AN INVESTIGATION INTO THE FLOOD HAZARDS FACED BY THE COMMUNITY LIVING NEAR KALIKILIKI DAM IN MTENDERE COMPOUND – LUSAKA

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A Projected submitted to the Department of Geography at the University of Zambia in partial fulfillment of the degree of Bachelor of Science, BSc.

DECLARATION

"I **Chrispin Moyo**, declare that this project report has been composed and compiled by me and that the work recorded has been done by me, that the sources of all materials referred to have been specifically acknowledged, and that the project report has not been accepted in any previous application for an academic award."

Signature:..................................... **Date:** 13\09\02......................

DEDICATION

To my lovely daughter (Tinashe), brothers, sisters, mother and my late father.

ABSTRACT

Part of Section-D of Mtendere compound is located close to Kalikiliki Dam, an earth dam. It is therefore feared that if Kalikiliki Dam failed, the flood that can be generated by water escaping from Kalikiliki pond can have some disastrous consequences.

This study was therefore conducted in order to identify the flood hazards that Kalikiliki Dam poses to the nearby community. A field survey was conducted on Kalikiliki Dam. Some important observations were made and some photographs of some important features were taken. A transect was also conducted on the dam to show how close some houses are located to the Dam.

Some residents of Mtendere compound who live close to Kalikiliki Dam were interviewed, using a questionnaire, on what they thought about the flood hazards posed by Kalikiliki Dam. A Senior Council Official, from Lusaka City Council, was interviewed on, among other things, how safe the Kalikiliki Dam is against failure. Maps were used to establish the catchment area of Kalikiliki Pond and to identify factors affecting runoff from the catchment. Aerial photographs were used to map and show the expansion of Mtendere compound towards kalikiliki Dam.

Results indicated that Kalikiliki Dam lacks maintenance and protection. Consequently, the dam is under serious threats from human activities and natural factors such as soil erosion that can cause the dam to get breached. The catchment area of Kalikiliki Pond was found to be largely built-up, an indication that surface runoff flow is high from the catchment. It was found that the majority of residents in Mtendere compound perceive Kalikiliki dam as an environmental hazard with regards to flood hazards posed by the dam.

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CHAPTER ONE

INTRODUCTION

Man's invasion and occupancy of certain environments has subjected him to some environmental hazards that are life threatening in some cases. The occupancy of, for instance, areas of land below dams – downstream – has put man at risk from flood devastation in the event of the dams failing or bursting. In the United States of America (USA) alone, for example, 2000 communities have been identified at risk from dams which are believed to be unsafe (Smith, 1992). This report presents the findings of the study that was conducted to determine the flood hazards that the community living near Kalikiliki Dam, in Mtendere compound, is faced with.

1.1. BACKGROUND TO THE STUDY

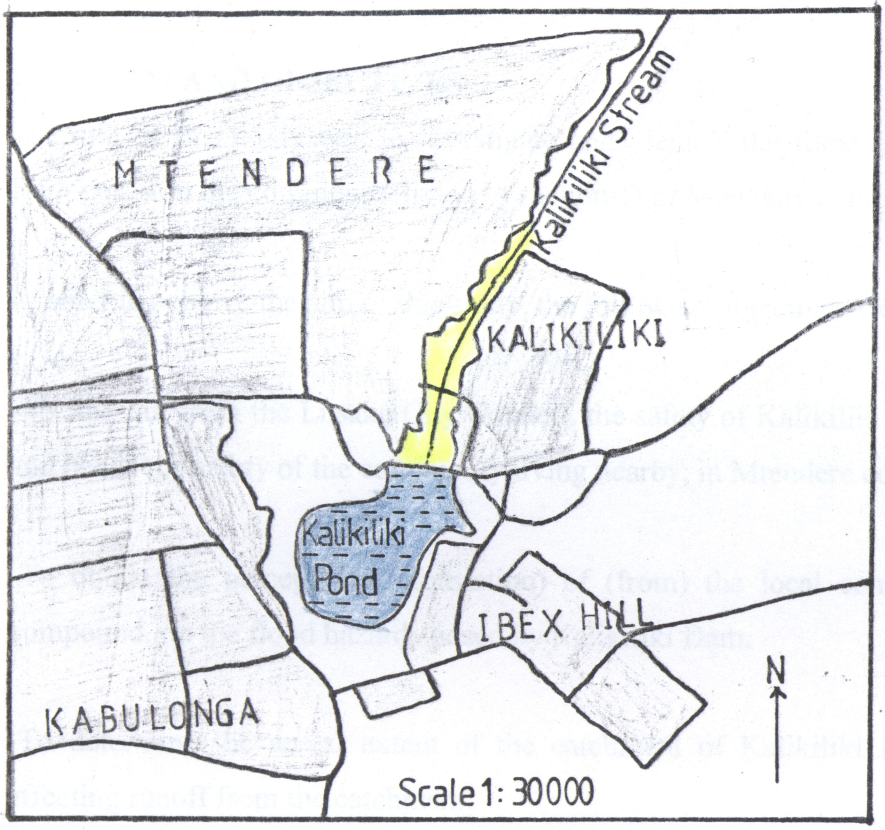
Part of section D of Mtendere compound has over the past years expanded towards Kalikiliki Dam, an earth dam. Hamungala et al., (2001) states that Kalikiliki Dam was built in the 1950's for irrigation purposes. However, as way back as 1987 when this researcher got to know the dam, the reservoir of the dam has not been supporting any irrigation farming activity.

In 1992, according to local residents, Kalikiliki Pond dried up completely following the drought that was experienced in the area (along with many other parts of the country) during the 1991-92 rainy season. This attracted people to settle down stream, adjacent to Kalikiliki stream which dried up too. Prior to the 1992 drought, the area of land adjacent to Kalikiliki was unoccupied. Figure 1.1 shows the land in question.

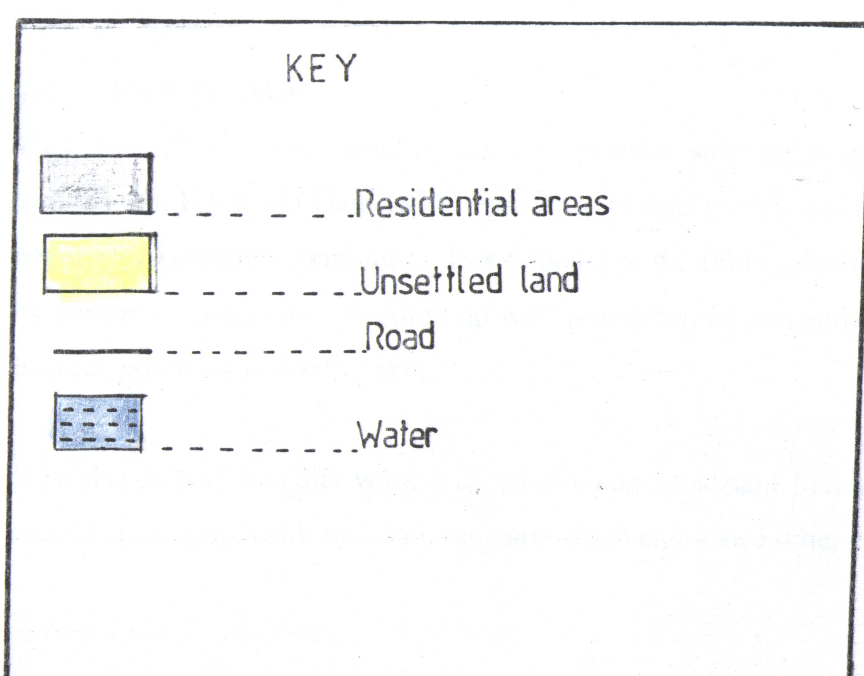
1.2. STATEMENT OF THE PROBLEM

Considering the fact that part of section D of Mtendere compound is located downstream, near Kalikiliki Dam, it is possible that loss of human lives, injury, destruction to household property and houses could be experienced in the event of Kalikiliki Dam failing.

FIG 1.1 MAP SHOWING UNSETTLED LAND ALONG KALIKILIKI STREAM BEFORE 1992



Source: 1991 Aerial Photograph (nö59:60)



Already, during the rainy season, the rise in water levels in Kalikiliki pond appears liable to overtopping of the dam. Soil erosion is also another worrying problem. The earthen embankment is being attacked by soil erosion. This can undermine the structure.

1.3. AIM AND OBJECTIVES

The aim of this study was to investigate and identify the flood hazards that Kalikiliki Dam poses on the community living in section-D of Mtendere compound.

In order to achieve the aim of this study, the following objectives were considered:

-To find out from the Lusaka City Council, the safety of Kalikiliki Dam (against failure) and hence the safety of the community living nearby, in Mtendere compound.

-To obtain the perception (information) of (from) the local community of Mtendere compound, on the flood hazards posed by Kalikiliki Dam.

-To determine the aereal extent of the catchment of Kalikiliki Pond and the factors affecting runoff from the catchment.

-To conduct a field survey on Kalikiliki Dam.

