ENVIRONMENT AND DEVELOPMENT: AN ENVIRONMENTAL IMPACT ANALYSIS OF THE PROPOSED UPPER ATHI DAM.

BY

DENNIS CHEGE KANIARU

A THESIS SUBMITTED IN PART FULFILMENT FOR THE DEGREE OF MASTER OF ARTS (GEOGRAPHY) IN THE UNIVERSITY OF NAIROBI

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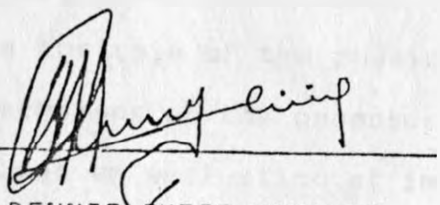
Candidate 

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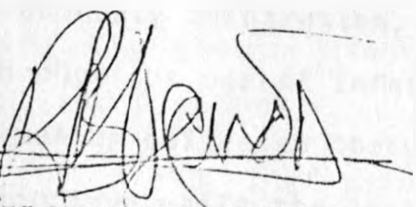
Supervisor 

PROFESSOR R.E. OGENDO

May, 1985.

ABSTRACT

This study undertakes an Environmental impact analysis of the proposed upper Athi dam on the Mbagathi river, the natural southern boundary of Nairobi National Park. Impacts have been examined on two major environments - the human and the physical environments.

The analysis has only been possible through exhaustive discussions of three broad objectives; The first objective involved the analysis of the physical, technical and socio-economic dimensions of the proposed dam, the second objective involved an evaluation of impacts on the non-human biological environment while the last objective involved an examination of the socio-economic characteristics of Nairobi National Park and its visitors as is related to the proposed dam and the continued socio-economic viability of Nairobi National Park.

The first objective was achieved through the use of descriptive analysis of secondary information, the second objective was achieved through the use of inferential analysis of primary information collected through the Delphi data collection technique while the last objective was achieved through the application of various statistical tools on data collected through the use of a self-administered questionnaire.

The study has revealed that the proposed upper Athi dam site is only part of a larger Ecosystem - the Nairobi National Park ecosystem - and whose presence would be manifested by negative effects within a wider spatial area. It has been predicted that the dam would pollute its own environment through sedimentation and Eutrophication. Further it has been demonstrated that the presence of the dam would exert a stress on the carrying capacity of Nairobi National Park as well as disrupting various biological characteristics of wildlife adjacent to the area due to excessive human interference. In view of such revelations, the hypothesis that the presence of the upper Athi dam would be compatible with the ecologic stability of the park was rejected.

In an attempt to achieve the third objective, it was shown that the utility of recreation areas is closely related to the range of attractions offered, levels of satisfaction achieved and perceived value of aesthetic and environmental resources within such areas. It was demonstrated that the higher levels the above variables attain, the higher the perceived utility of a recreational resource. Further, the study has revealed a desire by users of any recreation facility to achieve maximum satisfaction from such use.

There is therefore little or no opposition towards modifications percieved as bearing a positive relationship with such satisfaction. The study has gone further to show that users of recreational facilities are in fact willing to make optimum use of such modified recreation areas, a fact that bears implications on the continued social and economic viability of such resources.

ACKNOWLEDGEMENTS

I would like to thank Professor (Dr.) R.B. Ogendo who, in his capacity as my supervisor, followed most keenly this thesis in all the phases and whose support and detailed comments have been of great encouragement. I would also like to thank the University of Nairobi and the Department of Geography for providing the facilities that enabled me to persue my M.A. Course. My appreciation also to the teaching staff of the Department of Geography for either their useful comments and discussions of the drafts or their continued support of this project.

I would also like to express my appreciation to the Canadian International Development Agency (C.I.D.A.) for providing financial support for this project through the Directorate of Personnel Management (Office of the President) in collaboration with the wildlife planning unit (Ministry of Tourism and Wildlife).

I would also like to thank my fellow students Kareri, Kisovi, Ndolo and Mutero for their encouragement and comments during discussions of the drafts. Drs Pugh, Madin and Van Someren provided useful suggestions during the initiation of this study and are duly acknowledged.

I am most grateful to a group of ten specialists in various fields (who, due to professional or personal reasons declined to appear in this section in name) for participating in the delphi data collection exercise. Appreciation is also due to my colleagues in the wildlife planning unit (w.p.u.) of the wildlife conservation and management department for their useful inputs towards a better understanding of the Nairobi National Park ecosystem. Of special mention is Mr. M. Kaittany for his forbearance of my absence from the activities of the unit during the writing of this thesis and Miss Wanjohi for her provision of logistical support during visits into the park.

My thanks also go to Mr. Maina Karaba of the National environment secretariat (N.E.S) whose wealth of knowledge in Environmental impact assessment proved very valuable during numerous consultation sessions. The cartographic section staff of the w.p.u. were responsible for the drawing of maps and diagrams contained here-in. I would like to express my appreciation to them. My thanks also go to all respondents who reacted positively to the questionnaire.

I would also like to appreciate the encouragement, perseverance and understanding accorded to me by my family, Wanjiku and Kaniaru during the entire study period. Agnes Njeru deserves special mention for the typing of this thesis from near illegible drafts.

Finally, I would like to thank all other people who, through more ways than one, contributed either collectively or individually towards the successful undertaking of this study.

While I have tried by best to eliminate all mistakes and errors, I hold myself solely responsible for any other shortcomings which may still remain within the thesis.

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CHAPTER ONE

1. INTRODUCTION

1.1 Statement of the Problem

Development that is inflexible and little influenced by ecological considerations is unlikely to make the best use of available resources. Throughout the history of economic development, there are numerous instances where failure to account for the environmental factor(s) has led to economic loss and lower growth than would otherwise have been achieved. Decisions to implement such projects have been made as a result of careful weighing, by public or private bodies, of fairly narrowly defined economic costs and returns and often tabulated in a fairly sophisticated fashion. In short, it has in the past been the trend to accept a lower level of environmental quality in order to increase/accelerate economic development.

However, with the twin realization that environmental quality is not a 'system' by itself and that economic development hinges to a very large extent on the continued sustainability of environmental-cum-natural resources, it is being encouraged that environmental considerations be incorporated at the planning stage of projects in order to ensure that the pattern and style of development is consistent with a healthy natural environment (GOK/UNEP/UNDP, 1981).

This study was formulated and subsequently executed to fulfil such a need. It aims at investigating the proposed reservoir dam on the Mbagathi river, with a view to identifying, analysing and evaluating its potential impacts on its environment.

The completion of this study has largely depended on the analysis of potential impacts on two major environments, the human (social, cultural and economic) and the physical (natural) environments. Impacts on the social environment that have been examined centre mainly around impacts on aesthetic and visual attractions inside Nairobi National Park, but more specifically along the valleys and gorges designated for the proposed water resource development project.

Such impacts have been examined from two perspectives: - those resulting from the disruption of natural aesthetic features and those resulting from community - effected aesthetic features. In this study, natural aesthetic features have been taken to imply features resulting from major physical and natural factors like soils, topography, vegetation and drainage patterns, all of which are viewed as useful for people wishing to enjoy the aesthetic qualities of an area based on undisturbed natural appearance.

Community - effected aesthetic features are those that result from man's change of the landscape or scenic beauty in the form of developments such as roads, picnic sites and observation points blending with the environment to produce an eye-catching vista of interest to the park visitors. It is the thesis of this study that the construction of a dam on the proposed site will have negative impacts on the aesthetic environment of the park.

Consequently, major aesthetic attractions (as perceived by the visitors themselves) of Nairobi National Park have been examined with a view to assessing their importance and overall contributions to the park's economic environment. The intensity of use of areas bearing such attractions as opposed to areas not bearing any identified aesthetic attraction has been assessed in an attempt to determine whether the presence of such attractions influences the visiting patterns and frequencies inside Nairobi National Park.

Impacts on the economic environment have been undertaken through an investigation into the perceptions of Nairobi National park visitors to the proposed structural change and their willingness to accommodate such changes. It is the thesis of this study that such an impoundment would initially attract more visitors to the park and consequently enhance the short term economic utility of Nairobi National Park.

Impacts on the natural environment have been examined under four inter-related headings; effects on existing physical and chemical characteristics, effects on existing biological conditions, effects on existing cultural factors and, lastly, effects on selected ecological relationships.

Impacts on existing physical and chemical characteristics include effects on soils, of erosion and deposition. An attempt has been made to establish the relationship between identified activities which may cause environmental impact (i.e. those related to the project) and such existing characteristics.

Effects on existing biological (ecological) characteristics that have been examined include impacts on faunal species, such as birds, terrestrial and aquatic animals. Other envisaged biological effects are on trees, shrubs, and grasses. The study set out to examine the current status of some of the above with a view to identifying possible impacts on the same. It was the thesis at the initiation of the study that effects on both the biological and on physical and chemical characteristics may have ecological implications on the carrying capacity of the park. It was anticipated that the construction of the impoundment would result in the creation of new ecological habitats and the destruction of some of the established ones. The secondary implications of these aspects have been examined.

This review will serve two purposes; first it will help outline what other scholars have said and done on this as well as in other related fields. This will help reveal the shortcomings and omissions in previous similar studies, thereby fulfilling the important task of presenting complete and relevant findings by including what other scholars might have left out. Secondly, the review will help lay the basis and framework for this study in the sence that theoretical as well as factual findings of previous studies (as reviewed here) would be used as the starting point of the study.

Studies on the effects of water resource development projects on the environment are not numerous, and especially so in the African context. However, the following works are related to the issue and have therefore been reviewed.

Porter, A.L. et al (1980) explain the complexity and interconnectedness of ecological systems, and draw attention to the fact that individual and, seemingly, unimportant disturbances may produce systemic effects in the different life forms of the Ecosystems. It is observed that while the nature of 'threats' to each life form may vary drastically (and are sometimes difficult to foresee), it is, however, apparent that technological intrusions on the environment may, and in most cases will, directly affect the number, distribution and stability of life forms.

Effects on existing social-cultural factors include those on the prevailing land use, those on recreational activities and structures and those that are aesthetically and human-interests orientated,while effects on some selected ecological relationships include impacts of eutrophication.

Other independent impacts that have been evaluated are based on the concept of pollution in its broadest sense. It has been observed that, while air pollution is likely to be minimal in short-term and restricted to the construction phase only, water pollution is likely to be more intense and long-term. Effort has been made to try and ascertain whether industrial and agro-based effluents are gradually finding their way into the Mbagathi river and if so, what are the short and long term implications. This question has been answered by analysing the rate of growth of urban centres within the catchment, the nature of industrial activities and the intricate relationship between these and the Mbagathi river, tied together with projections for future industrial development of the area.

1.2 Literature Review

This section examines and assesses literature, both published and unpublished,that has been written, firstly, on the theoretical effects of water impoundments on the environment and, secondly, any actual (or empirical) literature on the Nairobi National Park.

(1977)

Jain, R.K. et al. identify some typical 'threats' to various life forms resulting from the construction of water impoundments. In their study, they identify several life forms, viz; fish and water birds, natural land vegetation, aquatic plants, large animals, small game and terrestrial birds. The typical "threats" identified vary from reduced range, reduced food supply, destruction of habitat and erosion, to dissolved oxygen reduction and changes in water levels and quality.

The framework for both Porters' and Jains' arguments had been laid down by Warner, M.L. et al (1974), who identified some potential ecological impacts associated with water resource development projects. Warner identifies potential impacts on two environments; "terrestrial biological" and "aquatic biological" environments. The potential terrestrial biological impacts identified are, firstly, inundation of habitat leading to a loss in vegetation-producing land, displacement of natural wildlife populations and the interruption of animal migration patterns and secondly, a change in the land-water interface which is manifested by the stimulation of growth of normally suppressed organisms possibly to the detriment of others, the appearance of new dominants, the formation of localised marshes or swamps and the restriction of shoreline vegetation due to reservoir level fluctuations.

Lastly, a change in downstream habitat occurs and is manifested by a reduction of natural fertilization from flooding, and the change in vegetation profiles. The magnitude of the above impacts has been observed to vary widely depending on factors like the size of the impoundment, water quality upstream of the impoundment, nature of land-use within the catchment zone and the nature of use of the impounded water.

Warner argues further that aquatic biological impacts are brought about by reservoir pool formation and the alteration of downstream flow. Such impacts might occur in the form of reduced dissolved oxygen, increased bacterial decay, the creation of a rich organic food supply for insect larvae, reduced flow of food downstream and the modification of spawning areas and conditions downstream, among others.

Abul-Ata, A.A., (1979) critically reviews the negative impacts of large impoundments. His main argument lies on the premise that the damming of any river results in **aggradation** both upstream and downstream of the dam. Such **aggradation** comes about as a result of the dam holding up all the silt and releasing only clear water. Depending on its velocity, the clear water erodes the river bed on its course downstream, because of renewed regime activity due to the absence of the heavy silt load.

Abul-Ata argues that in extreme cases, the river might even form a new course downstream, thereby restarting all over again the process of erosion.

Similar views are expressed by Blench,T. (1957) in "Regime behaviour of canals and rivers". He argues that the creation of barriers across free waterways inevitably leads to the problem of aggradation. Apart from recognising the problem of renewed erosion downstream, Blench argues that the problem of siltation is critical, especially around the mouth of the reservoir, with a high possibility of the gradual growth of deltaic formations around the mouth of the dam in extreme cases due to a sudden reduction in velocity of sand-silt-clay loaded waters. Such formations have been known, sometimes, to 'consume' the river completely through the formation of marsh lands, a process referred to as the 'killing' of the river, because the river terminates at the impoundment due to its becoming a weed-choked lake from siltation and eutrophication.

Discussing the same issue, Cullen (1964) argues that due to the deposition of mud, branches and stones, the reservoir is bound to become shallower and thereby reducing its water retention capacity.

Through the process of seepage and evaporation, Cullen argues, such a reservoir is unlikely to eventually hold back all the water that enters it. Alternatively, depending on the volume of water entering the lake, the spreading out of the reservoir into neighbouring areas might take place with consequential catastrophic results on agriculture, range or physical developments like roads and buildings. Cullen, however, cautions that most of the above effects depend on the nature and intensity of land use in the lake's catchment zone.

Problems associated with sediment flows are explored more deeply by Adeniji, H.A. et al. (1981), in a paper presented at a workshop to the United Nations Environment Programme, UNEP. Specifically analysing problems associated with man-made lakes in Africa, he draws up a long inventory of problems associated with such lakes. He has observed the problem of delta formations in many African man-made lakes, a factor which he says is governed by the size and length of the reservoir. Such sedimentation may take place either at the influent ends or may be distributed throughout the reservoir resulting in the siltation of the lake. Such sediments, it has been argued, may carry adsorbed pesticides, heavy metals, nutrients or other toxic organic substances into the reservoir.

Adeniji argues that, provided such sediments remain adsorbed, then the problem is minimal. However, if they become desorbed or otherwise enter the water or food web, severe problems related to exposure of human beings and animals to harmful amounts of the same may be encountered. Such sediments may otherwise form 'blankets' covering and consequently destroying vital aquatic habitats.

Adeniji postulates that aggradation has been known to increase the river level at the inflow to man-made lakes thus causing extensive flooding, seepage, elevation of the water table, swamping, water-logging of adjacent lands and the formation of stagnant pools, providing suitable ecological conditions for diseases like bilharzia or Schistosomiasis. Further, such sedimentation may hasten the formation of 'weed mats' and shoreline vegetation, which in turn increase the rate of evapotranspiration. In fact, a particularly controversial question concerns the cost to water resource development projects from the possible increased loss of water through leaf evapotranspiration brought about by the invasion of water weeds. It has been proved that "the loss of water through evapotranspiration from the leaves . . . . is 3.2 to 3.7 times greater than free evaporation from a water surface" (Dasmann, R.F., et al. (1973).

Adeniji discusses four main changes that take place in any newly flooded area. Firstly, such flooding has got a substantial effect on the water table in the area around the new lake and a loss in arable land. Such changes are reflected in plant growth and evapotranspiration rates. Further, losses in arable land have a direct bearing on the carrying capacity of the area involved. Secondly, the flooding of an area results in deoxygenation due to decay of submerged vegetation or reduction processes, resulting in explosive growth of phytoplankton, floating vegetation and different fish species. Thirdly, such flooding results in changes in the micro-climatic system with subsequent influence on rainfall, vegetation, and agricultural production and lastly, such flooding results in changes in terrestrial and aquatic flora and fauna of the lake and river downstream coupled with a consequential increase in the variety of human activities within the surrounding environment.

Odingo, R.S. (1977) echoes similar views as regards submerged areas during the creation of man-made lakes. Studying the Gitaru/Kamburu dam complex, Odingo identifies several impacts of dams on their environments. There is the inevitable problem of both the destruction of old and the creation of new habitats. On its negative side, such an aspect results in the disturbance of already existing wildlife, forcing some species to migrate from the area. However, the creation of new habitats was observed to carry with it the positive aspect of attracting new forms of wildlife which

Questions must however be raised as to the adaptive capacity of exotic species to such a new environment.

In the Kamburu/Gitaru case study, it was observed that the creation of an extensive aquatic environment attracted more aquatic species in the area than had previously been present. This had the effect of further increasing the water bird life in the area due to an abundance of food from fish and other aquatic life. A negative aspect of the creation of the dam complex was its attraction of more human life to the area, automatically upsetting the wildlife populations and habitats.

Odingo makes an important observation; namely, that effects are not only felt upstream and within the area of inundation. On the contrary, life of aquatic animals below the dam site may be thrown in danger of extinction and especially during periods of drought when water levels are normally very low. This carries important implications for Nairobi National Park's hippo pools which carry a variety of aquatic life and incidentally lie below the proposed upper Athi dam site.

There is one distinct characteristic of all the studies reviewed above; while they have discussed the physical and biological impacts exhaustively, they fail to dwell on the socio-economic impacts.

Perhaps this stems from the acceptance of the fact "that the environment, both physical and biological, is undermined by the projects due to the destruction of ecologically stable habitats" (Odingo, R.S. 1977). It is not by accident, therefore, that previous scholars have failed to take note of, or only given lip service to social impacts of the projects they are reviewing.

Throughout its short history of existence, numerous studies have been carried out in and around Nairobi National Park. However, not a single study has attempted to analyse the environmental impacts of any development projects in and around the park. However, the literature, both published and unpublished, is relevant to this study and is to be reviewed in this section.

Studies on the ecology of Nairobi National Park have one similar characteristic; they all lay emphasis on the fact that the ecology of the park is extremely fragile. Taiti, S.W. (1979) argues that the park is almost an 'artificial ecological island' when compared to its physical environment by virtue of the fact that it is only in the park where there is to be found a delicately managed ecosystem bearing any characteristics of a natural ecosystem.

In the park are to be found the only clusters (for miles around) of forests of Croton schrebera and Olea, riverine thickets and forests of Acacia xanthophloea and Acacia kirkii, all of which provide a natural stability to the geomorphologically young stage of the Mbagathi River which forms the southern boundary of the park. Taiti, S.W. cautions that while the ecology of the park might appear simple, it is all the same very dynamic and can only be managed through strict adherence to environmentally sound ecological principles, implying therefore the undesirability of an unplanned interruption of the park ecosystem.

Taiti observes that different vegetation zones in the park are inhabited by different wildlife species, with the riverine forests being ideal for black Rhinoceros , Hyrex, Bushbuck, Giraffe, Leopard and Lion, most of which find it difficult to adapt to other habitats.

Rudnai, J. (1979) observed that the riverine forests are particularly important to the Lions in that they provide suitable cover for daytime resting as well as for reproduction purposes. Jari, R. (1982) also argues that riverine forests act as an important habitat for a wide variety of wildlife species and especially during dry seasons when vegetation elsewhere is sparse since animals move freely in and out of the park through the southern boundary.

Jari argues further that, of late, silting of the Mbagathi river has been noticeable. She attributes this to the present heavy cultivation and settlement of the Ngong area as well as the presence of too many open surfaces in the park in the form of roads and open murram pits. She has further identified three other possible sources of pollution to the Park. First it has been observed that the Mbagathi river provides a useful source of domestic water to people living along the southern boundary of the park and further upstream. The river is therefore used by a large number of people to wash their clothes using soap which is not soluble in ordinary water. She, in fact, wonders how many more people will be using soap to wash their clothes in the Mbagathi river in future, what with the current development rates in the Kitengela.

Secondly, Jari observed that on the western part of the park where Langata road crosses the Mbagathi river, motorists have acquired the unfortunate habit of washing their cars along the banks of the river and later discharging the oily and greasy water back into the river.

Thirdly, she speculates that a battery factory near Ongata Rongai is reportedly disposing its effluents into the Mbagathi river.

The relevance of such revelations must be viewed in the light of their total effect on the park's ecosystem and especially when such waters are confined in areas neighbouring the park. Jari argues strongly that development in the Kitengela as well as the Ngong region will strongly affect the park's ecosystem in future through the above outlined activities.

Land-use in Ngong division has been examined exhaustively by the Government of Kenya in the Kajiado District Development Plan (1979-83). Ngong is a medium potential agricultural area that experiences heavy pressure of population (over 100 people per square kilometre). Due to low rainfall, agricultural activities in the area are inhibited, leaving people with the only alternative of leading semi-nomadic lives basically concentrating on livestock production. These circumstances carry overtones of over-utilization of land, leading to erosion.

It is argued in the plan that although such short comings could be overcome through afforestation, such efforts have not been particularly successful. This is because people view afforestation as denial of access to severely limited land resource that is under their disposal. People therefore create resistance to such alienation of land.

This fact then creates a shadow of doubt on Rofe Kennard and Lapworths (1982) assessment of the problem of siltation of the proposed upper Athi dam. They argue that sediment accumulation in the dam is likely to take two forms. Firstly, fine sediment derived from soil erosion in the catchment zone would be carried into the reservoir and secondly, there is the likelihood of boulders and cobbles being transported by incoming streams during periods of floods, which are not infrequent. They arrive at the conclusion that sedimentation would not occupy more than 10% of total reservoir volume, this depending on the success or failure of soil conservation measures within the catchment zone. This assumption is rather dubious when viewed from the perspective of circumstances influencing land use in Ngong division as discussed above, and more so because Ngong division lies in the dam's catchment zone.

The idea of building a series of dams along the Nairobi National Park/Kitengela boundary was suggested by Ecosystems Ltd, (1982). After studying the movement of animals into and out of the Park, Ecosystems Ltd observed massive influxes of some wildlife species in the park from the Athi-Kapiti Plains.

Such influxes were seen as sometimes being detrimental to the stability of the park in that they sometimes went beyond the normal carrying capacity of the park. The study concludes that the park is hardly dependent on the Kapiti plains as has been the belief in the past and that the park could enter a "phase of stability" (Ecosystems, 1982) if it were to be disconnected with the rest of the plains, hence the suggestion of the dam to create a natural barrier between the animals in the park, on the one hand, and the animals and human beings outside the park, on the other hand.

The creation of such dams would also "conserve water in an area where the need for new water supplies is becoming progressively more important" (Ecosystems, 1982). They argue that although the dams would destroy some pieces of the park's habitat which do contain a different flora and fauna from other parts of the park, such inundation would also create new aquatic habitats ideal as bird and other aquatic animal habitats. Further, such dams could offer additional activities of boating and fishing, both of which have been viewed as cheaper ways of enjoying the various recreational amenities being offered by the park.

Karaba,M. (1981) has studied the general impacts of such a dam on the park's ecosystem. He has argued that the gorges and riverine forests are ecologically unique in the park, being habitats of rare species like the Rhinoceros and the Leopard as well as breeding habitats for numerous small mammals, birds and reptiles as well as areas of unique diversity in flora.

Karaba (1981) argues that the construction of the upper Athi dam would not only eliminate vital species of flora and fauna, but would also exert stress on the carrying capacity of the park, resulting in severely degraded landscapes.

Taiti S.W.(1979) has also suggested that the construction of dams within and around the National Park would hardly have any positive contribution to the park's ecosystem. Contrary to popular belief, it is argued in the paper that the provision of water through the construction of dams does not significantly affect the carrying capacity of the park because water supply has never been limited in the area even during periods of drought.

On the contrary, the already existing dams in Nairobi National Park are not used regularly for drinking purposes by the large animals or the large migratory herds. Instead, such dams are overgrown with papyrus and other macrophytes along the edges.

This section has so far only reviewed literature considered relevant to this study. There is, undoubtedly, a large literature whose ideas and suggestions have not been incorporated into this review but will, never-the-less, be included in the study. The literature reviewed has been carefully selected to portray the strengths and flows of previous studies.

1.3 Justification of the Study

This study was prompted by two reasons:

1. Environmental impact assessment is a fairly new discipline not only in Africa but in other parts of the World. As such most of the studies that have been undertaken (and especially in Africa) are inconclusive and narrow in scope in that they have tended to incorporate within their framework more of philosophical than empirical arguments. Further, they have failed to integrate the environment with other subsystems of the systems under study.

Abul-Ata's (1979) Study of the Aswan dam exhaustively looks at the physical impacts of the lake. No attempt has been made to assess the interlinkages between the physical, the social, cultura and the economic systems of the Aswan dam environment with the dam itself.

In his discussion, Adeniji, et.al.(1981) discuss the wide range of impacts of African man-made lakes within the all too narrow spectrum of biological and physical impacts. No efforts are made to assess the impacts of such dams on the prevailing land uses ,as though the social , economic and cultural aspects were independent of the physical biological and ecological environment.

Baumann, et.al.(1973) details the major profits perceived to accrue from the impoundment of free-flowing rivers. While such profits are only too well outlined, the major shortcoming of his study is that perceived profits detailed are limited to such as can be computed in dollars and cents, totally failing to point out the importance of other statistically non-computable impacts like the creation or destruction of scenic attractions with its subsequent effects on both internal as well as external tourism.

This study will push the field of impact assessment in this country one step further. Through taking advantage of the above and other related shortcomings this study has attempted to fill in some gaps in other studies by attempting to integrate and interrelate the various subsystems of the environment into a totality, an aspect that has not been given much thought or space by other studies. While this study does not in any way lay claim to a total deviation from the philosophical as opposed to the empirical approach, some attempt has been made at the quantification of some social and economic dimensions. This has largely been achieved through the assessment of impacts on the above two environments as they are related to the physical sub-system.

2. Although Nairobi National Park covers only 114 KM², it is of tremendous importance to the entire Kenyan Park system due to its close proximity to the City of Nairobi. Tourists to the rest of the country pass through Nairobi National Park on arrival to witness at close quarters *1 what they are likely to see in the other larger parks of the country.

*1 - Its small size and diversified habitat has led to concentrations of a large variety of animals.

Dignitaries and businessmen on visits to the country take time off to visit the park. The park also attracts a considerable number of local tourists due to its close proximity to the most populous town and major concentration of economic activities in the country.

As discussed elsewhere in the study, Nairobi National Park is viewed appropriately as an Island Ecosystem. With such a wide diversity in habitats, the park, though among the smallest in size, is the most heavily patronised.

While it still maintains that status, Nairobi National Park has been hedged in by conflicting land uses to the extent that it might well be on the verge of total collapse. At the moment, therefore, it requires very intensive methods of planning and management. Nairobi National Park can therefore hardly afford to accommodate any trial and error procedures. Many alterations of the environment are not immediately reversible should it be discovered that such alteration was a mistake. It is critical therefore that the introduction of exogeneous activities within the park system be preceded by extensive investigations into the possible implications of such activities to the continued existence of this unique heritage. Such is the nature of the problem that has prompted this study.

1.4 Objectives, Scope and Limits of the Study

(a) Objectives and Scope

In the light of the stated problem, the main objectives of the study and their related scopes are as follows:

(i) To analyse the various dimensions of the proposed upper Athi dam, namely :

(a) Physical characteristics ,

(b) Technical dimensions , and

(c) Socio-economic aspects .

(ii) To evaluate the potential impacts on the non-human biological environment resulting from the proposed water resource development along the Mbagathi river , namely:

(a) Impacts on the fauna of Nairobi National Park ;

(b) Impacts on the flora of Nairobi National Park ; and

(c) Impacts on the avifauna of Nairobi National Park .

(iii) To examine the various socio-economic characteristics of Nairobi National Park and its visitors as related to the proposed upper Athi dam and the continued viability of Nairobi National Park; namely:

(a) Visitor characteristics;

(b) Visiting (utilization) patterns;

(c) Major factors of attraction; and

(d) Perceptions towards proposed structural changes.

