
4-wheel drive		X	
Bird watching	X	X	
Backpacking	X	X	
Cultural tourism	X		

Source: Zimbabwe Tourism Authority

The hotel properties were based on a "values for rates" survey done in 1995. These were significantly lower that market value of these properties. The figures were given as follows:

Table 3.26: Estimated valued of Hotel Properties

Property	Estimated value
Breezes hotel	$6.5 million
Zambezi Valley hotel	$1.5 million
Caribbea Bay hotel	$12.2 million
Lake View hotel	$ 5.5 million
Tamarind Lodges	$ 1.6 million
Cutty Sark hotel	$ 7. 0 million
Most High hotel	$ 1.1 million
Mopani Caravan and campsite	$ 4.2 million

Source: Kariba Town Council

Although most of the shoreline of the eastern basin consists largely of harbours and marinas, there was no available estimate of the capital that could have been spent in constructing the facilities or the value of the boats and equipment available.

It is however believed that there are 4 000 vessels in the lake. The majority of them are houseboats (about 1 500), followed by canoes (1 120 in number) and lastly Kapenta rigs (380).

3.10.3.2 Tourism Activities in Kariba

Most of the outdoor activities carried out along the lakeshore are water based and the main reasons for tourists visiting the lake include game viewing, angling, canoeing and bush walks. In particular, boating (including power boating), fishing (including spear fishing), canoeing, scuba diving, water skiing, water rafting and sight seeing generate significant appeal. Angling (for tigerfish and bream) is one of the most popular activities, with tournaments being held annually at Msuma. However, the whole lake and rivers are open to angling all year round. The most heavily used areas are Sanyati basin (at Nyaodza, mouth of Sanyati river and Charara shoreline), Bumi Hills and Milibizi.

With regard to boating, a number of marinas of varying capacity, with storage sheds for small boats and mooring facilities for larger boats, are available in Kariba. It is estimated that currently 2 080 are on the river, within the middle section, with the majority being on lake Kariba. A wide selection of houseboats are available for spectacular trips and wildlife viewing on the shore and magical sunsets.

Tourists who are inclined to terrestrial pursuits partake in game viewing, backpacking, photographic safaris, bird watching, and hunting. In Kariba this is made possible by the existence of three extensive wildlife areas, namely Charara, Chete and Matusadona National Parks. Activities are organised from Kariba town. Tables 3.27 and 3.28 give an illustration of the hotel and lodge capacity in the Kariba area for both the Zambia and the Zimbabwe side. They list the existing hotels and their capacities in terms of rooms and beds.

Table 3.27: Lodge Capacity on the Zambian side of Lake Kariba

Lodge	Beds	Rooms
Machichi Bay	55	30
Leisure	28	14
Eagle Nest Chalets	51	18
Sandy Beach	12	6
Zambezi Lodge	50	25
Kariba North Bank	13	9
Gwembe Safaris	6	3
Nchete Island	12	6[21]
Total	227	111

Source: Zambia Tourism Authority

[21] Banana Island Lodge is still under construction

Table 3.28: Hotel Capacity on the Zimbabwean side of Lake Kariba

Lodge	Beds	Rooms
Bumi Hills	40	20
Kariba Breezes	123	41
Zambezi valley Hotel	40	15
Caribbea Bay Hotel	166	83
Lake View Inn	90	42
Forthergill Island	31	16
Cutty Sark Hotel	132	58
Most High Hotel	44	15
Spurwing Island	40	20
Total	706	210

Source: Zimbabwe Tourism Authority

The total bed capacity in the Kariba region is 933 beds and 321 rooms for both the Zimbabwean and Zambian sides with a greater proportion being in Zimbabwe. These figures show that the extent of the hotel industry in Kariba has developed far beyond what was envisaged, considering that it had not even been taken into account in the planning process and came largely as an unexpected impact.

Kariba however, experiences seasonal variations in tourism. January–March are slack months registering, in 1993, 6 000–7 000 visitors a month, while the peak period is July–October, with about 12 000 a month. These variations are typically linked to school holidays, both local and overseas, and to weather conditions.

Economic Impacts of Tourism

In analysing the economic impacts of tourism in Kariba it has been noted that revenue from tourism tends to accrue to central government rather than the Local Authority. This was the case particularly in Binga, where Local Authority officials expressed the view that tourism brings very few benefits to the people living in communal areas, except for selling crafts. While houseboats were coming to Binga in larger numbers, this brought little economic gain and led to pollution in the locality (Gunby, D. 1993). Despite this limited impact of tourism to the local communities around Kariba it is however felt those urban areas, particularly Kariba town, have benefited from tourism. Kariba has expanded as a result of tourism and local authorities have benefited from levying rates on business and residential units.

The industry has over the years – through strong backward linkages – provided extensive infrastructural services such as accommodation, food and beverage, entertainment, clothing, drugs and cosmetics, transportation, water, garbage disposal, real estate and miscellaneous manufacturing industries.

In addition, the benefits of tourism have been realised through employment, which has been manifested at three different levels:

- direct employment from expenditure on tourist facilities like hotels, shop assistants, tour guides, boat servicing and repairs and other attractions that employ people directly;
- indirect employment in businesses affected by tourism in a secondary way, such as local transport, handicrafts and banks; and
- employment generated through the construction of large infastructural works such as airports, roads, electricity networks, water and sanitation.

Kariba has been successful as a tourist destination in Zimbabwe. By 1995 bed-nights in Lake Kariba alone were of the order of 90 000, with the receipts from all tourism activities in the Zambezi valley estimated to be in excess of $35 million per annum. (ZTA, 1999). In an industry that contributes about 7% of GDP, employs over 180 000 persons directly and indirectly and is estimated to be employing about 200 000 persons during the year 2000, the role of Kariba in the national economy remains highly significant in the generation of national welfare through the tourism industry.

Although the injection of tourism into the Kariba region has had direct benefits, cognisance must be taken of the fact that the increased spending in the region has resulted in inflationary pressures. Tourists typically spend more than the local population, either because they have higher disposable incomes or they have saved for the trip and are inclined to "splurge" while on holiday. This has encouraged local suppliers to inflate their prices. Speculative profiteering by estate agencies occurring around the tourism facilities has also led to inflated prices for properties, making them unaffordable to the local people.

Environmental Impacts
The curio industry has developed as a by-product of tourism, and is a big consumer of indigenous hardwoods. Demand for curio products has increased with the expansion of the tourist industry. Localised over-harvesting of large and increasingly-rare indigenous trees is believed to be occurring at an unsustainable rate, and often illegally.

Although most of the water-related activities do not reduce the quality or quantity of water resources in the lake, maintenance of the water quantity is however important in terms of the habitat requirements of the river gorges and water-based activities in the lake. Water quality can be impaired by sewage discharges from lodges and towns, siltation due to erosion caused by riverbank developments, over-exploitation of wetland resources such as reeds and fish, and pollution by fuels and pesticides. In addition the flora and fauna, which constitute greatly, if not solely, the attraction of the lake, requires adequate supplies of good quality water. The environmental and biophysical impacts of tourism that have been observed in Kariba and their potential causes are shown in the schematic presentation in Table 3.29.

Table 3.29: Environmental and Bio-physical Impacts of tourism

Bio-physical	**Potential cause**
Land take and habitat loss	Hotel construction, airports, additional roads and access points.
Soil erosion	Roads, boat traffic, bush clearing, deforestation and increase in upgrading and maintenance costs.
Wildlife disturbance	Workers, visitors and traffic around key species and prime view points. Movement constrictions by canoes, hotels and fences, resulting in changes in animal behaviour; increased human and wildlife conflicts.
Loss of biodiversity	Trampling and picking of flora and disturbance of nesting birds, increased fire hazard.
Fire hazards and litter (waste)	Cigarettes, barbeques, tins, bottles, plastic bags.
Visual impacts and landscape deterioration	Inappropriate structures.
Loss of archaeological sites	Road infrastructure, purposeful damage.
Pollution	Motorised crafts, litter, sewage, effluent, dumps.
Degradation of water quality and quantity	Domestic water use, effluent discharge and interference with natural water flow regimes for activities such as white water rafting.

Source: Nyakunu, E.P. Tourism and its Impacts on the Environment. Paper presented at a Regional workshop, Chinhoyi, Zimbabwe, July, 1998.

Social Impacts

The social impacts of tourism in Kariba have been expressed in terms of the socio-economic developments that have taken place with the growth of the tourism industry. A view expressed by Magadza(unpubl.) states that prostitution has become endemic among women who have no prospects of moving out of the poverty trap, in an environment where tourists spend, in a day, what a family might earn in a year. Although no documentary evidence was available to make this direct link, the problem still remains a real and significant aspect of tourism externalities in Kariba.

3.10.4 Conclusions with respect to Tourism.

What follows is a list of the major findings of this study and conclusions reached with respect to tourism:

- although tourism was never considered in the planning for the Kariba project, it has become one of the largest economic activities of the Kariba Dam. This is a direct outcome of the existence of a large water body, opportunities for water sport, abundant wildlife resources in close proximity of the lake, the existence of a good tarred road, and an airport;
- it was observed that a large amount of revenue is being made in tourism in both Zimbabwe and Zambia. However, the local communities, especially the Tonga people who were displaced by the dam have not benefited in a considerable way from this development. The reason for this is that these people generally do not have the capital or the specialised expertise to enter this industry. As a result, most of the tourist dollars go to "outsiders". The little that the Tongas receive arises from the wages earned from working at the tourism facilities;
- since tourism development was not considered as part of the Kariba project at the planning stage, it is difficult to know if there are other tourism opportunities that could have been exploited. All the tourism development that has been carried out on Kariba has arisen from initiatives of individuals and independent organisations;
- the development of tourism and the activities associated with it often results in conflicts in terms of property rights. In Kariba, instances of fishing and tourism competing for land based sites, often the strategic lakeside sites, have been sited with more serious conflicts between wildlife, tourism and human settlement; and
- the growth of tourism has increased the number of visitors to the area and induced development pressures. Tourism related projects, and to a large extent agricultural ones – designed to exploit the perceived available resources – have been executed without a full understanding of the ramifications of such projects and whether long-term damage is being done. Many of the problems concern questions of capacity and priority; for example "how much tourism should the region permit?"

3.11. Hydrological Impacts on the Lake Kariba

Hydrology is one of the technical subject areas that have the longest running data at Kariba. The first river flow measurements on the Zambezi River were made as far back as 1907. It is therefore not surprising that the scoping report identified the following issues with regard to the hydrology of the Zambezi River and Kariba:

- That the hydrological studies should look at the hydrological operating regime to assess if any improvement might have been possible. It could consider whether the design of Kariba Dam and its generation capacity might have been different if the hydrological information of the preceding 40 years had been available at the design stage.
- Is it possible to build predictive models on the hydrology of the Zambezi River based on historical data collected by CAPCO and ZRA?
- Is there any need to modify the current hydrological monitoring being carried out by ZRA?
- Is the current water use regime (Kariba, Kafue and Cahora Bassa) the most desirable or the optimum for deriving optimum benefits from the current installed and the potential hydropower from the Zambezi?

- Does the incidence of droughts prove the desirability of providing a mix of thermal and hydro generating facilities in an electricity supply system?
- The lake is at its highest for the first time since 1981 - after almost 20 years. What ecological lessons can be learnt from this event? What planning lessons can be learnt from this experience?
- Is it possible to change the operating regime of Kariba to minimise the impacts on downstream areas and dams?
- What impacts will climate change have on the Zambezi River system, and hence on the hydroelectric power generation of the system?
- What has been the effect of droughts on the availability of water for power generation at Kariba, and can any lessons be derived from these experiences? Please refer to a publication by Ngara et al, on drought in Zimbabwe and possible neighbouring countries. In this analysis, apply the concept of firm energy in consultation with the hydropower engineers.

3.11.1 Review the Hydrological Analysis that Preceded the Construction of Kariba

- **Data Available for the Design of Kariba Dam**

The most important data for planning and design of dams are flow and evaporation data. For reservoirs of the magnitude of Kariba, monthly flows are required for estimating the yield of the reservoir, or firm energy, which can be produced with a specified reliability level. Data concerning flood magnitudes is also required for the design of spillways, and establishment of operating rules in order to minimise damages to the dam by floods. Table 3.30 below shows the river-flow measuring stations whose data were available in 1955 for the planning and design of Kariba Dam.

Table 3.30: Zambezi River flow measuring stations within the catchment of Kariba Dam

Station	Date Opened	Comment
Livingstone	1905	Records before 1924 considered unreliable, but the 1924 to 1955 monthly flows were used for the design of Kariba Dam.
Balovale	1926	Gauge post washed away in 1932. Station was operating between 1937 and 1941, but not rated.
Katima Mulilo	1942	Very few records were available.
Kazungula	1947	Station was not rated, and its data was not used.
Lukulu	1948	Station was not rated.
Senanga	1931	Records not available from November 1931 to June 1932, and from July 1937 to March 1943. Station was not rated
Kariba Gorge	1947	Monthly and peak flows were used during the design of Kariba Dam.
Chirundu	1943	Station was rated and the monthly flow figures were used to estimate inflows between Livingstone and Kariba Dam

- **Estimation of Monthly Kariba Inflows**

Monthly inflows into the proposed Kariba Dam were estimated using: (i) the 1924–1955 Zambezi River monthly flows at Livingstone; and (ii) 1936–1955 Chirundu flows. The differences between the Livingstone and Chirundu flows for the 1943–1955 period, which would have been inflows into Lake Kariba from the lower catchment (ie, between Victoria Falls and Kariba Dam), were related to rainfall. There were 18 rainfall stations in this lower catchment.

This relationship enabled an estimation of inflows from the lower catchment for the 1924–1955 period. The estimated mean annual flow at Kariba and Livingstone are given in Table 3.31 below.

Table 3.31: Mean Annual Flow Estimated Using the 1924/25–1954/55 Records

	Livingstone	**Kariba**
Flow in million acre feet	26.8	35.5
Flow in km^3	33.0	43.8

Monthly flows estimated using the 1924–1955 data were used to simulate the operation of the proposed reservoir, and determine the firm energy that could be generated by the proposed dam.

- **Estimation of the Design Flood**

The design flood was estimated using the flood frequency method. It was observed that for large reservoirs like Kariba, the instantaneous and daily peak flows were not important, as these could be stored in the reservoir. What was important was the peak flood volume for 1-month and 3-month periods that the reservoir would contain and safely discharge. Gibbs et al (1955) noted that the maximum flow recorded at Kariba Gorge during the 1947–1955 period was 280 000cusecs (7929 m^3/s) with a level of 1320ft (402.3m). Since flow records at Kariba Gorge covered only a limited period, from 1947 to 1955, rainfall measurements were used to estimate flood flows from the lower catchment. It was decided that Kariba Dam should be able to store and safely discharge a flood flow with a return period of 1 in 10 000 years.

The French Mission engaged by the Federal government estimated the 1 in 10 000 year design flood volume for the 3-month period using the 34 years of available flow data to be 67.8km^3 (55 million acre-feet). The consulting engineers, Alexander Gibbs et al, accepted the recommendation by the Irrigation Department that this was a slight over-estimate, and agreed on the following design flood volumes: for 1 month in March 33.6km^3; for 3 months, February–March–Apr 64.9km^3; for 1 year 107.9km^3

A submerged gated spillway was selected for discharging flood flows. The spillway would have 4 gates that rise for 2.74m above the normal retention level of 484.63m. This submerged spillway was regarded as having several advantages. Firstly, the gates would discharge a jet of water that is thrown further away from the foot of the dam, which will minimise the cost of protecting the concrete apron. Secondly, water levels behind the dam could be controlled particularly during the period of first filling. A peak flow of 8200m^3/s occurred on 25 March 1957 at Kariba Gorge during the construction of the dam. This was the highest flow ever recorded on the Zambezi River at that time, and subsequently, the design floods were evaluated and increased to 39km^3 for a 1-month flood volume; and 74km^3 for the 3-month flood volume.

During 1958, extreme flood flows from both the upper and lower catchments coincided in their arrival at Kariba Gorge. A peak flow of 16 000m^3/s passed at Kariba on 5 March 1958. This was again the largest flood ever observed on the Zambezi River. These floods resulted in the maximum 1-month flow volume being 28km^3, and the 3-month flow volume of 61km^3, which were very close to the design flood magnitudes. Therefore, the design floods were re-evaluated to 42.7km^3 for the 1-month flood volume, and 85.1km^3 for the 3-month flood volume.

It was however decided to increase the 3-month flood volume to 92.5km^3 in order to be on the safe side. The number of gates were increased from 4 to 6, with each gate being 9.1 x 8.5m. The total discharge of the 6 gates was 9500m^3/s.

- **Evaporation rates**

Pan evaporation measurements, which had been made at Livingstone, and meteorological observations at Chirundu were used to estimate evaporation rates form the proposed reservoir. The estimated evaporation rates at these 2 places were:

Chirundu 1196mm/year
Livingstone 1163mm/year

Using the above figures, the estimated average annual evaporation loss from Lake Kariba was 1434mm/year. In most of their reports and calculations, ZRA use a rounded off figure of 1500mm per year for Lake Kariba.

- **Firm Flow**

The 1924–1955 flow and evaporation data were used to estimate the firm flow available for hydropower generation. It was assumed that the top water level would be 478.5m with a live storage of 9.1m. The average annual inflow was estimated at 43km^3. From the analysis done it was concluded that the available average firm flow would be 36.4km^3, which is an equivalent of 1155m^3/s.

3.11.2 An Analysis of Hydrological Data for the Zambezi River after Kariba Dam

The effect of the increase in the record length was investigated in this study by determining if this increase had changed the characteristics of those hydrological variables that were used in the design of Kariba Dam. The design parameters, which were estimated using hydrological data, are the capacity of the reservoir to be created by Kariba Dam, and the discharge capacity of the spillway. The first task that needs to be undertaken is to determine if the increase in the record length has changed monthly and annual average flows, their variability, and distributional properties. Changes in the frequencies of annual maximum flood flows would have affected the design of the spillway.

The most important flow measuring point for inflows into Lake Kariba is at Victoria Falls. The flows of the Zambezi River at this location contribute about 75% of Lake Kariba inflows. Annex 13 shows mean monthly flows at this location for the 1924/25–1954/55, 1955/56–1998/99, and 1924/25–1998/99 periods. These data do not show any major differences in the mean monthly flows for these periods.

A t-test was performed to test the hypothesis that flows during the 1924/25–1954/55, and 1955/56–1998/99 periods were from the same population. This hypothesis was rejected at the 5% significance level for the August, September, October, November, and December monthly flows, but was not rejected during the other months. The 1955/56–1998/99 flows are generally greater than those for the previous period, 1924/25–1954/55. The increase in the mean monthly flows for these periods is about 13%. Although there are no statistically significant differences in the wet season, wet season flows for the latter period are on average 6% greater than those of the former period.

The coefficient of variation (CV) of the above 3 different time periods is plotted in Annex 14. The increase in the record length has greatly increased the CV of monthly flows by 10% during the dry season and 20% during the wet season. The mean annual flow for the Zambezi River at Victoria Falls was estimated for the three different time periods and the results are shown in Table 3.32.