1.4. RATIONALE

This research was conducted in order to provide substantial information on the flood hazards that Kalikiliki Dam (with regards to its reservoir) poses on the community living nearby, in Mtendere compound. It is hoped that the findings of this research can be used by concerned authorities to come up with mitigation or prevention measures to the flood hazards posed by Kalikiliki Dam.

It is also hoped that this work will serve as an important literature document on flood hazards posed by Kalikiliki Dam (an earth dam) and hence other earth dams.

1.5. DEFINITION OF SOME KEY TERMS

Community : "The people living in one area". The Mini Oxford School Dictionary (1994, p 116).

Flood : A high flow of water arising from a dam failure or from excess water escaping from a reservoir that leads to the inundation of a given area.

Hazard : "A potential threat to humans and their welfare" (Smith, 1992:p6)

Overtopping: The overflow of water from the top of the dam when water in the reservoir exceeds the water level control facilities of the dam.

Pond : The water impounded behind the dam.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents the literature that was studied on the subject of this research.

2.1. EARTH DAMS

A dam is a barrier that is either natural or artificially constructed to impound water or to divert the flow of water on small streams or large rivers (Whalstrom, 1974). Earth dams are made of unconsolidated earth materials. The principal materials of earth dams are gravel, sand, silt and clay (Longridge, 1960; Schwab et al., 1966, 1971; Fair et al., 1966).

Earth dams are classified as embankment dams. In Zambia, earth dams that measure upto 4.5 metres in height are known as small dams and those that measure more than 4.5 metres are known as large dams (Longridge, 1960).

2.1.1. Stability

With proper maintenance and if properly built, earth dams are known to be as permanent as the best and permanently safe (Creager et al., 1945; Schwab et al., 1966, 1971). However, Libreton (1985) as referenced by Macchione and Siranjelo (1989, p. 213) argues that earth dams have been observed to be likely to fail about four times greater than that observed for concrete or masonry dams.

2.1.2. Maintenance

Earth dams need to be regularly maintained. Regular maintenance helps to increase their life span (Phiri and Luamba, 2001). Lack of maintenance can lead to the failure of these dams. In 1889, on 30th May the collapse of the 24 metres high South Fork Dam, in the USA, was blamed on neglectful maintenance of the dam during a ten year period of private ownership (Zebrowski, 1997).

In Zambia, Luamba and Phiri (2001) observe that there is generally a lack of maintenace of most earth dams. Luamba and Phiri (2001) further observe that the lack of maintenance of earth dams in Zambia is evidenced by the numerous trees and bushes growing on the dams.

2.1.3. <u>Protection</u>

Protection of earth dams is very important. The embankment and spillway need to be protected against damage caused by humans, animals and soil erosion (Schwab et al., 1966, 1971; Luamba and Phiri, 2001).

Schwab et al., (1966, 1971) recommends fencing of the entire pond area as an important protection measure. Luamba and Phiri (2001) mention that trees should not be allowed to grow on the embankment. This is so because, when dead and decomposed, trees enable animals, insects and water to create pathways, following the paths taken by the roots of the trees.

2.1.4. Causes of Earth Dam Failures

2.1.4.1. <u>Overtopping</u>

Overtopping is known to be the main cause of earth dam failures (Macchione and Siranjelo, 1989; Schwab et al, 1966, 1971; Whalstrom, 1974; Creager et al., 1945; Luamba and Phiri, 2001). Luamba and Phiri (2001) argue that overtopping is caused by a spillway that is too small to handle a high flood.

When a dam is overtopped, water can erode the embankment, creating a breach through which the impounded water in the pond or reservoir escapes through (Macchione and Siranjelo, 1989). The collapse of the South Fork Dam mentioned in section 2.1.2, was caused by overtopping which resulted from a blocked spillway that was obstructed by a meshwork which was designed to keep fish from escaping. The meshwork got clogged with mud (Zebrowski, 1997).

2.1.4.2. Piping

Piping is another cause of earth dam failures. Piping is the situation that occurs when seepage (or leakage of water) establishes a tunnel or pipe either through the embankment or underneath (Luamba and Phiri, 2001). Fair et al., (1966) observes that if not put under control, piping can endanger the dam structure.

Apart from overtopping and piping, other known causes of earth dam failures are, foundation failures, slope failures, steepy side slopes, cracks and earthquakes (Longridge, 1960; Whalstrom, 1974; Macchione and Siranjelo, 1989).

2.1.5. Consequences of Earth Dam Failures

Earth dam failures, just like dam failures of other types of dams, can produce some disastrous consequences. In the Philipines, overtopping of an earth dam owing to a flashflood in 1981, broke down the flood in 30 minutes and destroyed houses and a market center. The disaster left 124 people dead and a total of 622 people were affected by the disaster (Sehmi, 1989).

The South Fork Dam (in the USA) mentioned in sections 2.1.2 and 2.1.4.1, collapsed in 46 minutes after getting overtopped, 2209 people died, 967 people were accounted missing and thousands of houses and business were destroyed. The disaster is described as the most devastating dam failure in the USA (Zebrowski, 1997).

On the magnitude of the flood resulting from a dam failure, Whalstrom (1974) mentions that it is related to the volume of water stored up in the reservoir behind the dam. Zebrowski (1997) observes that even in a slow moving flood, a house may float away because water can transmit its own weight in an upward direction.

2.2. WATER INFLOW INTO PONDS OR LAKES

According to Schwab et al. (1966, 1971) the amount of water that collects in a pond or lake depends on runoff input from the catchment area of the pond.

2.2.1. Runoff and Factors affecting runoff

Davis and Deweist (1966) define runoff as "the sum of surface runoff and groundwater flow that reaches the streams." Ward and Robinson (1990) define runoff as "catchment yield". A lot of factors are known to have an effect on runoff from catchment areas. The following subsections look at some of the important factors that affect runoff.

2.2.1.1. Urbanisation

According to Smith (1992), Miller (1989), Robinson and Ward (1990), Ward (1967) and Hall (1994), urbanisation or the spread of urban development leads to an increase in surface runoff. The replacement of vegetation with roads, houses, parking lots and buildings such as offices and schools impedes infiltration, leading to an increase in surface runoff.

Smith (1990) and Hall (1994) observe that urban structures such as storm drainages accentuate the flow of runoff to nearby streams where they are designed to empty into.

2.2.1.2. Topography and Soils

Runoff is affected by topography. Steepy grounds promote surface runoff (Wilson, 1990; Ward and Robinson 1966; Ward, 1967). On the other hand, Gilluly et al. (1968) notes that flat grounds hold much rainwater until it evaporates, thereby checking runoff.

Runoff is also affected by soil type. Tests conducted in the USA, for instance, established that a sandy loam soil will accept more than 10 times as much rainwater in a given time than will a soil wholly made of clay. A sandy soil, therefore, is less subject to surface flow (Gilluly et al., 1968). Kirkby (1978) observes that in areas where thin soils are found, surface runoff is high.

2.2.1.3. Vegetation Cover and Vegetation Clearance

Colman (1953) states that "vegetation acts to hold down the development of wastefully high stream flow by interposing barriers and interruptions to the rapid flow of water to streams and diverting water received by watersheds into flow beneath soil surfaces." Nemec (1964) argues that forests are the most important vegetation cover that check runoff.

The clearance of vegetation leads to an increase in runoff. A study that was conducted in Zimbabwe, on Save river, found that mean annual flow had increased by almost one third between the mid 1950's and the late 1970's (Chenje and Robinson, 1996). Chenje and Robinson (1996) further state that the increase in annual flow on Save river was attributed to more rapid runoff caused by a reduction in natural woodland and vegetation cover.

2.2.1.4. Rainfall and Shape of Catchment Area

Luamba and Phiri (2001) and Wilson (1990) observe that areas with higher annual rainfalls have higher runoff flows. Wilson (1990), Linsley et al., (1968) and Ward (1967) note that rainfall intensity and duration affect runoff. An intense storm, for instance, with a long duration, will exceed the infiltration capacity of soil by a larger margin than does a gentle rain. Hoyt and Langbein (1955) mention that the greater the margin of runoff produced by a storm, the more runoff results into flood runoff.

The shape of a catchment area is another factor that affects runoff. Wilson (1990), Nemec (1964) and Ward (1967) argue that catchments that are longer and narrow have smaller flood-peaks. On the other hand, compact or fan-shaped catchments have the highest flood-peak or runoff flow.

2.2.2. Runoff Depth and Precipitation Depth

Direct runoff from a given storm can be determined if the ratio of runoff depth to precipitation depth is known for a particular land cover type. Nemec (1964) mentions this ratio as "runoff coefficient" and is represented by the letter "C". Nemec (1964) gives the runoff coefficient ratio as:

$$\frac{hR}{hP} = C$$

The denominator, hP, stands for precipitation depth for a given storm with a given period and hR stands for runoff depth. Table 2.1 shows some runoff coefficient values for different landcover types.