(iv) To pinpoint key impacts resulting from the construction of small-scale impoundments in and around areas whose principle land-use system is wildlife conservation.

(a) Research findings;

(b) Recommendations - For planning purposes,

- For research purposes.

(b) <u>Limits of the Objectives and their various scopes</u>

(i) This research limits itself to the study of potential impacts within the park. This does not however, suggest that the park would be the sole impactee. It has been anticipated that impacts would be more diverse than has been suggested in the scopes of the objectives.

It is for example evident that a wide range of impacts would be observed and felt in the whole of the Kitengela game conservation area as well as further downstream of the Mbagathi including Athi-River township and Munyu dam further downstream.

Such dimensions have not been included in this study by virtue of the fact that this would render the study unmanageable due to its large spatial and contextual dimensions.

(ii) This study is geographical, and its emphasis is environmental. While there is an obvious integration of other disciplines into the study, no attempt has been made to push the study into a purely Natural Scientific context, although it forms an important component of the study. For example, the study has not undertaken to analyse practically the chemical properties of variables like soils, water and others, although they are discussed in reasonable depth. Such information has been collected through literature searching and consultations with authorities in related discipline. Essentially therefore, information on various scopes like fauna, flora, ornithology, carrying capacity and pollution has not been accumulated through field experiments.

It should, however, be pointed out that on-site observations have greatly supplemented information collected through the above mentioned techniques - that is, literature searching and consultations.

1.5 Hypotheses to be Tested:

In the light of the above stated objectives and their related scopes, the following hypotheses have been advanced to test the relevance of both the study problem and the related objectives.

(i) H_o - Any water resource development along the Mbagathi river would be compatible with the ecologic stability of Nairobi National Park.

H_1 - Any water resource development along the Mbagathi river would be incompatible with the ecologic stability of Nairobi National Park.

(ii) H_o - Levels of satisfaction achieved during visits into Nairobi National Park and willingness by visitors to pay more as park entrance charges are statistically independent.

H_1 - Levels of satisfaction achieved during visits into Nairobi National Park and willingness by visitors to pay more as park entrance charges are statistically dependent.

(iii) H_o - There is no relationship between effecting construction of the upper Athi dam and anticipated changes/increases in visiting frequencies into Nairobi National Park.

H_1 - There is a relationship between effecting construction of the upper Athi dam and anticipated changes/increases in visiting frequencies into Nairobi National Park.

1.6 Operational Definitions of the Concepts of the Study

This section looks at several terms requiring explanation and/or definition. The terms are important in two aspects: first, the study revolves around them and secondly, some of the terms might arouse confusion in that they are either technical, problem specific or perhaps carry more than one connotation.

1.61 Environmental Impact Assessment

Armour, A. (1977) defines environmental impact assessment as " a process of identifying, predicting and evaluating the environmental effects of proposed activities . . . at a stage in the planning process where serious environmental disturbances, degradation or damage can be avoided".

Implicit in this definition is the realization that the 'disruption' of the environment is not a goal or an end of any specific activity. Rather, it must be viewed as the by-product of activities or the means through which they are conducted.

Mathews, W.H. (1975) adds that such activities are in general initiated to fulfil certain key physical or emotional needs. The end product of such wants and needs has been the manipulation of both the biotic and abiotic environments by man.

Environmental impact assessment has therefore been developed to serve as an 'action-forcing' tool to ensure that environmentally sound planning policies are infused into on-going programmes and actions geared towards economic development. (Council on environmental quality ; Executive Office of the President, U.S.A., 1978).

Without diverting from Armour's definition, Dickert, J.G. (1975) puts it more explicitly by explaining that environmental impact assessment is essentially " a method developed to ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations".

The thesis here is that there has previously been an absence of environmental quality considerations within the broad framework of planning for economic development, an absence which has manifested itself in the rapid expansion of the economic base at the expense of environmental sustainability.

Although incorporating Armours definition to an extent, it is the aim of this study to rely more on Dickert's definition in view of the fact that the study will not only predict, identify and evaluate effects but will also attempt at quantification of amenities and values in as far as this is possible.

1.52 Environment

The concept environment carries with it a large array of connotations and has been defined by, among others, Watts, D. (1971), Daemann, R.F. (1972), Pavoni, J.L et al.,(1974), and Obara (1976).

Obara looks at the environment as that totality surrounding a particular object and embodies both the physical and human aspects.

Watts looks at the concept of environment as being holistic in application, "embodying aspects of physical phenomenon . . . as well as interorganism reactions of a biotic nature." This definition falls short of Obara's in that it hardly gives any allowance to the human environment.

Pavoni perceives the environment as the complex set of living and non-living components surrounding every living thing and from which it derives everything needed for the carrying on of all life activities. While this definition is more revealing, it fails to lay empbasis on the existence of different types of environments.

In view of the stated shortcomings of the last two definitions, this study aims at adopting Obara's connotation of the concept but with an addition of the fact that several environments can and do exist in a major environment. Hence, within the Nairobi National Park environment exists such environments as physical, social and others.

1.63 Ecosystem

The concept has been defined exhaustively by Park, C.C., (1980). Basing his premise on the hierarchical structure of food webs, he traces the reliance of green plants on the atmosphere for carbon dioxide and on the soil for water and nutrients, thus rendering the physical environment an integral part of the entire system.

The process is traced further to the death of plants and their consequential breakdown by decomposer species, while animals and man undergo the same process, thereby making decomposition a fundamental part of the ecological system.

The core of Park's argument is that different parts of such a hierarchical structure are linked to each other functionally to produce a dynamic system of inter-relationships between organisms and the environment, a system that has been referred to as the Ecosystem and is composed of two major parts; - the biome and the habitat. Biomes are the entire complex of organisms (both plant and animal) naturally living together as a sociological unit while the habitat, as will be explained later, is the physical environment.

Dasmann, R.F., (1972) describes ecosystems as the combination of assemblages of plants and animals inhabiting a common area and having therefore, effects on one another and with the physical environment, while Tivy J., (1971) looks at the concept as a term coined to express " the sum total of organisms and their physical habitat".

Pavoni, J.L. et al (1974) sums it up more precisely by viewing the concept as including "both living organisms (biotic community) and non-living (abiotic) components, as well as the interactions among them which produce the exchange of materials essential to maintaining life on earth".

Although all the above definitions are correct in their own ways, this study uses Watt's D., (1971) definition for reasons of clarity. Watts defines the ecosystem as organic-environmental assemblages which are "an intimate expression of the intricate relationships not only between organisms themselves, but also between organisms and the environment . . . . . ." . This definition is more precise in that while it emphasises the complexity of ecosystems, it also underscores the interconnectedness of not only the chemical and biological environments but also the two with the human aspect, since it is, in fact, an integral component of the entire ecosystem.

The concept of island ecosystem is closely associated with the above definition. It has been used in this study to denote such "intricate relationships" that have in the course of time evolved in near or total isolation from competition with external forms and are highly vulnerable to such competition.

A case in point is Nairobi National Park that has largely been shielded from such external interferences by established laws and regulations.

1.64 Habitat

Odum E.P., (1972) defines the concept as "living space for organisms," that is, the physical 'address' of an organism. The concept is holistic in application and while Odum's definition is precise, it is however too simplistic. This study perceives the concept as involving " not only the physical conditions of a particular site but also the organisms which occupy it; it implies the"sum total of both physical and biological conditions" (Tivy, J.,1971).

The concept is sometimes used synonymously with the concept environment. However, it is the aim of this study to treat environment as a more general and sometimes broader concept. For example, in a terrestrial environment, there is an infinite variety of physical habitats dependent upon variations of factors like rock, soil type and climate, among others.

1.65 Carrying Capacity

If one were to judge from the uses of the concept in the literature, considerable confusion seems to exist over the definition and implications of the concept.

It is frequently used interchangeably with such expressions as 'maximum population', 'absorptive capacity', 'environmental limit', 'productivity' and 'supportive ability'. It is however used more often interchangeably with productivity, with an underlying implication that a statement on 'carrying capacity' is largely (or entirely) a statement on productivity.

Whittaker, R.H., (1970) traces the relationship between population increase and resource availability. He argues that without any limits in environmental resources, a population may increase geometrically. However, since environmental resources are rarely infinite, growth of any population is inevitably slowed by competition "with increasing effectiveness the more closely the number of individuals approaches the maximum numbers the environment can support" (Whittaker, 1970). This maximum number is what is referred to as the carrying capacity of the environment. Population in this case does not only refer to human beings but includes all other kinds of species, be they animals or plants.

Dasman, et al.(1973), emphasise that the concept of carrying capacity, as a crude measure of the number of individual species that an environment can support, is determined by the environmental constraints on the growth of the species population.

Hadin, G., and Baden (1977) summarise both Whittaker's and Dasman's definitions. He defines the carrying capacity of a particular area as "the maximum number of species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation of the environment and without diminishing carrying capacity in future."

Mitchell, B., (1979) emphasises the relationship between the concept of carrying capacity and the man-environment theme in geography while acknowledging the problem involved in the operationalization of the concept. He argues that "the maximum intensity of use an area will continuously support under a management programme without inducing a permanent change in the biotic environment" is the carrying capacity of such an area. He stresses the fact that "every statement of carrying capacity contains an assumption that higher use will cause undesirable consequences."

It is the aim of this study to adopt Mitchell's definition with minor modifications. Consequently, the concept carrying capacity will be used in the study to refer to "the maximum intensity of use an area will continuously support under a management programme without inducing a degredation in the environment."

This definition has been deemed suitable in that it does not necessarily tie itself to the idea of 'number of species' typical of most definitions but instead embraces the wider concept of 'intensity of use'.

1.66 Development

The concept is used in the study in reference to the modification of the environment through the transformation of resources (both living and non-living) to "satisfy human needs and improve the quality of human life" (I.U.C.N.*1 1980).

1.67 Conservation

The concept is defined in this study as the management of human use of the environment so that it may "yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (I.U.C.N.,*2 1980)

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*1 and *2: International Union for conservation of Nature

1.7 Chapter Summary

Chapter two contains an explanation of the various procedures used in the study to enable the researcher to derive appropriate facts and relevant information of data that was collected both from the field as well as from secondary sources.

The third chapter examines various aspects of the study area. Its historical background is examined followed by its significance in both a regional as well as national perspective. Next comes a discussion on various geographical characteristics of the park, the chapter concluding with an examination of the park's faunal status.

The fourth chapter analyses the physical, technical and socio-economic dimensions of the proposed upper Athi dam. The need for the project is emphasized and is followed by an explanation of the environmental setting of the project. The technical and logistical aspects of the dam are then examined, the chapter concluding with an analysis of the socio-economic system within the proposed dam's environment.

Chapter five attempts to analyse the environmental/ecological components that might be affected or caused to occur as a result of the construction of the upper Athi dam. Such impacts are examined in their temporal as well spatial contexts. The chapter examines the physical, biological and purely ecologic characteristics and conditions that might arise as a result of the presence of the upper Athi dam.

The sixth chapter examines the social and economic perceptions of Nairobi National Park Visitors towards the proposed Upper Athi dam. Visitors' personal characteristics and their visiting patterns are analysed, followed by an examination of major factors of attraction, intensity of utilization of the Park, the visitor perceptions towards the proposed dam and the dam's potential influence on the patronage characteristics of visitors.

The seventh and final chapter synthesises the discussions contained in this study. The chapter carries a summary of the thesis findings, the conclusions based on the findings and a summary of the recommendations contained in the thesis.

CHAPTER TWO

2.0 METHODOLOGY

2.1 Introduction

> Research methodology has been defined as the use of "Systematic research procedures and techniques which help the researcher to avoid self-deception" (Prewitt,K.1975)

This chapter explains the various procedures and techniques used in the study to enable the researcher to derive appropriate facts and relevant information from masses of otherwise disorganised data. These procedures and techniques include those used in:-

(1) Determining from the universe, the limits of the working population for sample frame and, consequently, selecting the required sample(s) from the working population;

(2) The collection of required data and related information from the selected sample(s) and from other sources;

(3) The processing and, subsequent analysis of the gathered data and other information;and

(4) The presentation of the analysed data and other relevant information.

At this stage, it must be pointed out that this study involves the gathering and subsequent analysis of data from several sources, namely:-

(1) A selected sample of Nairobi National Park Visitors who are resident in Kenya ;

(2) A selected group of some wildlife conservation and management experts ;

(3) Two consulting engineers representing a consultancy firm that has been commissioned by the Ministries of Water Development and Local Government to undertake feasibility studies for the design of a water supply system for Athi river township ;

(4) A group of experts in various related disciplines from public educational, public non-educational, as well as, private non-educational institutions;

(5) Agriculture and Livestock Development officers from Ngong division of Kajiado district ; and

(6) Abstraction from published and unpublished statistics.

2.2 Sampling Design

Before any researcher embarks on a data collecting exercise, it is imperative to know exactly what one is seeking information about, be it a group of people, items or elements of a set. It is not statistically feasible to determine off-hand that one is going to collect information on items one, two and three. Rather, one must be aware of the characteristics of the whole from which one is going to draw the required information. This entire set of elements that one seeks information about is referred to as the universe or population.

However, it is usually not possible to collect information on the entire population. This may be due to several reasons some of which may be that:

(1) It must be extremely difficult to define the entire population;

(2) The population may be too big to effectively collect information on;

(3) Some of the elements of the population may be inaccessible - for example, a study of all Kenyans suffering from sore throat would obviously exclude those Kenyans suffering from sore throat who are out of the country at that particular time or those who are not even aware that what they are suffering from is indeed sore throat.

In this study, the **sample frame** was made up of all visitors to Nairobi National Park who are residents in Kenya. All people who had **continuously** stayed in the country for a period of six or more months were considered as being residents of this country even though they might not necessarilly be Kenya citizens. Reasons for not including non-residents in the working population are explained elsewhere in this study.

As was discussed earlier in this section, it would almost be impossible to collect information from the entire population due to outlined shortcomings. Scientists, both natural and social, have resorted to working with samples instead of working populations.

A sample is "a small part of a larger population which is thought to be representative of the larger population" (Prewitt, K. 1975)

Prewitt (1975) discusses three main characteristics that should be possessed by any good sample:-

1. A good sample should posses an adequate number of items in it.
2. It should cover a wide geographical spread; and
3. It should possess a wide range of element types to give all types of elements an equal chance of falling into the sample.

Using samples rather than entire populations carries several advantages, chief of which are:

(1) Working with samples results in the use of higher quality interviewers. Because fewer interviewers are required to interview only a small proportion of the total population, a much higher quality of interviewers can be employed;

(2) Working with samples results in the use of a more practical method. When, for example, the investigation entails the destruction of the sample, sampling becomes the only practical method to use. For example, a car engine manufacturer may wish to know the average speed in revolutions per hour a particular new invention of engines can run before it blows up. In such or similar circumstances, a total testing (100 per cent) would result in no car engines for the market since all engines must blow up at some level;

(3) Working with samples saves money and time. It costs much more in terms of money and time to examine the whole population, costs which "could easily exceed the value of the survey results" (Haper, W.M. 1970).

(4) A sample "can be given very careful attention and measurements made with a high degree of accuracy" (Haper, W.M. 1970).

In this study, two different sampling procedures were employed in collecting the relevant information:

(1) Stratified sampling is "better than purely random methods" (Harper, W.M. 1970) of data collection. It increases the accuracy of the results, provided the strata relevant to the investigation are chosen. In this method, the population is divided into strata (blocks of units), in such a way that each block is as homogeneous as possible. All the strata are divided in proportion with their occurrence within the population. If the same proportion of each stratum is taken, each stratum will be represented in the correct proportion in the sample.

Nairobi National Park has a total of six gates, five of which are used by visitors. While there usually is no discernible pattern as to the volume of traffic through each gate, a simple survey of gate records reveals that each of the gates falls within a certain rank in that aspect.

Stratified sampling was therefore used to determine how many samples were to be collected from each gate. First, the total number of visitors to the park in July 1982 was extracted from the existing records. 1982 was chosen as the base year because the survey was carried out in the same month of 1983. An analysis of visitor volume for the years 1980-82 indicatd that July 1982 was fairly representative of the general trend of patronage patterns since 1980. It was assumed that, other factors not withstanding, the trend would continue into 1983.

After the total number of visitors for 1982 was abstracted, proportions of each gate's contribution to the total were calculated (for July 1982). Samples were then collected from each gate in July 1983 using the above proportions.

2. Systematic sampling is a shorter method for obtaining random samples. When the population is known and a certain percentage is required, the sample can be selected by picking every nth item. Provided there are no characteristics of the items in the list which occur periodically with the same interval as the sampling interval, the sample would not be biased. The first entry would, of course, be obtained by random selection.

In this study, the first sample to be selected was the first visitor to go through a gate who fell within the sample frame. Thereafter, every seventh resident visitor was included in the sample.

It should be pointed out that there is no stetistical method which can be used to determine the interval. In this case, the interval was thought to be appropriate arbitrarily and as such cannot be justified. It is however hoped that such an interval safely eliminates the mischance of there happening to be some pattern in the population that might concide with an appropriate interval.

2.3 Methods of Data Collection

In this study, several data collection techniques were used to obtain results from the park visitors and other knowledgeable people on this subject. The first technique to be employed was the self-administered questionnaire.

This technique provides the quickest and easiest method of gathering data. In its simplest form, the questionnaire consists of a schedule of questions sent by mail or served by hand (as is the case with this research) to persons in a survey sample. The form is for completion and return by the recipient.

In this survey, a closed form questionnaire was served to members of the sample before their entry into the park. The questionnaire contained itemized answers to the questions being asked. The informant was required to choose from the itemized answers and put a tick against those approximating closely to their situation or opinion. Each informant was required to hand in the same at the gate on his way out. However, some respondents preferred taking the questionnaires with them and mailing them back.

This method of data collection (self-administered questionnaire) carries with it several distinct advantages, chief of which are:

(a) Questionnaires cover a wider geographical area and reach a much larger population with given funds than would personal interviews;

(b) Questionnaires eliminate the expensive and time-consuming task of training a team of research assistants;

(c) The questionnaire prompts the informant to answer many questions more frankly since anonymity is assured;

(d) By use of questionnaires, any personal antagonism to the investigator by the informant is avoided since there is either no personal or very minimal confrontation;

(e) In a questionnaire, questions are standardised and thus eliminate the implied or suggested answers given by investigators during personal interviews; and

(f) Questionnaires can be answered at the convenience of the respondent. (Prewitt, K. 1975, Harper, W.M. 1971 and Yang, 1955).

It should be pointed out that inspite of the above advantages, the technique possesses several limitations which might render the technique inappropriate in particular instances.

These are:

(a) The questionnaire (self-administered) is limited to only the literate population or to that group of the population which understands the language it is put in (Prewitt, K. 1975);

(b) The response rate in self-administered questionnaires is very low. For reasons best known to them, most people fail to return the questionnaires while others either misplace them or throw them away. As Prewitt, K. (1975) puts it, " it is much easier to refuse a researcher who contacts you through the mail than to refuse a researcher standing at your front door";

(c) In a self-administered questionnaire, the respondents may misinterpret questions, omit essential items or send in material which cannot be tabulated (Prewitt, K. 1975, Hsin-Pao, Y. 1955);

(d) In this type of technique, it is difficult to check on the honesty and reliability of returns. For example, there is no way of the interviewer knowing whether the questionnaire was completed by the person in the sample or whether the responsibility was delegated to somebody else (Prewitt, K. 1975), and

(e) Sometimes it becomes practically impossible to return unsatisfactory or incomplete schedules to the informant for correction.

However, inspite of the many drawbacks, the self-administering questionnaire remains a useful technique in various types of research and surveys.

In this study, it was used to collect the perceptions of Nairobi National Park Visitors towards existing amenities and conditions together with their perceptions towards proposed structural changes in the park. The information so gathered was used to assess the potential effects of the proposed impoundment on the park's economic system.

The second type of questionnaire that was used in this survey was in the form of a matrix - the Leopold Matrix (see Appendix **D**). This is a two dimensional matrix that has a list of activities which may cause environmental impact on one dimension and a list of existing characteristics and conditions that might be affected by the proposed activities on the other dimension. Respondents are required to assess:

(a) the activities of particular projects that might cause environmental impact; and

(b) the existing conditions that might be affected by the identified project-related activities.

The respondents are then asked to assess both the importance and magnitude of particular impacts identified by filling in the same in corresponding cells of the matrix. There is no orthodox way of assessing the importance and significance of particular impacts. Respondents are supposed to use their own value judgement - which makes the whole exercise subjective in a way - although they are encouraged to base their arguments and decisions on facts and figures in so far as that is possible. They are furnished with relevant information and figures about the project and its environment and are highly encouraged to consult the interviewer in cases of difficulties or problems.

The magnitude of an interaction is the extensiveness or scale and is described by the assignment of a numerical value from one to ten, with ten representing a large magnitude and one, a small magnitude. Values near five on the magnitude scale represent impacts of intermediate extensiveness.

The importance of an interaction is related to the significance, or assessment of the consequences, of the anticipated interaction. The scale of importance also ranges from one to ten, with 10 representing a very important interaction and one, an interaction of relatively low importance.

Before the Leopold matrix can be used, it is advisable to fully comprehend its range of strengths and weaknesses. Its advantages are that:-

(a) The matrix is useful as a gross screening technique for impact identification ;

(b) It provides a useful means of displaying impacts and major actions causing the environmental effects ; and

(c) It can be easily adapted to include probability of occurrence or the potential irreversibility of environmental effects ;

Its two major weaknesses are that:-

(a) It does not assist in identifying synergistic interactions, that is, secondary and tertiary effects ; and

(b) It is sometimes cumbersome to use. In the original matrix, there are 100 actions and 88 environmental items, making a total of a staggering 8,800 possible impacts (see Appendix C). The argument has been that some preliminary screening of the key issues should be done to narrow the focus of the search for likely environmental effects. This was done for this study and a smaller matrix was drawn up (see Appendix D). (Armour, A. 1981, Canter, L.W. 1977, Leopold, L.B., et al.1971, Porter, A.L., et al.1980).

The third data collection technique used in this study was in the form of an open-ended questionnaire - the Delphi technique. This is a technique that interactively 'iterates' the responses of surveyed experts. It serves to generate systematic thought about future courses of events that are difficult to treat by other means. The following procedure was used:

(a) A structured, formal questionnaire was administered in person to all participants, who in this case were ten in number. Participants did not have to meet face to face nor were they informed of the identity of the other participants. The questionnaire items were generated by the author of this study through consultations with other experts and scanning of the ten completed matrices which had been filled in by the same participants;

(b) The questionnaire was administered for four rounds. In these rounds, participants responded to scaled objective items, and sometimes to open-ended responses as well;

(c) Each iteration was accompanied by statistical feedback on each item, which involved one measure of central tendency, the median, and one measure of dispersion - the upper and lower quartile values and at the fourth round, the entire frequency distribution of the previous response was provided;

(d) Respondents in the upper and lower quartiles were asked to justify their responses and to state why they did or did not agree with views expressed by other respondents; and

(e) The respondents were asked to estimate probabilities of occurrence of predicted impacts and their temporal dimension.

The last two techniques described were exclusively applied to ten carefully selected experts in various fields related either directly or indirectly with this study subject. They included engineers, ecologists, environmental chemists, environmental planners and biologists. The idea behind the two exercises was to attempt to identify, evaluate and predict impacts of the proposed project on the natural (physical) environment.

The fourth technique applied in this study was collection of information through personal interviews with experts in a wide array of fields and occupations. The aim of interviewing was two-fold; one, to get objective information from people who felt that, although they were not part of the sample frame, they had a strong duty towards conservation of the environment, and secondly, to clarify through confirmation or nullification ideas and facts gathered through the other techniques discussed above.

There are several reasons why this technique is a useful information gathering tool in many types of surveys, some of which are that:

(i) Information secured is likely to be more correct than that secured by other techniques, since the interviewer can clear up seemingly inaccurate answers by explaining the question to the informant (Hsin-Pao, Y., 1955) ;

(ii) Return visits for clarification and/or correction can usually be made without annoying the informant due to the personal relationship established (Thirkettle, G.L., 1981) ;

(iii) Questions about which the informant is likely to be sensitive can be carefully sandwiched in by the interviewer;

(iv) The language of the survey can be adapted to the ability or educational level of the person being interviewed. It is therefore quite easy in this technique to avoid misinterpretation or misleading questions (Hsin-Pao, Y. 1955).

Against all the above advantages must be mentioned the techniques' disadvantages, chief of which are:

(i) Transportation costs and time required may make the personal interview unfeasible and especially if it involves the interviewing of a large number of people spread over a wide geographical area (Prewitt, K., 1975);

(ii) The human equation may distort the returns. If an interviewer bears a certain bias for example, he is likely to unconsciously ask and press the question so as to secure confirmation of his views.

The above disadvantages were fully taken into account while the personal interviews were being conducted.

The fifth technique employed was the collection of information through simple observation of phenomena in the field. This was achieved through the use of note books and the taking of photographs. Information about the environmental status of Nairobi National Park was written down in rough form during numerous visits to the park and was consolidated after each day in the field. Visitor behaviour while inside the park was observed and recorded in note form.

Such recorded information proven very useful during the period of writing up and was being consulted as the need arose.

Photographs of various features in the park were taken during the time of survey. They depict vegetation types, fauna and various attractions, among others. Photographs have a distinct advantage in that they are always more realistic and revealing than words and they help remind the investigator of certain details that might not have been recorded through writing. Besides, photographs have a tendency of lending greater authenticity to the facts that might have been already described (Yang, 1955).

The last technique employed was the collection of secondary data and information from both published and unpublished sources. Since it was not possible to undertake tests of various chemical and biological indices of elements existing within the study area, such sources were of great value in pushing this study to its conclusion.

This technique has got several demerits. Such data may not give the exact kind of information wanted, and they may not be in the most suitable form. Moreover, they might be outdated and collected in a totally different environmental, socio, economic or cultural setting.

Before any such information was used in this study, it was necessary to know the source of the information, how it was obtained and the exact definitions and methods of compilation of such information.

2.4.0. METHODS OF DATA ANALYSIS

2.4.1 Introduction

Data straight from the field areeither incoherent or inconsistent and is usually referred to as raw data. As Harper, W.M. (1971) puts it, "It is a psychological fact that data presented higgledy-piggledy are far harder to understand than data presented in a clear and orderly manner. Consequently, the next step after the figures have been collected is to lay them out in an orderly way so that they are more readily comprehended." This next step has been rightly described as the intermediate process between "the accumulation of data, in whatever form they are obtained, and the final reasoned account of the results shown by statistics" (Thirkettle, G.L., 1981)

This section undertakes to explain the procedure that was followed in the transformation of raw data into a ready and consistent format. During the process, several methods were used:

2.4.2 Cross - Impact Analysis

The term "cross-impact" has come to represent a family of different analytical techniques, the main ones being those dealing with how:

(a) Impacts interact to produce higher-order impacts, and

(b) The occurrence of certain events affects the likelihood of occurrence of other events (Porter, A.L., et al, 1980, Sage, A.P., 1977)

The former technique consists of tracing impact chains through successive impact matrices. The latter technique, also termed as cross-event analysis, is used either qualitatively or quantitatively to explore the change in likelihood of one event, given the occurrence of another. Both of these techniques were employed at different stages in this study.

(a) Cross-Event Analysis:

While the recommended procedure involves both the construction of the cross-effect matrix and simulation using the matrix, only the first stage of the procedure was undertaken in this study due to lack of any simulation tools.

The construction of the matrix involved several steps:

(i) An identification of the events critical to the assessment topic followed by the creation of a matrix by arraying this list vertically and horizontally. This list was obtained by a variety of means, including literature searching and the previously mentioned delphi technique.

(ii) Probabilities of occurrence of each event were estimated through the delphi technique. These estimates provided the marginal probabilities of occurrence.

2.4.3 Cross-Tabulation

A cross-tabulation can be defined as " a joint frequency distribution of cases according to two or more classificatory variables". (Nie, N.H. et al, 1975). They tabulate the respondent's response on two separate dimensions "in such a way that the reader can see the interrelationship between a respondent's score on one variable (dimension) and his score on a second variable" (Prewitt, K., 1975).

This study relied heavily on analysis through cross tabulations since most variables were found to be lacking in key characteristics that could have enabled the application of more statistically refined methods.