Table 3.32: Mean Annual Flows of the Zambezi River at Victoria Falls

	1924/25–1954/55	**1955/56–1998/99**	**1925/26–1998/99**
Mean (m^3/s)	1045	1156	1111
Mean (km^3)	33	36	35
CV (%)	29	42	38

The hypothesis that the annual flows for the various time periods come from the same population was not rejected. Therefore there is no significant difference between the mean annual flow used in the design of Kariba Dam, and the mean annual flow based on the current and longer series of flow data. The effect of the increase in the record length on the characteristics of flood flows was analysed using the Victoria Falls flow records. Table 3.33 shows average of the annual maximum flows for the

1924/25–1957/58, 1958/59–1998/99, and 1924/25–1998/99 periods on the Zambezi River at Victoria Falls. The hypothesis that these series come from the same population was not rejected at the 5% significance level.

Table 3.33: Average of the Annual Maximum Flows of the Zambezi River at Victoria Falls

	1924/25–1957/58	**1958/59–1998/99**	**1924/25–1998/99**
Average (m^3/s)	3433	3770	3631
CV (%)	40	54	32

An analysis of the frequencies of annual maximum flows during the 1924–1958, and 1924–1999 periods was also undertaken. These flows were fitted to a Log-Pearson Type III distribution. These curves show that the earlier period tends to slightly over-estimate flood flows. The estimated 1 in 10000-year maximum flow at Victoria Falls is given Table 3.34 below. There is no significant difference between the estimate based on the earlier period and one, which combines the most recent data.

Table 3.34: Estimated 1 In 10 000-Year Annual Maximum Flood Flow of Zambezi River at Victoria Falls

	1924/25–1957/58	**1924/25–1998/99**
Flow (m^3/s)	16 700	15 200
Standard error (%)	42	27

Kariba Dam was designed so that it can safely store and discharge the 1 in 10 000-year flood volume due to inflow in a 3-month period. Annex 15 shows the estimated return periods of the highest inflow volume occurring over a consecutive 3-month period in each year for the 1924/25–1957/58, and 1924/25–1998/99 periods. These curves do not show any significant differences. Table 35 gives the estimated 3-month flow volume at Victoria Falls, which has a return period of 1 in 10 000 years. There is again no significant difference between the above estimates. The 3-month design flood volume estimated in 1958 was 85.1km^3

Table 3.35: Three-Month Flow Volumes at Victoria Falls for the Highest Flows

	1924/25–1957/58	**1924/25–1998/99**
Flow volume (km^3)	78	77

3.11.3 Implications for the Design of Kariba Dam

The increase in the record length has not significantly changed the mean annual inflow and the design flood. The CV of inflows has, however, increased. This increase would have caused the designers of the dam to increase its capacity in order for the dam to generate the same firm energy with the required reliability. Santa Clara (1988) examined the effects of the increased record length on firm energy. The firm energy for Kariba Dam was established in 1959 to be 8500GWh per year (970MW). An analysis done by Alexander Gibbs and Partners using data up to1972 concluded that the firm energy was still 8500GWh/year. A reappraisal was undertaken in 1981 by Santa Clara and gave the following results:

Firm energy based on 1924/25–1946/47 data was 8400GWh/year; and
Firm energy based on 1946/47–1978/79 data was 10500GWh/year.

A similar exercise was done using data up to 1985/86, which captured some of the droughts that occurred during the 1980s; the firm energy was estimated to be 7750GWh/year (884MW). This value is similar to the one obtained by both Shawinigan Engineering and Hydrotecnica Portuguesa (1992), and the Batoka Joint Venture Consultants (1993). Both used data up to 1991. The difference between the firm energy estimated in 1959 and that using data up to 1991 is 9%.

Such difference would not have affected the design of Kariba Dam, since the safety factor used would have taken care of such minor differences.

3.11.4 Analysis of the Impacts of Droughts on the Hydrology of the Kariba Dam

Annex 13 shows standardised annual flows of the Zambezi River at Victoria Falls. These that show inflows into Lake Kariba are highly variable. Therefore droughts are an inherent characteristic of these inflows. The following seasons had very severe droughts:

1914/15	1915/16	1921/22	1923/24	1948/49
1972/73	1983/84	1989/90	1991/92	1994/95
1995/96	1996/97			

The lowest annual flow of 390m^3/s occurred on the Zambezi River at Victoria Falls during the 1995/96 season.

The impacts of droughts on power generation within the Zambezi River basin were analysed by the Batoka Joint Venture Consultants (1993). This study noted that the 1907–1992 period had some droughts that were much more severe than those within the 1930–1989 period. The 1910–1920 and 1987–1997 periods had some very severe droughts. Firm energy, which was obtainable with a 99% reliability, was estimated for these two periods. Table 36 shows the results obtained.

Table 3.36: Firm Energy Obtainable With A 99% Reliability

Power Plants	**1930–1989**	**1907–1992**	**Difference**	
Kariba + Kafue	1625MW	1350MW	- 275MW	-16%
Kariba +Kafue+ Cahora Bassa	3525MW	3290MW	- 236MW	- 7%

The Batoka Joint Ventures Consultants were of the view that the decrease in firm energy was due to droughts. The magnitude of the decrease in firm energy, which has been attributed to droughts, is within the range that could also be attributed to several other causes. Inflows from the lower catchment, evaporation from and rainfall over the lake are not yet accurately known. Therefore while the designer would take into consideration the possible effects of droughts, it is unlikely that the 7–16% decrease in firm energy would have played an important role in decision-making. A safety factor would have been incorporated to take care of all these unknowns, including impacts of droughts.

3.11.5 Analysis of the Conjunctive Operation of Power Plants in the Zambezi River Basin

There are four major dams within the Zambezi River basin that generate hydropower. The characteristics of these dams are:

Kariba Dam:	Live storage	Live storage
	Installed capacity	1266MW
Itezhitezhi Dam:	Reservoir capacity	780 million m^3, which is stored and released for hydropower generation at Kafue Gorge Dam,
Kafue Gorge Dam:	Reservoir capacity	885 million m^3
	Installed capacity	900MW
Cahora Bassa:	Reservoir capacity	51 782 million m^3
	Installed capacity	2075MW.

Since the above dams are located within one river basin, there is a possibility that their power plants can be operated in conjunction so as to maximise the benefits. Shawinigan and Hydrotecnica (1992), and the Batoka Joint Ventures Consultants (1993) investigated this issue. The results obtained in these two separate studies are very similar. These studies established the benefits of operating these power plants in terms of the amount of firm energy that could be supplied with 99% reliability. Table 3.37 shows the results obtained by Shawinigan and Hydrotecnica (1992) of the firm energy produced for the different cases.

Table 3.37: Firm Energy for Kariba and Kafue Power Plants

	Firm Energy (MW)
a. Kariba stand-alone	850
b. Kafue Gorge stand-alone	630
c. Kariba and Kafue non-conjunctive operation	1480
d Kariba and Kafue conjunctive operation	1590

The benefit of operating these two power plants conjunctively is an additional 110MW, or a 7.4% increase in firm energy. The results of the Batoka Joint Ventures Consultants were slightly different, indicating that when Kariba and Kafue are operated as stand-alone power plants, they had a combined firm energy of 1330MW, and when operated conjunctively this is 1350MW. These figures are slightly lower than those obtained by Shawinigan and Hydrotecnica. The Batoka Joint Ventures Consultants were of the opinion that the benefits of conjunctive operation were minimal due to the Kafue Flats, which regulate naturally inflows into the Kafue Gorge Dam.

Table 3.38 shows the results obtained by Shawinigan et al (1992) when Cahora Bassa is included in the system.

Table 3.38: Firm Energy for Kariba, Kafue and Cahora Bassa Power Plants

	Firm Energy (MW)
a. Kariba + Kafue non-conjunctively	1480
b. Kariba + Kafue conjunctively	1590
c. Cahora Bassa stand-alone	1880
d. Kariba+Kafue+Cahora Bassa (a+b+c)	3470
e. Kariba+Kafue+Cahora Bassa conjunctively	3500

When Cahora Bassa is operated conjunctively with other power plants on the Zambezi River its firm energy increases by 30MW. The overall benefit to the whole system is 140MW (110MW of which is the increase of Kariba and Kafue).

3.11.6 Impacts of Kariba on the Hydrology of the Zambezi River Downstream of the Dam

There are three major features, which are downstream of Kariba Dam, and these are: the Mana Pools section of the Zambezi River, Lake Cahora Bassa, and the Zambezi River delta at the Indian Ocean.

The Zambezi River passes through a terraced alluvium in the Mana Pools region. These terraces indicate river migration. Several islands, which are due to sand deposition, occur along the river in this region. Channels that separate these islands can be as much as 100m wide.

The Cahora Bassa Dam regulates flows downstream of its location, and therefore the direct impacts of Kariba Dam on the stretch downstream of Cahora Bassa are now difficult to identify. This section will therefore concentrate mostly on the downstream effects of Kariba Dam on the section of the river between Kariba and Cahora Bassa. The issues, which were considered during the planning of the dam, will also be presented.

- **Downstream Impacts Considered during Planning and Design**

The most important issue considered during the planning of Kariba Dam was the need to ensure that water would be available for downstream water users. An international agreement was therefore entered into between the Federation of Rhodesia and Nyasaland, and the Portuguese government, which required that a minimum of 10 000cusecs (283m^3/s) should be released from Kariba Dam, unless the incoming flow was less than this value.

Another issue considered during planning and design of the dam was the manner in which spillway discharges have to be undertaken in order to avoid adverse effects on the downstream region. It was planned that water levels in Lake Kariba should be managed through a flood control rule curve. Spillway gates would, if necessary, be opened gradually to avoid excessive spillage of short duration.

- **Downstream Impacts of Kariba Dam**

Turbine releases and spillage from Kariba Dam have always been greater than 283m^3/s. Therefore, the minimum flow requirement, which was specified in the international agreement, has always been satisfied.

Kariba Dam traps all the incoming sediments from especially the Gwayi and Sanyati Rivers. Water released from Kariba Dam is expected to be erosive since it has a low sediment load and this is likely to have changed channel processes in the Mana Pools region. Kariba Dam has increased the dry season (August–October) flows by about 90%, from an average of 350m^3/s to about 700–900m^3/s. Wet season flows in the Mana Pools region have been decreased by about 40%. These changes in the flow regime of the Zambezi River downstream of Kariba Dam have caused changes in channel properties. Nugent (1983) concluded that the channel upstream of Chirundu had increased its depth by about 2m, while the width decreased. The width of the river at Mana Pools increased by 200–300m. Prior to 1981 there were several periods when flood gates were opened. This caused the discharge of high flows, which sometimes extended into the period when, without the dam, flows on Zambezi River would have been lower. These high discharges, particularly those which were occurring when normally the channel would have relatively low flows, caused the channel to degrade.

There has not been any spilling of water between 1982 and 1998, and turbine discharges have in most cases been less than 1000 cubic metres. Nugent (1988) was of the view that the Zambezi River downstream of Kariba Dam has stabilised, and no major changes in channel characteristics are expected if the releases are not greater than 1000m^3/s.

- **Analysis of the Impacts of Climate Change on Kariba Dam**

Impact on Kariba Inflows

The impact of climate change on river flows is usually determined using a hydrological model. The models employed vary in their complexity from the simple lumped rainfall-runoff models to physical -based and distributed models. There are several uncertainties relating to the use of models for this purpose. In most cases model parameters are calibrated on the basis of the present conditions, and then applied to a scenario representative of say a 2xCO_2 scenario. However the conditions that will exist in the catchment for this scenario, and which affect the values of model parameters are not known. For example, vegetation is likely to change as a result of changes in both temperature and precipitation. But the manner in which these changes will take place is not known. Furthermore the application of a rainfall-runoff model to large basins like the Zambezi River is problematic. It is impossible to apply physically-based and distributed models to basins of this scale.

The impact of climate change on Kariba inflows was determined from a review of studies of similar basins. It has been established that changes in precipitation and evapotranspiration are amplified by catchments to produce major changes in streamflow. It has been estimated that climate change will cause decreases of about 43% to the Indus River flows, 31% for the Niger, and 11% for the Nile River (Watson, et al, 1996). Mazvimavi (1998) concluded that decreases of flows of the Gwayi River in Zimbabwe could be as high as 50%. Thus, although the exact changes in Kariba inflows are not certain, if temperature increases and rainfall decreases, then inflows could decrease by 10–50%.

Impact on Hydropower generation

The impact of climate change was analysed in this study by simulating the operation of Lake Kariba for prescribed plausible changes in inflows and evaporation. It was assumed that evaporation from the lake will increase by 10%, while inflows could change by the following values, -30%, -20%, -10%, + 10%, +20% and +30%. The historical monthly inflow series into Lake Kariba were adjusted by these factors. Historical monthly evaporation figures were increased by 10%. Then the Hydrologic Engineering Centre of the US Corps of Engineers model for simulating hydropower schemes, HEC3, was used to determine the performance of Lake Kariba for the various scenarios. The version of the programme used is that modified by the SADCC AAA.3.4 Project (Shawinigan Engineering, 1992). The impact of climate on hydropower generation was assessed using the reliability with which Lake Kariba could generate 1100MW. The results for various possible changes in inflows are shown in Table 3.39. The results indicate that decreases in inflows such as reductions of 20–30% would have major adverse effects on the ability of the Kariba Hydroelectric scheme to provide the required energy. If climate change causes an increase in the variability of inflows and a decrease in inflows, then the adverse effects will be far worse than is indicated in this table.

Table 3.39: Reliability of Generating 1100MW

Change In Runoff	Reliability
-30%	56%
-20%	71%
-10%	84%
Historical flows	88%
+10%	90%
+20%	93%
+30%	95%

The impact of climate change on lake levels was also analysed using HEC3. The probabilities of the lake having a level less than 476m (minimum operating level = 475.5m), and greater than 488.0m (maximum retention level = 488.5m) were determined for the various scenarios. These are shown in Table 3.40. The simulation was done for generation of firm energy equal to 1100MW.

Table 3.40: Probabilities (%) Of Lake Levels Less Than 476 And Greater Than 488m

Scenario	Less Than 476m	Greater Than 488m
-30%	52	0
-20%	35	2
-10%	20	11
Historical	16	19
+10%	13	25
+20%	10	30
+30%	8	34

The above probabilities were calculated using all the months simulated.
The results show that with a 20–30% decrease in inflows, Lake Kariba would rarely fill up.

3.11.7 Implications for Reservoir Planning and Design

All water resources systems, including dams like Kariba Dam were planned and designed assuming that all hydrological variables especially runoffs are stationary. The climate and hydrology in the future were assumed to be similar to experience in the past. Dams such as Kariba Dam are designed to satisfy the water demand with a specified reliability during their lifetimes. Lifetimes of major dams like Kariba are of the order of hundred years.

When Kariba Dam was designed, the possibility of climate change was never considered. The reliability of this scheme was therefore assumed to be stationary. But results of investigations done, particularly during the 1980s and 1990s, have demonstrated that the climate is likely to change, which will cause a change in the reliability of the reservoir. However, the greatest challenge at the moment is that we do not have sufficient information on the regional specific impacts of climate change. If information about climate change was available at the time of the design of Kariba Dam, it is likely that a larger safety factor could have be been adopted when selecting the reservoir capacity. A larger capacity of the reservoir could have been selected in order to ensure that a high reliability level is maintained even under climate change conditions. However, Kaczmarek (1990) showed that a very large and prohibitively expensive dam would be required to overcome the decrease in reliability due to climate change

3.11.8 Application of Predictive Models to the Hydrology of the Zambezi River and Kariba Dam

- **Main Purposes of Forecasting Models on the Zambezi River**

The major objective of using predictive hydrological models on the Zambezi River in the context of Kariba Dam is to forecast flood flows. Lake Kariba was designed so that it has a very large storage per unit elevation plus a discharge capacity through its spillways, which would enable it to handle large flood flows (Santa Clara, 1988; Shawinigan, 1994).

Kariba Dam was designed so that it can store and safely discharge a 1 in 10000-year inflow of 92.5km^3 over a 3-month period. However, the dam was not designed to store such an inflow when it is already at its maximum retention level. Therefore in any wet season, water levels in the lake have to be managed so that the lake can safely discharge such flood flows if they do occur.

In order to achieve this management objective, information about the magnitude and timing of expected flood inflows into Lake Kariba is required. This information is derived using flow-forecasting models, as discussed by Shawinigan (1994).

- **Adequacy of the Predictive Models**

The performance of the predictive models that are currently being used, could be improved by improving the quality of the input data particularly on the upper Zambezi catchment. This will require the standardisation of gauge plates and observation procedures. Rating curves of some of the stations require improvement.

There is an urgent need to increase the density of rainfall stations used in flow forecasting. Estimation of rainfall based on satellite images is likely to assist in providing rainfall data for those areas with a poor coverage of rainfall stations. This is particularly important for the Angolan section of the upper catchment where physical measurement of flows is being made difficult by the prevailing security situation.

Flows from the lower catchment are difficult to forecast because they have steep slopes and are therefore “flashy” in nature. The monthly lead time is also too long for this area. Forecasting of flows from these rivers requires daily rainfall data. The other limitation is that long-range rainfall forecasting is still poorly developed, and therefore forecasting methods that use rainfall as the only input variable cannot have lead times greater than a week.

The amount of water stored at various levels within the Barotse Plain is also not clearly known due to lack of accurate topographic data of this flood plain.

The relationship between the Zambezi and Chobe Swamps in terms of inputs and outputs has not been clearly defined. This affects the accuracy of forecasting flows at Victoria Falls.

3.11.9 Expected versus Unexpected Impacts of Kariba Dam with Respect to Hydrology

- **Expected Impacts**

The Zambezi River flows downstream of Kariba Dam have increased during the dry season, and decreased during the wet season. It was expected during the design of this dam that it would regulate the Zambezi River flows due to its large storage capacity. It was also expected that due to this flow regulation, spillway discharges could extend into the May–August period, which without the dam would not have large flows.

Spillway discharges have caused the erosion of the channel immediately downstream of the dam. Measures to minimise the adverse effects of this erosion were therefore put in place when the dam was designed (ie, stabilisation of the stilling pool).

The reservoir created by Kariba Dam has inundated an area of about 5577km^2 that was mostly uninhabited, and this had also been expected.

- **Unexpected Impacts**

The available flow data up to 1955 were inadequate for accurately determining the magnitude of the design flood. Flow data obtained in 1957 and 1958 caused a re-evaluation of the design flood. Flow data that were available by 1955 did not indicate that periods with generally below average flows could extend for over 11 years. No plans for alternative sources of power generation were therefore put in place in the event that such situations occurred and caused a decrease in power generation.

Kariba Dam has caused changes in the channel morphology at some downstream sections of the Zambezi River. There were no measures put in place to minimise adverse effects that may result from these changes.

The historical hydrological data that were available at the time Kariba Dam was designed was assumed to be representative of future conditions. The possibility of climate change occurring during the lifetime of this data was not considered. Climate change has the potential to affect the reliability of Kariba Dam with respect to firm energy that will be available in the long-term. Furthermore, although the evidence available is rather inconclusive, Lake Kariba could have changed the local climate (eg, increase in atmospheric moisture content leading to increased rainfall).