Table 2.1: Values of Runoff Coefficients, C, for Various Surfaces

SURFACE	RUNOFF COEFFICIENT, C
Single houses (Urban residential)	0.3
Garden Apartments (Urban residential)	0.5
Commercial and Industrial	0.9
Forested areas depending on soil	0.05 – 0.2
Parks, Farmland, Pasture	0.05 – 0.3
Asphalt or Concrete pavement	0.85 – 1.00

Source: After an Original table by the Ministry of Agriculture, Food and Fisheries, MAFF (2000)

2.3 PREVIOUS STUDIES ON KALIKILIKI DAM AND POND

There is only one known previous study on Kalikiliki Dam and Pond. The study is a survey that was conducted by the Water Management Board under the Ministry of Energy and Water Development in October, 2001. The survey was aimed at establishing the volume of water in Kalikiliki Pond in order to facilitate the complete draining of the pond by December, 2001. The findings of the survey are summed up in a report by Hamungala et al., (2001).

Hamungala et al., (2001) states the volume of water in Kalikiliki Pond was found to have been 325, 592.6m^3 in October, 2001. Hamungala et al., (2001) further mentions that

Kalikiliki Dam has been identified by the Water Management Board as a potential source of disaster to the lives of the local people in Mtendere compound. The following reasons are therefore, stated for the need to drain up the pond:

(i). During the rainy season, the Pond floods easily, forcing water to overflow into the nearby compound (causing disease to spread).

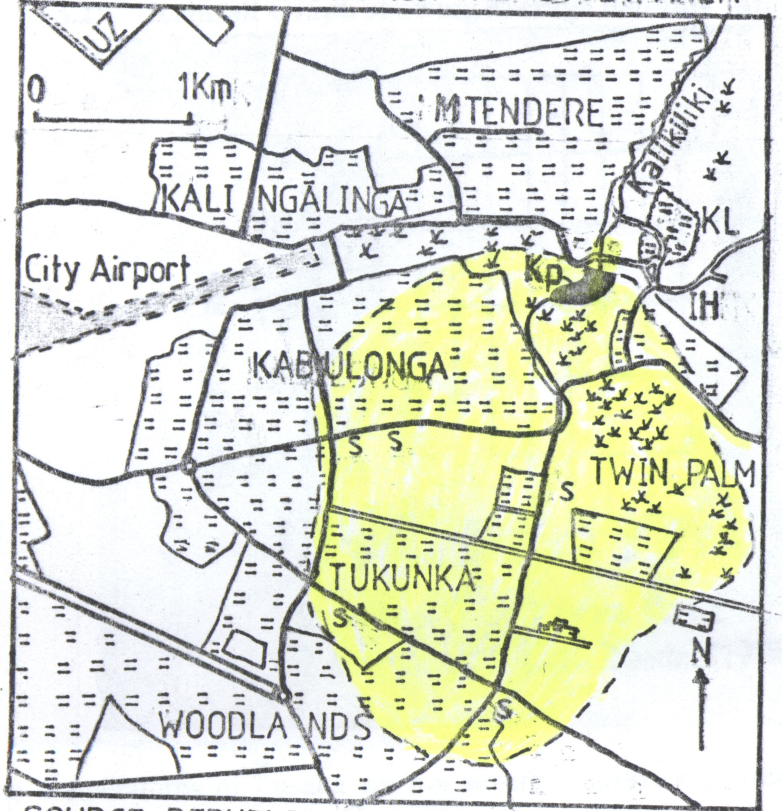
(ii). Since Kalikiliki Dam is an earth dam, it is continuously being weakened by:

   (a). Soil erosion due to water (in the rainy season)
   (b). People cutting (digging) into the dam wall to create space for construction of their houses.

(iii). The previously constructed drainage pipes at the base of the dam wall are blocked due to sedimentation.

(iv). The dam spillway can no longer function due to construction of houses and churches along its course.

FIGURE 3.1 LOCATION OF THE STUDY AREA



SOURCE: REPUBLIC OF ZAMBIA MAP (Sheet no 1528 A4) and an Orthophotomap.

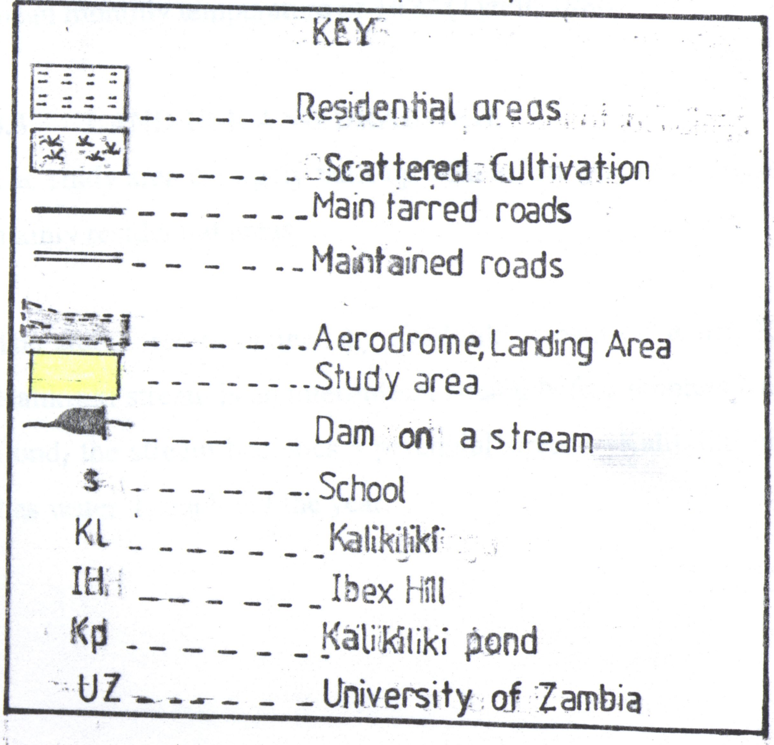
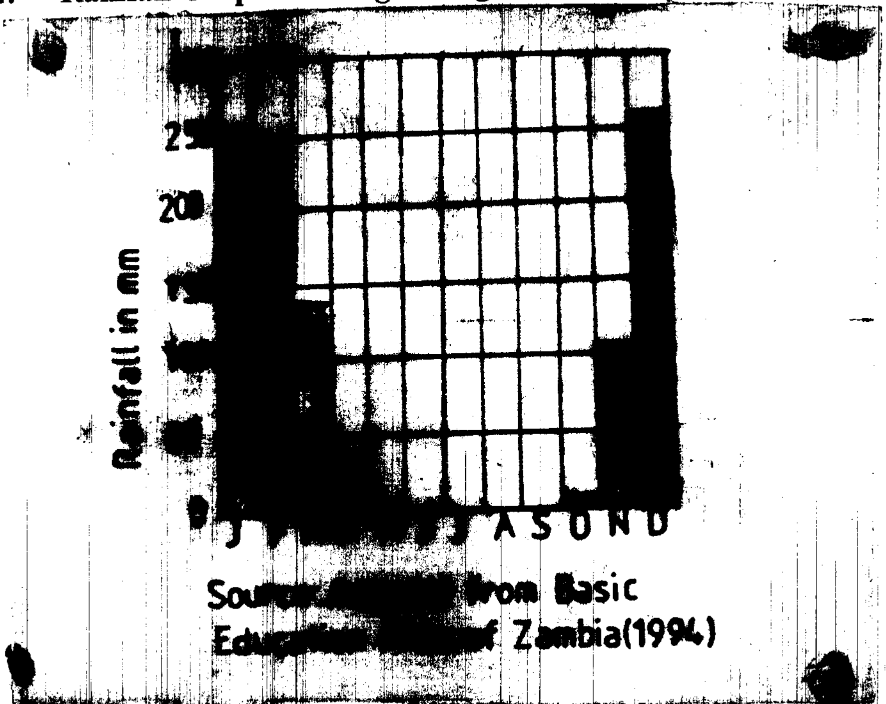


Figure 3.2: Rainfall Graph showing average monthly rainfall for Lusaka



The temperatures of Lusaka are not severe. Lusaka experiences its warmest period in October with a mean monthly temperature of 25°C and the coldest month is July with a mean monthly temperature of 16°C (Tyrell, 1986).

3.3. LAND USE AND DRAINAGE

The study area is largely built-up with urban type of development. The built-up areas are mainly residential areas.

The study area is drained by Kalikiliki stream on which Kalikiliki Pond is located on. Kalikiliki stream is an intermittent stream before it enters Kalikilki Pond. After Kalikiliki Pond, the stream becomes a perennial stream. Kalikiliki pond is a fairly large pond: It has water through out the year.

3.4. GEOLOGY

The rocks underlying the study area are of the metamorphic type, belonging to the Katangan system and are of the pre-cambrian age. They are more than 600 million years old (Williams, 1986).

There are three types of rocks found in the study area. These are; limestone, schist and quartzite (Williams, 1986). The type of soil found in the study area is related to the geology of the area. However, little is known about the soil types of the area because no detailed soil mapping has been done in Lusaka (Williams, 1986).

CHAPTER FOUR

METHODOLOGY

This chapter outlines the methods that were employed in collecting data for this research. The chapter also mentions the sources of the data and the methods that were used to analyze the data.

4.1. PRIMARY DATA

Primary data for this research was obtained from an interview, a household survey, a field survey and some ground surveys.