The variables that were cross-tabulated include:-

(i) Frequencies of visits into Nairobi National Park and the adequacy or otherwise of such visits;

(ii) Levels of satisfaction achieved and factors controlling frequency of visits;

(iii) Reasons prompting visits into the park and perceived adequacy or otherwise of total number of visits in a year; and

(iv) Levels of satisfaction and purpose of visit into Nairobi National Park.

2.4.4 The Chi-Squared Test of Significance - X^2

This test measures whether observed frequencies differ significantly from the expected frequencies. The main purpose of this statistic is to help ascertain "whether a systematic relationship exists between variables" (Nie, N.H. et al., 1975). In this study, X^2 was used on two crosstabulations to determine the statistical significance of the associations observed earlier. The following formula was used to compute X^2:

$$X^2 \sum_{i}^{K} \frac{(f_o - f_t)^2}{f_t}$$ (Smith, G.M., 1970)

Where:

$\sum_{i}^{K}$ = Sum of the $(f_o - f_t)^2/f_t$ terms for all K categories involved in the problem

f_o = Observed frequency

f_t = Theoretical frequency

Theoratical frequency was computed through the formula

$$f_t = \frac{(C_j r_j)}{N}$$ (Nie, N.H. et al., 1975)

Where:

f_t = Theoretical frequency

C_j = Frequency in a respective column marginal

r_j = frequency in a respective row marginal

N = Total number of valid cases.

After the X^2 was calculated, it was interpreted by use of the X^2 distribution tables. The final probability enabled the author to determine whether the differences between the theoretical and observed frequencies in any category could reasonably be attributed to chance variations during the period of sampling, and if this was the case, then the null hypothesis that "there was no relationship between the variables" was accepted. A large chi-square was taken as implying that a systematic relationship existed between the variables leading to a rejection of the null hypothesis at related probability levels.

While the criteria for the acceptance or rejection of hypotheses are arbitrary, it is accepted that in general," if p lies between .10 and.90, there is no reason to reject the hypothesis being tested; but if p is less than .02 the hypothesis is pretty dubious" (Smith, G.M. 1962).

2.5 Research Limitations

(i) Time:

An extensive research topic was chosen for study. It has therefore proved very difficult to observe and analyse all phenomena within the limited time allowed for field work and subsequent writing up.

(ii) Accessibility of Study Area:

The entire study area was confined within the boundaries of Nairobi National Park where organised public transport is non-existent. Access to the study area therefore had to depend on the goodwill of others since hiring of private transport is a very expensive exercise. It was not possible to visit the field whenever it was necessary every time unless prior arrangements had been made, a fact that was not always possible.

(iii) Non-Response

This proved a more serious problem than had been previously anticipated. During the pilot survey, a total of ten questionnaires were handed out. At this stage, the non-response level was found to be 20% - that is, only two questionnaires were never returned. During the actual survey, 160 questionnaires were handed out. Out of this, only 87 questionnaires were eventually returned, the non-response level having risen from 20% to around 46%.

CHAPTER THREE

STUDY AREA

.1 Location of Study Area

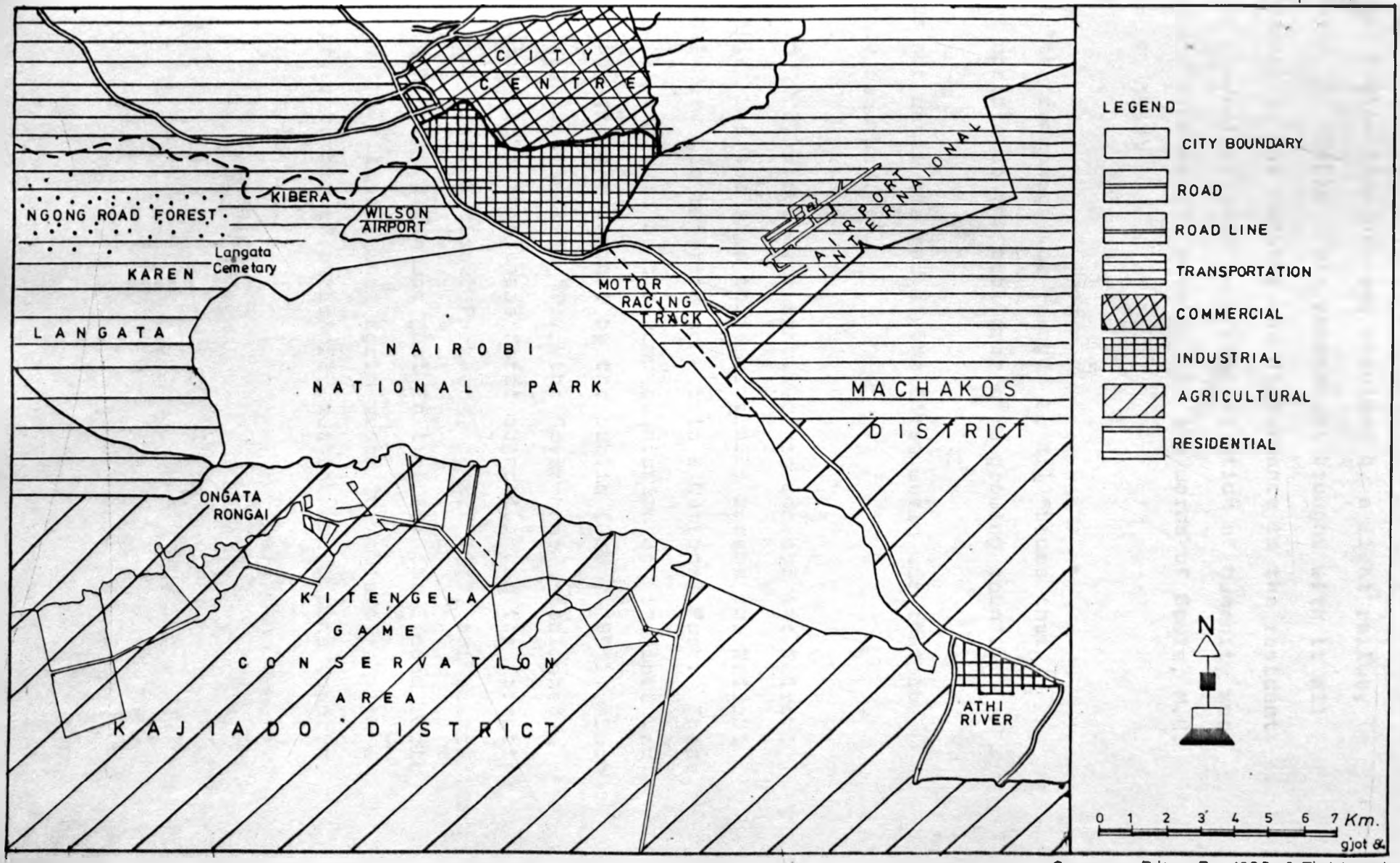
Nairobi National Park is situated about 8 km south of the ity of Nairobi and covers an area of 113 km^2 (Ecosystems, 932). To the North, the park is separated from the airport, esidential and industrial areas by the Nairobi-Mombasa road map. 1). To the west of the park lie the higher income racket residential areas like Karen, Langata and Otiende. To he south of the park lies the Kitengela game conservation area, ith the Mbagathi river forming a natural boundary between the outh and the park, while the Athi river township lies at the outh-eastern end of the park.

.2 Legislative and Historical Background of the Study Area

The birth of Nairobi National Park can be traced to the ear 1900 when the British Colonial Government established the outhern game reserve which included not only what later became he Nairobi National Park but also parts of what are now Narok, ajiado and Kiambu Districts (Map No. 2). In the same year (1900), welve Somali families were allowed to settle with their livestock n the Northern bank of the Mbagathi river as a reward for their ervices in various military campaigns preceding the year 1900.

EXISTING LAND USE AROUND NAIROBI NATIONAL PARK

Map No 1



Source: Rita R. 1982 & Fieldwork observation 1983

In 1914, the area that is now Nairobi National Park became a military encampment complete with field firing ranges, battle trenches and serviced by a light railway (Rudnair, J. 1982). This encampment brought with it all the damage to the habitat and disturbance to the resident animal population that such concentration of humanity and machinery necessarily entail. In the words of Cowie, M.H. (Anon, A. 1951)

> "the commonage was ravaged by all forces that operate at the back door of a growing town".

It was not until the end of the first world war that the military decamped.

In 1933, plans were conceived to convert the Nairobi commonage - as the area that eventually became the Nairobi National Park was referred to - into a National Park. These plans were approved by the land commission and the idea was given considerable support by the public (Anon, 1951). Such was the support that in 1939, the Government established a game policy committee whose first objective was the formation of Nairobi Royal National Park and, by mid 1939, the boundaries had been finally drawn up: just in time for the Second World War when the military once again moved in, this time with a much larger number of personnel, machine and weapons than in the First World War.

To the earlier military training and defence facilities was added a bombing range (Rudnai , 1982). The military however pulled out again after the end of the war but not without much reluctance as there had been some lobbying from some quarters to have the area reserved for continued military use and settlement (Rudnai, 1982).

In December 1946, 13 years after the first idea had taken shape, Nairobi Royal National Park was finally born and was accorded the strongest protection the colonial government could device:

> "human intruders into the park were restricted, salt licks were replenished and hooligans prosecuted" (Anon, 1951).

There was at this time one problem; the somali settlers could not be moved out as they held a strong claim to the land they were occupying. However, following the recommendations of the Kenya land commission, the somalis were allowed to stay in the park during the lifetime of the head of each household after whose death the particular household would have to move off, (Jari, R. 1982). Their livestock was also drastically reduced in numbers and limits set to their increase such that in the first nine months of the park's existence, they were reduced from 3,500 to 220 heads of livestock (Ecosystems, 1982).

In 1949, three years after the inception of Nairobi Royal National Park, the Ngong National Reserve, covering an area of 312 Km^2 was gazetted (map 3). This area was felt to be of primary importance as a dispersal zone for the animals of Nairobi Royal National Park. Cowié, H.M., the then director of the Royal National Parks of Kenya, considered

> "the preservation of game in this area as an absolutely essential factor for the security of Nairobi National Park" (Anon, 1951)

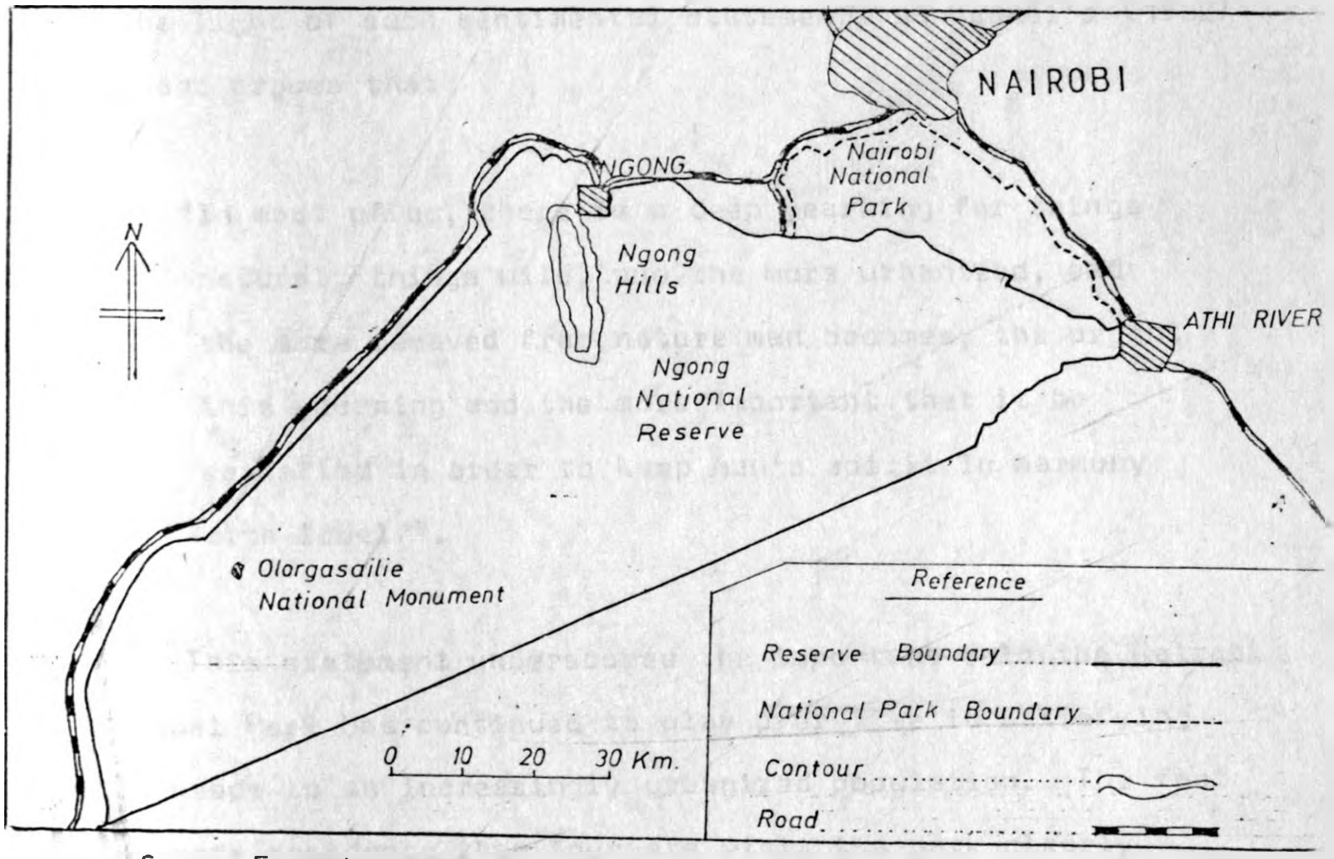
After its inception, Nairobi National Park was administered by a board of trustees and was thus independent of the central government, as was the case with all the other parks set up between 1946 and 1976 when the Game Department and the park's administration became amalgamated and the parks fell under the Ministry of Tourism and Wildlife.

According to the words of Captain A.T.A. Ritchie, game warden for the Kenya colony, Nairobi Royal National Park was created for the benefit of the peoples of Kenya as

> "an unspoilt heritage for posterity" where "people can commune with nature and find peace of mind and soul" (Rudnai, 1982).

Map No.2

NAIROBI NATIONAL PARK AND NGONG NATIONAL RESERVE



Source: Ecosystems, 1982.

3.3 National Significance of Nairobi National Park

Nairobi National Park is unique in that it presents an assemblage of large and small wild animals and numerous amounts of birds in a natural setting on the doorstep of a large city, thanks to the many types of habitats existing within the park. The significance of this unique aspect can only be understood in the light of such sentimental statements as Rudnai's (1982) when she argues that

> "in most of us, there is a deep yearning for things natural, things wild, and the more urbanized, and the more removed from nature man becomes, the urgent this yearning and the more important that it be satisfied in order to keep man's spirit in harmony with itself".

This statement underscores the important role the Nairobi National Park has continued to play over time in satisfying such needs to an increasingly urbanized population. The fact that more residents than tourists visit the park clearly illustrates the fact (table 3.1). In fact, due to its close proximity to the capital, Nairobi National Park remains the most heavily visited park in the country (table 3.2), not to mention the fact that it has had to occasionally play host to several world dignitaries including heads of state who have found time off their busy schedules within the city of Nairobi.

TABLE 3.1

A BREAKDOWN OF CATEGORIES OF VISITORS TO NAIROBI NATIONAL PARK BETWEEN 1971-1979

YEAR	TOTAL VISITORS	RESIDENTS	TOURISTS	CHILDREN	RATIO of RES:TOUR
1971	177,304	89,697	53,814	33,293	1.6:1
1972	135,770	81,491	70,993	33,286	1.3:1
1973	275,275	142,801	70,250	62,224	2.0:1
1974	153,699	79,104	43,758	29,837	1.6:1
1975	132,318	60,765	43,634	27,919	1.4:1
1976	134,779	73,945	42,230	18,604	1.8:1
1977	134,577	79,961	34,780	19,836	2.3:1
1978	139,482	83,836	27,597	28,049	3.0:1
1979	108,308	54,190	19,467	16,266	2.8:1

Source: Warden, Nairobi National Park.

TABLE 3.2 TOTAL NUMBER OF VISIT

NAME OF NATIONAL PARK	1975	1976
Aberdare	43,798	44,907
Amboseli	82,641	100,339
Kisite Mpunguni	598	1,463
Lake Nakuru	78,098	68,098
Marine	34,609	37,764
Marsabit	4,413	3,230

RS TO NATIONAL PARKS OF KENYA FROM 1975-1980

1977	1978	1979	1980
46,033	39,891	44,892	39,551
83,233	67,379	80,905	82,128
831	852	2,378	3,911
80,635	94,805	72,399	96,720
37,245	41,242	48,705	38,319
3,701	2,673	2,701	2,748

Cont'd

Table 3.2 (continued)

NAME OF NATIONAL PARK	1975	1976
Meru	22,826	25,826
Nairobi	132,318	134,779
Saiwa Swamp	-	830
Shimba Hills	9,999	9,882
Tsavo (East)	60,133	61,580
Tsavo (West)	79,567	89,882
Mt. Elgon	2,414	2,455
Mt. Kenya	8,600	9,790
TOTAL	568,453	590,890

Source: Wildlife Planning Unit records.

1977	1978	1979	1980
36,945	32,296	25,867	22,443
134,577	139,482	108,300	124,554
1,853	1,719	1,350	1,352
12,112	12,124	14,000	15,809
65,530	57,001	55,081	60,589
82,537	80,336	97,832	117,822
2,782	2,634	3,134	3,557
9,484	8,919	8,200	7,358
603,899	561,417	565,812	608,563

Nairobi National Park also plays an important educational role. Priding itself with being host to the largest wildlife conservation educational centre in the country, the centre's related activities and facilities make it the focus of visits by a large number of school children in school parties from all over the country. After being introduced to the activities of the educational centre, the parties are conducted on a guided tour of both the animal orphanage and the National Park. Such attention helps instill a sense of awareness towards the increased need to conserve the country's wildlife heritage.

3.4 Regional Influences

Ever since its inception, Nairobi National Park has been existing under "threats" of one form or another. In 1956 for example 1.57 km^2 was excised from the park along the Northern boundary in order to meet part of the requirements for Embakasi Airport (Ecosystems, 1982). Since then land use patterns in the periphery of the park have been changing rapidly due to rapid rates in population growth and increased rates of urbanization.

Through the 1960 s and '70 s agricultural expansion to the west of Nairobi National Park continued at an alarming rate such that by mid 1970's, it had extended southward along the whole eastern base of the Ngong hills to as far as the Kiserian river.

Throughout the 1970's agricultural activities rapidly picked up along the southern boundary of the park. Along the western boundary, "settlements are dense and are accompanied by fencing, paddocks and even stone walls" (Ecosystems, 1982). Although permanent dwellings are widely spaced along the southern boundary, the land is all privately owned and likely to be developed more intensively in the near future. In any case, it appears like subsistence farming is taking first priority in preference to pastoralism in the area (fieldwork observations, 1983).

As a result of the above changes, two problems have arisen. First, there is a growing competition between domestic livestock and wildlife for grazing within fast diminishing grazing lands (Jeri, 1982). As a result, more and more cattle are being grazed inside Nairobi National Park and especially during times of prolong drought. Apart from reducing the standing crop biomass of plant matter available to wildlife in the park, intermingling of wildlife and domestic stock has resulted in the spread of wildlife diseases to livestock, some of which are incurable.

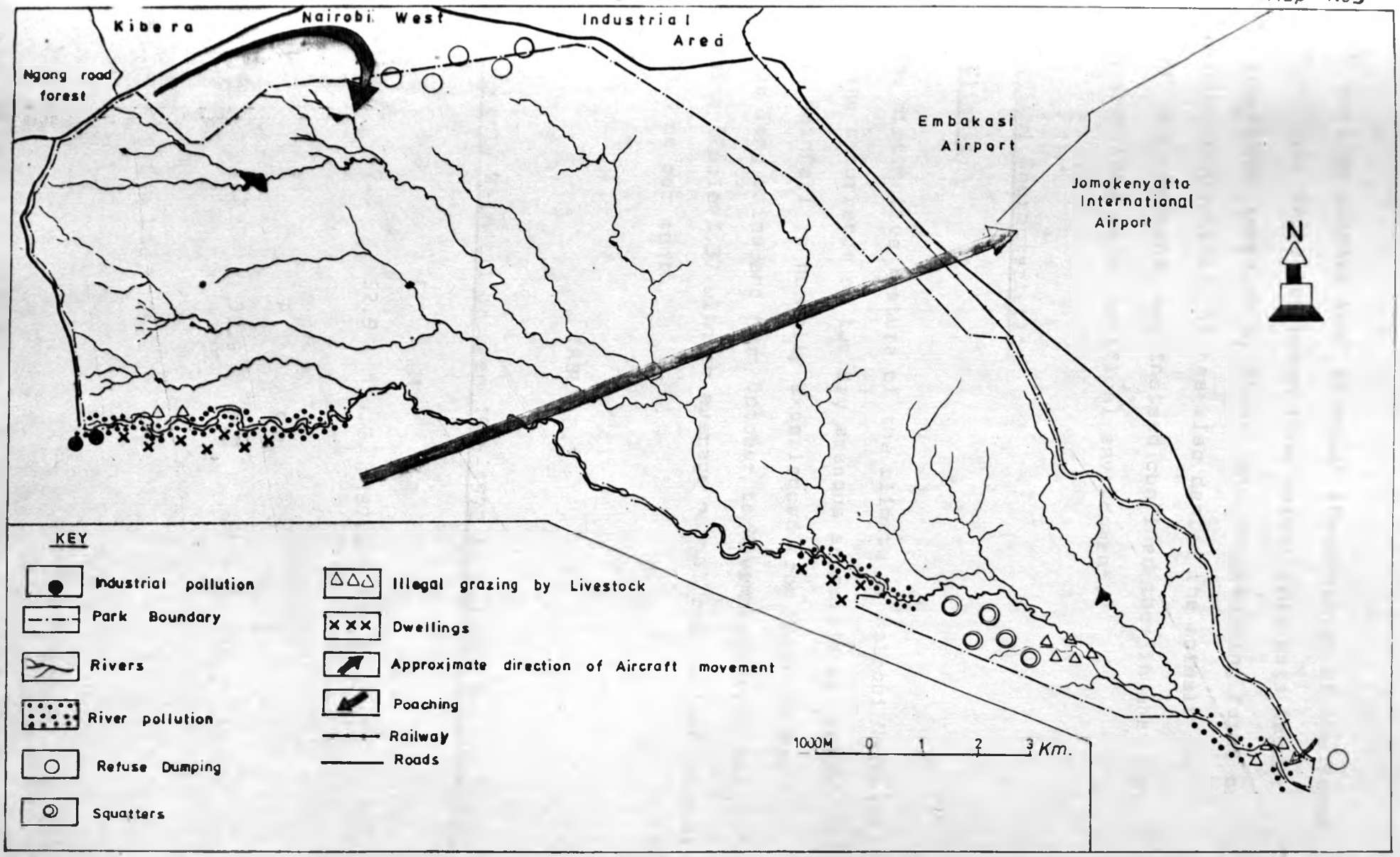
Second, loss of crops, livestock and human life sustained through wildlife rampages has encouraged fencing in the Kitengela and consequently, drastically affected the migration patterns of animals within and without the park.

Urbanization and its related activities is posing another equally serious threat to Nairobi National Park. Rapid population growth in Nairobi city has led to a greater need for more land, resulting in an outward growth of the city in all directions. Residential estates - Rubia, Southlands, Golden Gate, Plainsview, South B/C, inter alia, have spread out all over the Northern periphery of the Park, while the rest of the Northern periphery has been taken up by industrial development and communication facilities - old Embakasi Airport, Jomo Kenyatta International Airport and Wilson Airport. This last aspect has led to tremendous noise pollution in the park from low flying aircraft to and from the airports (map 4).

In Athi river, residential and industrial premises have sprung up next to the park while small scale industries are sprouting up in Ngong and Ongata Rongai in the west. This encroachment has resulted in not only the erection of a chain-link fence along all but the southern boundary of the park but also heavy pollution of the Mbagathi river at the upper and lower segments from industrial effluents (map 3).

NAIROBI NATIONAL PARK: PROBLEM AREAS

Map No.3



Source: J. Rita (1982)

It must be pointed that although the erection of the fence has effectively separated human from animal interests (apart from occasional rampages by lions into neighbouring farms or residential properties), it has also denied the animals the right of free movement, and instead confined them in what can be only described as an artifical environment.

3.5 Physical Characteristics

3.5.1 Climate

One distinctive feature of the climate of Nairobi National Park is the occurrence of two dry seasons separated by rainy seasons. Rainfall is normally experienced from March to May during the long rains and from October to November during the short rains (Table 3.3) with an average normal rainfall of approximately 90.0 mm per month.

TABLE 3.3

Average Monthly Rainfall between 1966-1979 in Nairobi National Park

MONTH	J	F	M	A	M	J
RAINFALL-mm	47.5	62.9	114.2	187.8	220.3	26.9

MONTH	J	A	S	O	N	D
RAINFALL-mm	5.3	38.9	9.3	47.3	139.8	28.7

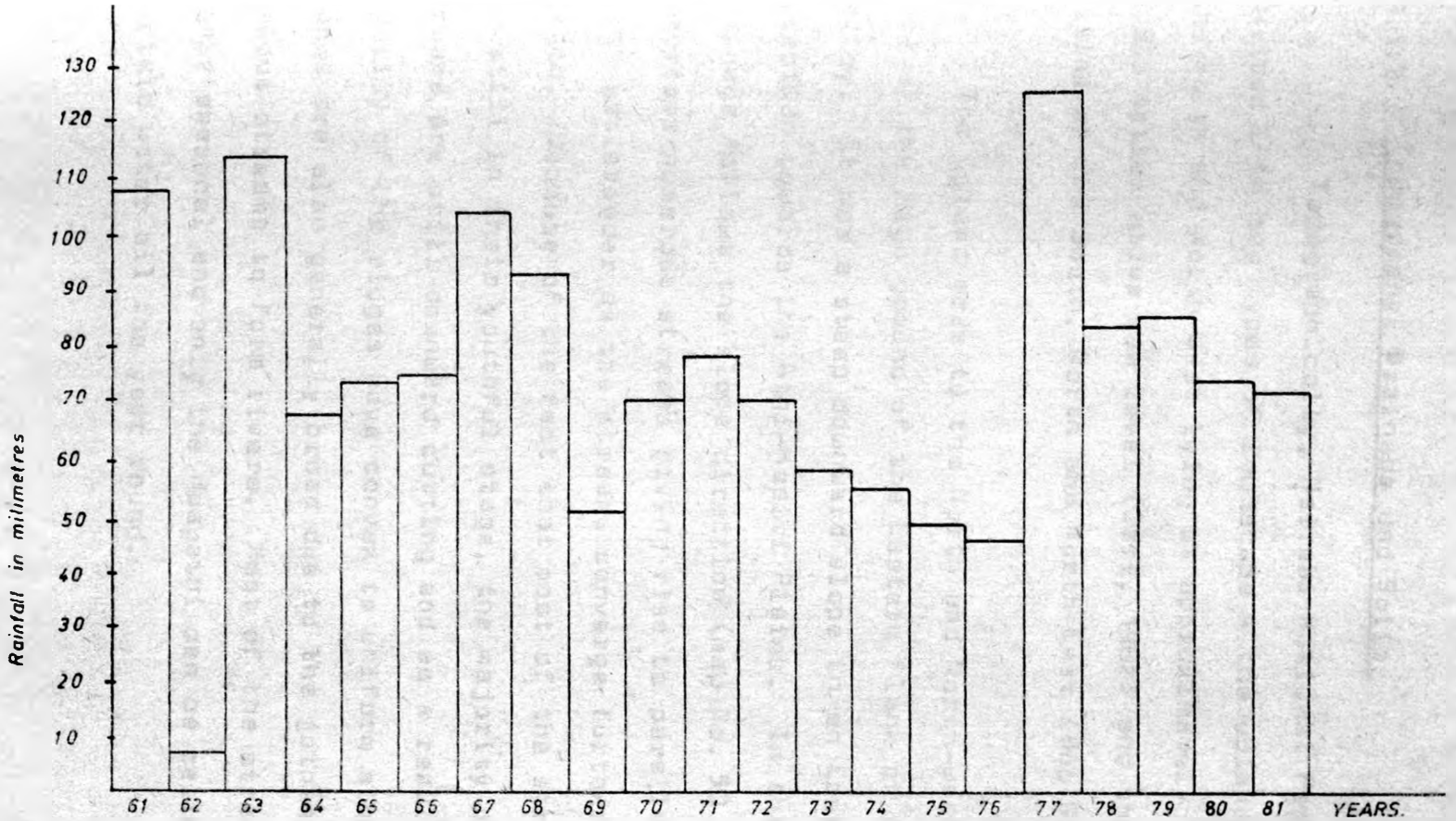
Source: Ecosystems Ltd, 1982

The average annual rainfall pattern does not depict such a systematic trend. While the average annual rainfall was generally high between 1961 and 1968 (with the exception of 1962 which had an all time low of 8 mm), it started to decrease after 1968 (again with the exception of 1977 which had an all time high of 124 mm as its average). While this pattern might correspond to a general trend in the rest of the climatic region, its implications to Nairobi National Park are far-reaching and will be discussed later.