3.11.10 Conclusions with Respect to Hydrology

In the Kariba case study, the following conclusions were reached with respect to hydrology:

- hydrological data is not always available at sites where future dams will be located. Therefore extrapolation of data from sites with data will always be inevitable in order to overcome the problems encountered during planning and design of dams at sites with inadequate data;

- countries should be encouraged to establish networks of stations measuring both hydrological and climatological variables. These networks should cover the major physiographic regions of each country. While the maintenance of such networks seems, in the short-term, to be a costly exercise without any significant tangible benefits, the long-term development of water resources will depend on the availability of these data;
- conflicts such as civil wars and major economic down-turns within a country adversely affect routine monitoring of hydrological variables;
- organisations involved in such conflicts need to be sensitised about the importance of the data collected for long-term development of the country, especially after these wars;
- international rivers require the full co-operation of the basin states for their monitoring. The setting up of joint river basin authorities or commissions will greatly facilitate both the monitoring and management of these rivers. Data of reasonable quality is still being made available on the Zambezi River due to the existence of the ZRA;
- the usefulness of predictive or forecasting models will greatly depend on the quality and adequacy of data on which these models are based. With regards to international rivers, the quality and adequacy of data made available by each of the basin states will determine the usefulness of these predictions or forecasts;
- optimisation of water use is rather difficult to achieve on hydropower plants on international rivers in developing countries, where optimal operation of these power plants requires that some countries have to import power from one or more countries, and then pay for this power using foreign currency. In addition, optimal operation is also difficult to achieve when these power plants are under the management of different utilities;
- droughts are an inherent characteristic of semi-arid regions. The failure of any dam to provide the required water is a distinct possibility, which can occur during the economic lifetime of a dam. Measures for minimising adverse impacts of such an eventuality should be included during the planning of dams in semi-arid regions. With respect to dams for hydropower generation, one of the measures which can be considered is the importation of power from regions or sources which are not likely to be affected by the same drought;
- the impacts of climate change were not taken into consideration during the planning and design of dams 20 or more years ago. It was assumed that future climatic conditions would be similar to the past, but it is now widely accepted that climatic conditions in the future may change. While the possible changes are reasonably understood at the global level, the likely changes in climate at the catchment level are unknown. Further, there are several uncertainties regarding the hydrological response. The available evidence suggests that any changes in rainfall and evapotranspiration will be amplified in terms of changes in runoff. Therefore, climate change may in some regions decrease or increase the reliability of dams. This uncertainty has to be taken into consideration when designing water resources projects; and finally
- hydrological data is extremely important in the design of large dams to ensure dam safety. The unprecedented floods that occurred at Kariba Dam in 1957 and 1958 clearly exemplify this conclusion. The spillway design for Kariba was changed twice as a result of these floods. If the two extraordinary floods had not occurred, the spillway gates for Kariba would have been constructed smaller than they are today with the result that the dam may have failed in floods that were experienced after construction.

3.12 Public Health and Water Borne Diseases Impacts of Kariba Dam

The establishment of a lake at Kariba, in an area that is semi-arid, created opportunities for the incidence and propagation of water borne diseases and a risk to public health. However, in reading the Kariba project document (Federal Power Board, 1955) it is clear that the planning process for the dam did not consider the possible impact of the lake on the incidence of water borne diseases. The project document confined itself to civil engineering and hydropower issues. The only health issue that was included in the project planning process was the provision of adequate health facilities for the workers on the dam project, including the construction of a well-equipped hospital.

The scoping report for the Kariba case study identified the following issues with respect to public health and water borne diseases:

- review the impact of the dam on health of the people of the basin, in relation to the incidence of water borne diseases, for example human schistosomiasis;
- examine the relationship between tourism and the incidence of communicable diseases (eg, HIV, AIDS and sexually transmitted disease (STD)); and
- the study needs to review the disease epidemiology patterns following the formation of the lake with reference to bilharzia, malaria, common infections and diseases in the villages and urban settlements around Lake Kariba. This must now also include STDs, HIV and AIDS, which have an important relationship to social patterns and to communal dysfunction.

3.12.1 The Situation of Water Borne Diseases in the Zambezi River Basin Prior to Kariba

Although health issues were not included in the Kariba project document, the Kariba Lake Coordinating Committee through the participation of health officers from both Northern and Southern Rhodesia considered these issues. These health officers commissioned surveys of the incidence of diseases prior to the lake and instituted programmes for disease control after the establishment of the lake.

Schistosomiasis

According to the medical report prepared prior to construction of Kariba Dam, intermediate host snails for schistosomiasis were not present at the proposed site of the dam (Webster, M.H. 1960). The snails were, however, present north of the gorge where the dam wall was to be built. It was anticipated that construction workers would not be at risk of contracting schistosome infections since the area to be dammed was considered too rocky and therefore unsuitable for snail colonisation (Webster, M.H. 1960). The fear of outbreak of schistosomiasis once the dam filled up was, however, forecast.

An assessment of the medical implications of Kariba Hydroelectric Scheme considered schistosomiasis unimportant in Siavonga because the prevalence of the disease in indigenous people was low (Webster, M.H. 1960). *Schistosoma mansoni* was not mentioned in that report. The implications of drawing labour force from schistosomiasis endemic areas (Zambia and Zimbabwe) on transmission of the disease were realised and all incoming labourers were screened and treated. A prevalence of 45% for *S. haematobium* was recorded among the immigrants who came to Kariba during the construction phase. Considerations aimed at preventing an outbreak of schistosomiasis were made prior to commencement of construction activities at Kariba, although a poor prediction was made that schistosomiasis would not be a problem if immigrants were treated upon arrival. Considering the period (1950s) in which the dam was constructed it is impressive to note that a medical report highlighting possible negative health impacts was produced. Establishment of a health delivery centre at an early stage is evidence of the seriousness attached to health issues.

Malaria

Anopheles arabiensis is the major vector for malaria in the area around Kariba. Before construction work of Kariba Dam, the vector mosquito for malaria was already present and malaria was recognised as a problem, hence the aerial spraying with DDT before construction workers were brought to the site. An increase of the vector was anticipated because of the inevitable creation of borrow pits during construction of the dam.

3.12.2 The Situation of Water Borne Diseases in Kariba Area in the Life of the Dam, including the Construction Phase.

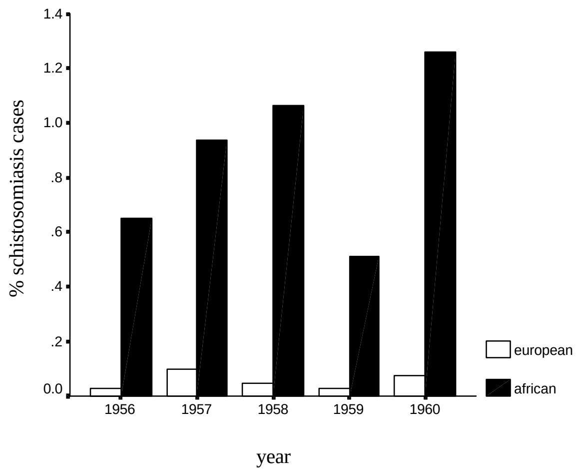
Schistosomiasis

Systematic records of common illnesses, including schistosomiasis treated at the hospital run by the Federal Power Board show that schistosomiasis was a common infection among construction workers.

Records from annual reports of the Federal Power Board show that more African than European workers were attended to with complaints of schistosomiasis between 1956 and 1959 (Figure 3.7). It must, however, be noted that proportionally, Europeans were fewer than Africans.

Studies conducted following the filling up of the dam showed the presence of *Biomphalaria pfeifferi* (intermediate host for *Schistosoma mansoni*) *and Bulinus globosus* (intermediate host for *Schistosoma haematobium*) on the Zimbabwean side (Blair Research reports, 1967) and *B. pfeifferi* and *B. africanus* but no *B. globosus* on the Zambian side (Hira, P.R. 1970a). Hira (1970a) confirmed the involvement of *B. pfeifferi* in transmission of schistosomiasis but only implicated *B. africanus,* as no natural infections were found in the latter. He showed that presence of snails on the lake followed a seasonal pattern suggesting seasonal transmission of schistosomiasis. A recent publication, however, suggests that what Hira (1970a) referred to as *B. africanus* could have been *B. globosus* (Brown & Rollingson, 1996).

Figure 3.7: Annual Numbers of Schistosomiasis Cases Attended to at the Federal Power Board (FPB) Hospital
(In percentage of the total labour force)



Source: *FPB Annual Reports and Accounts, 1956-1957*)

Van der Lingen (1973) reported an increase of snails in Lake Kariba at depths less than 5m, from 1964 to 1967. Dispersion of the snails was facilitated by drifting *Salvinia auriculata*. Reports of snail surveys conducted by Blair Research Laboratory confirmed the increase in snail numbers and the role played by *S. auriculata*. The areas reported as harbouring snails were Kariba township stream, Yacht club, Andora harbour and commercial fisheries harbours. In all the sites, infected *B. globosus* and *B. pfeifferi* were found. Poor sanitary conditions and discharge of effluent from sewage maturation ponds were responsible for the contamination that resulted in the observed snail infections. On the Zambian bank, Hira (1970b) mentioned the government harbour, Leisure Bay Motel, Siavonga water pump, Sampakaruma boating club sites, government campsite, Joc's boat hire, Kanyerere, Marine services, Game compound, Eagles Rest Chalets and Matinangala as areas where snails were found. Only *B. pfeifferi* were found infected. All the sites where snails were found were those frequently used by humans for domestic, recreation or occupational purposes. As on the Zimbabwean side, these sites were subjected to faecal contamination directly or through discharge from sewage stabilisation ponds.

10 years following the construction of the dam, hospital records showed that schistosomiasis was a local problem and not necessarily associated with immigrants only. Complaints of diarrhoea and haematuria from individuals who had had contact with water at Andora harbour and Kariba Yacht club were attended to at the hospital. Between March and May 1967, there were at least 5 cases of the acute form of schistosomiasis (Katayama Syndrome).

The first systematic survey on the Zambian side of Kariba Dam was conducted by Hira (1970a, 1970b). Prevalence of *Schistosoma haematobium* was found to be 69% in children and 29% among adults, while the prevalence of *S. mansoni* was 16% and 6% in children and adults, respectively. On the Zimbabwean side, a survey conducted in 1967 showed prevalences of 23.7% for *S. haematobium* and 19% for *S. mansoni* among Europeans. Thus, it became clear that infection was being contracted on the lake. After more than two decades following the survey by Hira, another survey was conducted at Siavonga (Mungomba et al, 1998). Prevalence of *S. haematobium* was found to be 17% and that of *S. mansoni* was 56%, indicating a reversed trend to that reported by Hira (1969). At Matinangala where people were resettled soon after the flooding of the lake, the prevalences were 88% and 75% for *S. haematobium* and *S. mansoni*, respectively. Higher prevalences at Matinangala than Siavonga were attributed to better facilities at Siavonga than Matinangala.

Routine records at Kariba Hospital and its health centres for the period between 1960 and 1994 were not available for inspection, but active surveys conducted by Blair Research Laboratory (Table 3.41) and some records from Siavonga Hospital (Figure 3.8) indicate that schistosomiasis was increasingly becoming a public health problem. Results of the Blair Research Laboratory (1967) indicate that *S. mansoni* was predominant over *S. haematobium* and that the prevalence among children was higher than that among adults. This is consistent with observations made on the Zambian side.

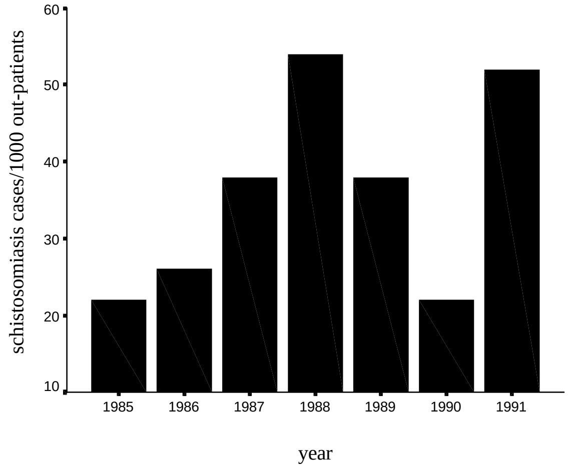
Table 3.41: Results of schistosomiasis surveys conducted around Kariba town

Year	Area	Population Category	Prevalence of *S. haematobium* (%)	Prevalence of *S. mansoni* (%)
1967	Kariba Town	Adult workers	13.3	8.6
1979	Mahombekombe Nyamhunga	School children School children	54.6 48	68 64
1984	All government depts and industries	Adult employees of all government departments and private sector	9.4	14.3
1985	All government depts and industries	Adult employees of all government departments and private sector	4.8	8.1
1986	All government depts and industries	Adult employees of all government departments and private sector	8.4	10.5

Source: Blair Research File B/A/6

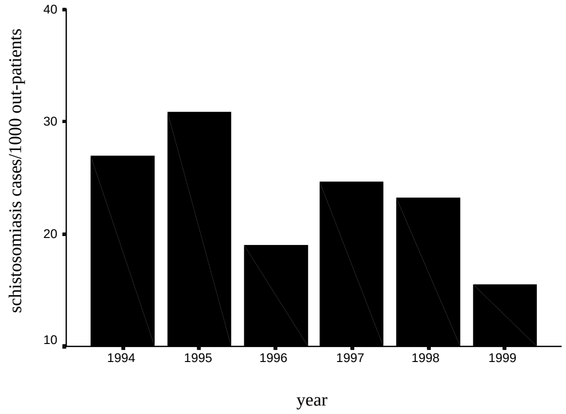
Siavonga records (Figure 3.8) show a gradual increase in number of cases from 1985 to 1988 followed by a slight decline until 1990. Mungomba et al (1993) who analysed the results gave no explanation for the cyclical pattern. The number of schistosomiasis cases attended to at health centres in Kariba district of Zimbabwe decreased in the period from 1994 to 1999 (Figure 3.9).

Figure 3.8: Annual Numbers of Schistosomiasis Cases per 1000 Patients attending Siavonga District Hospital



(Source: Mungomba et al, 1993.)

Figure 3.9: Annual Numbers of Schistosomiasis Cases per 1000 Patients attending Health Centres in Kariba (pooled data for 9 centres)



Kariba Hospital was originally designed to cater for 10 000 construction workers and was adequately staffed as part of the dam construction budget. In 1962 the labour force was reduced to 2000 comprising mainly maintenance personnel but it is pleasing to note that the hospital remained with its full staff complement. However, as the dam filled up, more people aggregated around the lake for various purposes including fisheries industry, hotel industry and tourism. Within a decade from the time the dam filled up, health services were beginning to be over-stretched. Human contact with water and thus contamination also increased, as sanitary facilities were inadequate, with incidence of sewage effluent being discharged in the lake, thus contaminating the water.

Schistosomiasis Control Efforts

By 1967 exploratory surveys were made with the ultimate objective of formulating a schistosomiasis control strategy on the Zimbabwean side. In 1969 similar work was done on the Zambian side. At that time the objective of controlling schistosomiasis, which had begun to receive attention at the number of cases in hospitals increased, was to protect tourists and the few Europeans who lived in Kariba.

All efforts regarding control of the disease were concentrated on the African community and unnecessary restrictions imposed upon them. For example, workers were only allowed to enter “tourist areas” if on duty. Some of the recommendations made in 1967 by one Blair Research officer following his visit to Lake Kariba recommended that action should be taken “to discourage township Africans from visiting the bay at the Yacht club, thoroughly test, regularly, all Africans living at the club and employ Africans to bring boats to jetty so that European owners and tourists board without water contact.”

These control efforts however only exacerbated the situation more, since Europeans went unchecked for the disease without knowing that some of them were heavily infected. Dr Shiff, in his 1967 report made it clear that something more serious had to be done to control schistosomiasis on the lake. He wrote: “Kariba imposes problems never before encountered in Rhodesia, or for that matter in the World, and here we need to use new techniques”.

The commitment of Blair Research Laboratory and the government’s concern of the welfare of tourists led to a well-coordinated schistosomiasis control programme with emphasis on snail control, which was the World Health Organisation’s (WHO) recommended strategy at that time. Areas suspected of harbouring snails were surveyed regularly and sprayed with niclosamid and shorelines were kept clear of weeds, particularly *Salvinia auriculata*, which was known to reintroduce snails in sprayed areas as it drifted to the shoreline. Systematic surveys of all residence in Kariba were eventually effected. The Lake Kariba Area Coordinating Committee was established and it met on a monthly basis to discuss schistosomiasis control activities and the funding implications. The committee comprised all stakeholders in Kariba, inclusive of commercial fisheries, government departments and hoteliers. Stakeholders met the costs for control activities, although there was one company that was not co-operative and did not participate in control activities. In 1968 the total cost of applying molluscicide (niclosamid) at specific sites within the controlled area was quoted as £1 372 per year. The harbour used by the company that refused to participate in the control programme, became a source for snails that spread to areas where control efforts were made.

The systematic control programme was well implemented until the 80s, at which time the Blair Research Laboratory’s commitment and that of participating stakeholders waned. Nevertheless, good progress had been made, as was evident from the health statistics. In 1995, an attempt was made to revive the control activities under the leadership of the town council but controversy over funding arose. To date no control programme has been implemented. Contrary to efforts made on the Zimbabwean side, not much was done on the Zambian side until about the 90s when the government of Zambia became seriously concerned about the protection of tourists in order to avoid negative publicity. There are current negotiations for Kariba town council and that of Siavonga to share experiences and begin a control programme on the Zambian side.

According to the 1992 census of Zimbabwe, the population growth rate for Kariba was 3.13% per year with a rural population of 27 717 and an urban population of 21 039 giving a total of 48 756. The current total population for Kariba is approximately 60 631. In Siavonga, the population was estimated at 5 348 in 1991 and was projected to be 12 490 by year 2000. The health service delivery system in Kariba appears to have responded well to the population growth of the area surrounding the Lake (Table 3.42). However, general drug shortage coupled with low staff levels has recently compromised the quality of services at Health Centres particularly in Zimbabwe.

Table 3.42: Establishment of Health Centres in Kariba District over years

Health Centre	Catchment Population	Year established
Kariba Hospital	1995	1959
Siakobvu	4919	1975
Nyamhunga	16544	1979
Negande	4152	1983
Gache Gache	2237	1984
Msampakaruma	3472	1984
Kanyati	6765	1987
Chalala	1848	1991
Mahombekombe	7326	1982

Malaria Control Efforts

During the dam construction phase, all workers were required to take prophylactic drugs for malaria. Despite the prophylactic provision, cases of malaria were recorded at the hospital. Figures 3.10 and 3.11 show malaria cases in the period from 1956 to 1960. There is no distinct consistent pattern over years but it is clear that many cases were registered in 1956. Two Europeans and one African died of cerebral malaria during that year. Europeans accounted for more cases in 1956 and 1957 and thereafter the African cases increased. This is not surprising as most of the Europeans relocating to Kariba were not previously exposed to malaria and hence lacked immunity. The reversed trend observed after 1956 may be an indication of better compliance to prophylaxis by the Europeans than the Africans. Differences in types of accommodation for the two groups may also explain the high numbers of cases among Africans. Housing for Europeans was much better than for Africans (Kariba Project Report, 1955).