4.1.1. Interview

Using an interview schedule (Appendix I) an interview was held with a relevant Lusaka City Council official, at the Civic Centre on 31st January, 2002. The interview was, among other things, aimed at obtaining information on the safety of Kalikiliki Dam, against failure.

4.1.2. Household Survey

A questionnaire (Appendix II) was used to obtain the perception (information) of (from) the local residents of Mtendere compound, in section-D on the flood hazards posed by Kalikiliki Dam. 35 household heads were selected randomly from an area that measured in width, about 250 metres into Mtendere compound from both ends of the approximately 300 metres along Kalikiliki Dam. This area was arrived at after making some careful observations, from the field, based on the slope of the area and the closeness to Kalikiliki Dam. This area was taken as a flood hazard prone zone. The area was, however, not taken as the entire flood hazard prone zone of Mtendere compound.

The 35 household heads were selected in a random manner where the entire selected area was covered by the 35 households. Respondents who could not answer the questionnaire on their own were assisted by the researcher to answer the questionnaire.

4.1.3. Field Survey

A field survey was undertaken on Kalikiliki Dam on 19th January, 2002. The survey was aimed at making some important observations on some features that were identified to be of relevance to this research.

Important observations that were made were noted down. Some oblique photographs of some important features were also taken. A transect was undertaken on Kalikiliki Dam. The transect was conducted just after the first culvert on Kalikiliki Dam when coming from the eastern direction going in the western direction. A distance of 33.75 metres from Kalikiliki Dam, into Mtendere compound, was the starting point of the transect. A clinometre, a surveyors tape, a prismatic compass and two ranging poles were used to conduct the transect with the assistance of a helper. The diameter of two pipes of the two culverts on Kalikiliki Dam was also measured.

The measuring tape was used to measure horizontal distance on the ground and the slope distance of the Kalikiliki Dam. The height of houses on the transect was calculated from the number of block courses of one unplastered house on the transect. The height a block was found to be 0.18 metres. Slope was measured in degrees, using a clinometre.

4.1.4. Ground Surveys

Some ground surveys were undertaken to identify tarred and untarred roads in the catchment of Kalikiliki Pond. This was done because some roads could not be distinguished as tarred or untarred from both the topographic map of the area and the street map of Lusaka.

Lack of a map showing surface storm drainages for the catchment area of Kalikiliki Pond necessitated some ground surveys which were undertaken on the main roads only. The identified surface storm drainages were surveyed again (during the month of February) after some rainy storms to identify the direction of the flow of water and where the drainages were emptying the water. Arrows were then used on the map that was drawn to show the surface storm drainages and direction of the flow of water.

4.2. SECONDARY DATA

Secondary data for this research was obtained from maps, aerial photographs and library research.

4.2.1. Maps

An orthophotomap for Lusaka was used to determine the catchment area of Kalikiliki Pond. Four map sheets (PN 4490, PN 4493, PN 4496 and PN 4494) were found to be covering the catchment area.

The orthophotomap had a scale of 1:5000 and a vertical interval of 2 metres, for the contours. From the contour lines, the slope of the ground was studied and the water divide for Kalikiliki Pond was established. The water divide or catchment area of Kalikiliki Pond was marked with pencil. The same area was then identified on the topographic map and was marked with a pencil. This was done because the topographic map had a smaller scale of 1:50,000. This made it easier to come up with a smaller map showing the catchment area of Kalikiliki Pond. The topographic map was also used to map the land use of the study area.

4.2.2. Aerial Photographs and Library Research

Two aerial photographs (photos number 1740 and 1840) were used to map the expansion of Mtendere compound towards Kalikiliki Dam. The two photographs were taken in 1996 and are the latest available photographs for the study area. The orthophotomap for Lusaka, which was produced in 1969, was used as a base map. Both the aerial photographs and the orthophotomap had a scale of 1:5000. Literature materials relevant to this research were studied.

4.2.3. Sources of Secondary Data

Maps and aerial photographs were obtained from the Survey Department of the Ministry of Lands. Literature materials were obtained from the University of Zambia main Library, the Ministry of Agriculture and the Water Management Board. The Environmental Council of Zambia and the Disaster Management Unit were also visited as initially proposed. However, there was no relevant data that was found at these two institutions.

4.3. DATA ANALYSIS AND PRESENTATION

Data that was obtained from the household survey with the questionnaire, was coded and edited manually. The number of some responses for some of the questions on the questionnaire were converted to percentages and averages. Tables were used to summarise information on other responses to the questions on the questionnaire.

A profile was used to present information obtained from the transect. An overlay of maps was used to show the expansion of Mtendere compound towards Kalikiliki Dam.

4.4. PROBLEMS ENCOUNTERED

Some problems were encountered when this research was being conducted:

1. Mapping of soils found in the catchment area of Kalikiliki Pond could not be done. The map found at the Ministry of Agriculture had a small scale of 1:1000,000. This map was therefore unsuitable for this research.

2. Land use change in the catchment area of Kalikiliki Pond could not be shown because the available photographs had a big scale of 1:5000. At this scale, a lot of photographs were going to be used to show land use change.

3. The Lusaka City Council had scant information on Kalikiliki Dam. Additionally, the land use plan for the Kalikiliki Dam area could not be found. Officials at the Civic Centre said the plan went missing from the Civic Centre.

4. A visit to the Ministry of Land to obtain a map that shows the size of the farm plot on which Kalikiliki dam is located proved futile. No such map could be found.

CHAPTER FIVE

RESULTS

This chapter presents the results of this study from the primary data and secondary data.

5.1. INFORMATION PROVIDED BY THE LUSAKA CITY COUNCIL

5.1.1. History of Kalikiliki Dam and Pond

According to Mr. Daniel Msoka, the Public Relations Manager of Lusaka City Council, Kalikiliki Dam was built in the early 1960's for irrigation purposes. The area around Kalikiliki Pond was allocated as a farm plot. The depression that forms Kalikiliki Pond was created through the extraction of laterite from the site which was used to build tarmac roads in the Ibex Hill residential area, during the colonial days.

A late Major Chanda once owned the Kalikiliki Pond and the farm plot on which the Pond is located. Mr. Msoka mentioned, however, that the Council does not know whether the Kalikiliki Dam was built by the late Major Chanda or not. The Council does not know also, the capacity of Kalikiliki Pond.

5.1.2. State of Kalikiliki Dam

Mr. Msoka stated that the Lusaka City Council is the institution that is supposed to be in charge of the maintenance and protection of Kalikiliki Dam following the death of Major Chanda and in consideration of the need to safe guard human lives and property downstream. The City Council has, however, failed to protect and maintain the dam owing to some financial problems and shortage of workers.

Mr. Msoka, therefore, described the state of Kalikiliki Dam as unsafe owing to lack of maintenance and protection. Mr. Msoka did not mention the period of time that Kalikiliki Dam has been lacking maintenance nor the year when Major Chanda died. It appeared the Council did not have this information. But from unofficial sources within the Council, it appeared the dam has not been maintained since 1990.

5.1.3. Status of Plots in Section-D of Mtendere Compound

Mr. Msoka mentioned that the plots that are located adjacent to Kalikiliki stream (after Kalikiliki Dam) in Mtendere compound, are illegal plots. These plots, Mr. Msoka noted, were allocated illegally by some local section political leaders. The Lusaka City Council considers the land on which these plots are located, unsuitable for settlement because Kalikiliki Dam poses the danger of flooding the area in the event of the dam failing.

5.2. RESPONSES OF MTENDERE RESIDENTS FROM THE HOUSEHOLD SURVEY

Out of a total of 35 household heads that were selected to answer the questionnaire, 34 household heads answered the questionnaire in full and one household head did not return the questionnaire.

The 34 respondents who answered the questionnaire represented a total household size of 204 people giving an average of 6 people per household. The ages of the respondents ranged from 19 years to 58 years and the period that the respondents have lived in Mtendere compound ranged from 3 months to 11 years.

Table 5.1 shows a summary of other responses to the questionnaire by Mtendere residents,

Table 5.1: Summary of some questionnaire responses from Mtendere residents

Variable	Responses	No. of Respondents	No. of Respondents (%)
Sex	Male Female	25 9	73.53 26.47
Education Level	None Primary Secondary Post Secondary	3 8 18 4	8.82 23.53 55.88 11.76
Type of House	Mud House Wooden House Cement-Block (concrete) House	0 0 34	0 0 100
Employment	Not employed Informal employment Formal employment	3 12 19	8.82 35.29 55.88
Distance (in metres) of household from Kalikiliki Dam	Less than 20m More than 20m but less than 100m More than 100m	12 11 11	35.29 32.35 32.35

Source: Data from Household Survey

5.2.1. Flood Hazards Perceptions and Flood Experiences

The possible failure of Kalikiliki Dam and the subsequent flooding of houses, loss of lives or injury and loss of property were mentioned by Mtendere residents as some of the flood hazards posed by Kalikiliki Dam. The residents also mentioned the overflow of water from the spillway of Kalikiliki Dam as another hazard, posed by the dam during the rainy season. They observed that in the year 2001, during the months of January and February, water overflowed from the Kalikiliki pond through the spillway. Some households were affected by the flood water. Some pit latrines got flooded with water and spilled human excreta into the compound, posing the risk of water born disease infections. The floods experienced in 2001 were mentioned by the respondents as the only floods they have experienced from an overflow of water from Kalikiliki pond.