Dry periods may sometimes total six months, though the longer dry season of the two does not usually last for more than four and one half months from early June to mid October. Rainfall in the park varies with the topography, with the highest rainfall being experienced within the higher Northern and Western areas. These upland areas experience an average annual rainfall of between 750 and 1,000 mm, with an evident decline in rainfall towards the plains which usually experience an average annual rainfall of between 500 and 750 mm (Jari, 1982).

FIG. 3.1

AVERAGE ANNUAL RAINFALL IN NAIROBI NATIONAL PARK (1961 – 1981)



Source: Ecosystems, (1982) and Warden, Nairobi National Park, (1983).

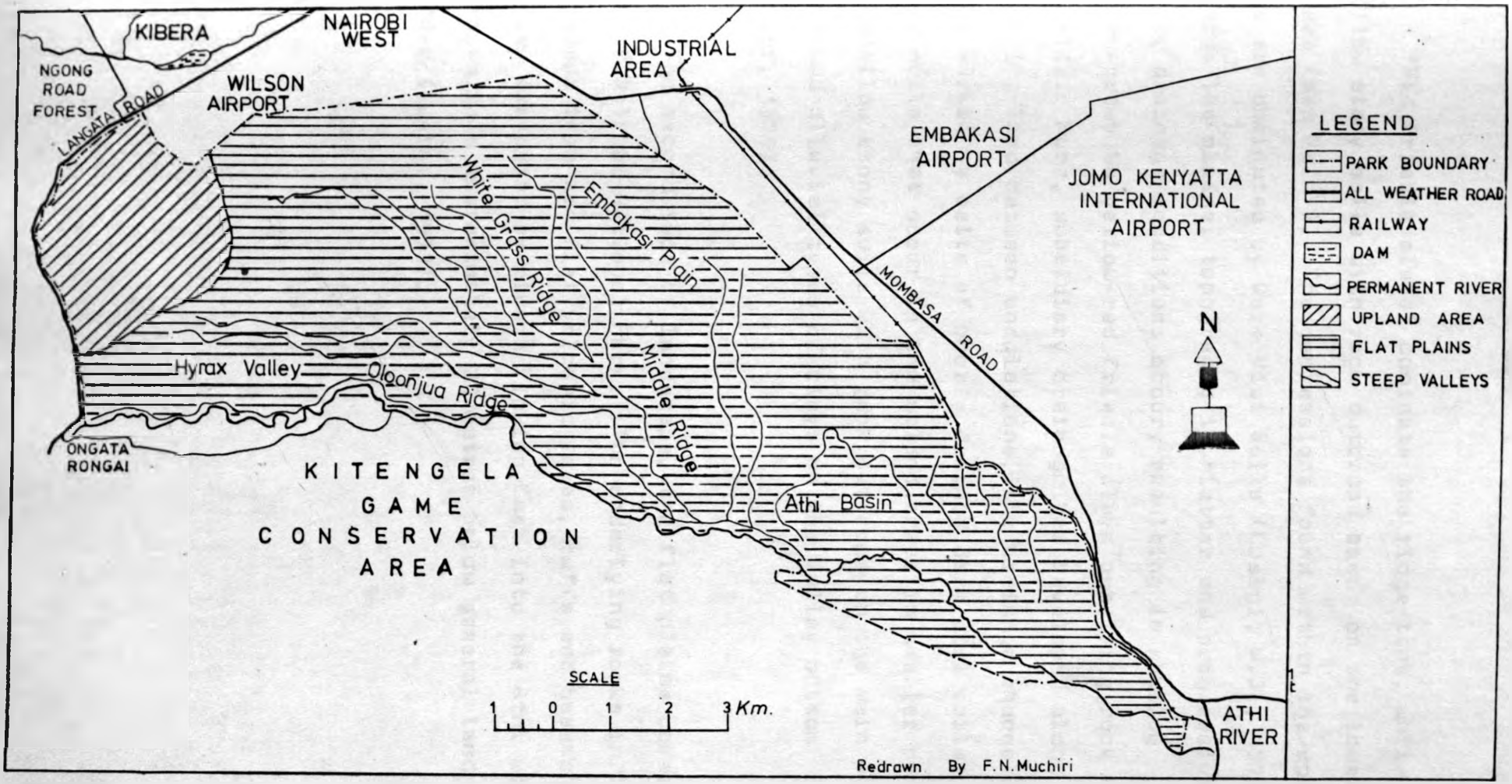
3.5.2 Topography, Drainage and Soils

Topographically, Nairobi National Park can be divided into two types of landscape - the upland area to the North and North West lying at approximately 1,700 - 1,800 metres above sea level (Jari, 1982) and the flat plains of the South, North and North-East (Map No. 5).

The upland area to the North and North-west is a part of the high ground of the Eastern flank of the Rift Valley. It has a steep downward slope in an Easterly direction towards the Athi-Kapiti Plains. In the area, drainage follows the slope direction (map No. 5) and comprises numerous streams giving rise to parallel ridges which get broader as the streams converge further down-stream. Because of the fact that most of the streams are still in their youthful stage, the majority of the streams are still downward cutting and as a result, the majority of the ridges have convex to uniform slope. The ridges are also generally broad due to the joining up of various streams to form rivers. Most of the streams are highly seasonal and only the Mbagathi can be relied upon to yield water all the year round.

NAIROBI NATIONAL PARK : DRAINAGE AND TOPOGRAPHY

MAP NO.4

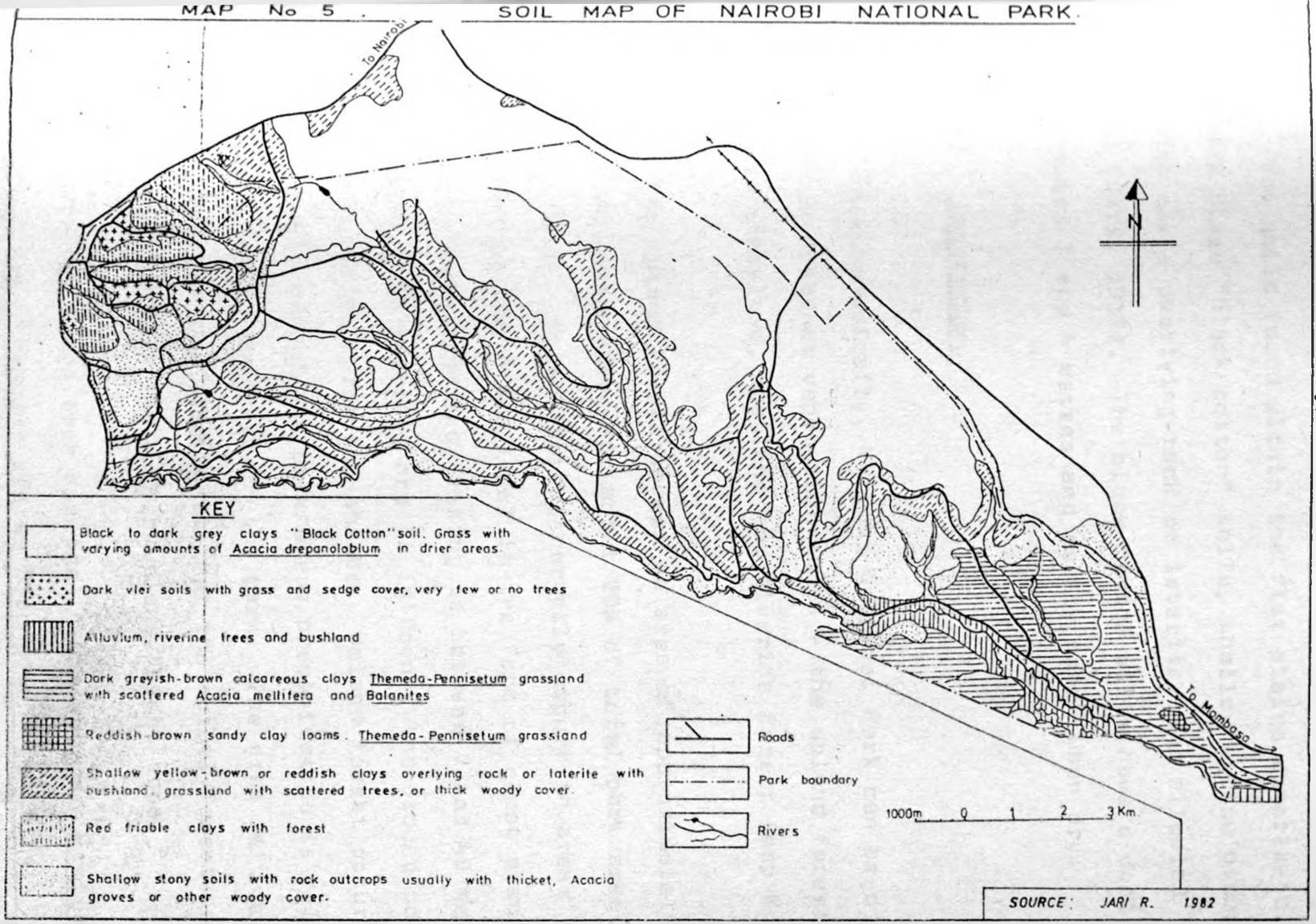


Source: Jari R., 1982

"Red friable clays" dominate the ridge tops, while shallow stony soils with rock outcrops occur on the lower slopes (map No. 6). The depressions found within the upland area are dominated by Dark Vlei Soils (Lusigi, W.J., 1978). Towards the plains, topography is flatter and progressively poorer drainage conditions occur, resulting in shallow yellow-brown to yellow-red friable clays overlying rock or laterite. Here, subsidiary drainage has developed along the low lying land between undulations, the drainage channels being marked by belts of poorly drained dark vlei soils. Other soils that occur in the upland areas in smaller patches are shallow stony soils with rock outcrops on the main valley sides and alluvial types of clays on the valley bottom (Lusigi, 1978).

The second type of landscape, the flat plains cover most of Nairobi National Park. The underlying rocks in this landscape type are flat volcanic lavas, tuffs and basement complex traversed by rivers flowing East into the Athi with steep valleys approximately 20 metres below general land surface (Lusigi, 1978).

MAP No 5 . SOIL MAP OF NAIROBI NATIONAL PARK.



The soils found within the flat plains comprise black to dark clays "black cotton" soils, shallow yellow brown or reddish clays overlying rock or laterite, and alluvial soils (Jari, 1982). The black cotton soils have a depth of between 3 and 4 metres and easily crack when dry.

3.5.3 Vegetation

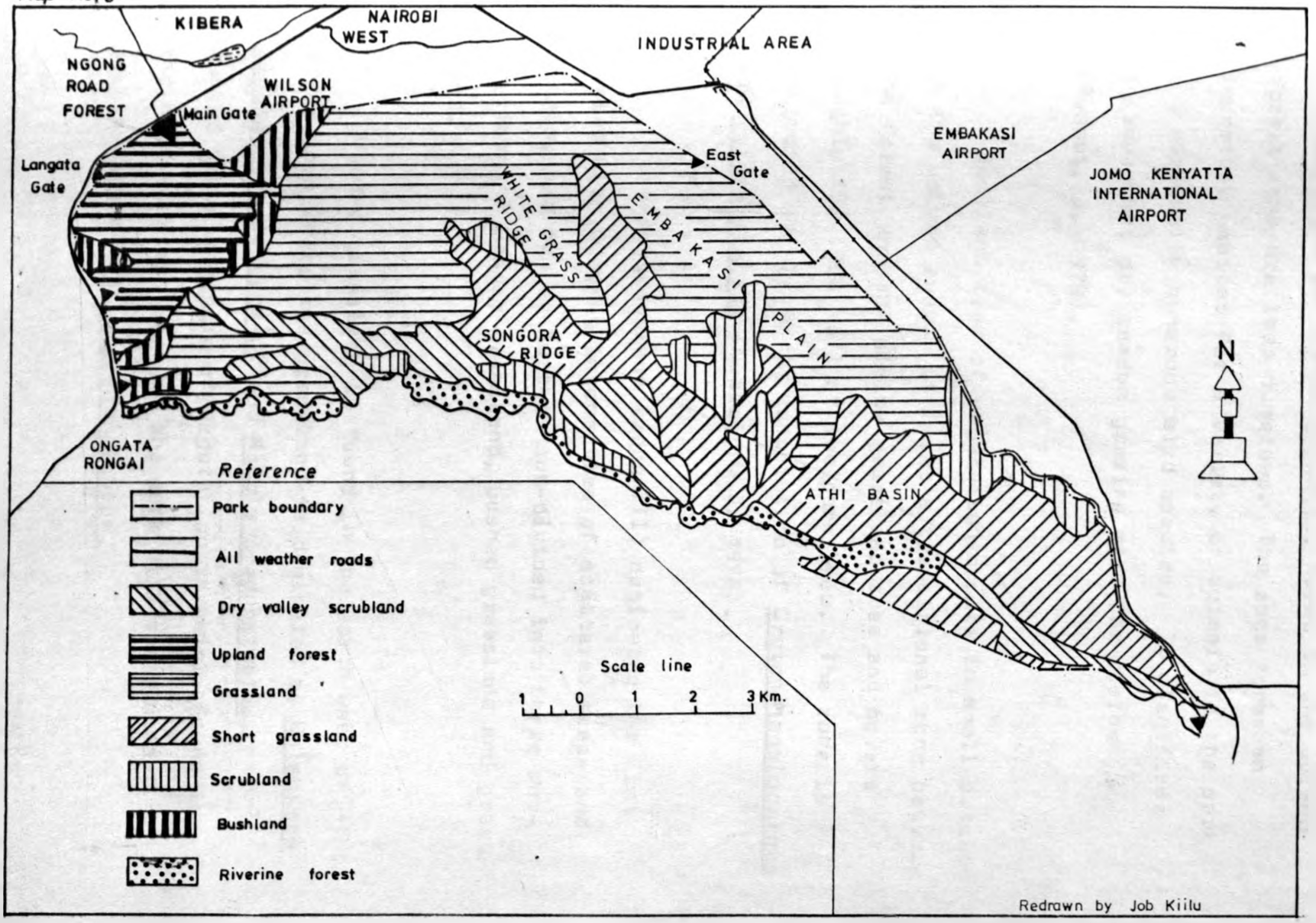
Physiognomically, Nairobi National Park can be divided into four distinct vegetation zones - the upland forest, derived grassland, bushland and riverine forest (map No. 7).

The upland forest covers an area of approximately 1,000 ha., accounting for about 20% of total park area (Jari, 1982). Upland forest normally occurs in areas above 1,000 metres above sea level in the form of close stands of one or more canopies rising to between 7 and 40 metres in height. In places where it is found, the ground cover is dominated by herbs and shrubs. Upland forest occurs in the western end of the park where precipitation is relatively higher than in the rest of the park. The area is interspersed by open grassland meadows so that the actual forest covers only about 35% of the entire upland forest zone.

The dominant tree species in the zone are Croton megalocarpus, Shrebera alata, Brachylaena hutchinsii and Olea africana (Jari, 1982, Lusigi, 1978)

NAIROBI NATIONAL PARK: NATURAL VEGETATION.

Map No, 6



Source: Jari R., (1982)

Unlike in the sorrounding plains, herbs in the upland forest zone are less numerous. The zone forms an important habitat for a variety of animals in the park and especially numerous bird species. It also forms an important dry season grazing area for plains game (Rudnai, J. 1979).

Bushland type of vegetation occurs in small patches in the upland zone. It forms a transitional zone between the forest and the plains grassland area and covers roughly 15% (750 ha.) of the park area. The zone is dominated mainly by an association of Croton megalocarpus and Psidia arabica (Lusigi, W.J. 1978).

Derived grassland (zone III) dominates the flat plains with varying intensities of scattered trees and bushes, and can be further sub-divided into three sub-divisions - wooded grassland, bushed grassland and grass-land.

Wooded grassland is found in the North west of Athi river town where the grassland is dominated by Balanites glabra, Acacia geraldi and Acacia drepanolobium. Bushed grassland type of vegetation is mainly found in the North-Eastern part of the park with the dominant species being Acacia drepanolobium.

Grassland occurs on the undulating plains while the common grasses found in the sub-zone include Themeda triandra, Bothriochloa insculpta and Pennisetum mezianum. (Lusigi, W.J., 1978).

The fourth vegetation zone, the riverine forest bisects the flat plains and is dominated by Acacia forests which open up in places to give way to an Acacia woodland. The most common tree species of the riverine vegetation are Acacia kirkii, Acacia xanthophloea and Markhamia hildebrantii (Karaba, M. 1981).

Like the upland forest, the riverine vegetation is an important habitat for various animal species including birds and also forms an important dry season food source for a wide variety of grazers and browsers. The riverine forest vegetation type is only found within a narrow strip along the Mbagathi river valley.

3.5.4 Faunal Status

Despite its small size, Nairobi National Park is witness to a rich faunal heritage, rich in both variety and in numbers due to a wide diversity in habitat types (Table 3.4 and Fig. 3.2).

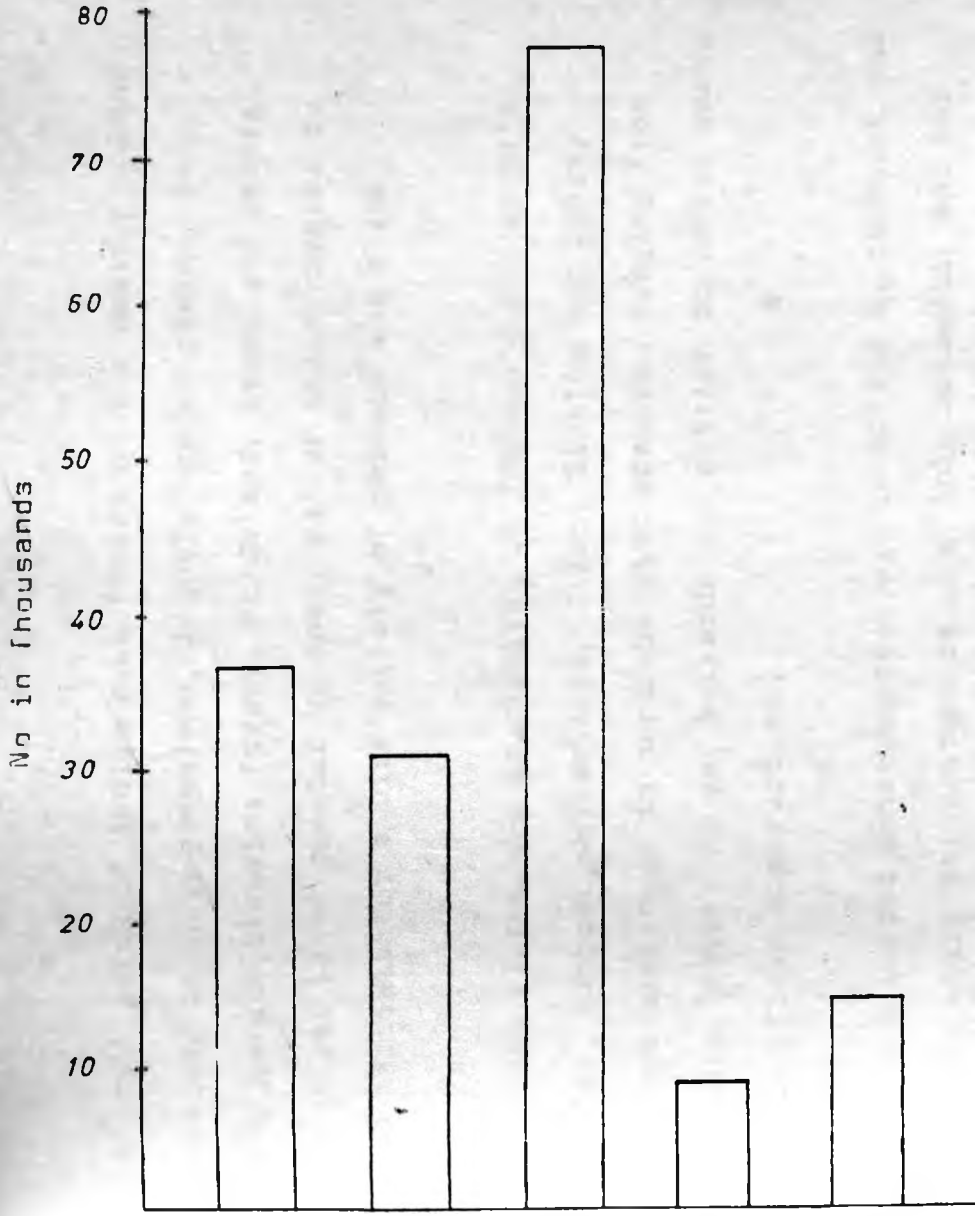
TABLE 3.4

ne relationship of selected species of wildlife and habitat in Nairobi National Park.

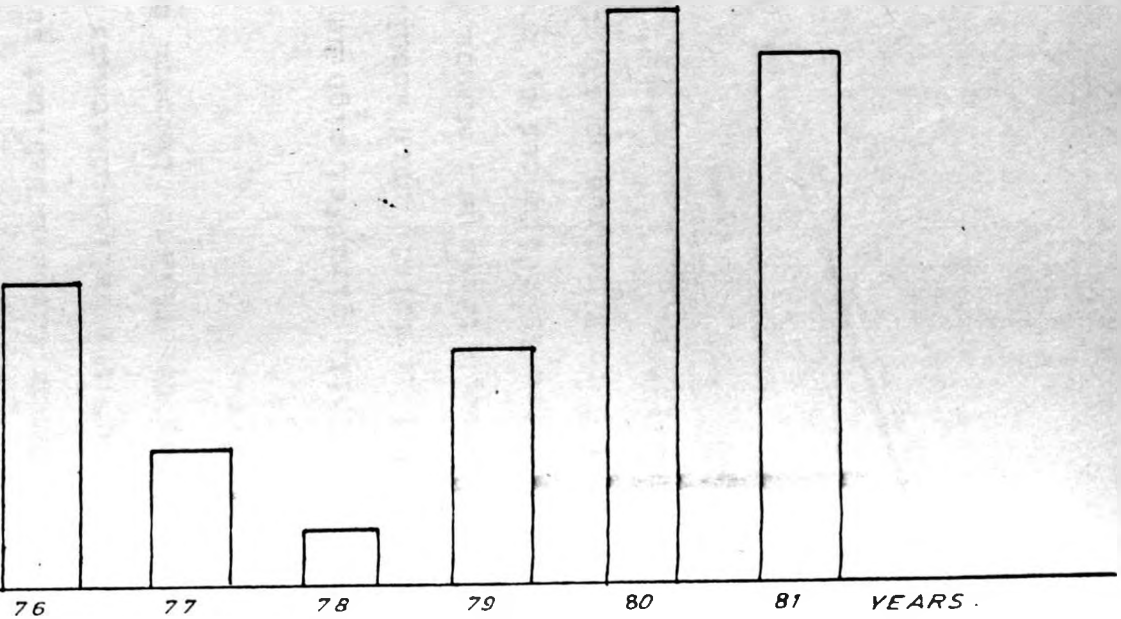
Animal Species	Habitat Description
Impala	Moderately steep slopes with tall grass and bushes
Grants gazelle	Moderately steep slopes with medium to short grass
[illegible]'s gazelle	Flat to gentle slopes with short grass
Reed-buck	Moderately rocky steep slopes with dense bushes
Giraffe	Gentle Slopes
Eland	Riverine forests dominated by Acacia drepanolobium
Warthog	Flat plains with short grass
Waterbuck	Rocky slopes with short grass
Steinbuck	Flat plains and medium slopes with short green grass
Buffalo	Flat to gentle slopes with medium to tall grass with bushes
Rhino	Gentle to moderately steep slopes with riverine bushes
Kongoni	Flat plains with short grass
Dikdik	Moderately steep stony slopes with bushes, trees and shrubs

Source: Monthly reports on game counts, Nairobi National Park, 1980.

FIG. 3.2 ANNUAL GAME COUNTS 1971



– 1981



The small patch of indigeneous forest on the western upland gives way to open grassland, lightly wooded plains, deep rocky gorges, riverine forest, scrubland, swamp and several artificial lakes created by dams, all of which combine to give habitats for a wide variety of animals and birds.

The plains are the habitat of Thomson's and Grant's Gazelle, Kongoni, Wildebeest, Eland, Giraffe and Zebra. They are also home to numerous bird species, ranging from vultures, kites, doves, buzzards and ostrich to larks, among others (field observations).

The wooded water courses are inhabited by bushbuck and reedbuck while the ecotone between this community and the grasslands forms a habitat suitable for lions which lie in the shade of the valley thickets during the day to escape the hot sun and the flies. Leopard and waterbuck are also common in this area.

While giraffes migh be found in the plains, their preferred habitat is mainly open woodland or wooded grassland where there are enough trees and shrubs to browse. Their preference for this area is evidenced by the presence of a sharp browseline at about 5 to 7 metres up the trees as a result of heavy browsing by the giraffe.

Many of the above species also use the bushland on the edge of the upland forest although it is the main habitat of the Impala, the Dik dik and the black Rhino. Hyrax and Baboon are normally found around rock faces and outcrops together with a variety of reptiles like cobra, python, puff adder, among others.

Associated with the riverine habitats are various species of fish, crocodile, water tortoise, hippos and monkeys while the small ponds and dams in the park attract a wide variety of water birds.

In the upland forest, Lions, Rhinos and Buffalos are a common attraction in the open grassland meadows together with Bushpig and Porcupine. Other inhabitats of this habitat include Jackal, Wild dog, Hyena, Serval cat and Cheetah.

3.6 Conclusion

When Nairobi National Park was first gazetted, there was then some constant seasonal migration of the wildlife of the Athi-Kapiti plains into the park and beyond to as far as the Ol Doinyo Sabuk National Park in the North-East.

On the other hand, the Athi-Kapiti Plains and the area between Nairobi-Mombasa and Nairobi-Kangundo roads to as far as the Mau Hills were used as a wet season dispersal zone by the wildlife of Nairobi National Park. This dispersion was however confined in 1967, when a chain-link fence was erected running along the Eastern side of the Ngong hills and south to the Kiserian river. Later on, a similar fence was erected along all but the southern boundaries of Nairobi National Park. Today, game is only free to move in out of the park through the southern boundary.

During dry seasons, the dams inside Nairobi National Park act as an irresistible attraction to wild animals in the Nitengela game conservation area, as evidenced by an influx of hooved herds of Kongoni, Zebra, Wilderbeest and Eland. This population explosion culminates in August-September, the end of the long dry spell between the April-May long rains and the short rains of October. Immediately the rains start,

> "unending lines of wildebeest are seen making their way out again, to give the grassland a much needed rest" (Rudnai, J. 1982).

It must be acknowledged that freedom of free movement in the form of migration should be a right of every animal for use in the event of its environment becoming uninhabitable or limiting in any factor.

Without this basic right, the individual or the population is denied its ultimate recourse against both natural and man-induced hazards such as droughts and fires, respectively. Forced to remain in one area, the population is liable to cause progressive deterioration of the habitat.

CHAPTER FOUR

4.0 THE PHYSICAL, TECHNICAL AND SOCIOECONOMIC DIMENSIONS OF THE PROPOSED UPPER ATHI DAM

4.1 Introduction

This chapter analyses the three dimensions of the proposed project outlined above. The chapter forms a critical and essential stage in any Environmental Impact Statement (E.I.S.) in that it is only through the proper understanding of a proposed action that its associated impacts can be clearly comprehended. The information contained in this chapter is limited to the various characteristics of the project and its immediate environments. Other supportive/ additional information to this chapter is contained in chapter three of this study.