Figure 3.10: Annual Numbers of Malaria Cases Attended to at the Federal Power Board Hospital (In percentage of the total Labour Force)

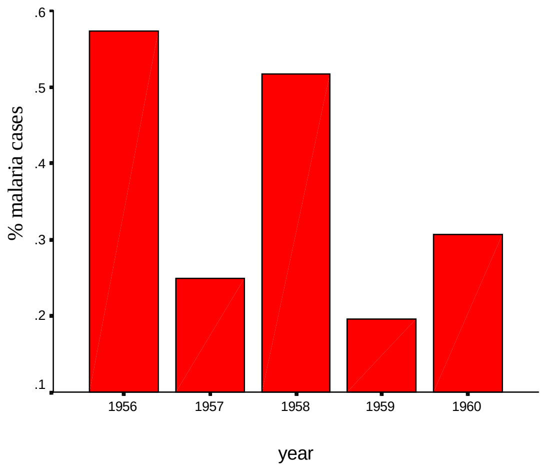
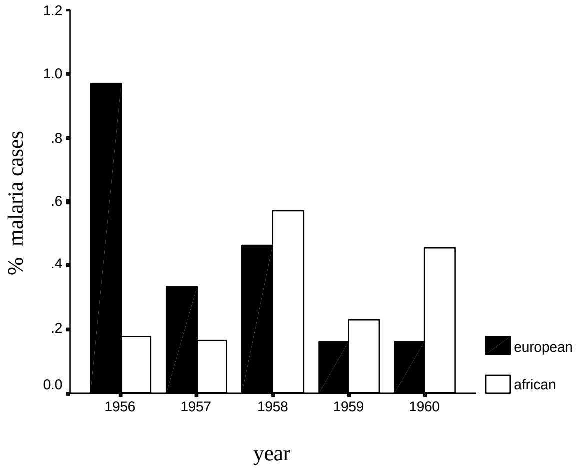


Figure 3.11: Annual numbers of malaria cases attended to at the Federal Power Board Hospital for Europeans and Africans expressed as a percentage of the total labour force.



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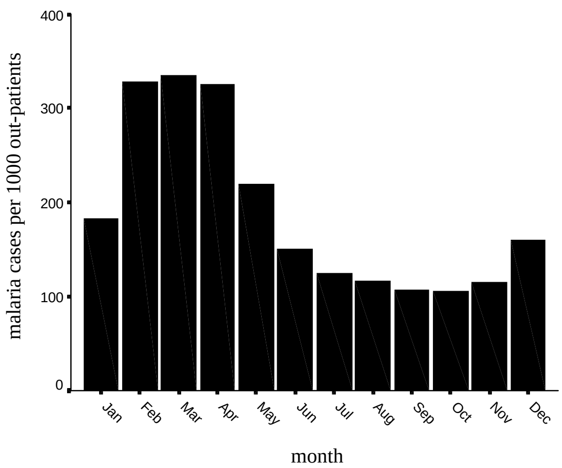
Studies conducted in the area around Kariba show that vector abundance follows a seasonal pattern that coincides with that of malaria transmission. The peak transmission period is between March and May. These studies indicate that Kariba Dam has not significantly changed this pattern, which seems to be determined more by rainfall pattern. Vectors are abundant towards the end of the rainy season. Recent statistics from health centres in the Kariba district also show a typical seasonal variation experienced in most endemic areas in Zimbabwe (Figure 3.12). Most of the cases are between February and May.

Figure 3.12: Monthly Numbers of Malaria Cases per 1000 Patients Attending Health Centres in Kariba (pooled data for 9 centres)



The presence of the transmitting vector as well as a human reservoir of the malaria parasite in Kariba prior to dam construction indicated the potential of an epidemic as construction workers were moved in. All workers coming from non-endemic areas, particularly the Europeans were at greater risk of contracting malaria.

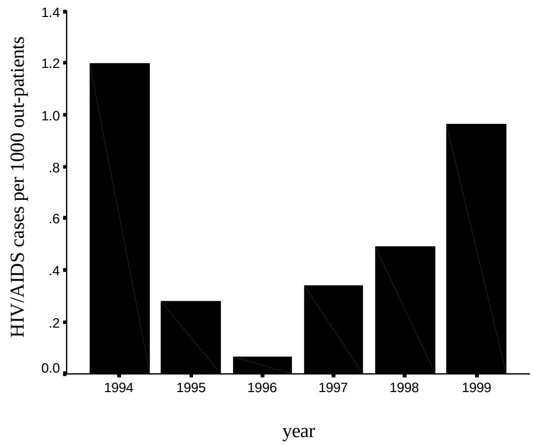
The contribution of Kariba Dam towards the risk of malaria was mainly in the construction phase and is attributed to creation of borrow pits, poor living conditions, lack of appreciation of the importance of prophylaxis and high susceptibility among the immigrants. Flooding of the dam did not in any way worsen the malaria situation, as the vector mosquito does not breed in large water bodies. The similarity of transmission patterns in Kariba in relation to other areas within the same region but far from the lake, indicate that the influence of the dam is insignificant.

3.12.3 Influence of Lake Kariba on incidence of HIV/AIDS and other diseases

During the construction phase of the dam, HIV/AIDS was not yet known and possibly did not yet exist. Sexually transmitted diseases (STDs) were, however, known and the annual reports of the Federal Power Board reflected high numbers of sexually transmitted infections (STIs).

With increasing population and growth of the tourism industry, cases of STIs have increased with time. The problem of HIV/AIDS was exacerbated by the growth of the town, particularly the fishing and tourism industries. Improved incomes resulted in an increase of disposable cash, which created a good medium for promiscuity. Statistics from health centres around Kariba show high numbers of HIV-related illnesses in 1994, and low numbers in 1995 and 1996; and a sharp increase from 1996 to 1999 (Figure 3.13). The high numbers of HIV/AIDS cases observed in Kariba are comparable to those of other urban areas like Chiredzi and Beit Bridge in Zimbabwe and therefore may not be directly related to the dam. Tourism may however be a contributing factor to increased cases of HIV-related illnesses. Studies conducted in Zimbabwe have suggested several factors believed to be responsible for high incidences of HIV. These factors include, high incidence of STIs (Latif et al, 1989), multiple partnerships and commercial/casual sex in the absence of protective measures (Gomo et al, 1998) and use of intravaginal herbs (Runganga et al, 1996; Wilson et al, 1991), just to mention a few. However, there has been no indication to date, that some of these factors are influenced by dams.

Figure 3.13: Annual Numbers of HIV/AIDS Related Cases per 1000 Patients Attending Health Centres in Kariba (pooled data for 9 centres)



The records kept at Kariba hospital from 1956 to 1960 show that gastrointestinal and respiratory infections were among the most reported cases and these were largely associated with poor living conditions at that time. Number of cases gradually decreased, as the living conditions became better.

3.12.4 Conclusions

- Construction of Kariba Dam led to an increase in the transmission of schistosomiasis by creating a suitable habitat for intermediate host snails and promoting human contact with water.
- The unexpected declining trend of schistosomiasis cases at health centres needs further investigations to establish the actual extent of the disease.
- The influence of the Kariba Dam project on transmission of malaria was only during the construction phase when borrow pits were created. After completion of the dam wall and flooding of the lake, the impact of the dam on malaria became minimal, as the vector mosquito for malaria does not breed in large water bodies.
- Transmission of HIV/AIDS is high in Kariba largely because of the tourism and fisheries industries. The situation of HIV/AIDS cannot be directly attributed to the dam, as the situation is typical of

situations in other urban areas. However, during construction, increase in STI was directly related to dam construction activities, as most of the construction workers were immigrant workers who stayed separate from their spouses, a situation known to promote promiscuity.

- Other diseases associated with poor living conditions (eg, gastrointestinal and respiratory infections) can only be attributed to the dam project during the construction phase when sanitary facilities were inadequate. At present, the living conditions are very poor in some residential areas but this should be viewed as a problem of urbanisation and only indirectly attributed to the dam, which is a catalyst for the urbanisation taking place in Kariba.
- Dam construction introduces or exacerbates transmission of schistosomiasis. The situation may, however, be contained if proper impact assessments are done during the feasibility studies. In the Kariba project, emphasis was placed on protecting construction workers and the responsibility for post construction phases were not seriously considered.
- HIV/AIDS is not directly influenced by the creation of dams. However, where tourism becomes an important activity, cases of HIV/AIDS are likely to increase.
- Planning for disease prevention or control measures in dam projects must consider non-project individuals who, if ignored, may introduce new infections or worsen those that exist.
- Racial or/and class discrimination in the provision of social and health amenities may be counter-productive as the neglected groups will continue to harbour infections and contaminate the environment. In Kariba Europeans had better housing than Africans and were believed to be free from schistosomiasis infections. Consequently, Europeans were not screened for infection until at a later stage when some of them suffered acute infections. Squatters who settled near the dam construction site formed a social group that had no access to health services and other social amenities. Despite the schistosomiasis and malaria control/prevention efforts by chemotherapy and prophylaxis, transmission was maintained at a high level as the squatters continued to contaminate the environment with schistosome eggs and were a reservoir of malaria parasites.
- Institutionalisation of disease control strategies within the project budget should be extended beyond the construction phase, or at least provisions must be made to pass the responsibility smoothly to local authorities.
- In the Kariba project, particularly on the Zimbabwean side, some of the measures initiated during the construction phase (eg, screening of employees and treatment, and focal mollusciciding) were continued long after construction of the dam ended.
- The Kariba case study demonstrated that the private sector can effectively contribute financially and participate in the provision of health services and in disease control. In future dam projects, the opportunity to involve the private sector on this issue needs to be pursued at the dam planning stage.

3.13 Summary of Actual and Unexpected Impacts of Kariba Dam

Table 3.43: Summary of Projected, Actual, and Unexpected Impacts of Lake Kariba

Issue	Predicted	Actual	Unexpected
Schedule	Phase 1 for completion in 1962	Completed ahead of schedule	
	Phase 2 for completion in 1971	Completed 5 years late in 1976	– Unexpected poor ground conditions and problems with contractor caused delay in completion. – Deterioration of political relation between Zimbabwe and Zambia caused start of project to be deferred from 1968 – 1971.
Design	4 spillway gates	6 gates; spillway capacity revised upwards twice	Capacity of spillway increased as a result of unprecedented floods of 1957 and 1958.
	Phase 1 power station originally planned for 500MW.	Installed capacity of 600MW in 1962	6th generation set of 100MW installed after realising savings in budget.
Project Costs	Phase 1: £79.38 million	Completed at £ 2.5 million below budget.	– Unexpected poor ground conditions necessitated unplanned work at an additional cost of £ 8 million. – Project completed below budget despite this additional expenditure.
	Phase 2: $52.9 million	Completed at 2.5 times budget at a final cost of $147.3 million.	–Unexpected problems with the contractor and increased cost of procurement of power station equipment.
Hydropower	Kariba expected to meet power needs up to 1971	Actual Power demand fell slightly below prediction	– Unexpected drop in international copper price in late 1960s led to reduction in power demand from Kariba.
Hydropower price	Unit cost of hydropower predicted to be below that for thermal	Actual power costs showed cost of hydropower from Kariba to be cheaper that thermal	-
Municipal Water Supply	Not predicted and not quantified	Insignificant extraction from the lake by the towns of Kariba and Siavonga	-
Tourism and Recreation	Project document did not consider these opportunities	A large tourism industry developed around the lake, with about 20 hotels and about 1000 beds	– All tourism development was unexpected
Irrigation	Project document did not analyse irrigation potential and benefits	Some 2700ha of irrigation developed using lake Kariba water.	-
Social Impacts	Project initially estimated that 29 300 people would be displaced. A global budget of £ 4 million allocated for resettlement	In the end, 57 000 people were displaced by the dam. Budget for resettlement static.	– Number of displaced people underestimated.
	Public Consultation	Displaced people not consulted on their resettlement.	– Some resistance to resettlement occurred and people killed in dispute over resettlement
National Development	Unqualified in project documents	Quantitative data on direct economic benefits of Kariba not available. However power needs were met with Kariba	-
Environmental Impacts	Not predicted	-	Examples: – downstream hydrology affected – flooding of delta reduced leading to death of Mangroves and reduced shrimp production. – pollution of lake by urban settlements around dam.

4. Distribution of Costs and Benefits in the Kariba Dam Project

The fourth question set by WCD for address in the case studies was an examination of who lost and gained from the development of the project. The nature and types of costs and benefits generated by Kariba Hydro-project were identified and in some cases quantified in Chapter 3. This section identifies those who were impacted most either positively or negatively. It allocates the costs and benefits to various categories of participants at local, project, national, regional and global levels.

Table 3.44 summarises the project benefits, costs and impacts and identifies who gained and who lost from the project effects.

4.1 Anticipated Direct Outputs from the Project

The World Bank 1956 Appraisal report provides reference to potential beneficiaries of increased power supply from Kariba in the three Territories that composed the Federation of Rhodesia and Nyasaland. In Southern Rhodesia, the anticipated beneficiaries were inhabitants of big cities who depended on electricity in two ways, firstly because urban water supply required pumping by electricity; and secondly for direct domestic consumption. According the World Bank (1956) project appraisal report (p.1), in the years preceding the commissioning of the dam, there were periods when it became necessary to resort to power rationing. Apart from electricity other anticipated direct outputs of the project include new settlement areas, reservoir water from the Lake Kariba and employment from the development around the project.

4.1.1 Power/Electricity Generation

Who benefited: the Kariba Hydro-project was basically designed for one purpose: the generation of electricity. The major beneficiaries for this purpose were the copper-mining corporations in Northern Rhodesia, the Anglo-American Corporation of South Africa, Ltd (under South African and British ownership), and Roan selection Trust, controlled by American Metal Climax, Inc. (AMAX). Together these two companies accounted for virtually all copper production in the territory. Secondly, electricity was made available to existing and potential industrial centres in Southern Rhodesia (Payer, C. 1982: 252). European settlers/entrepreneurs and urban populations miles away from the lake benefited from the cheap hydropower and propelled the development of the manufacturing industries in both countries. Others who have benefited since then are rural/commercial farmers, towns like Kariba, growth points (small towns) and business/administrative centres.

Who lost: the dam led to the inundation of a large area. Actual figures indicate that the rising waters displaced about 57 000 locals, which constitutes a significant cost. The great resistance displayed by the Tonga to resettlement showed the extent of the unexpected impact on the people of the Zambezi valley, who felt they would lose in a number of ways notably:

- loss of flat arable lands on which they grew various crops, under the drawdown system of cultivation;
- inability to grow crops twice annually due to absence of drawdown system referred to above;
- submerging of pastoral lands used for cattle, goats and sheep;
- loss of ancestral lands and shrines causing a breakdown in cultural and economic ties;
- separation of Zimbabwean and Zambian Tonga by the dam. Prior to the construction of the dam, these Tonga were one people who travelled freely across the river for social, cultural, and religious gatherings. After the dam, they were firstly separated by long distances in excess of 50km, and secondly by an international boundary. Travel across this border became difficult and was later prohibited due to poor political relations between the two countries.

The Valley Tonga were thus particularly vulnerable to the impact of resettlement because of their land tenure system. They were also faced with the reorganisation of their methods of land usage. The majority of the people were settled in the hills where they were allocated land, which normally would have been subject to shifting cultivation (Payer C 1982:255). No consideration or research to establish the most appropriate mode of resettlement was undertaken. Officials believed that there was sufficient land for resettlement but when the time for filling the reservoir approached, it became clear that this was not the case and resettlement became a hasty, tension-ridden programme to move the people before inundation. The various Tonga groups who had always communicated and intermarried across the river, were resettled on land further away from the river on both sides, disrupting the social unity of the community.

The Valley Tonga on both sides were promised that their new settlements would be electrified. However, no provisions were mage to enable the displaced communities to benefit from the new resources like electricity and water, and the provision of social infrastructure was completely inadequate. To date, the local district centres for Nyaminyami, Siakobvu, and Lusitu in Chief Chipepo's area not connected to the national grid lines.

Table 4.1: Impact Distribution Effects of Kariba Dam

	Project Benefits									**Project Costs**					**Project Impacts**				
Stakeholder	Direct Outputs				Indirect					Direct		Indirect Costs			Direct & Indirect				
	Electricity supply	**Settlement in new areas/Chiefdoms**	**Kapenta**	**Gillnet fishery**	**Irrigation & irrigated agriculture**	**Recreation/ tourism opportunities**	**Employment opportunities**	**Domestic & industrial water**	**Development of remote areas**	**Capital costs**	**Operating costs**	**Compensation Payments**	**Land clearance in new settlement areas**	**Development of infrastructure in new areas of settlement**	**Displacement of people**	**Cumulative environmental effects**	**Local resource access & control**	**Biodiversity loss/change impacts**	**Forced social change (social capital losses)**
Valley Tonga People	**0**	-	**0**	-	**0**	-	**0**	**0**	+	**0**	**0**	+	-	-	-	-	-	-	-
Plateau/host settlers	**0**	-	**0**	**0**	-	+	+	**0**	**0**	**0**	**0**	+	-	-	-	-	-	-	-
National population	+	**0**	+	+	**0**	+	+	**0**	**0**	-	-	-	**0**	-	-	**0**	**0**	-	**0**
Basin Municipalities	+	-	+	+	+	+	+	+	+		**0**	-	-	-	-	-	**0**	-	-
European Settlers	+	**0**	+	+	**0**	+	+	**0**	+		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Contractors	+	**0**	+	**0**	**0**	**0**	+	**0**	**0**	+	+	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Urban/National Industries	+	**0**	+	+	+	**0**	+	**0**	**0**	-	**0**	**0**	**0**	**0**	**0**	-	**0**	**0**	**0**
Recreators	+	**0**	+	+	**0**	+	**0**	**0**	+	**0**	**0**	**0**	**0**	**0**	**0**	+	**0**	**0**	**0**
Recreation Industry	+	**0**	+	+	**0**	+	+	+	+	**0**	**0**	**0**	**0**	**0**	**0**	-	**0**	-	**0**
Fishing Industry	+	**0**	+	+	**0**	**0**	+	+	**0**	**0**	**0**	**0**	**0**	**0**	**0**	-	**0**	**0**	**0**
Federation govt	+	-	+	+	-	+	+	**0**	**0**	-	-	-	-	-	-	-	-	-	-
Global community	+	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	+	**0**	**0**	**0**

Cost/ Negative Impact - 0 + Benefit /Positive Impact

4.1.2 New Settlement Areas/Chiefdoms

Who benefited: Siavonga and Kariba towns have grown appreciably due to the dam. Kariba town has grown from an initially small cluster of temporary housing for workers on the Kariba Dam, numbering 4000, to a sprawling town of about 25000, although many still live in the temporary housing first put up in 1955. There is a town centre on top of a steep hill overlooking Kariba Dam and then a spill of housing down the hillsides to the lake shoreline. Though the settlement remains small by national standards, its current extent was nevertheless not taken into account and the mounting population pressures continue to exert an impact on the demand for resources.

Although the construction of the Kariba Dam and the displacement it caused was an economic disaster for the local people, it is important to note that the experience was not at all homogenous and there are some that gained from their new settlements. The gainers consisted mainly of those who successfully adapted to the environments, who were able to exploit the new structure of opportunities presented by the changed environment. These people were not encumbered by lock-in factors that prevented others from adjusting. These had resources such as grain stocks, large unpaid family labour forces and livestock that they used to redeploy themselves in the new place.

Who lost: that the resettled failed to adjust and attain the third stage of "economic development and community formation" in Scudder's 4-stage model is quite clear. At the beginning, people spent time learning about the new environment, experimenting with plants and soils. They were unwilling to cultivate huge pieces of land without first being sure of the likely yields. It was only in the 1962/63 season, five years after resettlement that signs of people conquering the new environment began to show. However, this was not to last for too long, as the carrying capacity of the new area had been exceeded, leading to land degradation and crop failures. This has led to food insecurity in new settled areas on both sides of the lake. Notable health impacts on the part of the displaced communities concern their poor nutritional status due to chronic food shortage. In Binga, for example, "the better off" in the communities only manage to have sufficient food for 6 or 7 months of the year (interview Agritex Officer, Binga). Chronic food insecurity leads to poor health and vulnerability to illnesses. This means that the displaced communities have to bear the recurrent costs of keeping healthy – the endless search for food – and meeting the costs of treatment in frequent cases of illness.