Table 5.2. shows some responses on flood hazards and floods experienced by Mtendere residents.

Table 5.2. Flood Hazard Perceptions and Floods Experienced by Mtendere Residents

Type of Response	Number of Respondents			Total
	A	B	C	
Kalikiliki Dam poses flood hazards to the community living close to the Dam	10	11	11	**32**
Kalikiliki Dam poses no flood hazards to the community living close to the Dam	2	0	0	**2**
Flood hazards posed by Kalikiliki Dam are serious	10	10	9	**29**
Flood hazards posed by Kalikiliki Dam are not serious	2	1	2	**5**
Household can be affected by floods from Kalikiliki Dam	9	11	6	**26**
Household cannot be affected by floods from Kalikiliki Pond	3	0	5	**8**
Household affected by floods in 2001, from the spillway of Kalikiliki Dam	0	2	5	**7**
Household not affected by floods in 2001, from the spillway of Kalikiliki Dam	12	9	6	**27**
Members of household had to vacate their house in 2001, due to floods	0	0	3	**3**

Source: Data from household survey

Note : The following letters represent;
A : Households located less than 20m away from Kalikiliki Dam
B : Households located more than 20m but less than 100m away From Kalikiliki Dam
C : Household located more than 100m away from Kalikiliki Dam.

5.2.2. Community Action against Floods

The residents of Mtendere compound mentioned that, following the floods experienced in 2001, they started helping the Water Management Board to drain water from Kalikiliki Pond using pipes (Siphons) in October. This exercise was aimed at draining the pond completely by December, 2001.

After draining the Pond, the residents mentioned that the Water Management Board intended to establish some permanent water level control points on the Kalikiliki Dam. The researcher, however, found water still being drained by February, 2002 and no points had been created on the dam. A visit to the Water Management Board in March established that the plans had been put to a hold, pending consultations with other stake holders.

5.3. OBSERVATIONS MADE ON KALIKILIKI DAM

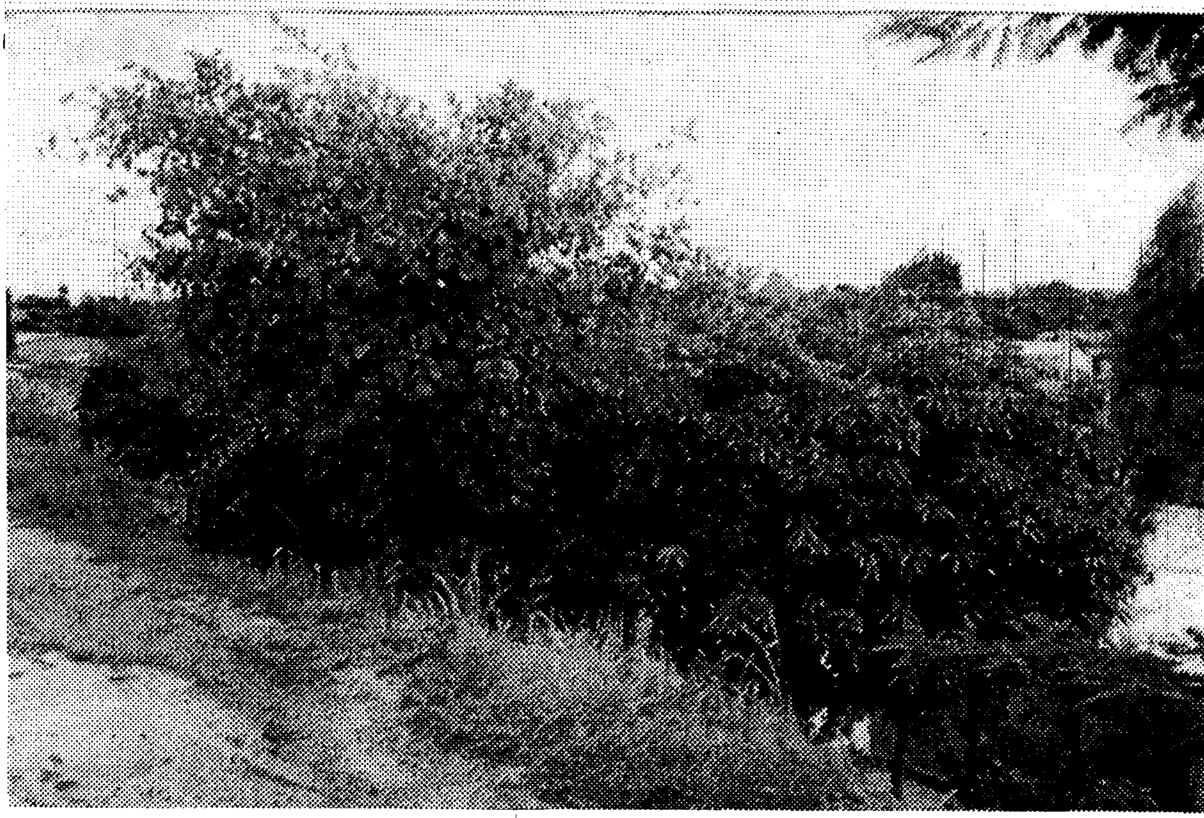
5.3.1. Soil Erosion and Seepage

Soil erosion was taking place on the downstream face of the Kalikiliki Dam and on top of the dam which serves as a road (Plates 5.1 and 5.2).

Plate 5.1: Soil Erosion taking place along a human path on the downstream face of Kalikiliki Dam

Rain water appeared to be the main eroding agent. On some human paths on the dam, soil erosion had resulted in gullies with no visible signs of measures put in place to control the erosion. The top of the dam, was also being attacked by soil erosion.

Plate 5.2: Soil Erosion on top of Kalikiliki Dam and trees growing on the Dam



Seepage was identified at the toe of the Kalikiliki Dam. It was identified near the middle of the dam. Little water was escaping through the point. This might have been caused by the low water level found in Kalikiliki pond. The water level in Kalikiliki pond was low due to a dry spell experienced by January, 2002.

5.3.2. Trees and Shrubs on the Embankment

Trees and shrubs were found growing on the Kalikiliki dam, on the damstream face of the dam. Plate 5.2 shows some of the trees that are growing on the dam. Mango trees, which appeared to have been planted on the dam (in a row), were among the trees found growing on the dam (Plate 5.2).

5.3.3. Cultivation and Digging

A maize field was found on the downstream face of Kalikiliki Dam. The field was small in size. Digging of soil from the downstream face of Kalikiliki Dam is another human activity that was observed on the dam. Soil, apparently meant for building purposes, was found to have been dug from some points on the dam. A wall fence of a house plot, near the western end of the dam, was found to have been built in the dam wall.

Water Level Control Facilities

Kalikiliki Dam has got a spillway that is located at the western end of the dam (figure 5.2). The width of the spillway was estimated at 50 metres. A completed and an uncompleted church were found to have been built in the water way of the spillway. Some houses are located at the end of the spillway (figure 5.2.).

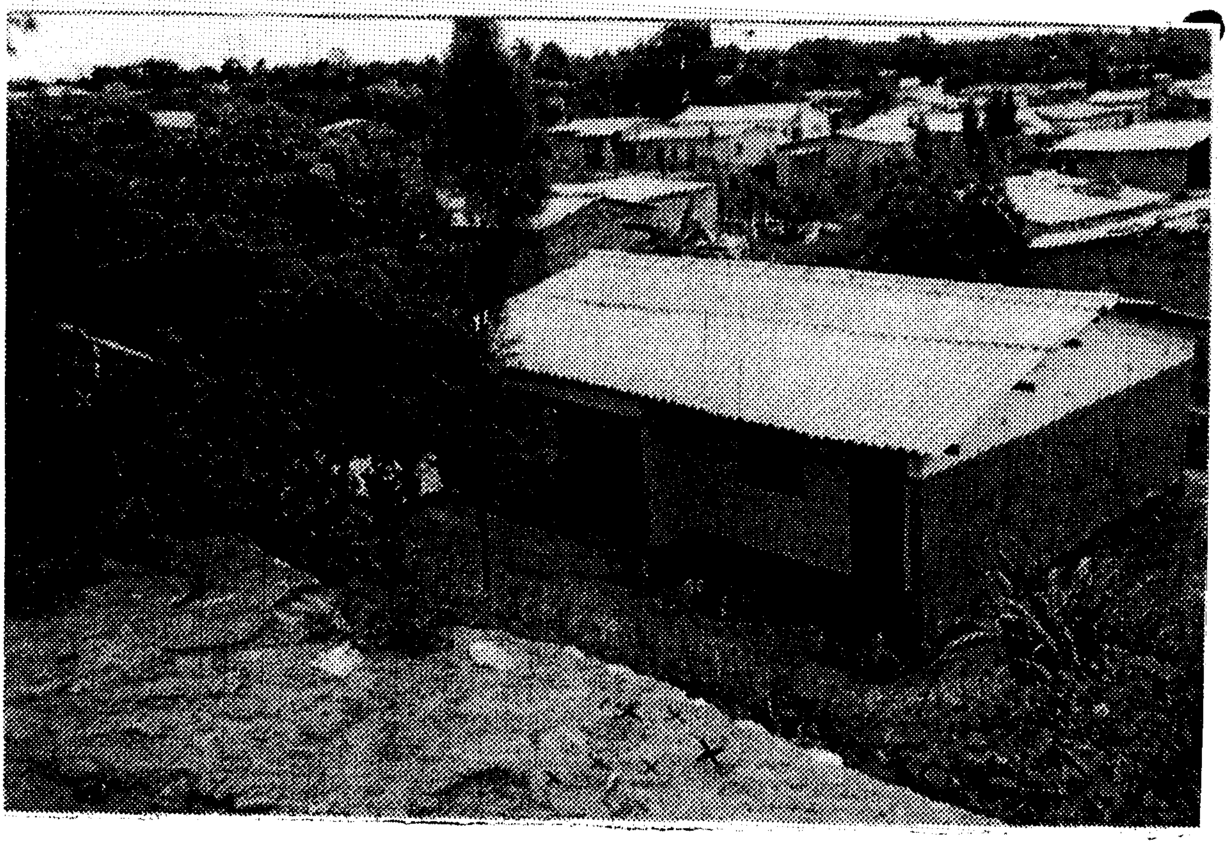
Apart from the spillway, Kalikiliki Dam has got two culverts that are located under the road on top of the dam. Plate 5.3 shows the location of one of the two culverts. The diameter of the two culverts (pipes) was found to be 0.6m each.