4.2 Purpose (Need) of (for) Proposed Action

Athi River town is suitable for development as an industrial satellite town for Nairobi, now that the latter's growth is being severely constrained by acute congestion. The development of Athi River town has however been constrained due to the absence of an adequate and reliable water supply (Town clerk, pers. comm.[1]). The industrial potential of the town has been apparent for some time and "apart from existing industries, numerous applications for industrial plots are being processed by the council" (Rofe Kennard and Lapworth, 1982).

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1. Personal communication.

If the water problem can be quickly resolved, Athi River "would rapidly expand and possibly become an industrial boom town, alleviating many of the pressures existing on the services of Nairobi, especially employment" (Rofe Kennard and Lapworth (E.A.) LTD., 1982; Town Clerk, Pers. Comm. 1983).

The following tables summarise the water demands for Athi River Town up to the year 2005.

Year	existing works output M^3/d	private supplies M^3/d	Treated water requirements of new supply M^3/d	Total treated water demand M^3/d
1982	966	4148	1914	7028
1983	1466	4148	2444	8108
1984	2066	4148	3140	9354
1985	2066	4148	4578	10792

TABLE 4.01: SUMMARY OF TREATED WATER REQUIREMENTS AND OUTPUTS FROM THE VARIOUS SOURCES 1982-85

Source: Rofe Kennard and Lapworth (E.A.) LTD. 1982

Most of the major industries provide their own supplies mostly from boreholes. Abstraction without reference to recharge has resulted in an over-drawdown and mining of groundwater. It is necessary therefore to control ground water abstraction, explaining the zero growth in private supplies. (Rofe Kennard and Lapworth (E.A.) Ltd. 1982).

YEAR	DEMANDS LOWER LIMIT M^3/D	ANNUAL GROWTH RATE	DEMANDS UPPER LIMIT M^3/D	ANNUAL GROWTH RATE
1980	5694		5694	
		7%		7%
1981	6092		6092	
1983	8100		9878	
		15.4%		15.4%
1985	10792		16018	
1986	12249	13.5%	19542	22%
1987	13596	11%	22864	17%
1988	14752	8.5%	25608	12%
1990	16005		38431	12%
1995	22182		41121	
		6%		7%
2000	29684		57674	
2005	39724		80891	

Table 4.02: Assumed treated water demands and growth rates 1980-2005

The above estimates show both a lower and upper limit. The lower limit shows demands for planned areas for industrial, domestic and other consumers. However, further demands are expected from industrial and associated residential consumers outside the planned areas, hence the figures for the upper limit.

The above tables clearly indicate the need for expansion of water supply to Athi River township, a factor that has given rise to the need for the upper Athi dam.

4.3 Environmental Setting

4.3.1 Vegetation types

The proposed area of development lies within the riverine forest vegetation type which stretches along the Mbagathi river and is also found in small pockets along river valleys in Nairobi National Park. [illegible]. The riverine vegetation around the three sites is dominated by *Acacia* forests with the forests opening up to give way to *Acacia* woodlands especially around site C (Map No. 3). The most common *Acacia* tree species *Xanthophloea* and *Acacia Kirkii* (Karoba, M. 1981).

4.3.2 Wildlife

Apart from the animals that permanently inhabit the valley, the area forms an important dry season grazing and browsing ground for a wide variety of wildlife. During field excursions, the following species of wildlife were observed within or around the proposed development site:

1. Rhinoceroses
2. Giraffes
3. Waterbucks
4. Wildebeests
5. Bushbucks
6. Dik Diks
7. Leopards
8. Rock hyraxes
9. Baboons.

The above notwithstanding, the riverine forests in the area form a very good sanctuary for numerous species of birds. The area provides particulary good breeding and roosting cover for such birds.

4.3.3 Agricultural activities

Being a protected area, Nairobi National Park is free of any agro-based economic activities. However, the Kitengela area towards the south of the park is heavily settled.

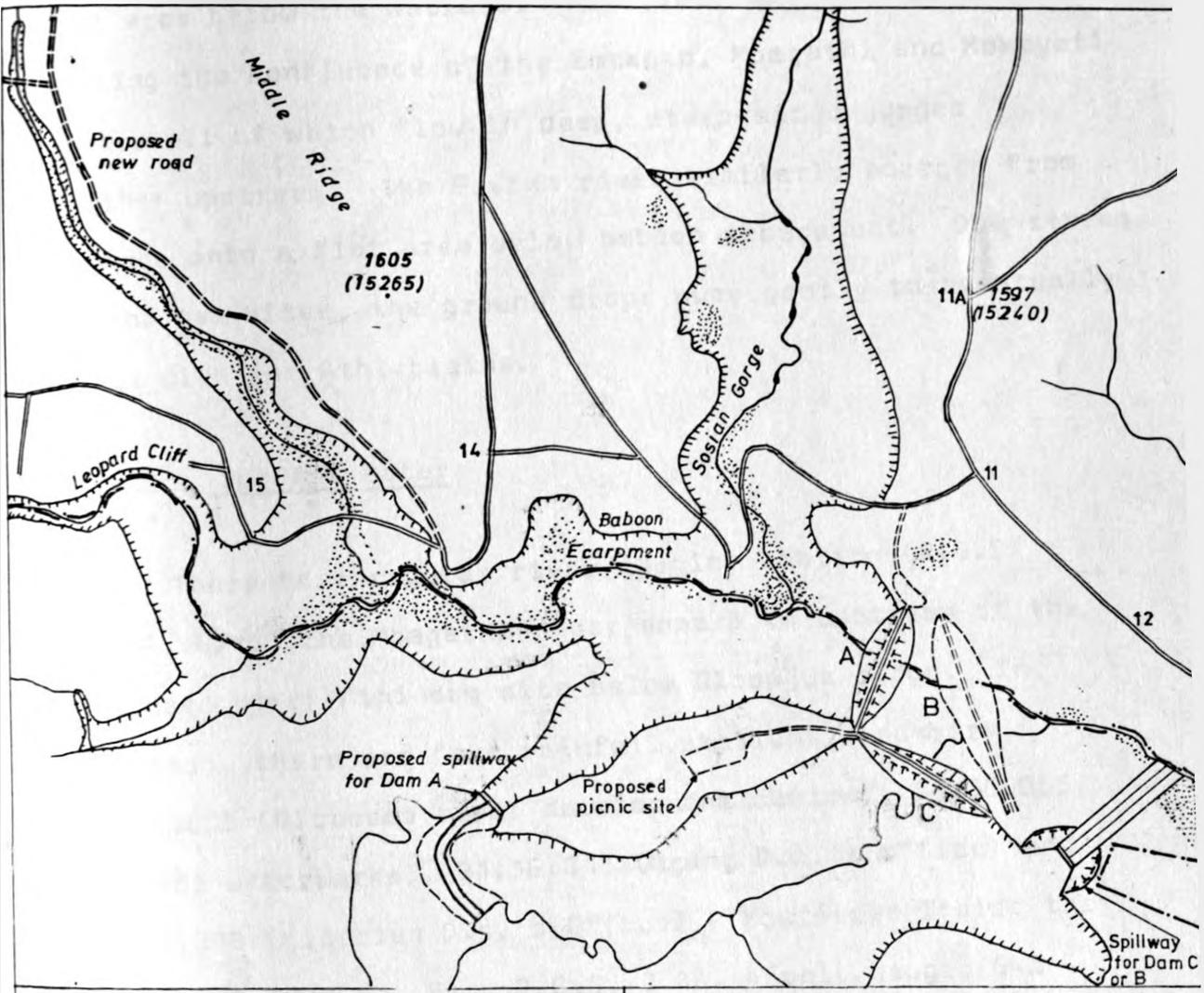
While pastoralism has been the main agricultural activity in the past, field visits indicated a rapid changeover to subsistence agriculture. Next to the three sites - A,B and C, - land is privately owned and, while there is no evidence of tillage in areas covered by the project, their immediate environs are interspersed with permanent dwelling structures where subsistence agriculture is practised in enclosed spaces which are free from wildlife disturbance. However, livestock use the area for watering and grazing purposes. Field visits also unearthed evidence (Pers.Comm. with affected landowners) that there exists a desire and/or need to extend subsistence farming in the near future. The landowners expressed a strong desire to develop the riverine strip in future due to the presence of sufficient water. They however concede that such efforts at present would be frustrated by continuous raids by marauding wild animals from Nairobi National Park. They feel the area is particularly suitable for the growth of horticultural crops and other fast growing subsistence crops.

4.3.4 Regional Topography

All the three sites are located along the Mbagathi river or its tributaries. Site A is located at the end of a 'neck' in the Athi valley.

LAYOUT OF PROPOSED DAMS IN RELATION TO NAIROBI NATIONAL PARK.

MAP NO.



REFERENCE

Main park road	
Proposed park road	
Forest scattered trees	
Spot elevation, metres [feet]	1505 (15765)
Top water level [T.W.L]	
River	
Park boundary	
Proposed dam 'A'	A
Future dam 'C'	C
Alternative 'B'	B

Scale

0·5 0 0·5 1 Km.

Drawn by (WPU) staff.

Source: Rolf, Kennard & Lapworth (E.A) Ltd, 1982.

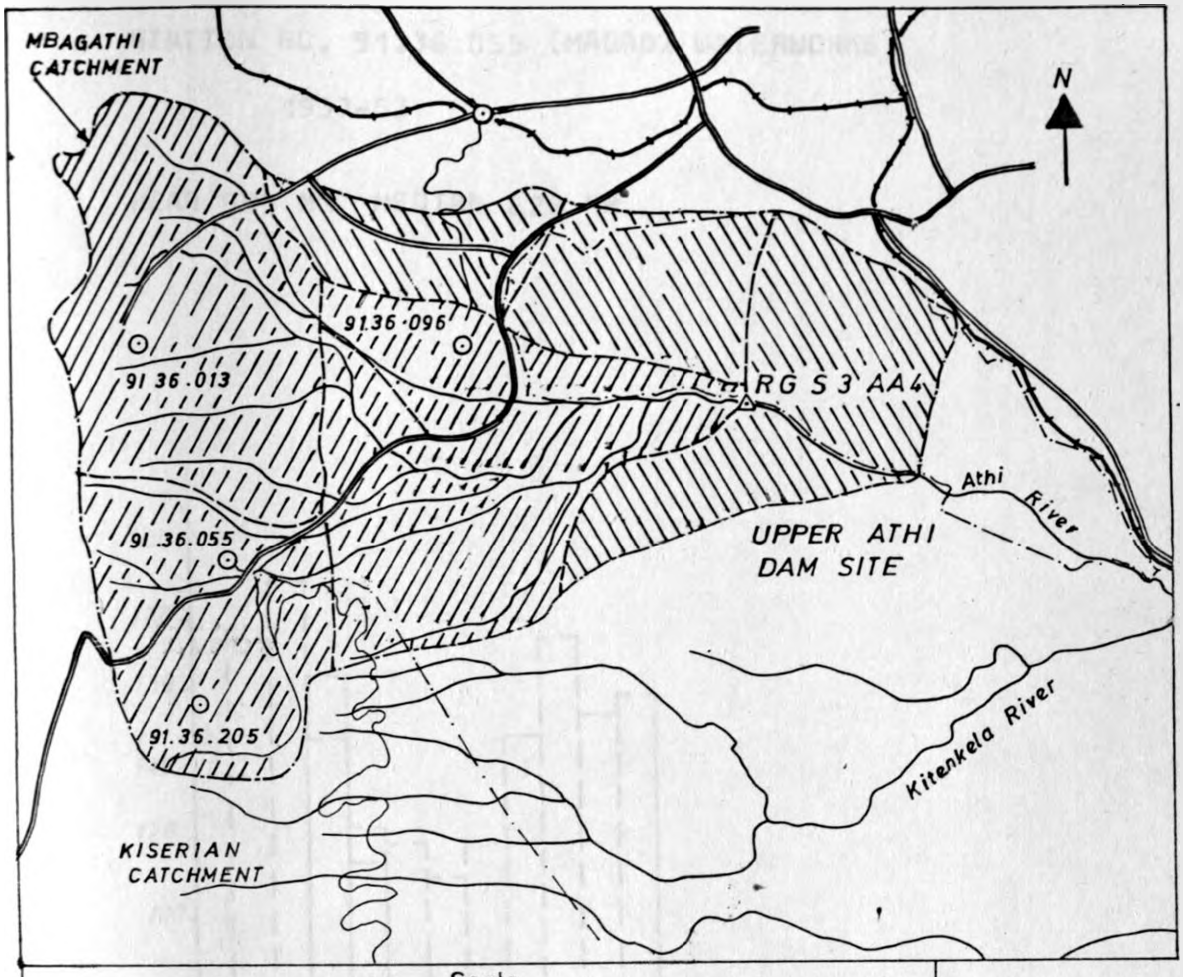
From here, the valley widens above this neck into a broad flat area below the National Park viewpoint (map no. 8), marking the confluence of the Emakoko, Mbagathi and Mokoyeti rivers all of which flow in deep, steep-sided gorges further upstream. The Sosian river similarly emerges from a gorge onto a flat area below baboon escarpment. Downstream of the dam sites, the ground drops away gently to eventually merge with the Athi plains.

4.3.5 Surface Water

There is a regular river gauging station (R.G.S 3. AA. 4) on the Mbagathi river some 8 km upstream of the proposed upper Athi dam site below Oloonjua ridge. In addition, there are four rainfall stations - numbers 91.36.205 (Olooseos rural development centre), 91.36.055 (Magadi waterworks), 91.36.013 (Ngong D.o.'s office) and 91.36.096 (Kiserian D.o.'s Office) - scattered inside the catchment (map no. 9). R.G.S. 3 AA. 4 only gauges 64% (256 sq.km) of the catchment to the dam site (map no. 9). The remaining 36% of the catchment is ungauged, leading to insufficient gauged flow data for direct determination of the reliable yield of the reservoir.

The rainfall stations have irregular rainfall records. The following rainfall and evaporation figures were constructed through the use of existing records and abstraction from published secondary information.

THE UPPER ATHI DAM CATCHMENT . MAP No.8



Scale
5 0 5 10 15

LEGEND

Catchment to R.G.S 3 AA 4 .....

Additional Catchment to Upper Athi Dam Site .....

Mbagathi Catchment Boundary .....

Rainfall Station .....

River .....

Road .....

Railway .....

Source: Rofe Kennard & Lapworth (E.A) Ltd., 1982.

STATION NO. 91.36.055 (MAGADI WATERWORKS)

1937-53

MEAN 699 MM MEDIAN 628 MM

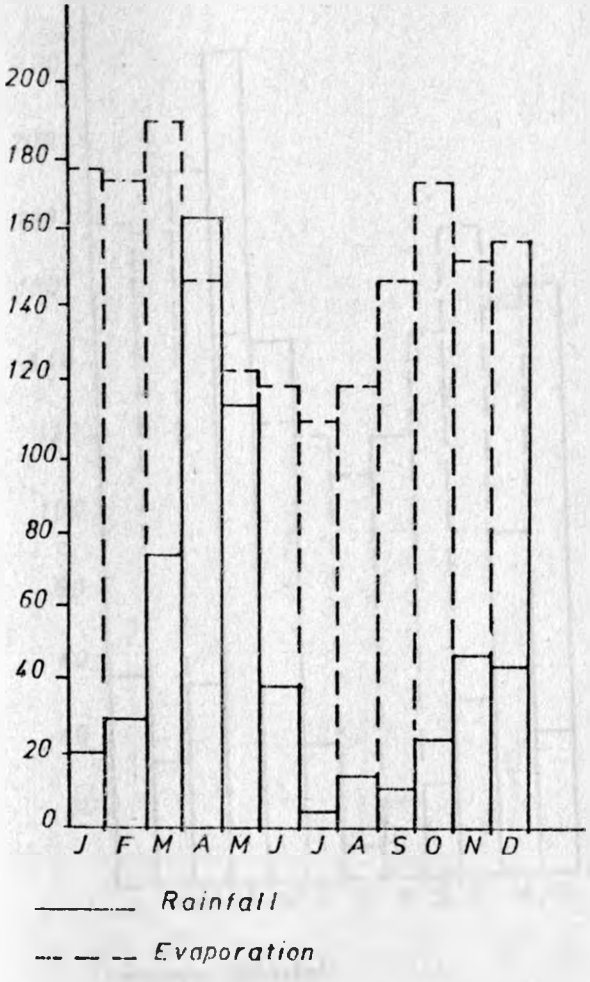


Fig. 4.01 ANNUAL EVAPORATION VERSUS RAINFALL

SOURCES: Rofe Kennard and Lapworth (E.A) Ltd, 1982

Woodhead, T (1968): Studies in potential Evaporation in Kenya. Physics division, E.A.A.F.R.O. NAIROBI.

STATION NO. 91.36.096 (MBAGATHI, MDIGO FARM)

1962-79

MEAN 892 MM MEDIAN 858 MM

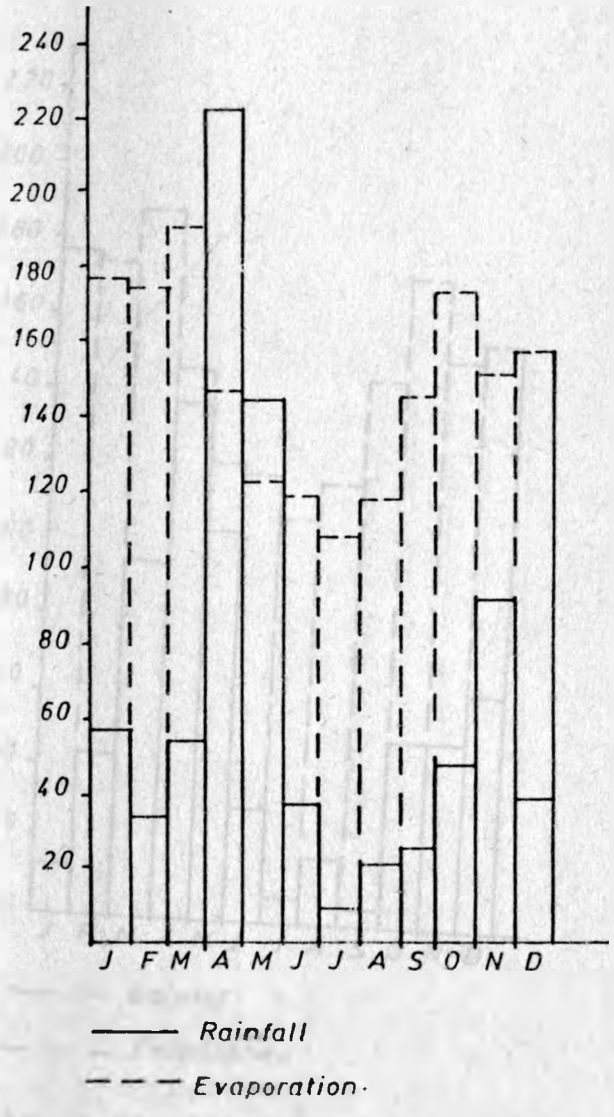


Fig. 4.02 : ANNUAL EVAPORATION VERSUS RAINFALL

Sources: Rofe Kennard and Lapworth (E.A) Ltd, 1962

Woodhead, T (1968): Studies of potential evaporation in Kenya. Physics division, E.A.A.F.R.O., NAIROBI.

STATION NO. 91.36.013 (NGONG D.O.)

1937-53

MEAN 752 MM MEDIAN 727 MM

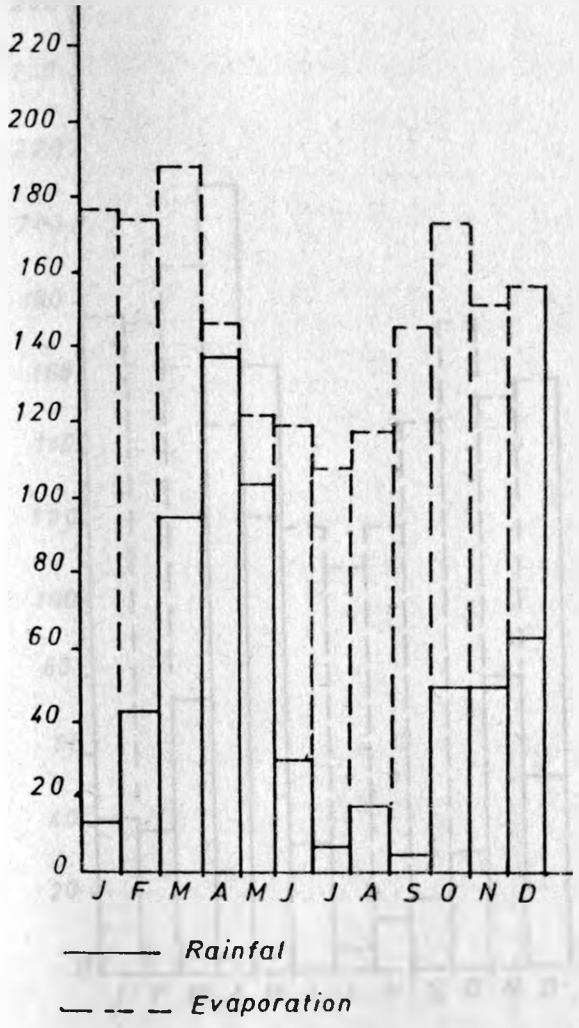


Fig. 4.03 ANNUAL EVAPORATION VERSUS RAINFALL

Source: Rofe Kennard and Lapworth (E.A) Ltd, 1982

WOODHEAD, T (1968) - Studies of potential evaporation in Kenya, Physics division, E.A.A.F.R.O., Nairobi.

STATION. NO. 91.36.013(KISERIAN D.O)

1962-79

MEAN 875 MM, MEDIAN 803 MM

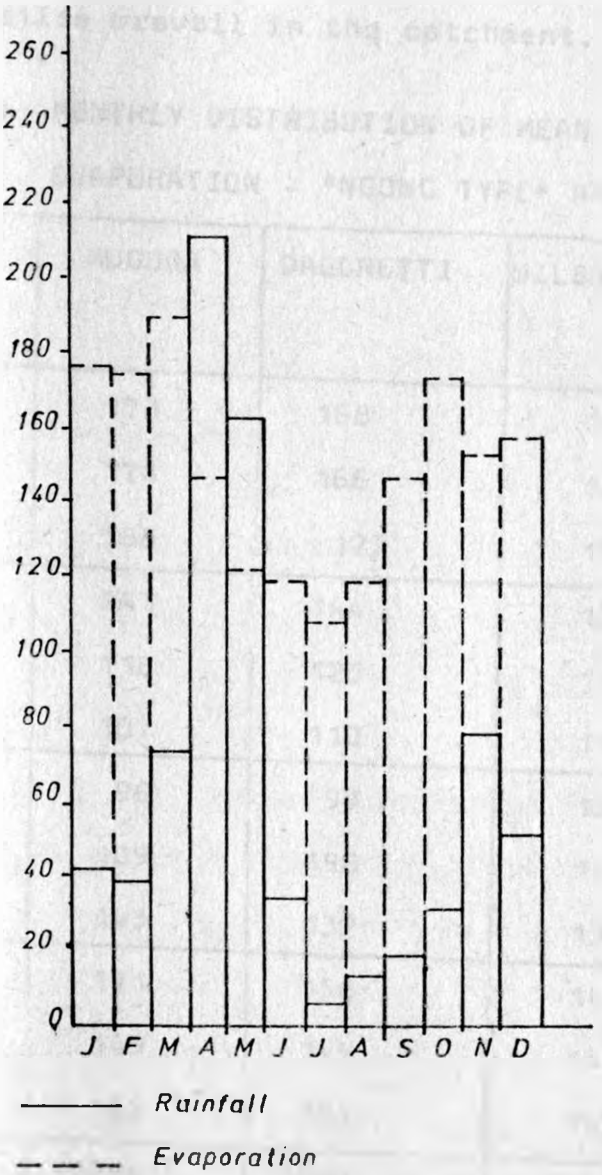


Fig. 4.04 ANNUAL EVAPORATION vs. RAINFALL

Sources: Rofe Kennard and Lapworth (E.A.) Ltd, 1982

Woodhead, T. (1968) - Studies of potential evaporation in Kenya. Physics division, E.A.A.F.R.O., MAFIRI.

Evaporation data are published by Woodhead (1968) for several stations in and around the catchment - Nairobi and Kabete (Dagdreti Meteorological Department Headquarters, Nairobi Airport, Embakasi and Agricultural and Forestry Research Station at Muguga). The table below shows mean annual potential evaporation of the "Ngong type" area. The Ngong type" climatic characteristics prevail in the catchment.

TABLE 4.03: MONTHLY DISTRIBUTION OF MEAN ANNUAL POTENTIAL EVAPORATION - "NGONG TYPE" AREA

MONTH	MUGUGA	DAGORETTI	WILSON AIRFIELD		
JAN.	173	168	171	173	138
FEB.	171	166	181	174	137
MARCH	186	177	175	186	149
APRIL	141	144	125	144	115
MAY	116	125	119	120	96
JUNE	107	110	117	117	94
JULY	96	97	107	107	86
AUG.	109	198	116	116	93
SEPT.	143	137	134	143	114
OCT.	171	158	143	170	136
NOV.	149	145	140	149	119
DEC.	152	154	163	154	123
YEAR TOTAL	1714	1689	1691	1750	1400
ALTITUDE M	2100	1800	1680	2460	1540

Sources: Woodhead, T. (1968) - Studies of potential evaporation in Kenya, physics division E.A.A.F.R.O. Nairobi.

Rofe Kennard & Lapworth (E.A) LTD. 1982.

4.4 Technical and Logistical Aspects of the Upper Athi Dam

After careful field studies by a consulting firm, the upper Athi catchment was found to be the only possible source formeeting such a demand. The upper Athi Site was found to have greatest available water in terms of depth per unit of area originating from the wetter upper Athi catchment (Rofe Kennard & Lapworth (E.A) Ltd, 1982). The other two potential sources - Kitenkela and Stony Athi catchments - are drier and would only produce a sufficient total run-off during periods of higher flood flows and would probably be associated with heavier sediment loads.

Two sites were considered on the Mbagathi river - the lower and upper Athi sites (map 8). The lower Athi Site, with an embankment some 2.5 kilometres inside the park would flood a large area of the park. The upper Athi site (upstream of hippo pool) would have a shorter embankment and have a smaller surface area for the same storage volume, resulting in lower evaporation rates. Moreover, "it would also involve less disruption to the facilities of the park and be less intrusive visually". (Rofe Kennard & Lapworth (E.A) Ltd, 1982).

Three schemes have been suggested for the construction of such a dam. Here-under are preliminary layout specifications for all the three schemes:

Scheme 1. A dam on the Athi at Site A (map. 8) to yield 26,000 m^3/d as a first stage in the development of water supplies for Athi river and whose technical specifications are as follows:

(i) River bed elevation - 1528 m

(ii) Spillway elevation, 1563m, utilising a saddle on the south bank to divert flood water into the Kapio Valley

(iii) Crest elevation of dam - 1566m

(iv) Crest length - 374m

(v) Dam height - 38m (3m freeboard)

(vi) Water storage 35m giving 27.8 mm^3 total less 10% dead storage gives 25.0 Mm^3 useful storage (Rofe Kennard and Lapworth (E.A) Ltd, 1982

Scheme 2: This involves a dam on the Kapio at site c (map. 8) to yield an additional 10,500 m^3/d as a second stage in the development and which would be implemented as dictated by demand on the first stage. This second phase would provide additional off-stream storage of flood flows from the dam at site A. The specifications of the dam are:

(i) River bed elevation - 1529 m

(ii) Spillway elevation, 1563 m, the spillway being an open channel into the Athi downstream of the Athi/ Kapio confluence and upstream of hippo pools.

(iii) Crest elevation of dam - 1566 m

(iv) Crest length - 538 m

(v) Dam height 37 m (3 m freeboard)

(vi) Water storage 34 m, giving 19.2 Mm^3 total, less 10% dead storage gives 17.3 Mm^3 useful storage or a combined Athi/Kapio reservoir useful storage of 42.3 Mm^3. (Rofe Kennard & Lapworth (E.A.) Ltd, 1982).

The third scheme, a dam at Site 8 (map. 8) is independent of the other two and incorporates both the Athi and the Kapio river valleys and is designed to yield approximately 36,500 m^3/day as a single stage development. Its related specifications are:

(i) "River bed elevation - 1529 m

(ii) Spillway elevation-1563 m, being the same spillway as that proposed for the second scheme.