Further, scarcity of land was soon to manifest in the settler-host hostilities despite the harmonious welcome the host population had given to the resettled people. A number, even up to the present generation, have been known to show serious marks of disillusionment as manifested in such anti-social vices as alcoholism.

Displaced people were resettled in very remote distant areas away from the lake and main communication routes or lines. This makes travelling costly and the costs are all borne by the members of the displaced communities.

4.1.3 Reservoir Water from the Dam

Who benefited: water from the reservoir is used for commercial and domestic purposes largely by the surrounding towns of Kariba and Siavonga municipalities. The water is also used by the recreation industry, basically for charter vessels. Commercial fishing is one of the major economic activities around the lake area.

Who lost: the local Valley Tonga on both sides of the lake who were resettled on the plateaus. The Federal government on the Zambian side undertook to rebuild schools, clinics, and other such facilities. It also promised to install and "maintain wells and other watering points in perpetuity". This has not been done and they are still waiting for the piped water they were promised. Whilst the 6 000 or so who were resettled at Lusitu in chief Sikongo's area received untreated piped water, others elsewhere have to make do with shallow wells or nothing at all.

4.1.4 Employment Generation During Dam and Post Construction Phase

Who benefited: ordinarily, the Kariba Dam Project should have created employment opportunities in two phases. The initial phase of dam construction should have provided temporary employment to the local residents. This did not happen to any considerable extent, and most of the labour was drawn from outside the valley during the construction phase, some from as far as Tanzania, Malawi and Congo. Fieldwork interviews conducted in the three chiefdoms of Chipepo, Mweemba and Sinazongwe suggest that an insignificant number of local men were employed during construction. These were mainly involved in bush clearing in areas that were to be part of the lake.

Once the lake was formed, however, a second phase of employment opportunities arose. The opportunities were largely created by development activities associated with the lake. Local labour has been employed in the fishing industry and farming. Kapenta fishing and crocodile farming have employed a number of local men and women. Kapenta fishing industry employs a large number of able-bodied men and women from the valley.

Who lost: the new developments around the lake has led to further displacement of the local people from their land. The case of the Gwembe Valley Development Company Ltd. established in 1985 in the Chiefdom of Sinazongwe is a classical example of how the Valley Tonga have been ill-treated primarily because of the existence of Lake Kariba, a direct product of the dam construction. This company was founded from detailed negotiations that took place in Lusaka between the Zambian government and the investors. Once the negotiations were completed and an agreement concluded, the local chief and village headmen were merely advised to ratify the agreement because the investors were bringing *Buchi* (honey) to the area, hence the name Buchi Farm.

The development of the farm dispossessed some 1 600 people of their land, they too lost their dwelling houses and granaries without adequate compensation. Today these people occupy the poorest and most marginal soils in Sinazongwe.

4.2 Anticipated Indirect Outputs from the Project

There are several outputs from Kariba Project, which were not addressed by the Federal Hydroelectric Board Project Report but were mentioned by earlier reports[22.] These include irrigation and irrigated agriculture, recreation/tourism, and employment opportunities.

4.2.1 Irrigation and Irrigated Agriculture

Who benefited: on both sides of the dam irrigation development was not given prominence in the planning for Kariba. However, on the Zambian side, four irrigation schemes were introduced, which were not adequate to cater for the needs of all the relocated people. In addition, no deliberate effort was made to include land management and soil conservation in general agricultural policies for the resettlement areas. As such, people went ahead farming, using the knowledge from the valley on the poor marginal soils of the plateau. This was probably due to the agreement that was made, that valley people would not be forced to change their agricultural practices.

Irrigation is very limited in Zimbabwe. There are two small irrigation schemes. In general, irrigation on the Zimbabwean side has not received much support.

Who lost: the resettled Valley Tonga lost access to abundant water from the Zambezi. Although their irrigation practices were not on a large-scale, the valley had a natural way of retaining nutrient status in the soil based on two rotations. Drawdown (recession) agriculture maintained nutrient status and

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22 “Report on Kariba Gorge and Kafue River Hydroelectric Projects” by The Inter-Territorial Hydroelectric Power Commisssion

allowed double-cultivation in a year. The 57 000 plus Tongas used to live on hectares of land and had access to a further hectares for hunting, fruit gathering and other uses. When they were resettled they lost access to this natural resource and to the water they believed would follow them, which never did.

4.2.2 Recreation/Tourism

Who benefited: the tourism industry, which has experienced significant growth in and around the Kariba region, benefiting mostly the entrepreneurs (owners of hotels and lodges). It is a sector that has the ability to raise per capita income, improve the distribution of income and wealth, reduce population pressure and improve the lives of those directly or indirectly employed in the industry. In the Kariba region the tourism sector has had an impact on employment on three levels:

- directly: employment from tourist facilities like hotels, shops, safaris and other attractions ;
- indirectly: employment in businesses affected by tourism in a secondary way such as local transport, selling of handicrafts and in banks; and
- investment employment generated through the construction of large infrastructure works such as airports, roads, electricity networks, water and sanitation works.

Who lost: though the injection of tourists' money into the local economy has had definite benefits, cognisance must also be taken of the fact that the increased spending in the region has resulted in inflationary pressures. Tourists typically spend more than the local population, either because they have higher disposable incomes, or because they have saved for the trip and are inclined to "splurge" while on holiday. This has encouraged local suppliers to inflate their prices. Speculative profiteering by estate agencies taking place around the tourism facilities has led to inflated prices for properties making them unaffordable to the local people.

The impacts from activities such as rafting, canoeing, motor boating etc, directly relate to pollution and waste. Noise pollution is high and continued wave action caused by the wake damages riverbanks disturbing the area's micro-ecology.

The curio industry has developed as a by-product of tourism and is a big consumer of indigenous hardwoods. Demand for curio products has increased with the expansion of the tourist industry. This has resulted in localised over-harvesting of large increasingly rare indigenous trees occurring at an unsustainable rate, and often illegally.

The development of wildlife-related land uses has been seen by some as threatening the food security of countries such as Zimbabwe. In the Kariba area the whole of the south bank is designated for wildlife and recreational land on which no agricultural activities are permitted.

Water quality can be impaired by sewage discharges from lodges and towns, siltation due to erosion caused by riverbank developments, over-exploitation of wetland resources such as reeds and fish, and pollution by fuels and pesticides.

Tourism attracts many people around the lake, and these increase the incidence of transmittable diseases, for example, STDs and HIV/AIDS. This is particularly the case in resort centres such as Kariba town and other smaller settlements along the lake. Treatment of diseases cost money and others such as HIV/AIDS, cost life. It is largely the local communities and their families who bear the cost of tourism associated activities.

4.2.3 Fishery Development

Who benefited: the gill-net fishery was the only major new development that was planned well in advance of post dam construction. It was not one of the original project's objectives. Fishing in the Kariba Dam was initially only restricted to Valley Tonga while other tribes could only be vendors. Commercial fishing and other developments based on the Zambian side of the lake were reserved for

Gwembe residents for an initial period, which ended in 1963. After the ban was lifted, this was made the subject of an order in council. The local authority became the licensing agent. By 1962 there were 2000 fishermen earning £50 per year (Ibid .184). The income was greater than one could obtain from agriculture excluding livestock sales. Today, Kapenta fishery is apparently the largest employer of local people, who are employed as crewmembers, processors, and security people

On the Zimbabwean side, a few fishing villages were established for the benefit of the Tonga who were not allowed to have permanent residence in the villages but could commute to the fishing villages or benefit from the employment opportunities offered by commercial fishing companies in the long-run. The benefits for the Zimbabwean Tonga were, therefore, extremely limited. Private companies in particular, have benefited although since independence a few co-operatives formed at designated fishing villages benefit some young men from the displaced communities.

Who lost: access to fisheries is limited for the displaced communities by distance, capital for purchasing fishing equipment and restrictive regulations.

4.2.4 Transport Development

Who benefited: the dam has helped improve access to communication and transport in the mid-Zambezi valley in two ways: (i) through access roads built during the construction of the dams; and (ii) through communication lines that developed as a result of the economic spreading effects of the dams. On the Zambian side for example, the fishing activity on the lake has had some positive impacts on communications over the years. Fish traders have provided transport to local people as well as to outsiders visiting the remotest parts of the valley, which are not accessible by ordinary bus passenger services. Despite bad roads and generally poor physical communication infrastructure in the area, at least all fishing camps and villages are accessible by light trucks and four-wheel drive motor vehicles. This has helped enhance and ease communication and travel within and out of the valley. For example during the recent food shortages some of the fish traders have assisted greatly by transporting foodstuffs down into the valley before loading their vehicles with fish for their return trips to urban or peri-urban centres. It is clear that the construction of the dam opened the valley to the outside world.

Although water transport is not fully developed (eg, the Lake Kariba Waterways collapsed in 1996), it still provides the quickest means of travel between some lakeshore villages. Today, 1 900 chartered vessels are in operation in the lake (Tumbare, M.J. 1999).

Who Lost: one of the common complaints among the Valley Tonga has been that the creation of Lake Kariba widened the distance between the Zambian and Zimbabwean sides of the lake, which has made the pre-resettlement local communication lines between kith and kin on the two sides difficult. Despite lines of communication, which have been open since 1980 when Zimbabwe attained independence, people could not cross the vast waters in their dugout canoes as they had done before the lake was formed. Kariba Waterways have not played a significant integrative role among the displaced communities nor among kith and kin across the lake.

4.3 Who Paid the Costs of Developing the Kariba Hydropower Project

4.3.1 Financial Costs

The question of who paid the cost of constructing the Kariba Hydropower project is answered by addressing both direct and indirect costs. Direct costs include finances, labour and material (including land resources on which Kariba is situated). Kariba Hydropower project required a budget of about £79.414 million. In order to finance this the Federal Power Board entered into agreements with seven different lenders. The terms were different in each case. The longest was for a period of 40 years and the shortest 20 years. Interest payable ranged from 4.5–6.75%. However, the loans were paid by taxpayers of the two nations that succeeded the Federation of Rhodesia and Nyasaland and the hundreds of workers who died in accidents while working on the dam itself. It was also the 57 000 people who inhabited the two sides of the Zambezi River that had to be flooded to form the reservoir, a cluster of ethnically and culturally related groups called the Batonka on the Rhodesian side and Tonga on the Zambian side. The following sections describe how various groups were impacted by the project.

4.3.2 Compensation of the Resettled People

On the Zimbabwean side, the Federal Power Board incurred some of the costs for resettlement, which included compensation in kind – grain or food in general, services (including drilling of boreholes) and transportation. This amounted to a total of £928,128. The rest of the costs were borne by the Tonga themselves – destroyed homes that had to be rebuilt on the escarpment, assets and livestock lost en route to the new settlement areas or livestock lost through tsetse fly infestation.

In reality, the losses to the Zimbabwean Tonga people cannot be quantified in any meaningful sense. All one can say is that the losses were all encompassing – psychosocial, cultural, material, economic and political.

On the Zambian side, compensation was paid by the Federal Power Board to the local authority to cover general losses to individuals required to move. The latter would receive a first payment to cover estimated value of abandoned dwellings and further payments to cover loss of production due to the move. The loss of production payments were assessed on a per capita basis, regardless of age, and were locally interpreted as per capita payments. They amounted to between £2.5–5. The local authority ultimately received a cheque for £200 000 for general losses, and individual losses totalled £372 000.

4.4 Unanticipated Indirect Outputs from the Project

4.4.1 Wildlife Development

Who benefited: wildlife is mainly in the hands of the Department of National Parks. Most of the benefits have accrued to the central treasuries of the Zambian and Zimbabwean governments who collect tourists and hunting safari fees. Tourists who frequent the parks have also benefited from the wildlife parks. The tourist operators and those employed by them have been the major beneficiaries of the wildlife parks.

Who lost: the local people lost their hunting grounds when the water inundated the area and restrictive laws that are associated with access to wildlife meant that the local people derived little benefit, which was usually in the form of employment as game guards or other lowly positions. Wildlife management is not labour intensive and therefore the potential of employing local people is limited.

4.4.2 Equity in Regional Distribution of Costs and Benefits

From the Zambian authorities perspective, the Kariba Dam appeared to have yielded more benefits to Zimbabwe than Zambia, a view that led to the dissolution in the 1980s of the Central African Power Company (CAPCO) which in 1963 took over the functions of the Federal Power Board. The board had the primary function of generating and transmitting power to the two countries. Part of Zambia's dissatisfaction arose from the fact that CAPCO made more investments in the transmission systems of Zimbabwe compared to Zambia. Total investments amounted to K63.3 million for Zimbabwe compared to K43 million for Zambia as of February 1971, respectively. In addition, CAPCO appeared to create more employment on the Zimbabwean side than the Zambian side, with 89% of staff based in Zimbabwe.

Furthermore, as the sole generation body for the two countries, CAPCO bought power at cost, which it resold at economic prices to major consumers in the two countries. This included power generated from Zambia's independent investments in electricity supply connected to CAPCO's 330kV system. These included power from the Victoria Falls, Kafue Gorge and Kariba north bank stations. With the two electricity markets being asymmetric, and with Zimbabwe having a higher growth rate, this situation favoured Zimbabwe from three fronts. Firstly, Zambia failed to derive returns on the generation of power using investments independent of CAPCO's that went to Zimbabwe. Secondly, Zimbabwe consumed more electricity from jointly held facilities. Thirdly, unlike Zambia, whose generating plant was predominantly cheaper hydropower, Zimbabwe's was a mixture of coal-fired and hydropower. This led to the view that Zimbabwe subsidised costs of Hwange Power Station, which is a thermal plant, with a high mark-up on inexpensive imported power from Zambia.

4.4.3 Conclusions

Only the enlightened and educated descendants of those who physically experienced resettlement are probably able to perceive the consequences of the Kariba Dam graphically. But the surviving generation of relocated people, who are able to compare the old and new environment, have not forgotten those "good old days". Their thinking of Kariba certainly has changed over time, but it is a matter of degree of that change. Because of the speed with which the decision was made to proceed with the project, Kariba was a rushed scheme. The effects of this hurried decision are still persisting to date. Kariba, therefore, can provide major lessons for similar projects that may be undertaken in future; it provides the following lessons:

- the Kariba resettlement programme was not a success, in part because it left the communities disturbed socially, economically and culturally. A successful programme must ensure that those relocated remain undisturbed at least in their basic spheres of life;
- after completion, the Kariba Dam attracted outsiders who conducted tourism, fishing, and other economic activities. These outsiders have enjoyed most of the benefits accruing at the expensive of those resettled. A clear policy to protect the future interests of relocated people and to reduce conflicts over the commons would certainly help reduce the negative impacts of influx of immigrants; and
- in the case of the Kariba scheme, monetary compensation was not adequate, and no clear difference in terms of living standard can be noted between resettlers who received cash compensation (Northern Rhodesia) and those who did not (Southern Rhodesia).

5. Options Analysis and Decision-making

A brief history of Kariba Dam was presented in Chapter 2 of this report as part of a discussion of the context of the Kariba Dam project. The main events associated with the planning, execution and operation of the Kariba Dam project were presented earlier as a summary table of important milestones in the life of Kariba (Table 3.1). In this section, the main emphasis will be to discuss the options that the planners and implementers of Kariba had to choose from and how they made decisions from various options available to them.

This section will draw on the brief history of Kariba presented in Chapter 2 as well as the table of milestones presented in Annex 1. Additional historical information not presented in the two earlier sections will be provided where necessary to facilitate the discussion on decision-analysis. In this chapter, the options and decision-analysis issues are grouped according to the stage of the Kariba project, beginning with the planning stage, through the implementation stage to the operation stage.

5.1 Options and Decisions during the Planning Stage

It was pointed out in Chapter 2 that the Kariba Dam site was identified in the early part of the 20th century and that a number of evaluation studies were carried out at the site by officers of the Southern Rhodesia Irrigation department. These officers collected river flow measurements, data that were later to be valuable for the design of Kariba Dam. However, real serious interest in Kariba as a dam site developed in the mid-1940s, particularly after the Second World War. At that time, as was explained in Chapter 2, the copper mines of Zambia were experiencing electric power shortages and there was urgent need for a large dependable source of cheap electric power. In addition, the fast developing industrial, agricultural and mining sectors of Southern Rhodesia were also suffering from a shortage of electric power. At that time, all the power needs of the two countries, including the mines of Zambia, were being met with power generated by small thermal power stations, most of which were not interconnected. It was therefore generally not possible for neighbouring towns or mines to share power.

5.1.1 Decision on Thermal versus Hydropower

After the Second World War, once the need for more electric power became widely accepted, two options presented themselves to the countries of Southern and Northern Rhodesia. The first option was to expand the existing thermal power stations – building new ones and enlarging existing ones. The second option was to construct a large hydroelectric power station and transmission lines, and to meet the power needs from a large source. The first option was heavily dependent on the need for an efficient, cheap and reliable supply of coal. The coal for all the power stations in Northern and Southern Rhodesia was supplied by rail from the Wankie coalmine in the latter country. It then became apparent that to expand the thermal generation network, there would be a need to expand the existing rail facilities, since at that time the railways were already failing to cope with demand for coal from the existing power stations. Thus, any expansion of the generation capacity had to be accompanied by further investment in the rail system.

Financial analysis, started in the mid-1940s and was carried out through to the mid-1950s, showed that although hydropower was more expensive in terms of capital investment, it was significantly cheaper with regard to running costs. On the other hand, thermal was cheaper than hydropower with respect to investment costs, but expensive to run, especially when the cost and inconvenience of supplying coal to the power station was considered. After careful examination of facts, it appears that there was a general consensus that the hydro route was the more efficient, and would serve the power needs of the two countries better.

5.1.2 Formation of the Inter-Territorial Power Commission (1946)

The two countries of Northern and Southern Rhodesia were sovereign states and colonies of Britain. Each had its own government. The two governments must have realised that a large power project was beyond the scope of one country to plan and to implement. Thus, in 1946, the two countries decided to form an Inter-Territorial Power Commission (ITPC), with the following responsibilities:

- studying the possibilities of the Kariba and Kafue hydroelectric projects and any other large sources of power available for joint development;
- determining the load development in participating territories; the extent of the initial hydroelectric development desirable and the time by which it should be in operation;
- selecting the site for initial development;
- transmission line details and routes (both sites were remote from centres of consumption so that 900 miles of transmission lines would be needed to serve those centres);
- determining finance, costs and the territorial division of exploration and of operating costs; and
- investigating irrigation and other relevant matters.

The investigation costs were to be shared by the two governments of Zambia and Zimbabwe. One of the greatest advantages of the ITPC as an inter-government body, was its ability to plan projects internationally. The two hydropower projects that had been identified as possible solutions for the power needs of the two countries, were Kariba and Kafue. Most of the interesting history of Kariba relates to the decision on which of the two projects was to be implemented first, Kariba or Kafue.

5.1.3 Decision on Kariba versus Kafue

The choice between Kariba and Kafue was complex. Kariba was on an international river, the Zambezi and thus a bi-lateral project with regional implications.[23] Zambia, a Protectorate, and Zimbabwe, a Settler-colony, were very different in legal, political, social and economic ways. In particular, Kariba would involve moving a large number of people, most of them within Zambia, as they lived on the north bank of the Zambezi River (see Figure 1). Kafue had no resident population to be relocated.