With a spillway that is about 50 metres wide and two culverts with a combined diameter of 1.2m, over topping of the Kalikiliki Dam appeared to be an unlikely event.

Proximity of Mtendere Compound to Kalikiliki Dam

Part of section-D of Mtendere compound is located close to Kalikiliki Dam. Plate 5.3 shows some of the houses in this part of the compound that are located close to Kalikiliki Dam as viewed from the top of the dam.

Plate 5.3: An overview of part of Section-D of Mtendere Compound



Note: There is a culvert under the concrete work on area marked x.

Figure 5.1 shows Kalikiliki Dam and Pond and two houses (in Mtendere compound) that are among many houses in the area, located close to the dam. The water level was low in the Pond, in January, 2002, as shown in figure 5.1, following a dry spell that was experienced in the 2001 – 2002 rainy season, by January, 2002.

5.4. CATCHMENT AREA OF KALIKILIKI POND AND EXPANSION OF MTENDERE COMPOUND TOWARDS KALIKILIKI DAM

Figure 5.2 shows the expansion of Mtendere compound towards Kalikiliki Dam. Two time periods are shown: 1969 and 1996.

FIG 5.1 A PROFILE SHOWING PART OF MTENDERE COMPOUND, KALIKILIKI DAM AND PART OF KALIKILIKI POND

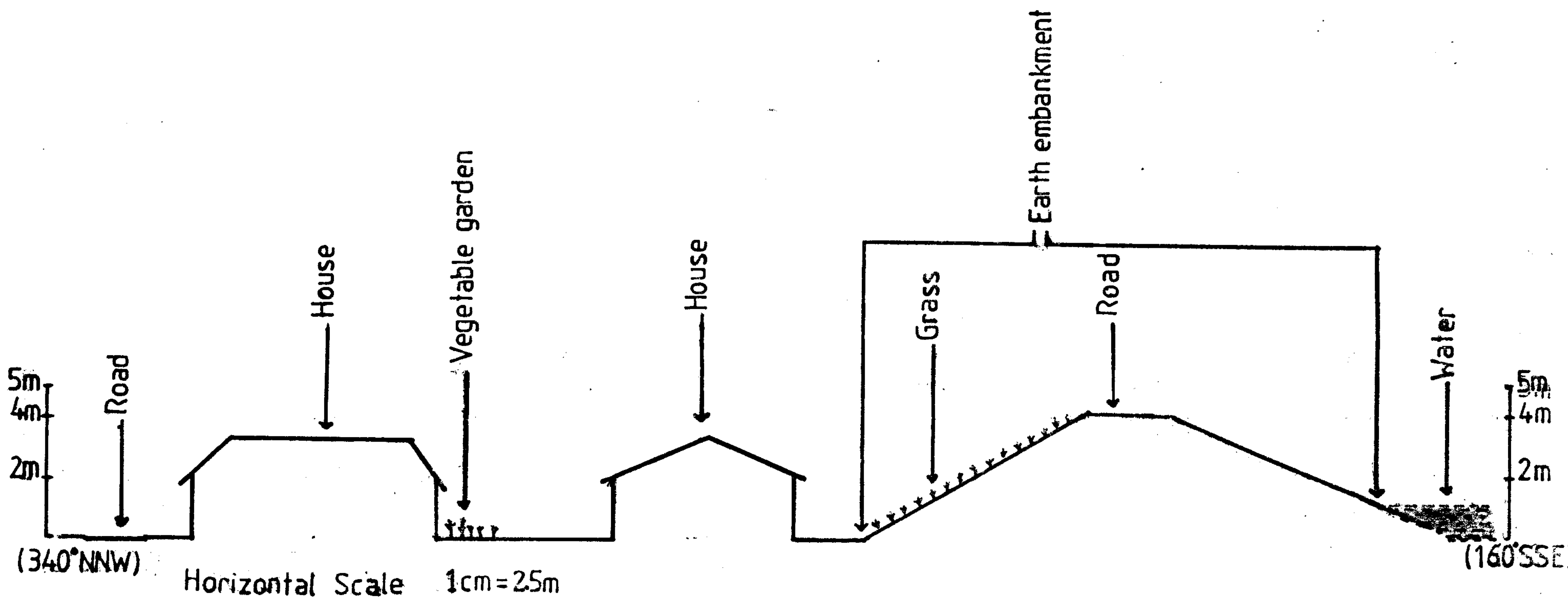
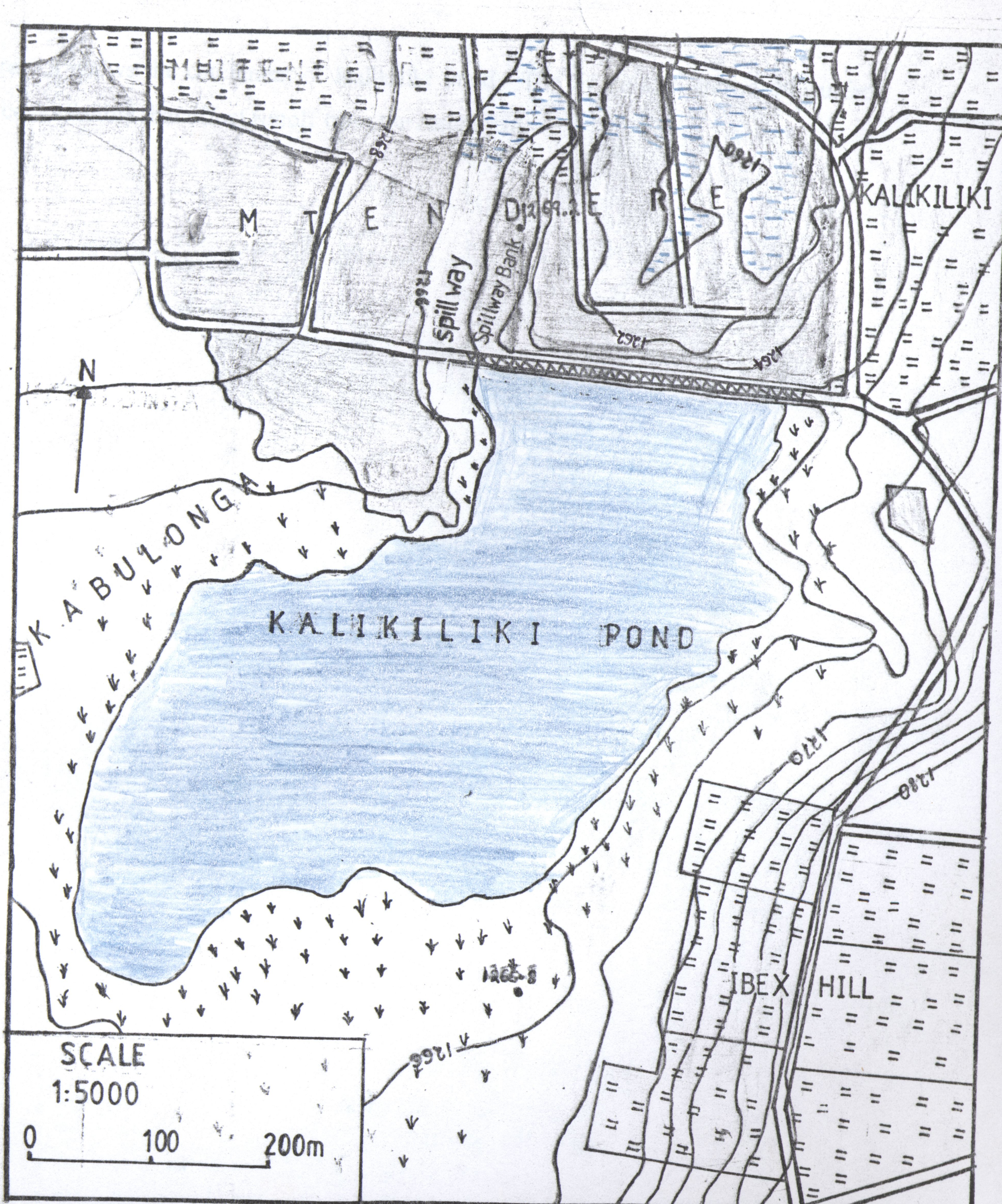


FIG5.2 AN OVERLAY SHOWING THE OLD AND THE NEWLY-BUILT UP PARTS OF RESIDENTIAL AREAS AROUND KALIKILIKI POND



Sources: Aerial Photographs, an Orthophotomap, and a Field Survey.