(iii) Crest elevation - 1566 m

(iv) Crest length - 662 m

(v) Dam height 37 m (3 m freeboard)

(vi) Water storage 34 m giving 49.5 Mm^3 total, less 10% dead storage gives 44.5 Mm^3 useful storage. (Rofe Kennard & Lapworth (E.A) Ltd, 1982).

While Scheme C is not located inside the Nairobi National Park, it has nevertheless been included in this analysis since it is a further stage of scheme 1.

4.5 SOCIO ECONOMIC SYSTEMS

4.51 Land Use: Patern and Trend

Most of the upper Athi dam catchment lies in Ngong Division of Kajiado district. Within the whole of the district, high and medium potential land constitute about 6.3% distributed as follows:

DIVISION	HIGH POTENTIAL	MEDIUM POTENTIAL
Central	10,176 ha.	25,536 ha.
Loitokitok	50,400 ha.	7,200 ha.
Ngong	28,800 ha.	12,000 ha.
TOTAL	89,376 ha.	44,736 ha.

TABLE 4.04: THE DISTRIBUTION OF HIGH AND MEDIUM POTENTIAL LAND IN THE THREE DIVISIONS OF KAJIADO DISTRICT.

Source: Government of Kenya, Kajiado district development plan, 1980.

Agriculture is the main economic activity in Ngong division. Such agriculture is practised by people exogenous to the area and who have come in with modern farming methods. Among the crops grown are coffee, English potatoes, maize, beans, bananas and cabbages (Government of Kenya, Kajiado district development plan, 1980).

Field observations have revealed two major trends within the agricultural activity - intensification of production and the physical expansion of agricultural activities into the marginal areas and forest zones.

Intensification efforts are manifested by an increased use of fertilisers and pesticides especially in areas where commercial-cum-subsistence crops are being grown. Most prevalent are the Northern and Eastern areas (D.A.O * Kajiado, Pers, Comm. 1983). Physical expansion is taking place along the fringes of Ngong forest and in western portion of the division while cultivation by squatters in the Ngong forest is not uncommon.

Land use analysis in Ngong division must also be seen in the light of the prevailing population dynamics. Kajiado district has an annual population growth rate of around 3.3% (Government of Kenya, Kajiado district development plan, 1980) and a population of around 114,000 by the end of 1984.

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* - District agricultural officer.

It has an average population density of 7 persons per square kilometre as per 1978 population estimates. However, this average varies from an upper limit of 100 persons per square kilometre in Ngon area to less than 1 person in the drier central and southern areas of the district. Such dynamism (in population) for Ngong division suggests that intensification and expansion of agricultural activities in the area are trends that planners are going to contend with for yet a little longer because in absolute terms, population in the area will continue to grow and with it new horizons in technological investments and greater levels of motivation. In turn, it can be speculated that such rapid growth in population and agriculture will be paralleled by a return impact from the amount of domestic sewage and agro-based effluents discharged into the Mbagathi river system above the proposed development site.

4.6 Summary

This chapter set out to analyse certain key factors of the proposed upper Athi dam, namely, its physical, technical and socio-economic dimensions. Such analysis was essential in helping to facilitate a proper appraisal of the nature of the project.

It was pointed out that Athi River township bears tremendous potential for industrial growth if only a prevailing acute water shortage could be alleviated through the provision of bulk water supplies such as the proposed upper Athi dam. It was indicated that by as near as the end of 1985, there would be a deficit of 4,578 M^3/d between total treated water available and total treated water demand.

The environmental setting of the proposed site was examined in detail. The site lies within the Nairobi National Park riverine type of vegetation dominated by forests of Acacia. The forests are inhabited by various wildlife species including Rhinoceroses, Leopards, Giraffe and waterbucks, among others. Baboons and hyrax inhabit the gorge walls.

The water budget raised important revelations. It was found impossible to determine the reliable yield of the proposed reservoir due to the fact that only 64% of the reservoir catchment is presently gauged.

The proposed site lies within the "Ngong type" climatic characteristics area with evaporation levels usually rising above rainfall levels, a factor that bears important implications to the proposed upper Athi dam in terms of evaporation/evapotranspiration levels.

An examination of the technical and logistical aspects of the proposed dam indicated that the water source that was finally chosen is the most viable of the three alternatives, if only in its technical dimensions. The other two potential sources - the Kitenkela and Stony Athi- are much drier and would only produce a reliable yield during periods of seasonal higher flood flows and would probably be associated with heavier sediment loads.

The dam at Site A is estimated as being capable of yielding 25.0 Mm^3 useful storage. Site C, a further development of Site A would yield an additional 10,500 M^3/d giving a combined Athi/Kapio reservoir useful storage of 42.3 Mm^3. Site B would yield a useful storage of 44.5 Mm^3.

An analysis of the socio-economic systems indicated that agriculture is the main type of land use in the surrounding area.

Observations revealed both intensification of production and physical expansion of agricultural activities in Ngong division, an area that carries 64% of the catchment of the dam. This bears important implications of both sedimentation and chemical pollution of the proposed dam. This problem is further magnified by the prevailing population dynamics. It was finally speculated that the prevailing rapid growth in population (3.3%) and agriculture will be paralleled by impacts from domestic sewage and agro-based effluents discharged into the Mbagathi river system.

CHAPTER FIVE

5.0 THE UPPER ATHI DAM AND ASSOCIATED IMPACTS ON THE NATURAL SUB-SYSTEM

5.1 INTRODUCTION

This chapter aims at deductively testing the hypothesis that "any water resource development along the Mbagathi river would be compatible with the ecologic stability of Nairobi National Park".

The chapter attempts to systematically analyse the environmental/ecological components (and their related elements) that might either be affected or be caused to occur, directly or indirectly, as a result of the construction of the upper Athi dam. The chapter then proceeds to asses the importance of such impacts in their temporal as well as spatial dimensions. Of special importance will be the probability of occurrence of such impacts within estimated time frames. At the end of this analysis, it should be possible either to validate or reject the aforementioned hypothesis.

In the following discussion, several existing and anticipated characteristics and conditions have been examined. They include those on physical, biological, cultural and purely ecological dimensions.

The effects accruing from sedimentation have been discussed within the wide spectrum of physical characteristics, while effects on, or accruing from either the absence or the presence of birds, terrestrial and aquatic fauna and flora have been discussed within the sub-theme of biological conditions and/or characteristics. Under cultural factors, effects on tourism and related scenic appeal of the area surrounding the dam have been highlighted. Within the ecological dimension, pollution has been identified as an important factor and has therefore been given corresponding emphasis.

5.2 Sedimentation in inland waterways and impoundments

Sedimentation can be directly or indirectly correlated to agricultural land use practices within the catchment of any water body, climatic changes, soil texture, exposure of soil to erosion through activities like forest clearing and burning, and lax or the total absence of soil conservation measures, among others.

Total amount of suspended sediment carried by a river and/or its tributaries may change from year to year or even season to season due to unforeseen changes in climate, nature of prevailing land use or due to other controlling variables. It is difficult to establish a rigid prediction model of sedimentation rates due to complexities of stream flow.

The human factor further complicates the issue largely because of its unpredictable dimensions and the associated very fast rate of resource utilization (Mwassco, 1982).

It may however be predicted that suspended sediment comes down the river during periods of high rainfall intensities and amounts and from newly denuded sub-catchments of the overall basin (Adeniji, H.A. 1981). Such high intensities and amounts of rainfall result in equally high discharge rates in streams which are related to high suspended sediment loads. Within 'normal' catchments, the above relationship may be represented graphically as follows.

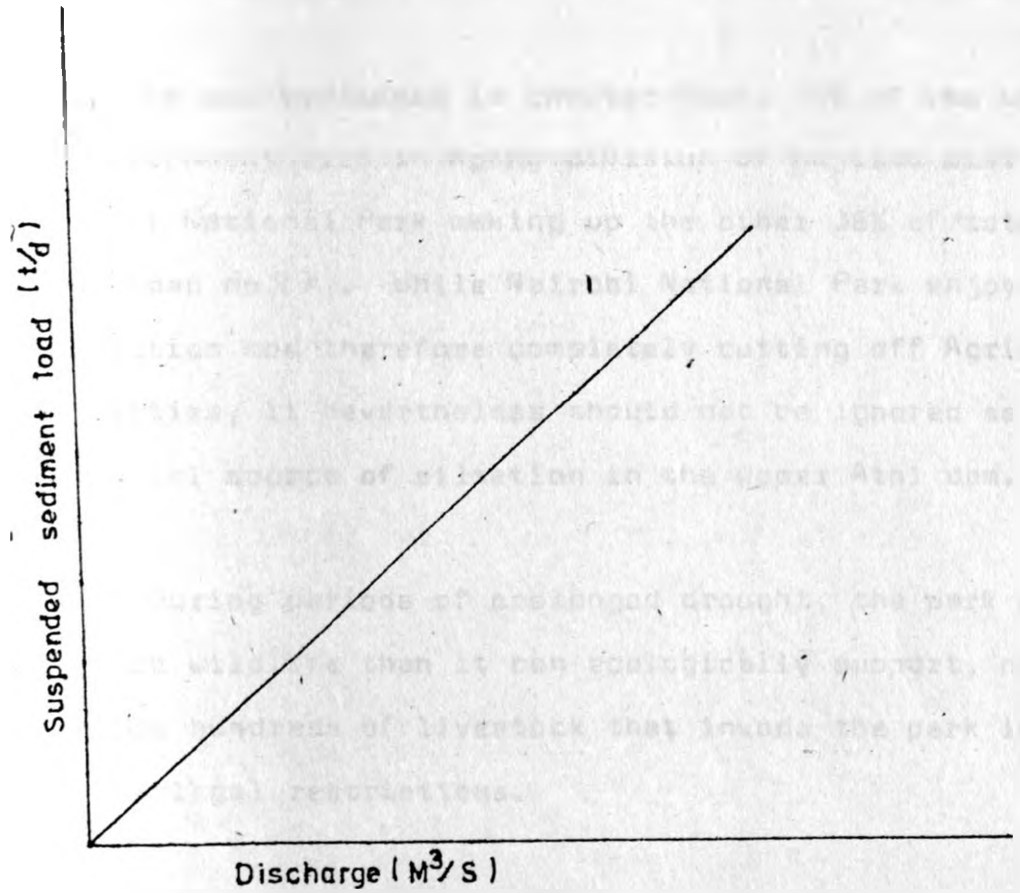

FIG. 5.1 RELATIONSHIP BETWEEN DISCHARGE & SUSPENDED SEDIMENT LOAD.

Source. Wain, A S [1981]

5.3 Sedimentation of the Upper Athi dam and its related effects

Although it is possible to ignore the issue of siltation on very large dams covering thousands of sq.km., it must be adequately considered in the case of small dams like the proposed one at Mbagathi. Impacts on such small impoundments are likely to affect not only the entire impoundment but most of its immediate environment as well. This is because the controlling variables in small impoundments are micro and therefore respond to very localised variations.

5.3.1 The Upper Athi catchment: An overview of the problem

As was mentioned in chapter four, 64% of the upper Athi dam catchment lies in Ngong division of Kajiado district with Nairobi National Park making up the other 36% of total catchment (map no.9) . While Nairobi National Park enjoys legal protection and therefore completely cutting off Agricultural activities, it nevertheless should not be ignored as a potential source of siltation in the upper Athi dam.

During periods of prolonged drought, the park plays host to more wildlife than it can ecologically support, not to mention hundreds of livestock that invade the park in defiance of all legal restrictions.

Such accentuated use has in the past left the park bare of any ground cover, providing ideal conditions for tremendous erosion (Wanjohi, E.W., 1984, Pers. Comm.). Moreover, it is during such periods that the risk of bush fires within the park is greatest. With the cutting off of the only wildlife dispersal area - the Kitengela - by human settlement, it is safe to assume that the carrying capacity of Nairobi National Park will continue to be exceeded in future, with the resultant acceleration of erosion.

For the most part, Ngong division displays climatic and pedological characteristics ideal for tillage agriculture, which is unlike most parts of Kajiado district. Such advantages have continued to act as pull factors to immigrants and resident Maasai. Most of the high and medium potential areas are fully under agriculture, while intensive pastoralism is being carried out in the low potential areas. In general, Ngong is faced with a very high population pressure - over 100 people per square kilometre, (Government of Kenya, Kajiado district development plan, 1980) with no signs of stabilization in the near future (Table 5.1).

Year	Central division	Ngong division	Loitokitok division	Total
1979	60,544	45,680	42,781	149,005
1983	76,265	57,542	53,890	187,697
1985	84,347	63,640	59,601	207,588
1988	98,139	74,046	69,346	241,531

TABLE 5.1 KAJIADO DISTRICT POPULATION BY DIVISION (1979-88)

Source: Government of Kenya, Kajiado district development plan, 1984.

Field observations confirm that erosion is already a serious problem in Ngong division. Moreover, soil conservation programmes in Kajiado district have had no apparent success. According to the 1984-88 district development plan, soil conservation programmes in the district were dismal over the 79/83 plan period because of 1. "Lack of knowledge on the dangers inherent in soil erosion and the importance of soil conservation on the part of the clientele, hence very limited local participation"; and 2. "Insufficient funds for carrying out the programme .....".

As yet, there is no evidence that attempts to arouse public awareness are going to be successful, always assuming they will be initiated in any case. Further, there is no cause to believe that a substantially larger amount of money will be made available to the district for soil conservation programmes. The thesis that is being advanced here is that soil erosion (and therefore river sedimentation) will continue to pose a problem in the foreseable future. Any predictions must justifiably adopt this assumption as their starting point.

5.3.2 Life-span of the upper Athi dam

Man-made lakes usually act as sedimentation tanks for the suspended sediments of the feeder rivers. This results in serious loss of the lake storage capacity by as much as 80% in acute cases (Adeniji, H.A., 1981).

Sediment accumulation within the Upper Athi impoundment is likely to take two forms. Fine sediment derived from soil erosion in the catchment would be carried into the reservoir and settled over the whole basin. Secondly the incoming streams transport cobbles and boulders during periods of high water velocity in floods (Rofe Kennard and Lapworth (E.A) LTD., 1982) Such material is likely to accumulate at the points of inflow to the reservoir, where velocities are reduced as the incoming streams merge into deeper water.

Consultants commissioned to undertake feasibility studies have estimated that sedimentation would not occupy more than 10% of the total reservoir volume (R.K.L (E.A) LTD. 1982) and that the impoundment would have an economic life-span of approximately 43 years. Such assumptions are in the very least misleading in that they fail to take into account the turbulent economic and social environments of Ngong divisions.

Ten academic and professional specialists interviewed by this author were of the opinion that the reservoir was likely to have 30% - 35 % deadweight after the first 8-12 years of operation.

The respondents further confirmed that even in the best of situations, such a small reservoir would normally be economically functional for a period of between 23 to 27 years at most (fig. 5.2). Other statistics for the lifespan variable were

mean = 24.8 years

median = 25 years.

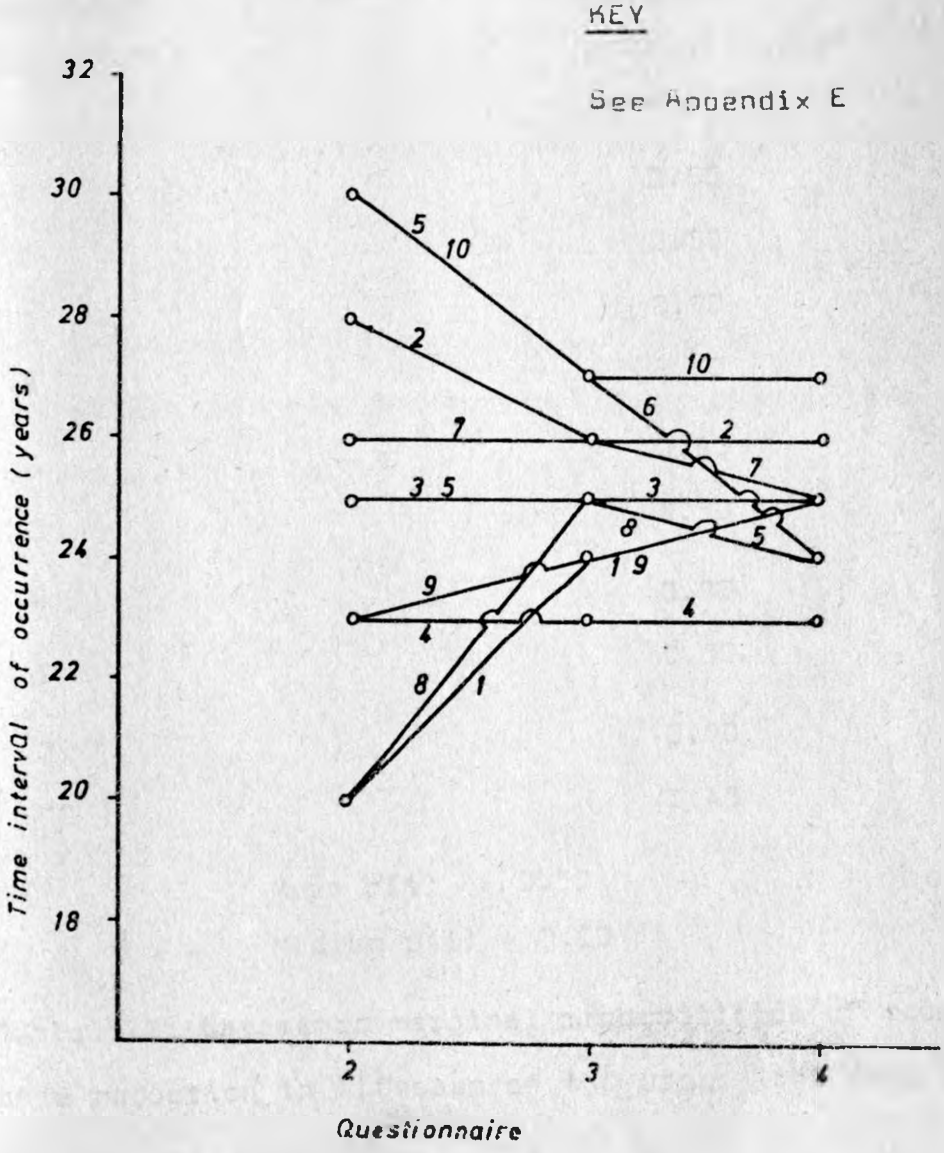

Fig. 5.2 Certain probabilities of units lifespan

Table 5.2 shows the estimated probabilities (marginal) of occurrence of the predicted event "change of economic life-span from 43 to between 23 and 27 years".

While the estimates below must be looked upon with reservations due to an obvious bias in sampling and the unpredictable nature of the problem, it can be concluded that it has to a very large extent been collaborated by the discussion in section 5.3.1

Respondent number	Estimated probability of occurrence.
1	0.60
2	0.50
3	0.70
4	0.60
5	0.60
6	0.50
7	0.70
8	0.60
9	0.70
10	0.40

Mean p(i) = 0.59

Median p(i) = 0.60

Table 5.2: Estimated marginal probabilities of occurrence of a reduction in lifespan of the upper Athi dam.

Source: Fieldwork data, 1993.

An analysis of the above estimates and information immediately bring three facts to light; one, that sedimentation will be a serious problem in the impoundment; two, that the lifespan of the impoundment will be shortened due to sedimentation, and three, that while the probability of such an event might not be very easy to arrive at, an estimate of between 0.40 and 0.70 can be justified.

5.3.3 Economic Value of Sediment

Elsewhere in the world, impoundment sediment has great potential as a raw material of potential value. Depending on its source such sediment might be used for at least some of the purposes to which these materials are commonly put (Adeniji, H.A., 1981). However retrieval methods are too expensive and furthermore, the limited quantity of the resource might not justify the development of ways and means of exploiting it. Even assuming it were possible, none of the material likely to find its way into the reservoir is in short supply elsewhere in Kenya and at a negligible cost. It is therefore being concluded that such siltation in the Upper Athi dam would only have negative attributes both to itself and its environment.

5.4 Biological implications of the upper Athi dam

Many impacts from water impoundment actions occur on floral, faunal and bird species that are components of the biological environment within and adjacent to the project areas. They are however difficult to discern due to the complexity and interconnectedness of the various subsystems of the biological system (Porter, A.L., et al, 1980). General impacts on the biological environment are related to changes in community types and their geographical distribution (Canter, L.W., 1977). Technological intrusions may directly or indirectly affect the numbers, distribution and conditions of life forms. However, effects on the habitats of life forms have more significant effects on life forms (Porter ,A.L., et al, 1980) over the long term. This is because while life forms are highly adaptive to external stimuli, a total change in habitat from factors other than natural succession are difficult to adapt to due to the unpredictable and uncertain nature of the new habitat. Discussions in this section therefore lay more emphasis **on** the impacts **on** life forms from a change in their habitat.

5.4.1 Implications on the bird populations of the Mbagathi riverine forests.

It is now generally assumed that the 'advantage' of a diversity of species lies in increased stability.

The greater the gene pool, the greater the adaptation potential of species (Odum, E.P., 1969).

The Mbagathi riverine forests are characterised by a wide diversity of bird species which inhabit either the trees or forest floor. During field excursions, the following bird species were identified within the forests:

1. Grey Kestrel
2. Martial eagle
3. African Goshawk
4. Grey-wing francolin
5. Red-necked spurfowl
6. Yellow-necked spurfowl
7. Thick kneed plover
8. Hamerkop
9. Heron
10. Secretary bird
11. Spekes weaver
12. Masked weaver
13. Grey-headed social weaver

This list consists of species that were readily identifiable and is only a small proportion of the entire species population of the riverine forests of Nairobi National Park.

The riverine forests play three key functions towards the ultimate survival of the bird species. First, the numerous flowering plants provide food in the form of seeds and invading/resident insects to the birds. Casual observations indicated that most of the species hardly get out of the riverine forests in search of food since there is plenty of food within the habitat. Further, the ground surface provide food to birds that normally feed on micro-organisms on the ground floor.

Secondly, the forests provide escape cover to some species both from predation by larger birds and from unnecessary human interference especially to shy and retiring birds like the Red-necked spurfowl (Angwin, J., 1968).

Lastly, and perhaps of greatest importance, the forests provide ideal breeding and reproduction facilities to a wide variety of bird species. The distribution of some of the birds like the Ploceus (weaver) species is highly clumped and breeding occurs within limited and clumped spatial boundaries (Lack, D., 1971). Other birds exhibit high levels in territoriality - the Hamerkop, the Plover, the Kestrel and the Eagle, to name a few - and it is to these group that attention is focused.

The securing of a territory by a bird species is part of a process which, in order to insure success to the individual in the attainment of reproduction, has been gradually evolved to meet the exigencies of diverse circumstances.

Normally, the male of a territorial species of bird will 'carve out' a definite area of its habitat (territory) and defend it against other males of the same species at the start of the breeding season (Odum, E.P., 1969). A male that is successful in holding its land has a high probability of mating and nesting, while a bird that is unable to establish such a territory will most likely not breed (Mac Arthur, R.H. and J.W., 1961). In such instances, density will be reduced or held in check by the competitive action - inadequate territory.

It is apparent that the destruction of the riverine vegetation through inundation would displace numerous species which depend on the forests for the provision of all the three amenities discussed above. The issue then is whether similar habitats are present elsewhere in the park and in sufficient quantities. Map. 7 indicates that riverine forests are found in small pockets along the few waterways in the park. While displaced species would initially try to rehabilitate themselves elsewhere, it should be important to point out that the numbers that can be absorbed in alternative habitats will be held in check by the

competitive action of territorial behaviour in most of the species since they would be invading territories that have been 'staked out' by other species elsewhere. Most of the displaced species would eventually migrate to suitable habitats elsehwere, implying that the park would lose some of the diversity and number of birds. Fig.5.3 shows the estimated time frames of the disappearance of such species from the park.

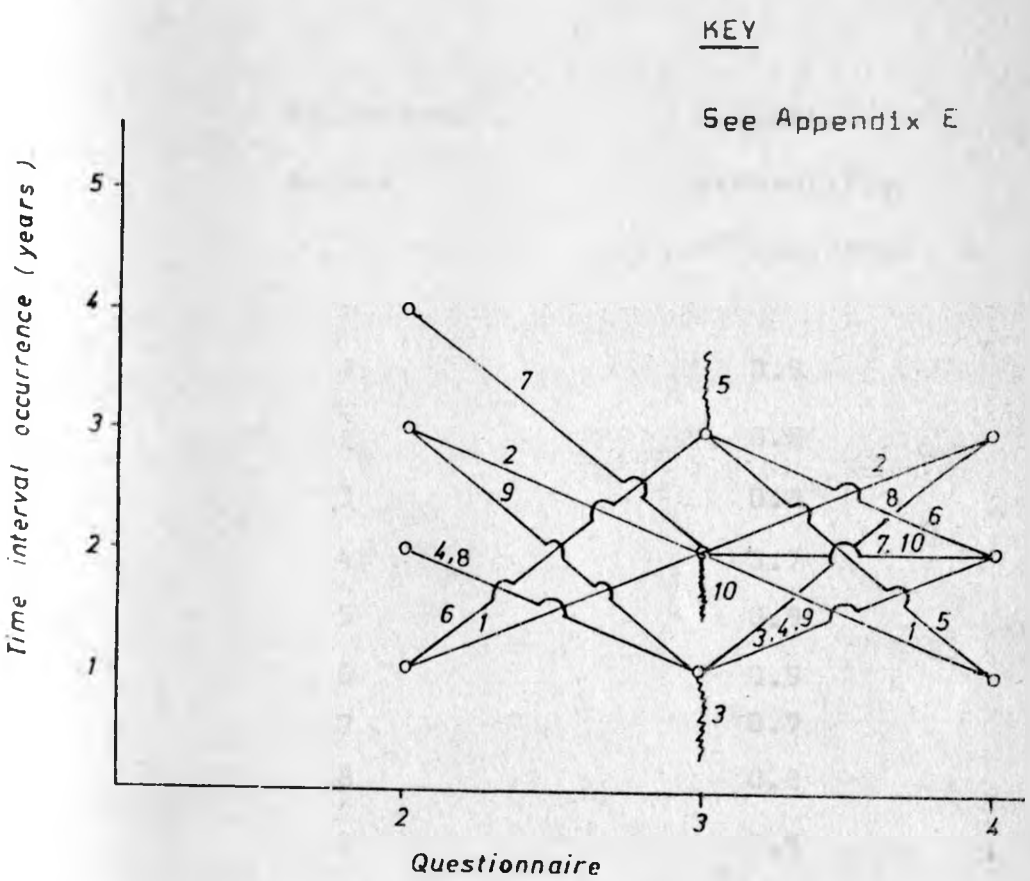

Fig. 5.3 Temporal estimates of disappearance of species from Nairobi National Park after construction of the dam.

Source: Fieldwork data, 1983

The figure shows that while the initial estimates of the occurrence varied between after 1 to 4 years, the final iteration narrowed the margin to between 1 and 3 years with 60% of the respondents estimating the event occurring in the second year of inundation.

Table 5.3 shows the estimated (marginal) probabilities of occurrence of the event "Elimination of species from the park".

Respondent number	Estimated probability of occurence
1	0.9
2	0.8
3	0.6
4	0.7
5	0.9
6	0.9
7	0.7
8	0.8
9	0.9
10	0.5

mean p (i) = 0.73

median p (i) = 0.8

Source: Fieldwork data, 1993

The species to be displaced obviously have ecological and biological value. What is not very apparent is whether they also have any aesthetic value to the park. During field visits, no observations were made of the riverine forest bird species being life forms of any special significance to the park visitors.

The inundation is likely to lead to a more positive aspect as far as birds are concerned. With any inundation comes about the invasion of the habitat by new life forms which are better suited to the new environment. One of the life forms that is most likely to inhabit the impoundment after some duration is aquatic bird species.

Elsewhere in the country, aquatic birds have provided a basis for bird-watching and photography-based tourism. Typical examples are lakes Nakuru, Bogoria and Mamnorok. There is no reason why substantial numbers of water birds should not inhabit the Upper Athi dam, and especially in view of the fact that half of the dam would lie within Nairobi National Park where any wildlife enjoys legal protection.