The decision as to which dam should be built first fell within the additional complexity of British moves to make the three territories (with Nyasaland) more self-reliant under what became the Federation of Rhodesia and Nyasaland. The Federation was short lived and was opposed by African nationalists in all three countries, as playing into the hands of the settler community.

Data for both sites was inadequate for any effective comparison. Both sites were remote and far from the centres of energy consumption, requiring 900 miles of transmission lines. The size, capital cost and the magnitude of the preparatory work for both were daunting. Timing was crucial if further investment – particularly on the Copperbelt – in thermal stations, coal mining and rail capacity was to be avoided and to be replaced by hydropower.

An advisory panel was appointed by the power commission to examine further the projects on the two rivers and see how they might best meet the urgent requirement for additional power that the commission forecast as a rapid increase in demand. The panel reported back in 1950. On the balance of factors, the panel recommended Kariba, with Kafue regarded as a potential extension of supply.

[23] At a Technical Conference on the Zambezi and the use of its waters in 1950, the Power Commission reached agreement on water flows past Kariba with the Portuguese (Angola and Mozambique) and the respective authorities of the three territories (Zambia and Zimbabwe and Malawi).

In 1951, the commission endorsed the Panel's main findings and reported as such to the Central African Council. Kariba was an unusually attractive project, justifiable on the basis of power alone. It noted that, with Kariba, 29 300 Africans (in fact it was 57 000) would have to be relocated. It also recommended that data collection be stepped up on both rivers and that a Zambezi River Authority (ZRA) be created to attend to all the related issues affecting the common usage of the river by the riparian states (power, navigation, transport, hydrological data, the measures necessary to preserve and improve the regime of the river).

Kariba's size meant that its potential generating capacity and its cost efficiencies would not be realised, except in stages and that its economic viability thus depended upon demand growing rapidly for 20 years. If not, it would prove a large and costly investment. It is noteworthy that in its appraisal, estimates of demand for Kariba power were carefully checked and rechecked.

At the time, Kafue was still seen as a run-of-river scheme since there was no natural storage at the dam site. This feature of Kafue made it less attractive to the copper smelters, the primary purchasers of power, because Kafue could not guarantee a reliable supply of power in the dry low flow seasons. The paucity of data also had its effect on this view.

The Zambian authorities remained concerned that Kariba might face delays and that the expansion and the progressive conversion to electrolytic copper of its mining industry would be hampered. Uncertainty about the realisation of and opposition to the Federation of Rhodesia and Nyasaland favoured the Kafue Project. Its smaller size, lower cost and quicker development (thought to be 3 years) would compensate for Kariba's lower unit cost at full development.

A race developed between the two territorial governments to promote the project of their choice. In 1951, the Kariba scheme was taken to the Commonwealth and an attempt was made to raise funding on the London capital market. Preliminary works were started, notably the road link. Zimbabwe sought a direct contract with Zambia to jointly build Kariba.

The Zambian authorities in 1953 decided to proceed with the Kafue scheme, created the Kafue River Hydroelectric Authority, and let out contracts for the access road and other preliminary works. The authority began to raise the finance. In a reverse move, it invited Zimbabwe to join forces to build Kafue and then Kariba.

The mining companies – fearing that whichever project went ahead first, they would face severe shortages in the late 1950s – raised funds internationally to enlarge their own thermal capacities and to connect with hydropower from the then Belgian Congo. This served to take the pressure off an early decision between Kafue and Kariba.

With the advent of the Federation of Rhodesia and Nyasaland in late 1953, the Federal government decided, given the role of copper in the federal economy, that Kafue must be operational by the end of the decade. It also proposed that it be a joint project of the Federal and Zambian governments. This decision did much to vindicate the ability of the Federation to look after its three constituent territories equitably. Kariba was to proceed immediately afterward if it was still the best way to meet demand as forecast at that time.

Despite these decisions, the debate raged on: time, cost, demand. Kariba promised more power at a lower cost per unit, fisheries and navigation. Kafue answered only the timing issue.

In 1954, a newly formed Hydroelectric Board continued to look at both schemes. A new development at each site called for re-thinking and delay. New consultants on Kafue revised the river flow upwards and the generation capacity to 690MW if a dam was added at a cost of £46 million, and envisioned expansion when a large storage dam at Iteshi-Teshi was agreed. All this would take considerable preparation, perhaps eight years.

Then a new and an excellent dam site was located at Kariba, which reduced its cost.

The Federal Government decided that these new developments called for an external, impartial review.[24] Electricite de France was asked to appoint consultants. The review was to focus upon: (i) the dependable power from each river in dry years; (ii) the sites and the methods of construction chosen; (iii) the timing and the cost estimates of each project; (iv) the costs per unit of power generated; and (v) other relevant factors.

Kafue's cost was revised upward, its construction period reduced and its power potential altered conservatively because good data was still scarce.

Two studies on demand in the two countries exposed the possibility of Zimbabwe, with an inter-connection installed between Bulawayo and Munyati, having a power surplus it could send to the Copperbelt. This favoured Kariba.

During this period of exploration and review, the understanding grew that Kariba and Kafue, rather than merely filling power supply gaps, offered the chance to move away from a primary reliance on thermal power with its massive reliance on railway infrastructure to move coal to hydropower and that this, in turn, necessitated thinking regionally, at least to begin with within the Federation.

5.2 Moving to a Decision: Kariba First

5.2.1 Technical Justifications of the Choice of Kariba

The Federal government decided in early 1955 to proceed with the development of the Kariba hydroelectric project subject to a final report from Mr. Andre Coyne and an appraisal by the World Bank. Mr. Coyne picked Kariba because of the greater time afforded by the surplus made available to the Copperbelt, its greater certainties, simpler construction and cheaper unit cost of power. In March 1955, the Federal Government announced its decision to undertake Kariba, first subject to a review by Mr. Coyne. In April 1955 Mr. Coyne stated that he was satisfied with the choice of Kariba.

The urgency to commence Kariba followed on Coyne's pointing out the need for additional power by 1960. Construction had to begin in the dry season of 1955. The Cementation Company started work on the coffer dams, the right bank diversion tunnel, the left bank diversion channel, the access road and other works. The World Bank appraisal of Kariba, limited to financial, demand, cost and technical matters, found it to be a fully justifiable investment.

The appraisal found that: (i) the cost of constructing Kariba per annual kWh compared favourably with other recent hydropower schemes in Italy and Japan; from 25 to 33%, even with far longer transmission lines; and (ii) Kariba power would be appreciably cheaper than that from the expansion of thermal power. The World Bank appraisal calculated that Kariba power also compared favourably with the hydropower to be imported from the Congo to the Copperbelt.

At full development it was 0.33d/kWh compared to 0.7d/kWh. With an inter-connected system, Kariba's full capacity would be used by 1971 without any new power intensive industries.

Kariba, if developed to its full capacity, 1200MW by 1972, was estimated to cost £101 million. The "savings" up to 1972 that investment in Kariba hydropower would realise as against reliance on the expansion of thermal power, as estimated in the World Bank Appraisal of 1956, was: (i) thermal

[24] "Impartial" is the word used in the official documents; ie, using a neutral party. The intent was to compare the two dams. The term "impartial" is today a point of contention in the large dam debate. Some parties hold that the impartiality of dam studies is itself a key issue.

power station development, £44 million; and (ii) rail expansion, £40 million of which £16 million was for rolling stock. The concomitant expansion of Hwange coalmine was not estimated.

If Hwange expansion cost £17 million, the total "savings" provided by investment in Kariba would be virtually the same as the capital to develop Kariba, or £101 million. The final cost was less than budgeted £77.4 million.

5.2.2 Political Considerations and the Financing of the Additional Costs

The technical reasons for choosing Kariba did not stop the speculation as to the political reasons. These all fuelled the feeling that Zambia was the junior partner in the Federation. Why, for instance, was the first power station, to serve mainly the Copperbelt in Zambia, built on the south bank in Zimbabwe if not to deny Zambia the control Kafue would have provided? Or, more positively, was the Federal decision to build Kariba intended to provide the "the arch of concrete" across the Zambezi as the symbol of unity between the two countries? Or did that merely confirm that the Federal government had prime access to the taxation provided by the Copperbelt?

There were other suspicions. The Federal Hydroelectric Board opened its headquarters in Lusaka in July 1954, but had moved them to the Federal capital, Harare, by June 1955 when its first Annual Report was released. The Board was responsible for examining both Kafue and Kariba power projects. It absorbed the assets of the Kafue River Hydroelectric Authority, which was dissolved.

There was considerable media interest in Kariba, particularly in the "self-governing" colony that is today Zimbabwe. Without the British government so closely involved in day-to-day affairs, the size of the debt to be incurred was a matter for settler concern.

In January 1956 there were rumours that the cost estimates for Kariba had been reduced. This might have followed on the identification of a better dam site. Nonetheless, a month later, in February, an embarrassed Federal government announced that the cost estimates for Phase 1 had risen from £54 to £80 million. This was the result of checking done by cost accountants and followed on the decision to build a higher dam to handle the larger forecast power demand. That same decision, following Mr. Coyne's report, was set within an urgent timetable to build Kariba and so meet power requirements by 1960.

The Federal Government then went silent for a while whilst it sought how to raise the extra monies, and to do so quickly. The local papers demanded more information. The daily paper in Harare carried a banner headline, "*Give us the Facts*".

Lord Malvern, the Federal Prime Minister committed the Federation to provide the new financial requirement to meet the cost escalation. There then followed a fascinating arm-bending exercise that has been misinterpreted by historians and journalists.

The upshot whichever information is accepted, was to fuel further the Zambian suspicions of the domination of Federation politics and economic activity by the mining companies which were primarily based on the Copperbelt.

Colin Leys in his study, *European Politics in Southern Rhodesia*, observed of the mining companies: "Their role in the economy is in itself decisive and it is not too much to say that the meetings of their boards of directors can be as important for the inhabitants of the Federation as those of the Federal cabinet." Yet it is an exaggeration, as Cheryl Payer stated, "The needs of these two companies seem to have been the main impetus behind the entire [Kariba Dam] project." Zimbabwe had clear interests as well.

Lord Malvern summoned the copper mines, then enjoying a price bonanza, and pressed them to accept a "voluntary scheme" whereby they loaned their large profits to the Federal government so that it, in turn, could finance the extra costs. He did this with a matching threat of extra taxation.

A popular view holds that World Bank financial support for Kariba was crucial to the mining companies' calculations. This view holds that, as multinationals, they had a limited long-term commitment to Zambia; they extracted enormous copper wealth (until the 1958 copper crash) with very little reinvestment.

Lord Malvern's move on the mining companies "stole" funds from the Zambian government which the latter was hoping to realise in a similar manner. In fact the idea to raise a loan from the copper mines was that of the Zambian Governor, Sir Arthur Benson, as he had earlier explained his plans to Lord Malvern. Zambia was seeking funding for a large rural development programme long discussed and promised to reverse the accelerated flow of rural people into the mining towns and along the line of rail.

When Sir Arthur heard of Lord Malvern's coup, he tackled him, suggesting that Zimbabwe's tobacco farmers should be taxed more and that certain loan or bond systems be introduced by the Federal government to raise the Kariba funds. He wanted the loans provided by the mines to fund the Zambian rural development scheme first, even if it meant that the kudos went to the Federal government and not to the Zambian government when the rural development scheme was implemented. (Sir Arthur was also a proponent of the benefits of Federation.). He warned Lord Malvern in a letter that the "copper mine loans" for Kariba "cannot fail to affect Zambia drastically from the financial, the economic and the political angles."

Having financed the large Federal loan for Kariba, the mining companies were in no position to fund further official schemes. They declined finance in the same year, 1956, for the Zambian and a similar Malawi rural scheme. This has been seen as illustrative of their narrow short-term self-interests. Given the conditions and the size of the Kariba finance they had just provided, it seems far-fetched for commentators to use the Anglo American Corporation's refusal to finance another large £3 million loan to Zambia and Malawi for rural "upliftment" as anything more than financial exhaustion. Nonetheless, it was ammunition for those opposed to the Federation. Sir Arthur Benson's worst fears occurred almost immediately.

With the "copper mine loans" in his pocket, Lord Malvern hastened to London to finalise the deal with the World Bank. This resolved the awkward hiatus when in June 1956, the Federal government, now able to step in and play its part, was able to announce an agreement with the World Bank to grant a loan for £28.6 million. The total loan was made up of £15 million from the Commonwealth Development Corporation, £3 million from the Commonwealth Development Finance Co. Ltd., and a Federal government loan for £28 million, which it raised in turn from Anglo American, Rhodesian Selection Trust and the British South Africa Co. and from the Standard and Barclays Banks.

Lord Malvern had solved a Federal problem but left a burning Zambian issue unattended and in tatters whilst rekindling the suspicions of the Federation and its bias with regard to finances and development. The two countries in the mid-1950s were capital hungry. Now one would go empty bellied and frustrated. Sir Arthur was correct; there were other ways of raising the funds that Zambia needed but it was to take time to swallow the large Kariba borrowings before extra finances became available. By then the copper prices had crashed and Zambia's golden days were over. Zambia has never managed to create a working countryside since that moment in her short history.

5.2.3 Options and Decisions Relating to Resettlement of Displaced people

In the planning for the Kariba project, the issue of resettlement of displaced persons is only discussed in the 1951 report by the Inter-Territorial Power Commission. In further planning for the Kariba project, a decision was made to delegate the resettlement responsibility to the two territorial governments. As a result of this decision, the resettlement issue was taken out of the project documents.

As is discussed in the social impacts section in Chapter 3, there does not appear to have been any consideration made of different options of resettling the displaced Africans. The government officers made decisions and these were implemented.

A prominent feature of the decision-making processes on resettlement was the absence of consultation with the communities who were going to be displaced. As a result, the resettlement programme was not innovative in nature and reduced itself to an attempt at duplicating the life before resettlement. No attempt was made to explore new opportunities for the displaced people.

5.3 Options and Decisions During the Construction Phase

5.3.1 Design Changes to Spillway

The heavy floods of 1957 and 1958 led to a revision of the spillway design for Kariba. The original design provided for 4 gates, and these were increased to 6 following these floods. Further details and data on this issue are presented in the hydrology section of Chapter 3.

5.3.2 Additional Work on the South Bank Abutment

During construction of the dam wall, soft ground conditions were encountered in the south bank abutment and this necessitated the redesign of this section. The redesign led to an increase in construction costs for the dam wall by £8 million. Fortunately, this extra expenditure was fully covered by savings made elsewhere in the project. Overall, the project made a saving of about £2 million in spite of this unexpected increase in cost for the south bank.

5.3.3 Implementation of Kariba Phase 2 (North Bank power station)

The Kariba project was originally designed to be implemented in two phases, with Phase 2 being the installation of the north bank power station. Phase 2 was supposed to start in 1965, for completion in 1972.

This phase comprised the installation of a 600MW power station. Unfortunately, Phase 2 could not be implemented on schedule because of political events of the time. Firstly, the Federation of Rhodesia and Nyasaland broke up. Then, the attainment of independence by Zambia in 1964 brought a new government, which was not well disposed to its southern neighbour. This was made worse by the declaration of independence by Southern Rhodesia in 1965, and the subsequent deterioration in the political relations between the two countries.

Consequently, the decision to implement Phase 2 was deferred to 1971. In the interim, Zambia implemented Kafue Stage 1 before Kariba Phase 2. The Kariba north bank power station was only commissioned in 1976 instead of 1971 as in the original plan.

5.4 Options and Decisions during the Operation Phase

The Kariba is an international project, and was therefore subject to two sovereign governments and their laws. It is therefore instructive to follow how the project has been managed over time and as the political situations in the two countries changed. The following is a chronicle of the organisations that have managed Kariba over time, and some discussion on the decisions that led to the formation of these organisations:

- 1946 Inter-territorial Power Commission established to plan for Kariba;
- Federal Hydroelectric Board established in 1954 to oversee the implementation of the Kariba project;

- at its opening in 1960, Kariba fell under the Federal Power Board (Section 19 of the Electricity Act of 1956). The functions of the Board in relation to Kariba Dam were to operate and develop the system for the generation and transmission of electricity; and
- Central African Power Corporation (CAPC) established in 1963. Constituted under the Federation of Rhodesia and Nyasaland (Dissolution) Order in Council 1963.

The order in council also constituted the higher authority for power to control the corporation in relation to the supply of electricity. The higher authority for power consisted of two ministers each from Zambia and from Zimbabwe.

The general function of the Central African Power Corporation, apart from the maintenance of the Kariba Dam, was to supply electricity to undertakings within the territories and in particular to: (i) continue to operate and develop the system for the generation and transmission of electricity associated with the Kariba Scheme; (ii) establish such additional undertakings for the bulk supply of electricity as the higher authority may direct; (iii) generate or acquire electricity; and (iv) determine the prices at which electricity was supplied to the distributing electricity undertakings in the two countries.

The Zambezi River Authority (ZRA) was formed in 1987, replacing the Central African Power Corporation and was established by Acts of Parliament in both countries in accordance with the agreement between the Republic of Zambia and Zimbabwe concerning the use of the Zambezi River. The functions of the ZRA are now to: (i) operate, monitor and maintain the Kariba Complex, which consists of the Kariba Dam and reservoir, telemetering stations relating to the Kariba Dam and any other installations owned by the Authority at Kariba; (ii) collect, accumulate and process hydrological and environmental data of the Zambezi River for the better performance of its functions; (iii) subject to the approval of the Council of Ministers, operate and maintain any other dams on the Zambezi River; (iv) make recommendations to the Council of Ministers to ensure the effective and efficient use of waters and other resources of the Zambezi River; and, (v) liase with the national electricity undertakings in the performance of its functions under this agreement.

The council of ministers of the ZRA replaced the higher authority for power. It consists of the two ministers, each from Zambia and Zimbabwe, who are responsible for energy and water, and finance respectively. The ZRA has power to charge fees for water used by the two electricity undertakings for the generation of electricity. Water tariff by-laws were accordingly gazetted in both Zambia and Zimbabwe, and became effective on 1 October 1999. Since then, the Zimbabwe Electricity Supply Authority (ZESA) and the Zambia Electricity Supply Company (ZESCO) are being charged for the water that passes through their power stations on a monthly basis.

To effect these by-laws, a Water Purchase agreement was also signed between ZRA, ZESA, and ZESCO, in line with the Water Tariff by-laws. In February 2000, ZRA was charging for water at a rate that translated into a gross annual income of $6–9 million.

The dramatic change of 1987 is that the authority has no function over generation and transmission, this function having been transferred to the two national undertakings (ZESA and ZESCO).

The mistrust generated by the Kafue/Kariba argument in the 1950s continued to influence relationships between Zambia and Zimbabwe over the years. This reached a climax when the two countries decided to reconstitute the Central African Power Corporation (CAPC) and almost to part company in the common supply of electricity. At one stage the Zimbabwe government gave a unilateral instruction that all importation of electricity from Zambia was to cease. Generating stations and transmission systems passed to the ownership of the national power authorities while the Kariba Dam and responsibility for hydrology devolved on the new Zambezi River Authority on 1 October 1987. The reconstitution exercise, which involved the distribution of the assets of the CAPC, is still not complete, as the resolution of the position regarding Kariba North Power Station remains outstanding.

6. Criteria and Guidelines: Policy Evolution and Compliance

This section addresses the question of whether the project was implemented according to criteria, policies and guidelines of the day.