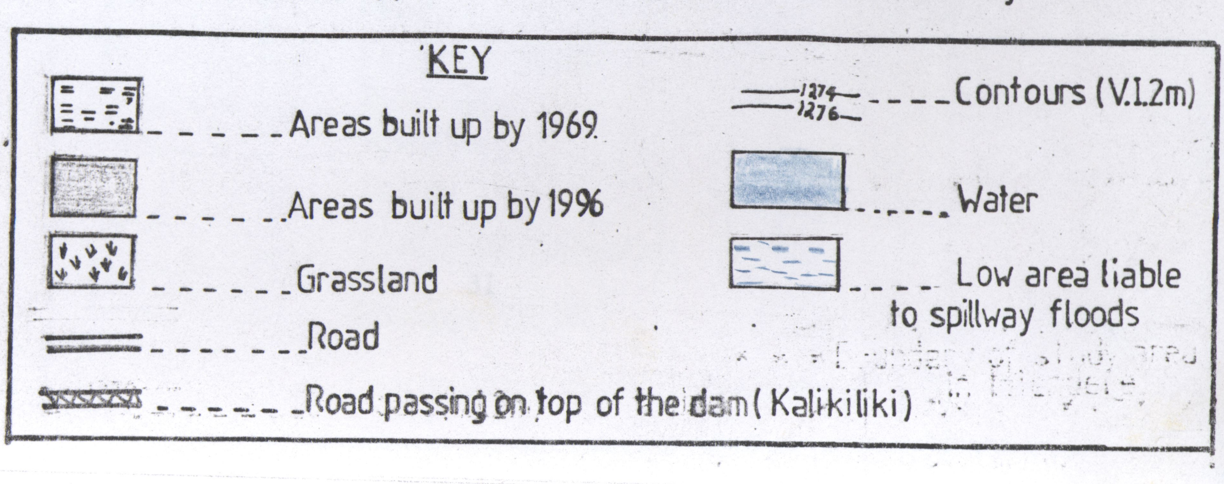
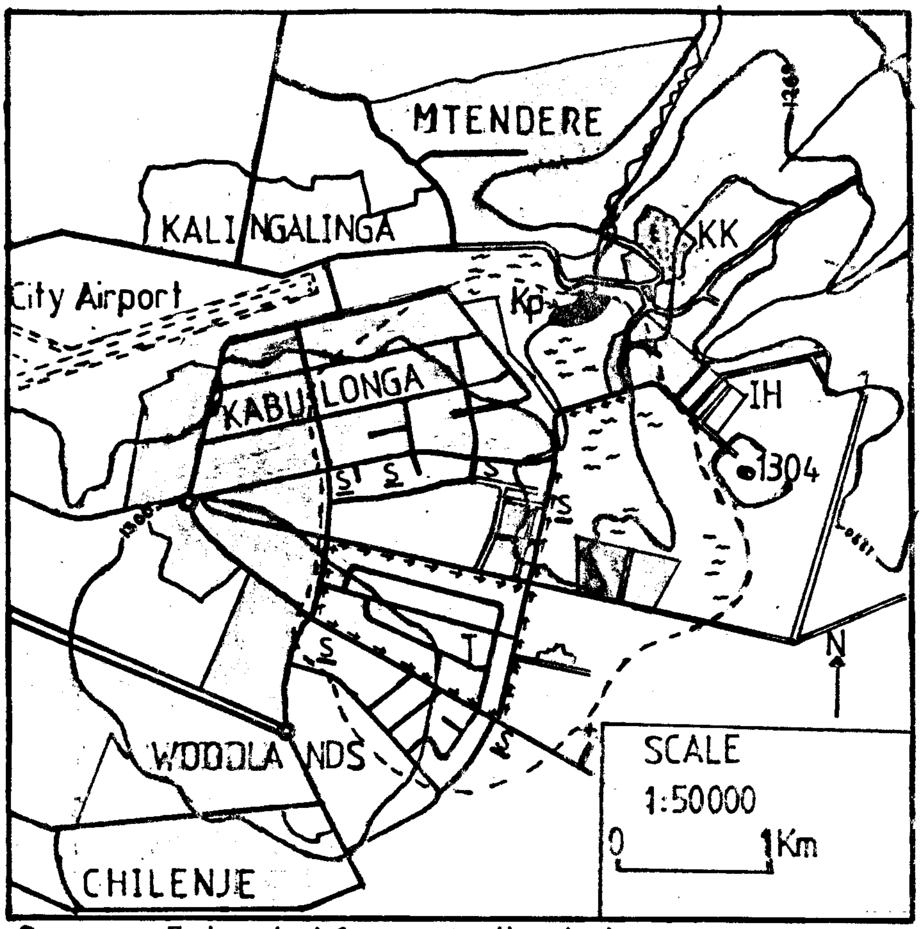


Figure 5.3 shows the catchment of Kalikiliki Pond. The figure also shows the surface land cover factors that affect runoff from the catchment.

FIG5.3 MAP SHOWING THE CATCHMENT AREA OF KALIKILIKI POND



Sources: Extracted from an orthophotomap (The City of Lusaka), Republic of Zambia Map (sheet nö 1528A4) and from Ground Surveys.

KEY

- ------ Residential areas
- ---- Aerodrome, Landing Area
- ----- Tarred roads or streets
- ----- Untarred roads or streets
- ----- Surface storm drainage channels
- ------ Pond on a stream
- KK ------ Kalikiliki
- Kp -------- Kalikiliki pond
- IH ------- Ibex Hill
- T -------- Tukunka
- s School
- ----- Scattered Cultivation
- 1300, 1280, 1260 ---- Contours (V.I 20m)
- ---- Catchment area of Kalikiliki Pond

CHAPTER SIX

DISCUSSION

This chapter discusses the results of this study from the previous chapter.

6.1. LACK OF MAINTENANCE AND PROTECTION OF KALIKILIKI DAM

Lack of maintenance and protection of Kalikiliki Dam by the Lusaka City Council, the institution that is supposed to maintain and protect the dam as stated by Mr. Msoka (Section 5.1.2) can undermine the dam. Earth dams need to be maintained regularly in order to increase their life span. The collapse of the South Fork Dam (in the USA) mentioned by Zebrowski (1997) was blamed on neglectful maintenance over a ten year period.

The seepage of water from Kalikiliki Dam that was observed by the researcher (section 5.3.1) can lead to piping if left unchecked. Hamungala et al., (2001) mention seepage as one of the problems facing the Kalikiliki Dam.

Piping is a serious problem that can lead to a dam failure. Piping can cause a dam to get breached. If this happened on Kalikiliki Dam, especially when the pond is full of water, the flood that could be generated can cause damage to some houses, loss of human lives and loss of property to the nearby community in Mtendere compound.

Lack of protection of Kalikiliki dam by the Lusaka City Council was evidenced by, among other things, trees and shrubs growing on the embankment. Plate 5.2 shows some of the trees that were found growing on the embankment. Some residents have, apparently, gone to the extent of planting Mango trees on the embankment (Plate 5.2). Trees should never be allowed to grow on the embankment because when they die and get decomposed, their roots create path ways for insects, animals and water. This can lead to piping and eventually to breaching of the dam.

Soil erosion and digging of soil from Kalikiliki dam are other signs that indicated lack of protection of Kalikiliki Dam. The gullies that have resulted from soil erosion on Kalikiliki Dam (section 5.3.1) are certainly weakening the dam structure. If left unchecked, they will grow deeper and further weaken the dam. Digging of soil from the Kalikiliki Dam for building purposes or other purposes (section 5.3.3) is an activity that must be stopped. Digging soil from the dam makes it weak to withstand the pressure of water in the pond.

6.2. CAPACITY OF WATER LEVEL CONTROL FACILITIES ON KALIKILIKI DAM

At the observed width of approximately 50 meters, the spillway of Kalikiliki Pond, along with the two culverts with a combined diameter size of 1.2 meters (section 5.3.4), appeared large enough to carry a high flood flow from Kalikiliki Pond. In this regard, overtopping , the leading cause earth dam failures seems to be an unlikely event to happen to Kalikiliki Dam. This argument is subject to criticism because the design flood flow of the spillway is not known.