Field investigations revealed that not only is the introduction of aquatic birds likely to occur, but also that the probability of occurrence of the event is fairly high. Fig. 5.4 shows the responses to the question as to when the event is likely to occur while table 5.4 shows the marginal probabilities of occurrence of the event.

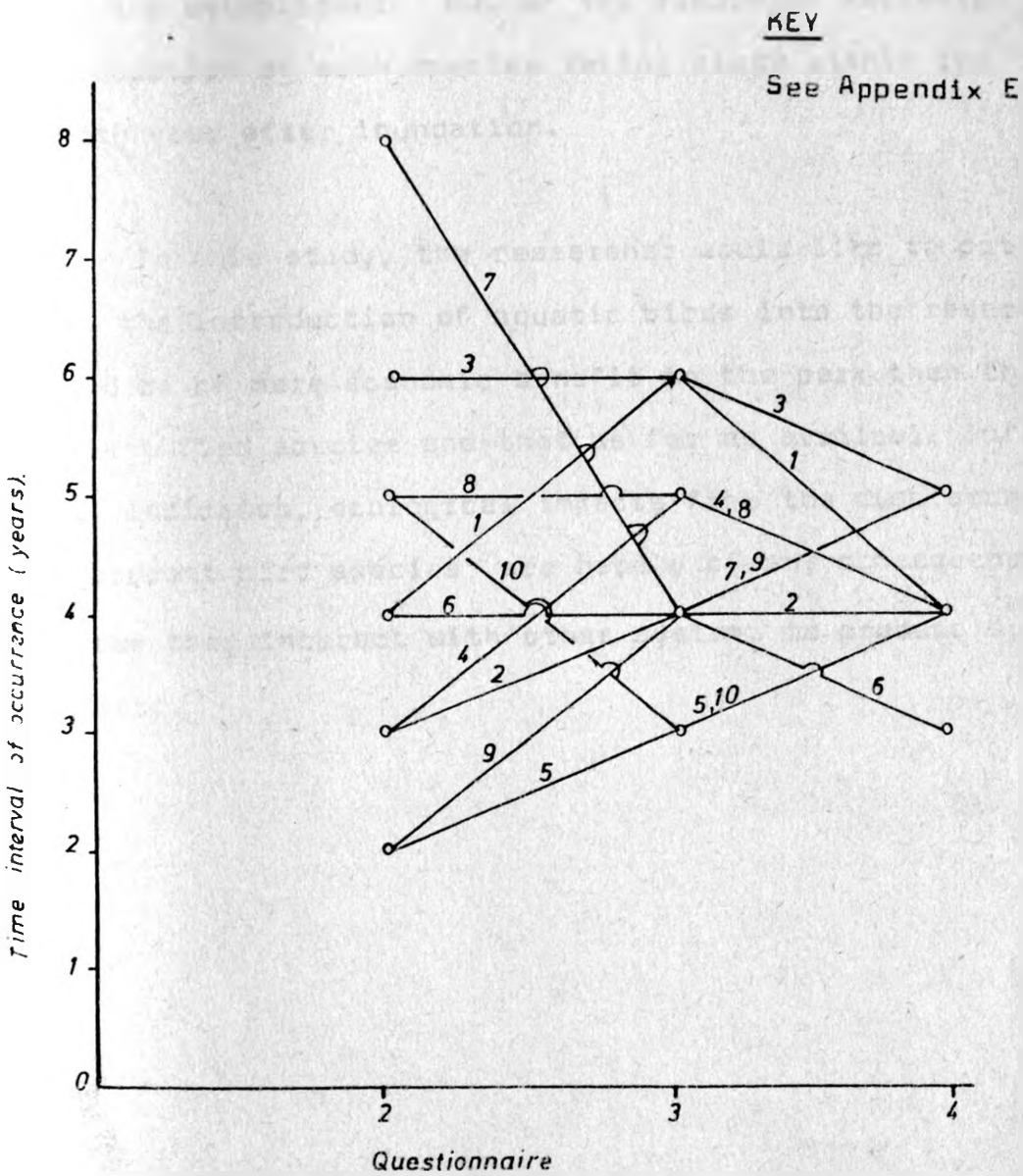

Fig. 5.4 Temporal estimates of introduction of aquatic bird species after inundation.

Source: Fieldwork data, 1983

There was a general concensus that the occupation by such birds would occur between the third and fifth years after micro-organisms and vertebrates ideal as bird feed are established. 60% of the responses estimated the introduction of such species taking place within the fourth year after inundation.

In this study, the researcher would like to put it that the introduction of aquatic birds into the reservoir would be of more economic benefit to the park than the present bird species and that as far as available information indicates, ecological impacts from the displacement of present bird species' are hardly of any consequence unless they interact with other systems to product systemic effects.

Respondent number	Estimated probability of occurrence
1	0.9
2	0.9
3	0.9
4	0.8
5	0.9
6	0.9
7	0.8
8	0.8
9	0.8
10	0.9

Mean = 0.86

Median = 0.90

Table 5.4: Marginal probabilities of occurrence of introduction of aquatic bird species into the reservoir.

Source: Fieldwork data, 1983.

5.4.2 Biological implications on terrestrial fauna

The inundation of the three gorges by the Upper Athi dam will affect both the resident and non-resident faunal species in many ways, chief among which include elimination of grazing and browsing ground, displacement of resident wildlife species, elimination of shade and cover (both breeding and escape), reduced animal range and disruption of migratory patterns. Most of the above effects will occur even as the reservoir is filling up while the rest will take place immediately thereafter. While all the above impacts are important in their own ways, it is their combined effects on the carrying capacity of Nairobi National Park that is of greater consequence to the ecologic stability of the park and which forms the focus of this discussion.

The term carrying capacity has been used elsewhere in this study to refer to the maximum intensity of use an area will continously support under a management programme without inducing a degradation in the environment. The peak biomass of animals in Nairobi National Park has been estimated at 12,775 kg/sq.km (Foster and Coe, 1968). During the drought of 1960-61 there was a mortality which reduced the biomass to around 7,154 kg/sq. km (56%). It has been estimated that during such times, slightly over 40% of total biomass (or more than 2,800 kg/sq.km) resides in the riverine forests and thickets (Karaba M. Pers. Comm., 1983). Even during normal seasons, between 20% and 30% of total biomass/ sq.km is normally resident in the river valleys (Wanjohi, E., Pers. Comm., 1984).

According to Foster and Coe (1968), the provision of water by construction of dams does not significantly affect the carrying capacity of the park because water supply has never been limited in the area even in times of drought; the carrying capacity is more likely related to the quantity and quality of forage during the dry season (Taiti, S.W., 1979). It has been observed that during dry periods, it is only along river valleys that is to be found green, palatable and nutritious vegetation, hence the increased biomass during such periods. In the researcher's observation, over 50% of total biomass of animals in the park were using the riverine vegetation as a permanent source of grazing and browsing during the 1983/84 drought. This would imply that at least 25% of biomass (kg/sq.km) occupied the area under threat of inundation or its immediate environment.

An over-view of the above discussion indicates that with inundation of the proposed site, the parks carrying capacity would be exceeded by between 10% and 15% during non-drought periods and by as much as 25% during drought periods. In this situation, the total biomass of animals is important only in a drought situation since excess biomass during non-drought periods can always be absorbed by the Kitengela area so long as it remains accessible to wildlife. The truth is that during drought situations, Nairobi National Park cannot support the large herds of plains game that migrate into the park even without inundation, not to mention the resident animal populations

Inundation of one of the critical dry season habitats will obviously lead to a serious stress on the carrying capacity of the park as well as to other biological mechanisms such as reproduction. This then raises the issue as to whether Nairobi National Park would survive as a viable ecologic unit after the inundation of the Mbagathi, Mokoyeti and Sosion gorges and their immediate environments by the proposed Upper Athi dam.

Fig. 5.5 shows the time estimates of such a stress after inundation while table 5.5 shows the estimated probabilities of occurrence of such stress to the ecology of the park.

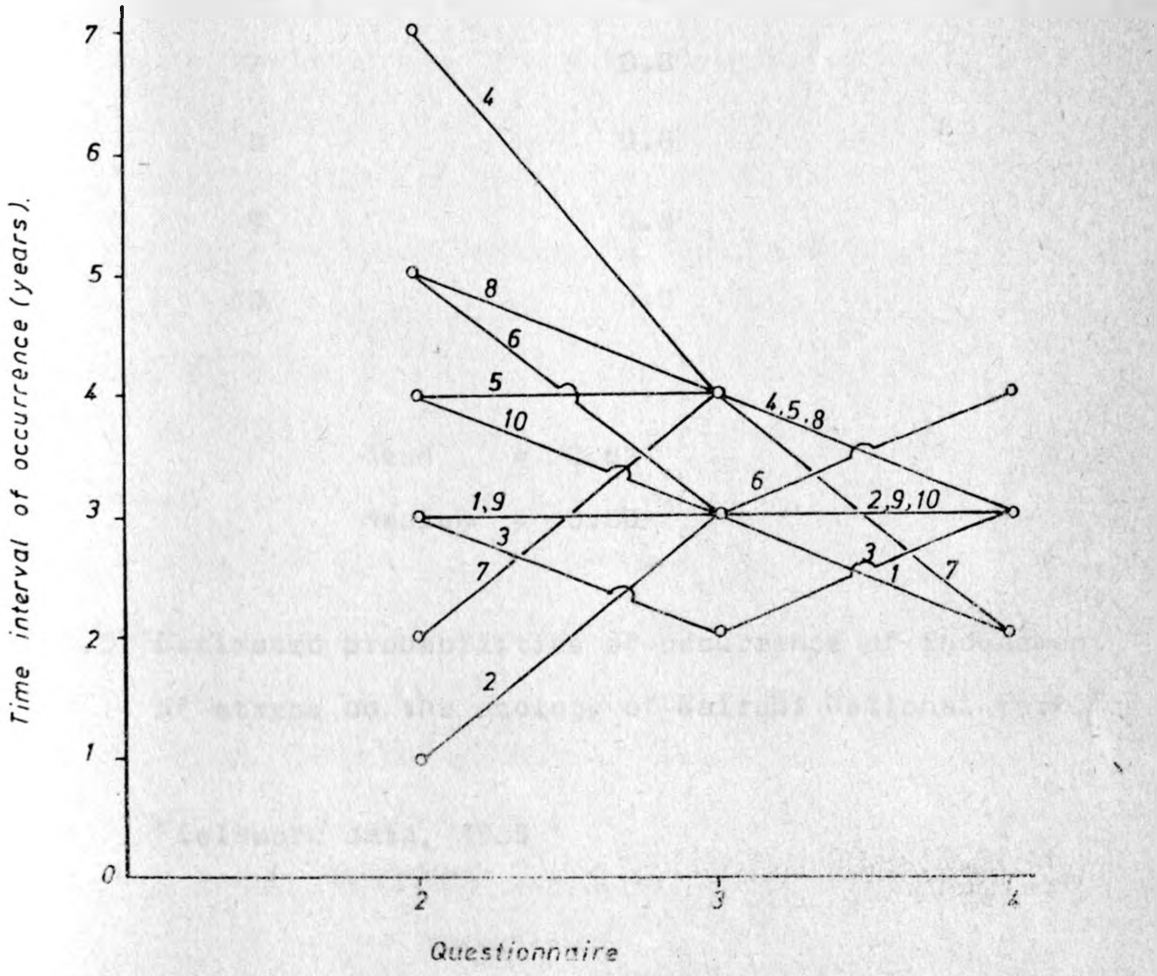

Fig. 5.5 : Time estimates of the occurrence of stress on the ecology of Nairobi National Park after inundation.

Respondent number	Estimated Probability of occurrence
1	0.7
2	0.6
3	0.9
4	1.0
5	0.9
6	0.7
7	0.8
8	0.8
9	0.8
10	1.0

Mean = 0.82

Median = 0.80

Table 5.5: Estimated probabilities of occurrence of inducement of stress on the ecology of Nairobi National Park.

Source: Fieldwork data, 1983

5.4.3 Proliferation of aquatic faunal species

At present, aquatic mammals are largely represented by the hippopotamus species. While animal censuses have not succeeded in establishing the correct number of hippos in Nairobi National Park, estimates (Wanjohi, E. Pers. Comm., (1984) put the figure at between 10 and 12 animals. Most of the animals inhabit hippo pools while one or two inhabit small dams inside the park periodically.

The first thing that becomes clear is that the water levels at hippo pools are bound to become lower after the construction of the reservoir has been effected since the pools are situated a few metres downstream of the proposed site.

At the moment, it would seem like the absence of sufficient suitable habitats is one of the limiting factors inhibiting the noticeable increase in numbers of the hippos since field observations over time indicate that the recruitment rate is rather low (Karaba, M. Pers. Comm., 1983). With the construction of the Upper Athi dam, it can be expected that the populations should normally increase since their habitat will in effect be expanded. While such an 'explosion' in population is in itself of no major consequence, its implications to the ecology of the park and to adjacent land-use are of more importance.

Hippos are selective and fairly intensive feeders and require large amounts of grassy green vegetation (Kormondy, E.J., 1969). While it can be assumed that the upper Athi dam's environment should be free of wildlife during the day due to human presence, the same cannot be said to be true at night. Due to higher soil moisture contents around the dam through infiltration, lush green vegetation would be expected to flourish within the environment, a situation that is likely to attract large numbers of grazers and browsers during the night. Green nutritious vegetation around the dam is bound to become a periodical occurrence and by no means not restricted to the hippos alone.

Such multiutilization can only lead to one possible eventuality - the increased hippo population is likely to wander further into the Kitengela in search of forage, an area that is currently the centre of great agricultural interest and especially with the prevailing speculation that the construction of the dam would likely lead to the opening up of new dimensions in agriculture within its environment (personal field observation, 1984).

Immediate landowners informally interviewed by this researcher indicated that with the presence of a reliable water supply, they would most likely engage in horticulture (to supply the mushrooming trading centres in the area) if the water body were to effectively restrict wildlife in Nairobi National Park. It must therefore be stated that an increased hippo population would only heighten the prevailing wildlife/man/land use conflict in the Kitengela.

In addition, it can be assumed that since man has more often than not emerged the winner in such conflicts, such a hippo population would eventually have to be contained within the boundaries of the park, further increasing the stress on the vegetation in the park as discussed elsewhere in this chapter.

While it may effectively be argued that the effects on the vegetation from such an increased population are likely to be minimal, it makes it clearer to emphasize that the issue at stake is not essentially that of numbers but of the quality of the environment upon which the existence of all life forms is ultimately based. Fig. 5.6 shows the temporal estimates of occurrence of heightened land use conflicts from an increased hippo population while table 5.6 shows probabilities of occurrence of the same.

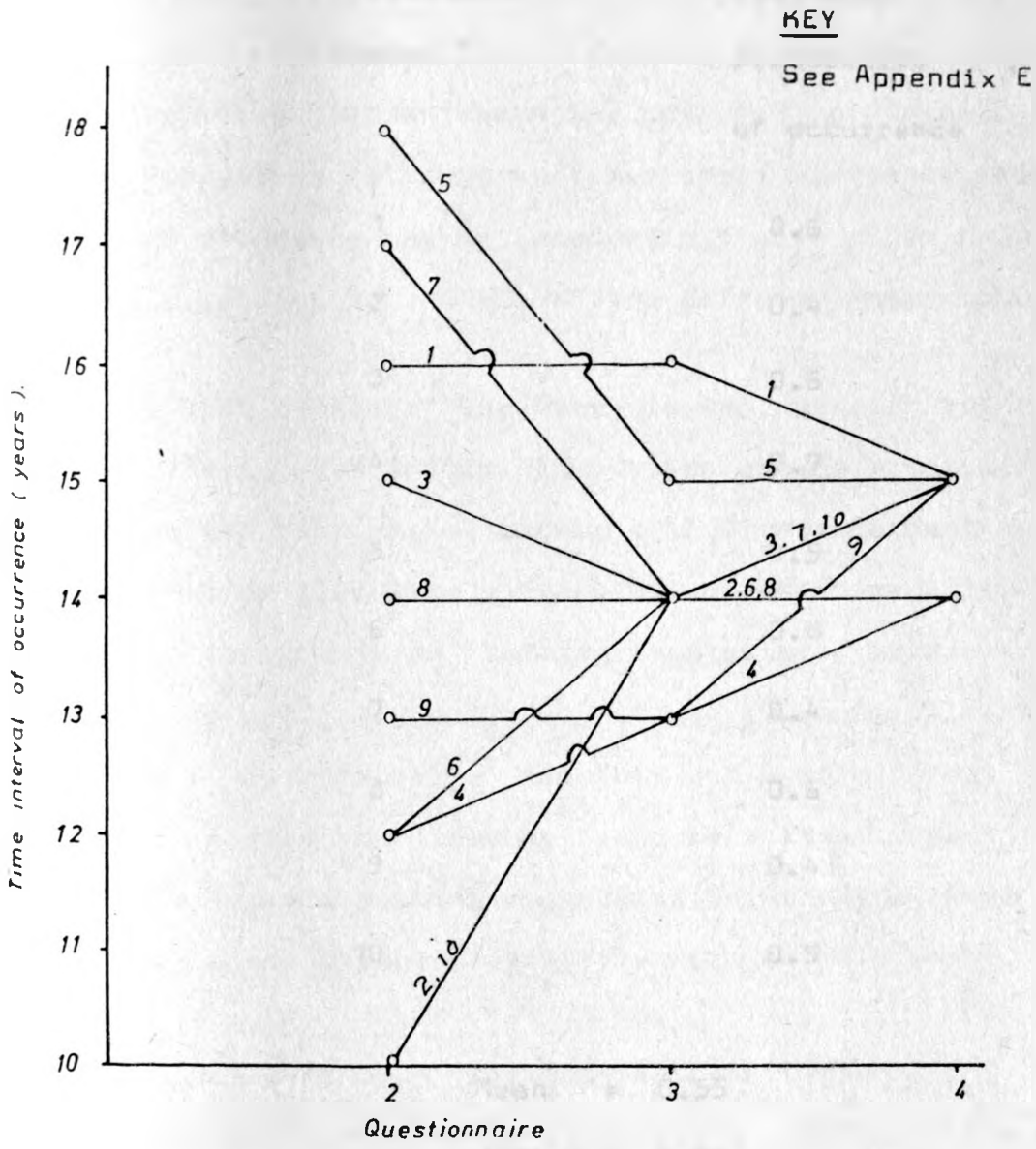

Fig. 5.6: Temporal estimates of occurrence of intensified land-use conflicts

Source: Fieldwork data, 1983

Respondent number	Estimated probability of occurrence
1	0.6
2	0.4
3	0.6
4	0.7
5	0.5
6	0.8
7	0.4
8	0.6
9	0.4
10	0.5

Mean = 0.55

Median = 0.55

Table 5.6: Estimated probabilities of occurrence of heightened land-use conflicts.

Source: Fieldwork data, 1983.

5.4.4 Emergent macrophyte populations: Their problems and benefits

New water bodies create new ecological conditions that favour rapid establishment of a variety of aquatic flora. Such macrophytes form an essential component of dynamic aquatic ecosystems although at times their emergence, distribution and abundance may be incompatible with other human activities related to the use of the affected water body.

The impoundment of any free-flowing waterway has one general effect. The initial inundation of the riverine vegetation and rich valley bottom soil (from abundant humus) brings about an immediate eutrophication which normally stimulates the growth of floating vegetation. Later, as the chemical and physical conditions of the impoundment stabilise, the pulse of eutrophication declines and a more normal succession of submerged and floating flora is evident (Adeniji, H.A., 1981). It is such instant succession in man-made lakes that has constantly posed potential problems with aquatic weeds.

The rates of such 'instant' eutrophication vary with some impoundments exhibiting very obvious changes while in others, the change is less dramatic. In some man-made lakes like Kariba and Volta, there was an initial rapid growth of floating and submerged species which persisted for several years before quickly declining to an insignificant coverage (Adeniji, H.A., 1981).

The length of time it takes for macrophytes to establish themselves varies from impoundment to impoundment depending on water chemistry, retention time, wave action and depth of the reservoir, among others. After careful consideration of some or all of the above factors, it was estimated that the establishment of macrophytes within the upper Athi dam would occur between the third and fourth years after inundation. Fig. 5.6 shows the time estimate of establishment of macrophytes into the upper Athi reservoir.

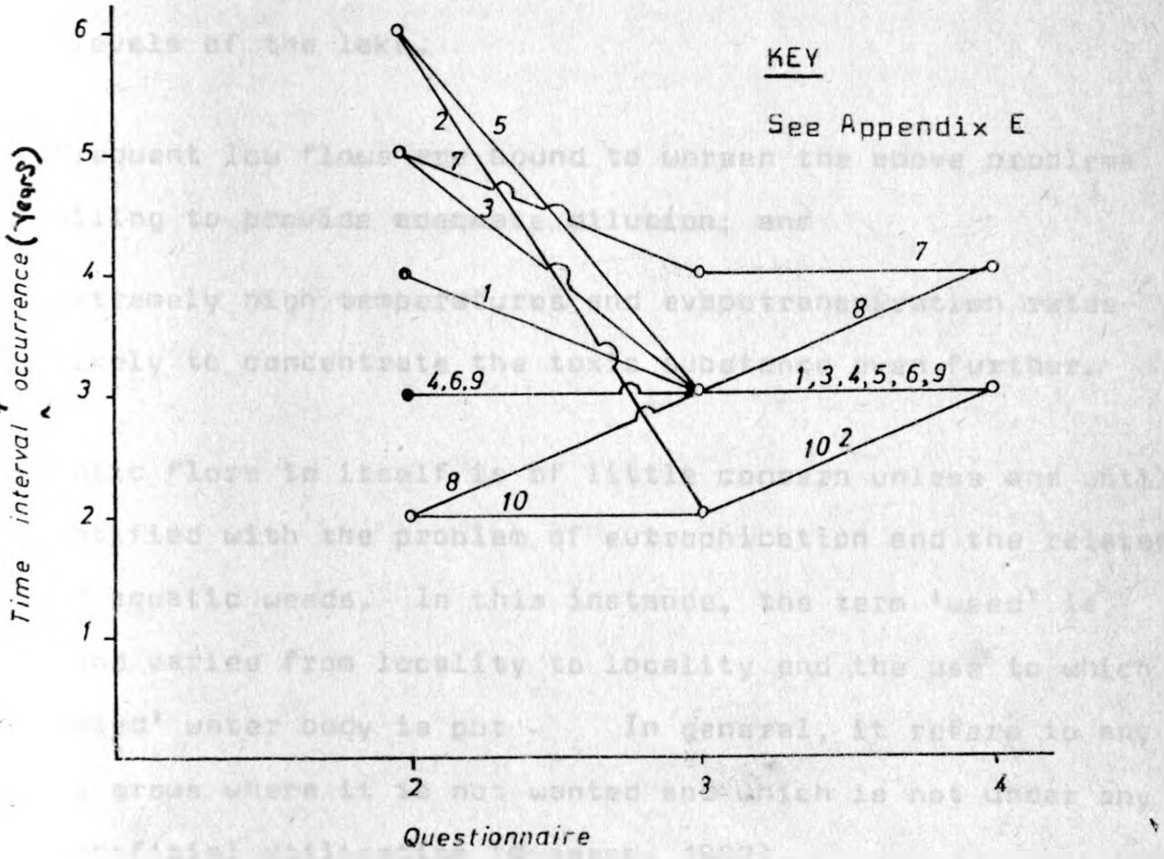

Fig. 5.6 Time estimates of establishment of macrophytes in the upper Athi reservoir

Fieldwork data.

The upper Athi reservoir is expected to exhibit very dynamic productivity rates even after the time when most impoundments normally stabilise. This will be due to an inter-play of several factors:

1. Unlike in most reservoirs, the proposed Upper Athi dam is to be located in a catchment basin where pollution is a relatively new phenomenon and is in factin its infancy. It is expected that pollution levels will steadily increase with increased developments in the catchment basin. Toxic substances from fertilisers (nitrogen and phosphorus based) and pesticides used in agricultural crop development and protection are bound to significantly increase the nutrient levels of the lake.

2. The frequent low flows are bound to worsen the above problems by failing to provide adequate dilution; and

3. The extremely high temperatures and evapotranspiration rates are likely to concentrate the toxic substance even further.

Aquatic flora in itself is of little concern unless and until it is identified with the problem of eutrophication and the related problem of aquatic weeds. In this instance, the term 'weed' is relative and varies from locality to locality and the use to which the 'infested' water body is put . In general, it refers to any plant that grows where it is not wanted and which is not under any form of beneficial utilization (Mwassco, 1982).

Problems associated with aquatic flora will be wide and varied. On the one hand, such vegetation will trap sediments, further increasing the problem of siltation of the reservoir. Such trapped sediments would normally be mineralised in the receiving environment and the nutritive elements resulting from this mineralization would greatly stimulate further plant production. This excessive production would especially be critical were it to involve some species which exhibit rapid rates of growth. For example, Salvinia molesta in Lake Kariba doubled its leaves every 8-12 days while Eichornia crassipes has been known to double its leaves every 12-15 days (Mwassco, 1982). (The observation of Salvinia traces along Mbagathi river, by the researcher, therefore poses serious implications for the upper Athi dam). Such rapid production rates would be manifested in severe de-oxygenation and further eutrophication. While this might not be of much significance to the productivity of aquatic faunal species due to the low levels of aquaculture, they should prove critical to water potability and the presence or absence of foreign odours and/or tastes. While definite estimates on such ordours were not possible due to the non-availability of several water chemistry variables, the panel of experts agreed that the creation of alien tastes and odours and the rendering of water impotable would occur around the 20th year after inundation.

This figure was arrived at after careful consideration and projections of changes in causal factors - land use urbanization and industrialization - in the catchment using the available information.

In conclusion and in view of the above discussion, it would be appropriate to hold the view that the introduction of aquatic flora into the Upper Athi reservoir will result in critical biological problems as will be manifested by eutrophication, sedimentation, de-oxygenation and general water pollution.

5.5 Partial test of hypothesis one

It was hypothesised that the proposed Upper Athi dam would not lead to deterioration of the park's ecologic environment. In this chapter, several events have been predicted to occur with varying degrees of probability. These are:

(i) Siltation of the dam. It was shown that even without the dam, the park's carrying capacity will in future continue to be exceeded due to the closure of the Kitengela and the massive migration of livestock into the park during drought periods. It was indicated that increased levels of cultivation in the dams catchment coupled with slack soil conservation measures will in future lead to massive erosion of the park.

This erosion from both the park and the rest of the catchment was predicted to reduce the lifespan of the dam from 43 to 23-27 years.

(ii) Avifauna

It was predicted with a lot of certainty that inundation would immediately lead to a loss in diversity of bird species. This would however be favourably balanced by the introduction of aquatic bird species which would provide the basis for currently absent bird watching and photography-based tourism. This would however reduce the wildlife species diversity around the park due to human interference, an action that is ecologically not acceptable.

(iii) Terrestrial fauna

It was predicted that the following events related to the fauna of the park would occur:

(a) Inundation would lead to elimination of grazing and browsing ground;

(b) It would also displace several wildlife species which would consequently move into the rest of the park; and

(c) Inundation would result in the loss of cover (breeding and shade) leading to a disruption in reproduction patterns for some species.

It was shown that events (a) and (b) would lead to a stress in the carrying capacity of the park. The capacity would be exceeded by 10-15% during non-drought periods and by as much as 25% during drought periods. This would inevitably lead to a degradation of the parks ecological system, and the park would no longer survive as a viable ecological unit.

(iv) Aquatic fauna

The impoundment would result in the population explosion of the hippopotami species. Being intensive feeders, it was argued that the increased population would quickly denude any vegetation in the vicinity of the dam, not to mention a tremendous increase in human/wildlife conflict in the Kitengela.

(v) Emergence of a macrophytic population

It is without doubt that impoundment will cause the immediate emergence of submerged and floating aquatic species. This emergence will lead to problems of eutrophication, aquatic weeds, siltation and water potability, among others. These problems bear ecological significance to the rest of the park since the dam would only be a part of a larger ecosystem.

Predicted events 1,3,4 and 5 have been shown to directly lead to a degradation in the parks ecologic system while predicted event 2 is indirectly related.

It has been partially proved through inference that the proposed upper Athi dam would inevitably lead to a deterioration of the park's various ecologic subsystems. We may therefore reject the null hypothesis and accept the alternative hypothesis that:

ANY WATER RESOURCE DEVELOPMENT ALONG THE MBAGATHI RIVER WOULD BE INCOMPATIBLE WITH THE ECOLOGIC STABILITY OF NAIROBI NATIONAL PARK.