The Kariba project was implemented on the basis of the following documents:

- the Inter-Territorial Hydropower Commission Report of 1951. The main purpose of this report was to advise the governments of Northern and Southern Rhodesia on which project to chose between Kariba and Kafue. However, unlike subsequent project documents, the 1951 report examined other issues besides the dam and hydropower. In that report, the possibility of using Kariba water for irrigation was briefly discussed and mooted, and the need for resettling people out of the Zambezi valley when Kariba was built was also considered;
- the French Mission report of 1954, which was intended to provide an independent assessment of the two projects of Kariba and Kafue and to recommend which of the two should be implemented first;
- the Andre Coyne report which was commissioned to verify the findings of the French Mission report;
- the final project report that was produced by the consulting engineers for Kariba Dam (Federal Power Board 1955). The first draft of this report was produced in September 1955, followed by the final report in December 1955.

Following the decision to proceed with Kariba early in 1955, the government of the Federation of Rhodesia and Nyasaland approached the World Bank for a loan of $80 million. A World Bank appraisal mission visited the Kariba project site in the first quarter of 1956 and produced an appraisal report in June 1956.

The Federal Power Board (1955) report is the project document for Kariba Dam, and will be used here in assessing compliance with guidelines and policies of the day. In addition, the World Bank appraisal report of 1956 was based on a thorough review of the project and, therefore, must have been based on some World Bank guidelines. It will be instructive to use the World Bank appraisal to determine what guidelines were used in assessing the project for funding.

The historical discussion of the project in Chapter 2 showed that the Kariba project was based purely on the need to supply power to the countries of Northern and Southern Rhodesia, especially the copper mines in the former country. It was also explained that the project documents and the World Bank appraisal reports confined themselves to the issues relating to the supply of hydropower. No other project benefits besides hydropower were considered in the project document and in the World Bank appraisal report.

To facilitate the discussion of whether the Kariba project complied with guidelines of the day, each of the following subject areas will be considered in turn: (i) engineering design and dam safety; (ii) environmental issues; (iii) hydrology issues; and (iv) resettlement of displaced people.

6.1 Civil Engineering Design and Construction

The process that was followed in the design of the engineering works appears to have been thorough and in compliance with high standards of engineering design. The involvement of world class engineering companies, Gibb, Coyne and Sogei Pvt Ltd for the civil engineering; and Merz and Mclellan for the electrical work, was intended to ensure a high standard of engineering design and supervision of the construction.

There was an unanticipated occurrence of poor foundation conditions on the southern abutment, which was only discovered during construction. The designs of this section of the dam wall were changed to suit these geological conditions. This cannot be considered a failure in compliance with engineering guidelines, but merely a case of some unforeseen ground conditions. In engineering design and supervision of dam projects, this is not unusual.

The Kariba phase 1 project had a large number of fatalities. Nearly 100 men lost their lives at the dam site. Men were caught in machines, electrocuted, crushed by falling rocks and killed on the roads. The heat, down in the breezeless depths of the gorge topped the 125^{o}F mark, killed at least one and weakened many others. In 1958 the highest flood ever recorded on the Zambezi River flooded the main cofferdam leading to the drowning of one African worker who was one of the crew placing explosive charges.

In 1956, following the award of the contract, the death toll mounted by ones and twos until one day in January 1959, when a party of African and European workers were plunged more than 200ft down No. 5 penstock shaft after some scaffolding collapsed. Tons of twisted steel and fast-drying cement came hurtling down on top of them, handicapping rescue operations. 17 men – 3 Italians and 14 Africans – died on that day. A few weeks later, shaft No. 5 killed again. This time a large pipe fell down the shaft from a scaffolding platform, killing one Italian and one African at the bottom.

One of Kariba's strangest deaths happened during a visit by a jet bomber in 1958. A Vulcan of the Royal Airforce, on a goodwill tour of the Federation, screamed low up the length of the gorge. A young Italian carpenter, working on the great curve of the wall, gazed up at the plane as it flashed overhead. He lost his balance and toppled into the swift river. His body was never seen again.

Despite the tragedies, Kariba however had its lucky escapes as well. Three Italian miners were trapped 200 feet underground in January 1957, when a fall of rock sealed them in a 20ft-wide cavern. Fortunately, through intensive rescue efforts, the three men were finally rescued after two days and two nights, and for one of them, it was the third time he was lucky – he had been trapped underground twice before.

All these tragedies represent the true human cost in lives of Kariba, which resulted in the eventual success of the world's largest man-made lake. It is in this regard that the dead of the Kariba will never be forgotten. They are remembered in the little round church on Kariba Heights, which is in part dedicated to their memory.

One issue that appears to have been overlooked in the engineering design of Kariba Dam, is the apparent failure by the Kariba Dam designers to recognise the location of the dam site in a tectonically active area at the southern end of the African Rift Valley.

The project document (Federal Power Board, 1955), and all other technical documents for the project (French Mission, 1954; Coyne 1954; Inter-Territorial Power Commission 1951) do not mention or discuss the location of the dam in this tectonically active area. This apparent oversight would also explain why no attempt was made to predict the likelihood of the earthquakes that have been experienced in the Kariba area since the dam was built, including 20 that were of magnitude 5 and higher.

The issue of potential dam-induced seismicity is one area that the project planners appear not to have considered. If, indeed, they considered this matter in the design of Kariba Dam this is not reflecting in the project documents.

Regarding Phase 2 of the Kariba project, namely the construction of the north bank power station, there seems that project designers failed to provide the contractor with some critical information regarding the geology of the site of the underground power houses. The geological report prepared under the supervision of Gibbs emphasized the very high quality of the rock of the site, and advised that the geological conditions in the project were ideal.

The World Bank Performance Audit Report of the Kariba North Bank Project, mentioned that the Consultant [referring to Gibbs' report] "failed to report the occurrence of biotite schist and structural weaknesses", and that "the document included in the bid described the rock as sound with few anomalous features" (ref?).[25]

The World Bank Appraisal report went further to state that "On the basis of the information on Gibbs' report, a flat arch design was adopted for the power house, a type of design "unsuitable for anything but first class rock"[26]. According to Morrell (op cit.), it later appeared that "Gibbs were suppressing two geological reports that made it clear that the rock [in the site of the planned north bank power house] was likely to be anything than the expected 'granite'." Two reasons are given for concealing the information on the real nature of the geology of the planned site, despite the gravity of the associated risks. Firstly, "the whole financial plan [of the project] would have collapsed; and secondly, the project to be financed through Zambia (formerly Northern Rhodesia), was vital for the economy of Rhodesia (formerly Southern Rhodesia) which was under international sanctions and was facing civil war. A determination of who was right and who was wrong in the dispute regarding ground conditions for Kariba Phase 2 is beyond the scope of this report. However, there is a good lesson to be learnt here; that for large dam projects of the size of Kariba, adequate time and resources need to be invested in background studies to ensure that the ground conditions are fully understood in advance. The problems experienced in Phase 2 were not the first time the Kariba project had been derailed by unprecedented ground conditions. It will be recalled that, in Phase 1, an additional £8 million was spent in additional work on the south bank abutment.

Several accidents occurred in the construction site, many in the form of rockfalls from the machine hall. Two deaths and injuries were reported between 1971 and 1972. Seeking to apply its Mines and Minerals Act to the project, the government of Zambia issued a series of instructions (regarding employment of temporary labour and safety measures) which, according the World Bank 1983 Audit Report "made it virtually impossible for the contractor to implement its work programme". The government of Zambia eventually agreed to terminate the application of the Act to Kariba in November 1972 in order to allow the project to proceed. Despite this, and certainly because the contractor, the UK-based Mitchells firm continued to be entangled in financial difficulties and went to receivership on 31 January 1973. A new contractor was selected a few weeks later. The Zambian Mineral and Mining Act remained unapplied during the rest of the construction work. The completion of the project was delayed by two years and experienced very significant cost over-runs, the final costs being 2.5 times the appraisal estimate.[27]

6.2 Hydrology

It was pointed out in Chapters 1 and 2 of this report that the Zambezi River, on which the Kariba Dam is located, is an international river and that the six countries of Angola, Botswana, Namibia, Zambia, Mozambique and Zimbabwe are riparian to this river. The first four countries in that list are upstream of Kariba Dam, while Mozambique is downstream of the dam.

One of the most noble actions that was taken by the Southern and Northern Rhodesia in the planning for Kariba, was to approach the Mozambican government of the day, (the country was called Portuguese East Africa as a colony of Portugal) in 1948 and to inform them of their plans to construct Kariba Dam. The downstream country was informed that this would obviously affect the hydrology of

[25] World Bank. 1983. Zambia: Kariba North Hydroelectric Project. Project Performance Audit Report. August. 12

[26] Information from David Morrell's book on *Indictment: Power and Politics in the Construction Industry.* Faber and Faber Ltd. London. 1987. Mr Morrell was head of the Mitchell firm, contractor for the Kariba North Bank project.

[27] World Bank., op, cit 1983, p. iv

the Zambezi River below that dam and in Mozambique. The outcome of those discussions was that an agreement was reached on a minimum flow that would need to be released by Kariba Dam at any one time. The minimum flow past Kariba was agreed as 10 000cusecs or 283m^3/s.

During the construction of Kariba Dam, closure of some by-pass gaps in the dam wall on the north bank had to be delayed for days until the overflow past the incomplete dam had reached this agreed level of flow. This signifies the effort that was made by the project planners and implementers to comply with agreements made with a downstream territory. This agreement to maintain a flow greater than 283m^3/s is still being observed at Kariba. Fortunately, the size of flow that is needed to comply with this agreement is less than that required for maximum electricity generation at Kariba.

Kariba was designed for the safe passage of a 10 000 year flood, based on river flow data available at the time. In the original design of the dam, the spillway had been designed for a 3-month flood of volume 68km^3. During construction, in 1957, a peak flood of 8200m^3/s occurred, the highest on record. As a result, the dam engineers revised their spillway design to a 3-month flood of 74km^3. In the following season, 1958, a peak flood of 16000m^3/s was recorded and a 3-month flood of 61km3 occurred. This led to a further revision of the spillway design to its present capacity of 92km^3. Had the project been completed before these two floods, the spillway would have been seriously underdesigned, with equally serious safety implications.

6.3 Resettlement of Displaced People

One of the major issues for which Kariba is known in history is the manner in which the people that were displaced by the dam were resettled. In Chapter 3, the issue of resettlement was discussed at great length and details were presented on how the process was carried out in the two countries involved.

It was shown that the Federal Power Board, which was essentially the owner of the Kariba project on behalf of the Federal government of Rhodesia and Nyasaland, delegated the responsibility for resettling displaced persons to the two territorial governments of Northern and Southern Rhodesia. This move effectively removed resettlement from the project, although a budget for this purpose was provided for in the project document.

It is further noted that the World Bank (1956) appraisal report never discussed the resettlement of displaced people as part of the project that was being evaluated for funding. The evaluation report confined itself to the issues of hydropower and the economic viability of the project, based on hydropower alone.

The World Bank prepared two reports. The first was an appraisal report for the project, prepared by the mission which visited the project site and which evaluated the project document. The second report was an internal report by the president of the bank to the executive directors of the bank, recommending the project for funding. Even the second report did not mention the issue of resettlement.

In reading the two World Bank reports no mention is made of whether there were any guidelines at that time with regards to the resettlement of people in dam projects funded by the bank. It would appear that there were no guidelines at the time and therefore that no guidelines were applied to this project in the evaluation. If there were any World Bank guidelines at the time, and this study could not find any, then the bank can be viewed as having overlooked its own guidelines.

There is a second level of compliance that must be considered with respect to resettlement, ie, the compliance with national guidelines of the affected territories. The sociology section of this report described the different ways in which displaced persons were resettled and compensated in Zambia and Zimbabwe. The two governments were different in constitution, with Northern Rhodesia being a colony governed from London, while Southern Rhodesia was a self-governing colony.

Examination of the laws of Southern Rhodesia at the time showed that there were no legal instruments in the laws of the country through which displaced persons could seek redress. The affected Africans effectively had no rights and therefore had to comply with whatever instructions were handed down by the government. Since there were no standing laws, policies or guidelines with respect to how people displaced by government projects such as dams should be treated, the question still remains whether the project complied with guidelines of the day. Unfortunately, one can only conclude that the resettlement programme did not transgress any guidelines of the day, mainly because there were none. The fault lay with the laws of the day more than it lay with the actions of the implementers of the project.

It will be recalled that the situation was different in Zambia, where some personal compensation was offered to displaced persons and some agricultural and infrastructural development programmes were financed by the project for these displaced persons. It is not clear whether this more sensitive approach to resettlement and compensation was a result of existing specific laws that safeguarded the rights of individuals in Zambia or whether this arose from the fact that Zambia was a direct colony (not a self governing colony) of England.

There were some casualties in the resettlement process. In Northern Rhodesia, protests against resettlement in June 1958 resulted in clashes between police and tribesman, leading to police opening fire. 8 Africans died and another 32 were injured. More deaths occurred towards the end of 1958 among the resettled people, with 81 out of 6000 resettled in the Lusitu area of the Gwembe valley having died, many of them from bacillary dysentery and diarrhoea. The following January another 15 died, including 6 children. First reports maintained that the deaths were caused by fouled and insufficient water holes. A subsequent official investigation attributed the disease to flies and unsanitary conditions. In the previous year, dysentery had claimed 40 victims among the resettled people on the south bank.

In judging the compliance of the two countries with respect to resettlement it must also be appreciated that the two countries involved had no previous experience in managing projects of the size of Kariba. There were therefore no precedents to the issues that confronted the countries. As a result, the administrations acted in the most expedient manner that they could.

6.4 Compliance with Environmental Guidelines and Policies

A project the size of Kariba, if implemented today, would involve an extremely complex and large EIA. It is therefore interesting to note that the documents for the Kariba project do not even mention one word with respect to the environmental impact of Kariba Dam. As was pointed out earlier, the project documents confined themselves to the hydropower issues and the cost of the project.

The question still remains whether the project complied with the environmental guidelines of the day. Since there appears to have been no guidelines at the time, the issue of compliance does not arise.

Even the World Bank, which today has developed a high sensitivity for the environmental impacts of projects that it funds, and has prepared detailed environmental impact assessment guidelines, does not appear to have had any guidelines at the time of Kariba. If the bank did in fact have guidelines at that time, then it can only be concluded that the bank ignored them or that the appraisal report did not report an environmental assessment that was carried out.

The fact that the project document did not consider environmental impact issues of the Kariba Dam as part of the project explains why no funding was allocated for this purpose in the project. Also, since the project documents do not discuss potential environmental impacts of Kariba Dam, it follows that any environmental impacts that occurred, as results of the dam were unexpected.

6.5 The Kariba Lake Coordination Committee

With the Kariba project implementers having confined themselves to the issues of the dam and hydropower plants, it was fortuitous that the Kariba Lake Coordination Committee was formed. This committee was created in December 1957 after the realisation that there was "no ready made organisation to explore and run developments on the banks of the lake" Its members were the Secretary for Power, Federal government, the Director of Irrigation, Zimbabwe and the Kariba Development Officer, Zambia.

The mandate of the committee was to: (i) advise the three governments on the coordinated development of the lake; and (ii) develop an implementation vehicle, which was named the Kariba Lake Development Company (KLDC) whose objective was "to develop or procure for development the whole or any part of Kariba Lake".

The capital budget it proposed for the KLDC was £3 million to the end of 1960/61 to be funded equally from the three governments (Federation, Zambia and Zimbabwe). The KLDC was to be formed hurriedly, with a brief to cover a wide range of subjects, transport, industries, fisheries, national parks, tourism, irrigation and forestry. It had Legal and Financial sub-committees. The minutes provide a good record of the work of the KLCC. At the collapse of the Federation the files end with no continuity in the record.

The first year of the committee – until the first meeting in December 1958 – was used to put in place numerous studies and to incorporate other departmental activities. Thus, for instance, at the first meeting of the KLCC, the Zimbabwe Director of Health, D. M. Blair, submitted a note on bilharzia control. He recommended preventative measures such as the concentration of settlements at points where there were steep slopes into the water, the provision of windmills offshore to pump clean water to consumers and other measures together with budgets for spraying against the host snail, and for staff and equipment.

The minutes of the first meeting, of 23 December 1958 noted that the Memorandum and Articles of Association for the Kariba Lake Development Company (Pvt Ltd. (KLDC) had been prepared. Its aim was to develop and to procure for development the whole or any part of Kariba Lake. It was to be a private company. Like the KLCC, the company would cover tourism, sports, transport, hotels, resorts, bottle stores and other commercial licences, and game reserves amongst a longer list.

The KLDC would promote and explore investment activities. It would preserve game, flora and fauna, and fish. It would conduct or commission research. It would regulate and control where necessary. It could build roads, railways, aerodromes, own and operate aircraft, run an airline, telegraph services, canals and harbours, place navigation buoys, set up transport systems, run boats, manufacture ice, run a dry docks and act as a shipping agent.

The formation of the KLDC is significant in that the committee effectively took over responsibilities for environmental management and protection on behalf of the project. The committee commissioned a survey of fish biodiversity in the Zambezi River before the dam was built, carried out studies with respect to the risk of incidence of water borne diseases, was involved in the development of plans for the management of wildlife after the completion of the lake and investigated tourism opportunities associated with the lake. The committee took responsibility for the environmental issues that had not been included in the project document. Unfortunately the activities of the KLDC were not funded by the project and the project cannot, therefore, claim any credit for them. If the KLDC had not taken responsibility for the environmental issues associated with Kariba Dam, it is likely that some serious negative environmental impacts would have occurred. For example the KLDC devised measures for bilharzia control on the lakeshore and was involved in the delineation of national parks and the saving of wildlife from the impoundment area. Other major achievements of the KLDC were the promotion of Kariba as a tourism destination with several hotels on the lakeshore, a thriving water sport industry and the development of the fisheries industry of the lake.

Because the KLDC was a body that was a somewhat voluntary organisation and independent of the project, it was easily disbanded at the break-up of the federation in 1963, and all the structures for co-operation between Zambia and Zimbabwe that had been set up were lost. However, without the existence of the committee to this point, there is a possibility that the Kariba Dam would have had some serious negative environmental impacts. The committee can be credited with averting some possible negative environmental impacts.

7. Views on Development Effectiveness and Lessons Learnt

The ultimate objective of the WCD case study process is to make an assessment of the overall development effectiveness of large dam development and to derive lessons for other large dam projects worldwide.

7.1 Assessment of the Development Effectiveness of the Kariba Project

It was explained earlier that the concept of development effectiveness is a subjective one. It represents the overall opinion, all things considered, that a person has of a dam project. In the WCD case study methodology, the development effectiveness of a dam was to be evaluated by the stakeholders of the particular dam. The stakeholder meetings were used for this assessment, with questionnaires being administered on the stakeholders (See Annex for the Minutes of the Meeting).