Although the spillway and the culverts on Kalikiliki Dam seemed large enough to avert overtopping of Kalikiliki Dam as argued by this researcher, these water control facilities present a problem to Mtendere residents. The pathways of water from the facilities are occupied by houses(Figure 5.2 and Plate 5.3). In 2001, excess water that escaped from Kalikiliki Pond, through the spillway, flooded some parts of the study area and forced some families to vacate their houses (Table 5.2)

6.3. FLOOD HAZARDS: PERCEPTIONS AND FLOODS EXPERIENCED BY MTENDERE RESIDENTS

From a total number of 34 respondents, a large number (32) of the respondents thought that Kalikiliki Dam poses some flood hazards to their community (Table 5.2). A large number (29) again, of the respondents, thought that the flood hazards (outlined in section 5.2.1) pose some serious threats to their community.

Although it was found that a large number of the respondents think that Kalikiliki Dam poses some flood hazards to their community, it is not known if these residents of Mtendere compound had this perception even before the floods experienced in 2001 (Table 5.2). Since the questionnaire was not designed to obtain this information it can be argued that the perception held by the respondents about floods hazards posed by Kalikiliki dam, stems from the floods experienced in 2001. What can be emphasized by this research, however, is that a large number of the residents of Mtendere compound perceive Kalikiliki Dam as an environmental hazard with regards to flood hazards outlined in section 5.2.1.

The floods that occurred in 2001 as a result of excess water escaping through the spillway of Kalikiliki Dam did not affect the households that are located within a distance of 20 metres away from the dam (Table 5.2). From the 7 households that were affected by floods in 2001, a large number (5) of the households are located more than 100 metres away from Kalikiliki Dam (Table 5.2). Of the five households afftected (from the area located 100m away from the dam) three families had to vacate their houses.

Figure 5.2 can be used to explain how the floods in 2001, did not affect the households that are located close to Kalikiliki Dam. The spillway of Kalikiliki Dam has got a 200 metres long and 3.2m high bank on the left handside of the waterway (figure 5.2). This bank prevented excess water, escaping through the spillway from the pond, from flowing to the houses on top of the bank and the houses located after the bank. Water from the spillway, therefore, only affected houses or households that are located further away from Kalikiliki Dam. From figure 5.2, it can be seen from the contour lines that the built-up area adjacent to Kalikiliki Dam is on higher ground than the area located further away from the dam. Spillway floods can only affect the built up area located further away from the dam as established from the household survey (Table 5.2).

6.4. FACTORS AFFECTING RUNOFF FROM THE CATCHMENT OF KALIKILIKI POND

The catchment area of Kalikiliki Pond is largely built-up with urban type of development (figure 5.3). The built-up areas are mainly residential areas with tarred roads. According to MAFF(2000) in table 2.1, residential areas have a runoff coefficient range of 0.3-0.5. This implies that the residential areas in the catchment area of Kalikiliki Pond produce 30%-50% runoff from rainstorms experienced in the area. Tarred (asphalt) surfaces yield 85% - 100% runoff from individual rainstorms (Table 2.1). It an be seen from figure 5.3 that the catchment area of Kalikiliki Pond has main tarred roads. The main roads in the area have surface storm drainages which empty runoff into Kalikiliki steam. Hall (1994) argues that storm drainages accentuate the flow of runoff to the streams they have designed to empty into.

The topography of the catchment of Kalikiliki Pond is generally not flat. There is a difference of 34 meters between the highest and the lowest points in the area (from figures 5.2 and 5.3). This means that the topography of the catchment influences runoff. The shape of the catchment, which is fan- shaped or compact (Figure 5.3), also promotes quick runoff from the area.

Considering the factors that affect runoff from the catchment area of Kalikiliki Pond, discussed in this section it can be deduced that a lot of runoff flows into Kalikiliki Pond during the rainy season. This certainly poses the risk of spillway floods to Mtendere residents as discussed in Section 6.2.

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.1. CONCLUSION

From the findings made by this study, it can be concluded that:

(1). Kalikiliki Dam lacks maintenance and protection by the Lusaka City Council. Consequently, the dam is under serious threat from human activities, trees growing on the dam, soil erosion and seepage. These factors can cause Kalikiliki Dam to get breached. The dam is therefore a threat to the community living nearby in Mtendere compound.

(2). A large number of residents of Mtendere compound who live near Kalikiliki Dam are of the view that Kalikiliki Dam poses some flood hazards to their community. This is the reason why these residents want some water level control points on Kalikiliki Dam to be opened up.

(3). The catchment of Kalikiliki pond is largely built-up. Therefore, runoff yield from this catchment is high.

(4). When excess water escapes from Kalikiliki pond through the spillway, some parts of Mtendere compound get flooded. Some households are therefore affected by the water.

7.2. RECOMMENDATIONS

1. Residents of Mtendere compound who live near Kalikiliki Dam need to be educated on the danger posed to Kalikiliki Dam by digging soil from the dam, planting or allowing trees to grow on the dam and establishing or using foot paths on the downstream face of the dam.

2. There is a great need for the Lusaka City Council to maintain and protect Kalikiliki Dam in order to prevent the failure of the dam which can have some disastrous consequencies on the settled area along Kalikiliki stream.

3. Local authorities or Councils in Zambia need to come up with a Policy (if there is none) that should restrict people from settling near earth dams.

4. There is a need to come up with alternative water level control facilities that can be used on Kalikiliki Dam without causing floods to occur in Mtendere compound.

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APPENDIX I

INTERVIEW SCHEDULE

Position of interviewee________________ Date of interview___________

1. When was Kalikiliki Dam built and who built it?______________________

   ____

2. What was the Dam built for? ____________________________________

   ____

3. What is the full storage capacity of the Dam? _______________________

4. Is the Council responsible for the maintenance and protection of the Dam?

   Yes [ ] No [ ]

5. If Yes, how regular is the maintenance? ___________________________

   ____

6. Are there any threats to the Kalikiliki Dam that the Council is ware of?

   Yes [ ] No [ ]

7. If Yes to question 6, state the threats and the measures, if any, that have been put in place by the Council or any organization.

   ____

   ____

8. What water level control facilities has Kalikiliki Dam got?

   ____

   Are they in their normal functional state?

   ____

   ____

9. During the rain season, the rise in the water level in Kalikiliki Dam appears liable to overtopping. Does the Council consider overtopping a threat to the Dam?

   Yes [ ] No [ ]

If Yes, state the measures taken by the Council or nay organization to avert overtopping of the Dam.

____

____

____

10. Have there been any recorded incidence of Kalikiliki Dam being overtopped?

Yes [ ] No [ ]

If Yes, when was the Dam overtopped and what was the impact on the nearby Mtendere compound? ______________________

____

11. How would you describe the safety of Kalikiliki Dam in its present state, against failure ________________________________

____

12. Were the plots in Section-D of Mtendere compound (downstream, below the Kalikiliki Dam) allocated by the Council?

Yes [ ] No [ ]

13. If No to question 12, who allocated the plots and does the Council consider the plots legal? __________________________

____

14. Does the Council consider the land where the plots in question 12 are located, suitable for residential development and settlement?

Yes [ ] No [ ]

15. If No, state the reasons ___________________________

____

____

Thank you very much for your co-operation

APPENDIX II

QUESTIONNAIRE

Dear Respondent,

You have been randomly selected in a study concerning the assessment of flood risks in your community area. The information that you will provide is meant for academic purposes only.

INSTRUCTIONS:

Please, answer the questions below by ticking or marking with a cross (X) your answer to each question in the boxes provided. Where boxes have not been provided, you are required to write your answer(s) on the space provided.

SECTION A

Sex Male [ ]
Female [ ]

Age _______________

Education Level: None [ ]
Primary [ ]
Secondary [ ]
Post Secondary [ ]

Occupation ______________________________

Household Size ___________________________

SECTION B

1. How long have you been living in your present house, or rented house?

____

2. What is the type of the house?

Mud House [ ]
Wooden House [ ]
Cement Block/Bricks House [ ]

State other type ______________________________________

3. How far is the house located from Kalikiliki Dam?

Less than 20 metres [ ]
More than 20 metres but less than 100 metres [ ]
More than 100 metres [ ]

4. Do you think that Kalikiliki Dam poses some flood hazrds to your community?
Yes [ ] No [ ]

5. If Yes to question 4, state the hazards ______________________________
____
____

6. Do you think that the hazards you have stated in question 5 are serious?

Yes [ ] No [ ]

7. Do you think that your house or household is also prone to the hazards that you have stated in question 5?

Yes [ ] No [ ]

8. Has your household ever been affected by an overflow of water from Kalikiliki Dam?

Yes [ ] No [ ]

9. If yes to question 8, state the year(s) and the period of the year when the Dam overflowed and the impact that the overflow had on your household?
____
____
____
____

10. What measures, if there any, has your community subsequently undertaken to avert the recurrence of the problem of water overflowing from Kalikiliki Dam?
____
____
____
____

Thank you very much for your co-operation