During the second stakeholder meeting for the Kariba case study, the stakeholders were asked for their view on the general effectiveness of the dam and to explain what they believed to be useful parameters on development effectiveness of dams. The stakeholders engaged in intense debate on this issue. In the end, they agreed on a set of questions that must be asked in order to evaluate the development effectiveness of large dams. Following are some of the questions (the order of listing is of no significance) that the stakeholders believed should be used in assessing the development effectiveness of large dams:

- **Was every possible development option considered and exploited in the planning and implementation of the dam project?** According to the stakeholders, the decision to implement an effective large dam project should be preceded by an analysis of all possible development options, to ensure that these are incorporated into the project. In the case of Kariba, one of the main weaknesses of the project, according to the stakeholders, was the failure by the project planners to look beyond the provision of hydropower to the two participating countries. The stakeholders were of the view that development options in fisheries, tourism, irrigation and rural electrification should have been considered at the planning stage and implemented as part of the project.
- **Did the project increase regional co-operation?** In the view of the stakeholders, a dam is more effective if it promotes regional co-operation. The stakeholders felt that large dams are best implemented in a regional rather than national context. In this regard, Kariba was viewed as being effective by the stakeholders because it became the nucleus for the development of the Southern African Power Pool and the power from the dam led to the industrial development of Zimbabwe and Zambia.
- **If people were displaced by the dam project, did these displaced people benefit from the dam project?** For a dam to be considered effective, the benefits from the dam must be enjoyed by those displaced by the dam. This is one area in which the stakeholders found Kariba to have failed the test of development effectiveness, because the Tonga who were displaced by the dam benefited little from the project.
- **Did the project meet the required rate of return?** This is a purely financial and economic consideration, whereby an effective dam project should meet the predicted economic performance targets.
- **Did the project exceed original objectives?** According to the Kariba stakeholders, an effective dam project should exceed original objectives. The stakeholders noted that Kariba did, in fact, exceed the original stated project objectives and that it can be viewed as having been effective.
- **Was there an equitable distribution of benefits from the project?** This was another one of the issues that were most hotly debated at the stakeholder workshop. The stakeholders were reacting to the fact that most of the benefits from Kariba were not being enjoyed by local people who had

suffered most as a result of the lake. In the view of the stakeholders, an effective dam project is one in which an effort is made to ensure that the benefits are distributed as equitably as possible. This was one area in which the stakeholders believed that the Kariba Dam project had not been effective.

- **Did the living standards of the people improve as a result of the project?** An effective dam project should be associated with an improvement of the living standards of the people; especially those displaced by the dam. Again, the Kariba Dam project was viewed by the most of the stakeholders as not having been entirely effective because the living standards of the displaced people were prejudiced.
- **Did the affected people participate in the decisions that related to the project?** In an effective dam project, the local affected people must be allowed to participate in decisions that relate to them. In the case of Kariba, the people were not afforded the opportunity to participate in the decisions that related to them and the dam, and stakeholders were mainly of the view that the Kariba project was not effective here.
- **Was an EIA carried out and was a costing of impacts carried out?** An effective dam project should have an EIA and an environmental management plan. Since no EIA was carried out at Kariba, this was one area where the project failed. However, the stakeholders excused Kariba on this issue because at the time, environmental issues were not yet in vogue.
- **Is the dam project multipurpose?** This question is linked to the one where the stakeholders believed that all development options must be investigated in the planning of a large dam project. The stakeholders felt that because the planners for Kariba confined themselves to hydropower issues, some opportunities for multipurpose use were lost.
- **Were efforts made to minimise the displacement of people?** The decisions that were made on the size of Kariba were aimed at maximising the amount of power from the project through the construction of the largest dam possible. No analysis was carried out to reconcile the need for a large dam and power station and the need to minimise the number of people to be displaced. In fact the Federal Power Board went on to increase the height of the dam wall by 20 feet resulting in the increase in the area inundation and a concomitant increase in the number of people to be displaced.

The stakeholders for Kariba Dam had divergent views on the different aspects of the development effectiveness of Kariba Dam. Views were mainly divergent with respect to technical and economic issues, but there was general consensus on issues relating to social impacts of the dam. This consensus is not surprising when one considers the high awareness of the stakeholders with respect to these social issues.

When the stakeholders were asked to give their overall assessment of the development effectiveness of Kariba Dam, 15.5 % rated Kariba very highly effective, 56% high, 13 % were neutral, while the remaining 15.5 % rated Kariba poor. None of the stakeholders rated Kariba in the lowest category of very poor. Therefore, overall, the negative social impacts notwithstanding, the Kariba stakeholders viewed Kariba Dam as having been effective. In interpreting these figures, it should be taken into account the fact that respondents are not necessarily representatives or even reflective of the population of all affected and interested parties.

7.2 Lessons Learned

The information and data collected by consultants with respect to the Kariba Dam and the views expressed at the stakeholders meetings were carefully examined to isolate lessons that may be useful or inform large dam development in the future. The following is a list of lessons that were identified in the Kariba case study, for the large dam debate. The consultants drew the list of lessons first and presented them at the second stakeholders meeting. The latter made their contributions and editions to the consultants' list of lessons. The lessons are:

- **The design of spillways for large dams should make allowance for hydrological uncertainty. For safety, the dam spillway should be designed for the Probable Maximum Flood (PMF), which would be the highest flood that can physically occur.**

Kariba was designed for the safe passage of a 1 in 10 000-year flood. In the original design of the dam, the spillway had been designed for a 3-month flood of volume $68km^3$. During construction in 1957, a peak flood of $8200m^3/s$ occurred, the highest on record. As a result, the dam engineers revised their spillway design to a 3-month flood of $74km^3$. In the following season, 1958, a peak flood of $16000m^3/s$ was recorded and a 3-month flood of 61km3 occurred. This led to a further revision of the spillway design to its present capacity of $92km^3$. Had the project been completed before these two floods, the spillway would have been seriously under-designed, with equally serious safety implications.

- **Hydroelectric schemes may have far more positive implications than just the production of electricity**

The Kariba project provided access roads to hitherto isolated area; led to the development of a thriving fishery industry; triggered the formation of important wildlife sanctuaries; became a major tourist attraction; and formed the basis for an interconnected electricity network of two countries. These developments cannot all be predicted accurately, but in future studies the development potential of non-electricity benefits should be accorded more attention.

- **Major hydropower projects can lead to continuously low tariffs, with major benefits for the residential, commercial and industrial consumers**.

As a result of the relatively low construction cost of Kariba and Kafue the average electricity cost in the region dropped by about 30% in the period 1961–977, while the average price for other commodities and services rose by more than 75%. It must be said however that ZESA almost went bankrupt during this time, as prevailing tariffs, dictated by the government, did not reach adequate levels.

The study found that there is good anecdotal and non-quantitative evidence of a good correlation between GDP of Zambia and Zimbabwe and electricity consumption. The completion of Kariba resulted in growth of manufacturing and mining sectors in Zambia and Zimbabwe respectively. For example, following Kariba, Zimbabwe established high power consuming industries such as fertiliser and ferrochrome plants.

- **Large man-made reservoirs can cause earthquakes, especially when they are constructed in a tectonically active area, as is the case of Kariba. The induced seismicity may affect dam safety and lead to other damages such as flooding of downstream areas; and should therefore investigated in the planning stages of the dam to ensure dam safety.**

The water storage volume of Lake Kariba of $180km^3$ translates into a mass of 180 billion metric tons. It was further noted that the lake is located in a tectonically active area, at the southern end of the African Rift Valley. Since its construction and filling in the early 1960s, Kariba has caused numerous earthquakes in the area, 20 of them in excess of magnitude 5. This has significance on dam safety.

The project documents for Kariba did not discuss the seismicity of the Kariba area, and the need to take this into account in the design of the dam. The planning of any future dams that are of similar size to Kariba, and which are located in tectonically active areas will need to take account of the potential dam induced seismicity in the design.

- **With the numerous unexpected impacts that arose since its completion, the Kariba Dam illustrates the importance of systematic Impact Assessment in the planning of large dam**

projects. Many of the negative impacts of Kariba could certainly have been avoided if some impact assessment had been applied in a systematic way at the time. The impact assessment should as a minimum, address the following components: environmental impact assessment (EIA), social impact assessment (SIA) and health impact assessment (HIA)

In the Kariba project, the project document and the World Bank project appraisal report did not consider any environmental impacts of the dam. These documents confined themselves to the issues of the construction of the dam wall, the power stations, associated civil works, and their costing. As a result, the Kariba Dam had numerous unexpected impacts, especially in the environmental fields of wildlife, water pollution, tourism, water borne diseases and fisheries, and in social sectors (displacement and resettlement in particular).

- **A dam project is governed and guided by the prevailing laws of the country. In situations where the laws are unjust, it is difficult for the project to deliver benefits equitably, and to minimise social and economic costs. As a minimum, it is important for a dam to ensure that the land rights of the people (especially the tribal land rights) are not lost as a result of the project.**

Because of the differences in the political settings in Zambia and Zimbabwe (Northern Rhodesia, an "indirect rule" colony, which became independent 5 years after the completion of the dam, and Southern Rhodesia, a White settlement colony until 1980), the resettlement procedures were different in the two countries. While still far from optimal, the resettlement of the Tonga in the north was less inhumane than what happened in the South. That said, in both countries the laws were such that people who were displaced (Africans) by the dam had little protection by the colonial authority of the time. According to the laws of both countries peasants did not have title to the land on which they were settled. They only had usufruct rights, and the land belonged to the state. Because of this legal situation, there was no need for the project to take the interests and land access rights of the local people into consideration. If the laws had been just, and the people had had some land access rights, the project developers would have been compelled to consult the people and to take their rights and interests into account.

- **In dam projects, cases of involuntary resettlement require detailed planning and the full participation of the affected people in the planning process. In addition, the planning process must be carried out well ahead of resettlement process and must ensure adequate infrastructure in the new areas of settlement to minimise the trauma of resettlement for those displaced by the dam. As far as possible, the displaced people must be equally or more comfortable in their new settlement areas than their areas of settlement in the dam basin.**

The Tonga people who were displaced by Lake Kariba were never involved in the planning of their resettlement. All evidence available shows that the government officers of the day did all the planning of the resettlement exercise and the general selection of the new settlement areas for the Tonga. The Tongas were not provided with an opportunity to explore alternative ways of resettlement and to state their preferences. Another weakness of the resettlement programme is the fact that it was hurried. Not enough time was allowed for the Tonga to be prepared for the relocation, with the result that some had to be rescued on islands as the waters of the lake rose.

On the same issue of the need to involve the affected people in the planning of their resettlement, dam project developers should involve the people and negotiate with them on the most appropriate manner of resettlement. In the Kariba case study, it is reported that displaced people were bundled into lorries and left at their new homes. Cattle were driven over long distances on the hoof and it is reported that some died in transit. Any materials of cultural value, such as clay pots, which could not be transported on the lorries, were left behind. These losses or some of them could have been avoided if the people had been involved in the planning of the move and allowed to participate in decisions on the best way of relocation.

- **Where resettlement process leads to community fragmentation, one of its potential consequences can be a loss of cultural identity.**

Some of the displaced Tonga people were settled in areas where they became minority groups. In these cases (examples of Tongas settled in Sambakarouma and Binga in Zimbabwe), they ended up speaking the languages of their host communities, and lost not only their native languages but also their cultural Tonga identity. This lost of identity has been accentuated by the fact that the frequency and feasibility of visits between groups settled in the South (Zimbabwe) and those settled in the north (Zambia) were practically eliminated after impoundment, because of the long distances involved (some were located over 100km from the Lake), and because of the tightening of the conditions for crossing the border, especially after the Federation of Rhodesia and Nyasaland broke up in 1963. As time passed, relatives and friends on the opposite side of the border lost contact with each other. It was during the stakeholder meeting organised to discuss the draft Kariba report that some of the representatives of these communities met for the first time since the displacement took place, 40 years ago. A 40 to 50-year old traditional Zimbabwean Tonga chief who attended the Kariba stakeholder meeting needed an interpreter in order to communicate in Tonga with other chiefs.

- **The effectiveness of a dam project must be evaluated on the basis of the extent to which it provides meaningful development opportunities for the people who are affected by the dam.**

In the Kariba case, it would be fair to say that the displaced Tongas were never viewed as stakeholders in the dam or potential owners of the dam. As a result, there was no attempt on the part of the dam developers and the governments of the day to investigate ways in which the Tonga could maximise their benefits from the dam. In Zimbabwe, for example, the settlement areas were located far from the new water body where they could not easily access the dam for fishing and/ or irrigation. Some of the communities were settled more than 120km from the dam, with most of them being about 50km. It is not feasible, from these distances, for the displaced people to take advantage of the dam.

The Kariba Dam was established for the production of electricity, and yet very few of the Tonga settlement areas are connected to the national electricity grid. In Zimbabwe, the first Tonga area to be connected to the national grid was Binga in 1985, 25 years after the first generator went into operation at Kariba. Since 1985, no other areas have been connected in the Tonga areas of Zimbabwe. It therefore follows that the Tongas of Zimbabwe were never provided with an opportunity to benefit from the main product of Kariba Dam.

- **In resettling people who are displaced by large dam projects, effort must be made to ensure that the relocated people are familiar with the agro-ecology of the new areas of settlement, and that they have the necessary agricultural skills for their new settlement areas. If the new and old areas of settlement are agro-ecologically different, the project should make budgetary allocations and adequate plans for the provision of long-term, appropriate agricultural training for the settlers, to ensure success. This recommendation applies to areas where agriculture is the main occupation for the displaced people. However, where the affected people are involved in non-agricultural activities, the project must ensure that the people receive skills training in their field of livelihood.**

The people who were displaced by Kariba in Zimbabwe were settled in areas that were agro-ecologically different from their original home on the banks of the Zambezi River. The agriculture studies carried out showed that while the Tonga were able to grow two crops per year in some areas along the Zambezi River, their new areas of settlement were in dry areas of unreliable rainfall and generally infertile soils. As a result, the Tonga have not been able to become self-sufficient in food during the last 40 years.

One of reasons why they failed to become self-sufficient in food is that they were never provided with the training to manage agriculture in the new areas. No investment was made into the training of these settlers to develop appropriate farming systems for their new area.

- **Resettlement is not completed when the people affected are relocated. In addition to compensation aimed at enhancing livelihood conditions in a sustainable way, continuous support is necessary over many years to help them to get adapted to a new style of life.**

Compensation packages offered to displaced people varied between the countries of Zimbabwe and Zambia. The Zambians were provided with cash compensation paid to each individual as well as funds for some development programmes in the new areas of settlement. On the other hand, the Zimbabweans did not receive any cash payments to individuals and there was little provision for development programmes in the new areas of settlement. The present study found that the displaced people in Zambia were unhappy with the compensation that was offered, considering it inadequate.

40 years after commissioning the project, the people resettled in both countries due of Kariba, still need help. Part of the project revenues should become available for this purpose.

The lesson that can be learnt from this observation is that designing an appropriate compensation package for people displaced by a dam is a complex and difficult exercise, and that dam developers need to be creative and to go beyond the provision of cash handouts. Compensation needs to be aimed at providing the displaced people with an opportunity to achieve a sustained improvement in their livelihoods. Compensation is best given in a form that provides opportunity to the displaced people to become economically self-reliant and must be consistent with the noble aspirations of the community.

In the Kariba Dam project, the compensation that was offered to the displaced people, in Zambia, was on a *pari passu* basis, (ie, a hut for a hut). This approach misses the opportunity to develop a compensation profile that enables the displaced people a chance to participate in economic benefits arising from the transformation of their land resources.

The United Nations principles on habitat, which state that "whatever the original conditions of the displaced community habitat amenities, the new homes must meet the basic needs of comfort, health and dignity". This United Nations dictate is exactly opposite to the "no worse no better" approach that was followed in the Kariba project by the Zambian territorial government in determining the situation of the displaced people after resettlement.

The Kariba study also shows that compensation alone does not suffice in many cases to guarantee improved livelihood conditions in a sustainable way.

- **In large dam projects, the affected people (especially those who would be displaced) must enter into legally binding agreements with the dam project developers with respect to the obligations of the developer to the affected people. This approach minimises misunderstandings between the dam project and the people.**

The Kariba stakeholders proposed this lesson at their second meeting, and it arose from the observation that all the complaints and expectations that the Tonga have with respect to the Kariba Dam could have been addressed through legal means if there had been a legally binding agreement between the people and the project. At the time that Kariba was constructed, some verbal promises are reported to have been made by the governments of Zambia and Zimbabwe with respect to what the project was going to do for the displaced persons. The local people claim that many or some of these promises were not fulfilled by the project. For that reason, the local people wish that they had recourse to a legally binding agreement for redress.

- **Effective institutional structures should be established to monitor and attend to all identified potential negative impacts after the implementation of the dam project. In projects such as Kariba, which are inter-country, it is important to ensure that these institutions can survive any changes in the political relations of the countries.**

In the Kariba case study, the project did not carry out any impact assessment. However, if the project had done so, it would have been important to ensure that effective institutions were identified to address any negative impacts after the project had been implemented. This lesson arises from the observation that the Kariba Lake Coordination Committee ensured that some of the potential negative impacts of Kariba were addressed by institutions that they established. An example is the assignment of all issues pertaining to wildlife to the game department, and how the latter has managed the wildlife of the area effectively ever since the dam was constructed. Similarly, through the efforts that were initiated by the KLCC, the Lake Kariba Fisheries Research Institute was established to oversee all issues relating to fisheries on the lake.

The role played by CAPCO in managing the dam and power stations during the 1965–1980 period when the relations between Zambia and Zimbabwe were at their lowest, shows the importance of strong inter-country institutions. The recent (1987) establishment of the ZRA as an inter-country body with wide ranging responsibilities, which include studying and making recommendations on environmental and social impacts of the dam as a lesson for future dam developers is a further testimony in favour of strong international institutions. It is interesting that the idea of the ZRA had been suggested as far back as 1948, by the Inter-Territorial Power Council, but it had to wait 30 years before it could be implemented.

The corollary of this lesson is that the implementation of large inter-country dam projects must be accompanied by the immediate establishment of strong, legally-constituted institutions that have clearly defined responsibilities with respect to the addressing of negative impacts. Without effective institutions it is not possible to address negative impacts of dams.

- **As shown in the case of the Kariba Dam, a number of initiatives (trust funds, targeted development projects) can be considered for addressing some of the unsettled issues inherited from the past.**

Most old dam developments, such as Kariba Dam, which were implemented prior to the 1980s did not have the benefit of thorough impact assessments, especially environmental and social impact assessment. As a result, these dams are likely to be associated with some negative social impacts. The current ZRA Trust Fund and ZESCO’s Tonga rehabilitation projects, initiated 40 years after the construction of the dam, are promising ex-post reparation initiatives. Some of the representatives of the Tonga people who attended the stakeholder meeting are doubtful about the effectiveness of these programmes, which they consider as too top-down if not mere cosmetic interventions.

- **Projects of the nature of Kariba not only require regional co-operation, but are also opportunities for fostering it. As a large international and inter-country hydroelectric project, Kariba facilitated the creation of regional power pools and ensured reliability of power supply to the participating countries. In turn, regional power pools can reduce the unit cost of power through the optimisation of use and economies of scale.**

As an international dam, shared by the two countries of Zimbabwe and Zambia, the Kariba Dam project automatically involved the erection of power transmission lines to the two countries, thereby connecting the national electricity grids. It also meant that Kariba became connected to any other power stations within the two countries. When Kariba was built, the Zambian Copperbelt was already connected to power stations in the Congo, and therefore, Zimbabwe became connected to the Congo. Kariba enabled the formation of the Southern African Power Pool in which the electricity grids of the countries of Zimbabwe, Zambia, Congo, South Africa, Mozambique, Botswana, and Lesotho became connected.

Regional power pools have many advantages, which include: (i) the maintenance of reliable power supplies in the event of any one station breaking down; (ii) the reduction in cost of power through the optimisation of use of the different power stations in the pool; and more importantly (iii) the savings in investment that accrue in foregoing the expansion of individual country generation capacity.

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