5.6 Summary

This chapter set out to examine the environmental/ ecological components of the Nairobi National Park that might either be affected or caused to occur as a result of the construction of the Upper Athi dam. Such impacts were assessed in their temporal as well as spatial dimensions.

Sedimentation of the reservoir was found to be an important component of the reservoir due to the rapidly changing nature of land-use within the catchment. It was predicted that the lifespan of the dam would be shortened by as much as 20 years due to sedimentation.

It was further predicted that while the dam would displace numerous bird species inhabiting the forests in the gorges, a more positive aspect is that the impoundment would most likely be invaded by various aquatic bird species, thereby promoting bird-watching and photography based tourism in Nairobi National Park.

An important prediction was related to the effects on the carrying capacity of Nairobi National Park. It was shown that the carrying capacity of the park would be exceeded by 10-15% during non-drought periods and by as much as 25% during drought periods due to the inundation of important dry season grazing and browsing grounds. The problem would be further heightened by a population explosion of the hipoopotami species due to the presence of ideal breeding conditions.

An eminent emergence of a macrophytic population was predicted. It was stressed that such emergence would lead to problems of eutrophication, aquatic weeds, siltation and water potability, among others.

After careful inferential analysis of all those variables it was found necessary to reject the null hypothesis and accept the alternative hypothesis.

CHAPTER SIX

6.0 THE UPPER ATHI DAM: RELATED SOCIAL AND ECONOMIC PERCEPTIONS OF NAIROBI NATIONAL PARK VISITORS

6.1 INTRODUCTION

This chapter aims at testing two hypotheses. The first one is that "levels of satisfaction achieved during visits into Nairobi National Park and willingness by visitors to pay more for park entrance charges are statistically independent" while the second one is that "there is no relationship between effecting construction of the Upper Athi dam and anticipated changes/increases in visiting frequencies into Nairobi National Park".

The chapter attempts to analyse the personal characteristics of visitors to Nairobi National Park and their visiting patterns within the park. Major factors of attraction have been examined in relation to visiting characteristics and more specifically, the intensity of utilization of areas bearing such attractions. The chapter then proceeds to examine the perceptions of Nairobi National Park Visitors towards the proposed upper Athi dam along the Mbagathi river and its potential influence on their visiting characteristics. At the end of this discussion, it should be possible to either validate or reject the aforementioned two hypotheses.

In the following discussion, several socio-economic dimensions of Nairobi National Park and its visitors have been examined. Frequency of visits and their adequacy together with factors controlling (regulating) such frequencies have been discussed within the broad spectrum of visitor characteristics, while reasons prompting such visits, levels of satisfaction achieved during such visits, areas of major interest and their perception on the adequacy or inadequacy of amenities offered within the park have been used to assess the visit characteristics.

A discussion based on the perceptions of Nairobi National Park visitors towards the aesthetic and ecological/environmental value of the park with particular reference to the area in and around Mokoyeti, Sosian and Mbagathi gorges follows. This is then related to visitors' willingness to accommodate the proposed physical changes within the park and their perceptions on the role of such a structure to the enhancement or otherwise of the aesthetic and ecological/environmental quality of the park system. This discussion is important in that it reveals the future role of the proposed Upper Athi dam towards the economic and social utility of Nairobi National Park and its ability to remain a viable income-generating and recreational enterprise.

6.2 Characteristics of Nairobi National Park Visitors

As mentioned earlier, the study concentrated on visitors who had attained resident status in this country and especially those who had continously stayed here for more than six months. The ratio of citizen to resident visitor was 3:1, respectively. This biased stand was taken primarily because of the erratic nature of the tourism industry. Being controlled by factors which are to a very large extent exogenous to the country, for example, global economic and political trends, shifts in preference to other tourism-offering areas among others, there is no reason to believe that the prevailing influx of tourists is likely to continue into the future. This study has consequently adopted the view that any long term planning for Nairobi National Park must essentially be based on the feelings, perceptions and preferences of those who are likely to continue availing themselves of the amenity in future regardless of changes in global trends, namely, the residents.

Located at the 'door step' of a major city which is also the centre of National political, economic and social activities, Nairobi National Park has in the past offered and continues to offer an ideal retreat from the hustles of the city.

This popularity was demonstrated by responses to a question asking for an approximation of the frequencies of visits to the park in a year from 80 selected respondents. Table 6.1 shows responses to the question 'roughly how many times do you visit this park in a year?'. Among the 80 people interviewed, 41.25% on average visit the park after every 3-6 months, while 37.75% on average visit the park after every 1.5 to 2.5 months. This implies that 79% do, on average visit Nairobi National Park between 2 and 7 times in a year.

It was revealing to note that even with the high frequency of visits, a high proportion of the respondents felt that they were not visiting the park as often as they would have liked to (Table 6.2).

Of the respondents who felt that they were not visiting the park as often as they would have liked to, 11.25% felt that more visits would be too expensive, 13.75 were of the opinion that more visits would be too time consuming, 28.75% felt that more visits were hindered by the fact that the park was lacking in a wider variety of attractions hence the risk of monotony, while 1.25% gave other reasons. These findings are important in that they highlight the fact that a wider variety of attractions is needed in the park if it has to continue possessing a distinct advantage of other wildlife sanctuaries.

Approximate number of times visited in a year	Number of responses	% of responses
1 - 2	8	10.00
3 - 4	33	41.25
5 - 6	27	33.75
7 or more	12	15.00
Total	80	100.00

Table 6.1:- Frequencies of visits into Nairobi National Park

Source: Field work data, 1983.

Responses on whether total visits in a year are adequate	Frequencies of visits (times/year 1 -2	3 - 4	5 - 6	7 or more	Total
Yes	3	16			
No	5	17			

Table 6.2: Crosstabulation of responses on frequencies of visits into Nairobi National Park and the adequacy or inadequacy of such visits.

Source: Fieldwork data, 1983

whether such a diversification may be achieved partly through the construction of the Upper Athi dam has been discussed elsewhere in this chapter.

The above information on factors controlling frequency of visits made important revelations when crosstabulated with levels of satisfaction achieved during particular visits into Nairobi National Park when the questionnaire was administered (table 6.3)

Levels of satisfaction	Factors controlling frequency of visits.				Number	%
	Economic	Time constraint	Lack of attractions	others		
very satisfied	1 (11.11)	2 (18.18)	3 (13.04)	-	6	13
satisfied	4 (44.44)	2 (18.18)	8 (34.78)	1 (1.00)	15	34
Dissatisfied	3 (33.33)	5 (45.45)	11 (47.83)	-	19	43
very dissatisfied	1 (11.11)	2 (18.18)	1 (4.35)	-	4	9
				Total	44	100

KEY

2 = Actual number of responses

(11.11) = Percentage of responses for that variable.

Table 6.3: Crosstabulation of responses on levels of satisfaction achieved and factors controlling frequency of visits.

Source: Fieldwork data, 1993

For example, 47.83% of all the people who felt that they would visit the park more often were it not for its low diversity of attractions were dissatisfied with this particular visit that they had made as compared to 34.78% who were satisfied with what they had experienced during this visit. Only 13.04% felt very satisfied with their experiences of the day. These statistics are a clear indication that Nairobi National Park is lacking in attractions and points to the need to diversify the range of activities in the park.

6.3 Visitor Use of Nairobi National Park

There are various reasons that attract visitors to Nairobi National Park. The Park is deemed to have the largest number of animals per km^2 (Karaba, M., Pers. Comm. 1984) which are easily observable due to the relatively flat and unobstructed terrain. In the sample, the wide diversity in wildlife was the leading factor in the attraction of visitors to the Park (26.25% of the total sample population indicated that they had visited the park to admire wildlife (table 6.4). Photography, which is in any case related to wildlife viewing was ranked second with 23.75%.

Love for scenery is another factor that attracts visitors to Nairobi National Park. While most of the Western, Central and Eastern areas of the park have monotonous terrain, the Mbagathi valley and the neighbouring rolling hills of the Kitengela to the south of the park are a major source of attraction.

Scenic appeal had attracted 22.5% of all respondents. This is a big contract to the 4.35% (Dari, R., 1982) who had given the response that they had chosen the park as an area of visit due to its scenic appeal. The discrepancy between these two findings can be partly explained by the fact that Dari's sample had only 61.4% residents. It would be inconcievable to believe that any of the non-residents (38.59%) had previously known of the scenic appeal of the park. A cross-tabulation of the reasons prompting visits to the park and response on whether the visits were being undertaken as often as the visitors would have wanted to reveals interesting implications of the role played by the scenic appeal of the park towards the attraction of visitors (table 6.5). Of the 10 people who had visited the park due to its scenic appeal, 70% were of the opinion that they were not visiting the park as often as they would have liked to, while 90% of the 21 people who had come to admire wildlife felt the visits they made within the year were inadequate. The above findings underscore the importance of scenic beauty in the park's economic and social systems and lay emphasis on the importance of maintaining or enhancing the scenic appeal of Nairobi National Park.

Reasons that prompted this visit	number of responses	%
Killing of boredom	4	5
Recreation	12	15
Love for the scenery	18	22.5
Photography	19	23.75
Admiration of wildlife	21	26.25
To overcome urban stress	6	7.5
Total	80	100

Table 6.4: Reasons prompting the choice of the park as an area of visit.

Source: Fieldwork data, 1983.

Response on whether total visits in a year are adequate	Reasons Prompting visits							
	To kill boredom	Recre-ation	Love for scenery	Photo-graphy	To over-come urban stress	To admire wildlife		%
Yes	2	4	5	13	2	10	36	4
No	2	8	13	6	4	11	44	5
						Total	80	10

Table 6.5: Crosstabulation of reasons prompting visits into the park and percieved adequacy or inadequacy of total number of visits in a year.

Source: Fieldwork data, 1983.

The researcher has frequently witnessed several people alight from their vehicles at the observation point on the rim of the Mbagathi gorge during the last minutes of the day to witness the sunset eclipse the hills of the Kitengela. This has become an area of over-use during the evening where sometimes crowds of upto 20 people are to be found in the late hours of the afternoon "soaking in the captivating beauty of the gorge at sunset", as one visitor put it to the author.

When visitors enter the park. they generally follow the tarmac road to Narogoman dam (Appendix G), then to the central flat area of the park where game is easily available. Field observations indicate that an estimated 80% of the vehicles go directly or indirectly to this central area; and even higher percentage then hurriedly follow on to the walking trail around hippo pools in the south-east. The sample indicated little or no use of the forest area in the west and the Northern sector with its sometimes impassable black cotton soils (Map no. 6).

The above findings draw important dimensions to the siting of the upper Athi dam. It would be located within part of the central-southern circuit, an area that has so far provided the only attraction and is most likely going to continue playing that role in future. The implication here is that an estimated 80% or more of the vehicles would directly or indirectly come into contact with the dam.

Whether the dam would play an enhancing or inhibiting role is critical to determine and an attempt to do so has been undertaken in the next section.

One might say that Nairobi National Park is losing its popularity. Such a statement is supported by annual visitor returns (Table 3.1) and the sample response on levels of satisfaction achieved during visits when the questionnaire was answered (table 6.6).

Levels of satisfaction	Number	%
very satisfied	15	18.75
satisfied	27	33.75
Dissatisfied	29	36.25
Very dissatisfied	9	11.25

Table 6.6: Levels of satisfaction achieved by Nairobi National Park visitors.

Source: Fieldwork data, 1983.

One of the reasons was seen to have been the narrow range of attractions within the park (table 6.3). This information was further collaborated by revelations of a cross-tabulation between levels of satisfaction achieved and purpose of visit into the park (table 6.7).

The table shows that those visitors who had been attracted by a specific tangible commodity like wildlife had higher satisfaction levels while those who had been attracted by sometimes indefinable and intangible commodities such as scenery and recreation experienced lower levels of satisfaction. For example, a total of 66.7% of those who had come to admire wildlife were either satisfied or very satisfied as opposed to only 42.1% and 38.9% of those who had come for photography and love for scenery respectively.

On the other had, only 33.3% of those who had come to admire wildlife were either dissatisfied and/or very dissatisfied as opposed to 66.6% for those who wanted to overcome urban stress, 57.9% for photography, 61.1% for scenery and 50% for recreation.

A question on whether the range of attractions being offered within Nairobi National Park were adequate elicited similar views. 62.5% clearly felt that the attractions were inadequate as opposed to 37.5% who felt the range of attractions was adequate.

Levels of satisfaction	Purpose of visit					
	To kill boredom	Recrea-tion	Love for scenery	Photo-graphy	To over-come urban stress	To admire wildlife
Very satisfied	2 (50)	3 (25)	2 (11.1)	3 (15.8)		5 (23.8
satisfied	2 (50)	3 (25)	5 (27.8)	5 (26.3)	2 (33.3)	9 (42.9)
dissatisfied	-	5 (41.7)	8 (44.4)	10 (52.6)	3 (50)	4 (19)
Very dissatisfied	-	1 (8.3)	3 (16.7)	1 (5.3)	1 (16.6)	3 (14.3)

Key

2 - Number of responses

(50) - Percentage of responses for that varieble.

Table 6.7: Crosstabulation of levels of satisfaction and purposes of visits of Nairobi National Park visitors.

Source: Fieldwork data, 1983

As mentioned earlier, the ability or otherwise of the Upper Athi dam to create new attractions becomes a critical dimension to the problem of diminishing utility of Nairobi National Park.

6.4 The Aesthetic and Ecological/Environmental value of the Upper Athi dam site

The Mbagathi valley provides a break from the rather monotonous flat terrain of the rest of Nairobi National Park. Apart from the walking nature trail along hippo pools, the observation point along the rim of the Mbagathi gorge continues to provide one of the few sources of satisfaction in Nairobi National Park. Of particular importance is the picturesque scene of the setting sun, with dusk slowly enveloping the gorges with the rest of the park and the Kitengela plains enjoying the golden-brown illumination of the setting sun.

Responses from the sample clearly indicates the importance of the Mbagathi valley; 33.75% felt that it was very attractive, while only 20% felt the area had nothing that was particulary attractive (table 6.8). 75% felt that the valley was fairly attractive and/or very attractive.

This compares favourably with responses on the perceived ecological/environmental value of the proposed upper Athi dam site (table 6.9).

Aesthetic beauty	Number	%
Very attractive	27	33.75
Fairly attractive	33	41.25
No particular attraction	16	20.0
Don't know	4	5.0

Table 6.8: Aesthetic beauty of the Mbagathi valley as percieved by visitors to the Nairobi National Park.

Source: Fieldwork data.

Environmental/Ecological importance	Number	%
Very important	19	23.75
Fairly important	33	41.25
No particular importance	18	22.5
Don't know	10	12.5

Table 6.9: Percieved ecological/environmental importance of the proposed upper Athi dam site.

Source: Fieldwork data, 1983

65% felt that the area was fairly and/or very important ecologically/environmentally while only 22.5% felt the area bore nothing of particular importance. This implies that 70% of the sample felt that the proposed Upper Athi dam site held positive aesthetic and/or environmental value as opposed to 21.25% who were of the opinion that the site held nothing of particular aesthetic and/or environmental importance.

6.5 The Proposed Upper Athi dam: its potential role towards the socio-economic viability of Nairobi National Park

As has been emphasised elsewhere in this chapter, the nature of interactions between the proposed dam and the various sub-system is a critical factor in the continued existence of the park as a viable system. The following section analyses the perceptions of this study's sample of the role of the proposed dam on the park's socio-economic subsystem.

6.5.1 Aesthetic Value

Table 6.8 indicated that 75% of the resident visitors felt that the dam site held positive aesthetic value. The perceptions of the visitors on the enhancing or inhibiting role of the dam are displayed in table 6.10.

41.25% felt that the dam would enhance the aesthetic value of the park as opposed to only 21.25% who were of the opinion that the dam would decrease the aesthetic value of the park. Table 6.10 shows 71.25% of the resident visitors do not percieve the dam as affecting negatively the utility of the park.

Effect of dam on aesthetic value	Number	%
Enhance aesthetic value	33	41.25
Wouldn't change aesthetic value	24	30
Decrease aesthetic value	17	21.25
Don't know	6	7.5

Table 6.10: Perceptions of the effect of the proposed dam on the aesthetic value of the proposed site.

Source: Fieldwork data.

6.5.2 Environmental/Ecological Importance

This variable was difficult to define since it requires some elementary ecological knowledge. This was evidenced by the high percentage (12.5%) of respondents who did not know whether the proposed site was of any ecological value (table 6.9). An even higher percentage (30%) of the respondents did not know whether the dam would enhance or inhibit the ecological importance (table 6.11).

The table shows that only 47.5% of the respondents felt that the dam would not inhibit the ecological importance of the site as opposed to 22.5% who were of the opinion that the dam would inhibit the ecological value of the site.

6.5.3 Attractions

Throughout this chapter, it has been indicated or implied that the range of attractions within Nairobi National Park is too narrow to permit the achievement of maximum satisfaction from the use of the park. Table 6.3 indicated that there was some relationship between levels of satisfaction achieved during visits and the range of attractions within the park. Table 6.7 indicated that there was a relationship between purposes of visit and levels of satisfaction achieved.

Those people who had been attracted by intangible commodities and presumably involving a diversification in attractions experienced lower satisfaction levels than those who had come to enjoy tangible commodities that require very low levels of diversification of attractions.

Effect of dam on environmental/ ecological importance	Number	%
The dam would increase ecological/environmental value	18	22.5
The dam would not change the ecological/environmental value	20	25
The dam would decrease the ecological/environmental value	18	22.5
Don't know	24	30

Table 6.11 Perceptions on the effect of the proposed dam on the ecological/environmental value of the proposed dam site.

Source: Fieldwork data, 1983

Table 6.12 shows the perceptions of visitors on the role of the Upper Athi dam on the range of attractions within the park. It is important to take into consideration the fact that the percentage of respondents who felt that the dam would decrease the range of attractions becomes almost insignificant when the fact that the sample involved resident visitors only is taken into account.

Effect of proposed dam on range of attractions	Number	%
The dam would increase the range of attractions	37	46.25
The dam would not change the range of attractions	28	35.00
The dam would decrease the range of attractions	15	18.75

Table 6.12: Effect of the upper Athi dam on the range of attractions within Nairobi National Park.

Source: Fieldwork data, 1983

6.5.4 Satisfaction Levels.

It was indicated in table 6.6 that an extraordinarily high percentage of visitors were distinctly dissatisfied with their experience of Nairobi National Park. This fact is further strengthened by the fact that the park has been undergoing a decline in patronage over the last few years. A significant percentage (52.8%) of visitors who felt that they were not visiting the park as often as they would have liked to said that lack of a wider range in attractions was hampering them from frequenting the park. A correspondingly high percentage of the resident visitors responded that they felt they would achieve more satisfaction from visiting the park if the upper Athi dam were to be constructed.

Table 6.13 indicates the perceived role of the dam on satisfaction levels.

Satisfaction Levels	Number	%
The dam would increase satisfaction levels	35	43.75
The dam would not change satisfaction levels	30	37.5
The dam would decrease satisfaction levels	15	18.75

Table 6.13: Construction of the upper Athi dam and perceived satisfaction levels from the presence of the dam

Source: Fieldwork

As in table 6.12, the percentage of visitors who felt that the dam would have a negative impact on existing characteristics is strikingly low (18.75) as compared to those who saw a more positive contribution emanating from the dam (43.75%).

6.5.5 Visit Frequencies and associated economic characteristics

The responses to this variable clearly indicate that nearly half of the visitors to Nairobi National Park have a positive perception of the proposed Upper Athi dam. 47.5% of the respondents felt that they would visit the park more often after the construction of the dam as opposed to only 20.00% who responded that they would decrease their visiting frequences with the construction of the Upper Athi dam (Table 6.14). 32.5% thought that the construction of the dam would not change their current visiting patterns. This implies that 80.00% of the respondents did not percieve a negative influence of the dam on their frequencies of visits.

Not as great a percentage however was willing to pay more as entrance charges as a result of the perceived positive contribution of the dam to the park's various subsystems. 67% were willing to pay more above the current rates while 32.5% were opposed to the idea of raising the charges (Table 6.15). The figure however compares favourably with perceived enhancement of various attributes of the park by the proposed dam. It does the same with responses on whether the respondents were in any way opposed to the construction of the dam on the proposed site. 56.25% did not have any objections while 43.75% were clearly opposed to the inundation of the Mbagathi, Mokoyeti and Sosian gorge of Nairobi National Park.

Frequency Changes	Number	%
Increase visit frequencies	38	47.50
No change in visit frequencies	26	32.50
Decrease visit frequencies	16	20.00

Table 6.14 Perceptions on changes in visit frequencies after construction of the upper Athi dam.

Source: Fieldwork data, 1983

Willingness to pay more	Number	%
Yes	54	67.50
No	26	32.50

Table 6.15 Willingness to pay more as park entrance charges after construction of the dam.

Source: Field da

6.6 The Chi-Squared Statistic and Test of Hypothesis

The following sets of variables have been cross-tabulated and the associated X^2 statistic calculated:

(i) Perceived changes in levels of satisfaction and willingness to pay more as park entrance charges following the inundation of the three gorges.

(ii) Effecting construction of the Upper Athi dam and perceived changes in visiting frequencies thereafter.

The X^2 statistic has been used to test the statistical significance of both sets of variables. The X^2 statistic for all sets of variables was calculated using the formula

$$X^2 = \frac{(O - E)^2}{E}$$

where: X^2 = Chi-squared statistic

O = Observed frequency

E = Expected frequency

where:

$$E = (C_i \quad r_i)$$

where: C_i = frequency in a respective column marginal

r_i = frequency in a respective row marginal

N = Total number of valid cases

The respective degrees of freedom were calculated using the formula

$$df = (C-1)(R-1)$$

where:

C = Number of columns

R = Number of rows

For all X^2 values, an X^2 distribution table was used to check for the presence or absence of relationships between variables.

6.6.1 Satisfaction level changes and willingness to pay.

The following sections contain the calculations of the X^2 statistic.

Cell	O	E	O - E	$(O - E)^2/E$
a	23	24	-1	0.04
b	22	20	2	0.4
c	9	10	-1	0.1
d	12	11	1	0.09
e	8	10	-2	0.4
f	6	5	1	0.2
	80	80		1.23

$$df = (C - 1)\ (R - 1)$$

$$= (3 - 1)\ (2 - 1)$$

$$= 2$$

A X^2 value of 1.23 at 2 degrees of freedom has a p value of more than .50,.

6.6.2 Effecting construction of the dam and changes in Visit Frequencies.

Cell	O	E	O - E	$(O - E)^2/E$
a	9	17	-8	3.7
b	15	11	4	1.4
c	11	7	4	2.2
d	29	21	8	3
e	11	15	-4	1
f	5	9	-4	1.7
	80	80		13.0

df = (3 - 1) (2 - 1) X^2 value = 13.0

= 2

For the second set of variables, the X^2 statistic is 13.0 with 2 degrees of freedom, whose p value lies at .01 and .001.

6.6.3 HYPOTHESIS TWO

It was hypothesised that there was no (statistical) association between perceived changes in satisfaction levels from the construction of the Upper Athi dam and willingness by visitors to pay more as park entrance changes. This hypothesis sought to prove the fact that the construction of the dam would not be reflected in the park's role as a money-generating enterprise.

The related X^2 value was 1.23 at 2 degrees of freedom. A X^2 value of 1.23 falls somewhere below 1.4 associated with the .50 level of probability. This implies that the probability of getting a X^2 as high as or higher than 1.23 is .50, indicating that the relationship under consideration is statistically significant at the .50 level. This means that we can reject the null hypothesis with confidence; in other words, perceived satisfaction changes are not inoependent of willingness to pay. Therefore, "LEVELS OF SATISFACTION ACHIEVED DURING VISITS INTO NAIROBI NATIONAL PARK AND WILLINGNESS BY VISITORS TO PAY MORE AS PARK ENTRANCE CHARGES ARE STATISTICALLY DEPENDENT.

6.6.4 HYPOTHESIS THREE

This hypothesis involved opinions on whether or not the construction of the dam should be effected and perceived changes in visiting frequencies into Nairobi National Park.

It was therefore hypothesised that there was no relation between the two variables. In other words, visitors who thought that they were not opposed to the construction of the dam did not necessarily feel that they would increase their frequencies of visit into the park after construction.

The related X^2 value was 13.0 at 2 degrees of freedom. A X^2 value of 13.0 falls between the 9.21 associated with the .01 level of probability and 13.82 associated with the .001 level of probability. The probability of getting a X^2 as high as or higher than 13.0 is .01. We may therefore say that the relationship under analysis is statistically significant at the .01 level, implying that we can be 99% certain that those people who were not opposed to the construction of the dam would increase their visiting frequencies into Nairobi National Park after construction of the upper Athi dam. We can therefore reject the null hypothesis with confidence and accept the alternative hypothesis that "THERE IS A RELATIONSHIP BETWEEN EFFECTING CONSTRUCTION OF THE UPPER ATHI DAM AND ANTICIPATED CHANGES/INCREASES IN VISITING FREQUENCIES INTO NAIROBI NATIONAL PARK.

6.7 Summary and Conclusions

The above findings are important and form the theme of this research. The thesis has been that the proposed Upper Athi dam would play a positive role in the socio-economic utility of Nairobi National Park.

It was shown that 43.75% of the visitors felt that the dam would help them achieve higher satisfaction levels as opposed to only 18.75% who thought they would experience lower satisfaction levels. Hypothesis two has proved that willingness to pay more as park entrance charges is partly dependent on perceived changes in satisfaction levels. We may therefore expect that the construction of the Upper Athi dam would lead to higher revenue returns to Nairobi National Park.

It has been indicated that 56.25% of the respondents were not opposed to the construction of the upper Athi dam. Hypothesis three proved that increases in visiting frequencies were in part dependent on the fact as to whether visitors were opposed or not to the construction of the dam. This implies in part that the presence of the dam would attract more visitors into the park who, as it has been proved would also experience higher satisfaction levels. It has therefore been proved that the presence of such a dam would lead to higher social and economic utilities of the park.

CHAPTER SEVEN

7.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter synthesises the discussions contained in this thesis. The chapter is important in that it carries the general summary of the thesis findings, the conclusions based on the findings and a summary of the recommendations contained in the thesis. The recommendations contained here-in are particulary addressed to policy makers and to scholars, both upcoming and established.

7.2 Summary of Findings

This research started with the formulation of a set of objectives aimed at guiding the study. These objectives were:

(i) "To analyse the various dimensions of the proposed Upper Athi dam", namely

(a) Physical characteristics;

(b) Technical dimensions; and

(c) Socio-economic aspects.

(ii) "To evaluate the potential impacts on the non-human biological environment resulting from the proposed water resource development along the Mbagathi river", namely

(a) Impacts on the fauna of Nairobi National Park;

(b) Impacts on the flora of Nairobi National park; and

(c) Impacts on the Avifauna of Nairobi National Park.

(iii) "To examine the various socio-economic characteristics of Nairobi National Park and its visitors as is related to the proposed upper Athi dam and the continued viability of Nairobi National Park; namely,

(a) Visitor characteristics;

(b) Visiting (utilization) patterns;

(c) Major factors of attractions; and

(d) Perceptions towards proposed structural changes.

To test the relevance of both the study problem and the objectives, the following three hypotheses were formulated:

(i) H_0 - ANY WATER RESOURCE DEVELOPMENT ALONG THE MBAGATHI RIVER WOULD BE COMPATIBLE WITH THE ECOLOGIC STABILITY OF NAIROBI NATIONAL PARK.

H_1 - ANY WATER RESOURCE DEVELOPMENT ALONG THE MBAGATHI RIVER WOULD BE INCOMPATIBLE WITH THE ECOLOGIC STABILITY OF NAIROBI NATIONAL PARK.

(ii) H_0 - LEVELS OF SATISFACTION ACHIEVED DURING VISITS INTO NAIROBI NATIONAL PARK AND WILLINGNESS BY VISITORS TO PAY MORE AS PARK ENTRANCE CHARGES ARE STATISTICALLY INDEPENDENT.

H_1 - LEVELS OF SATISFACTION ACHIEVED DURING VISITS INTO NAIROBI NATIONAL PARK AND WILLINGNESS BY VISITORS TO PAY MORE AS PARK ENTRANCE CHARGES ARE STATISTICALLY DEPENDENT.

(iii) H_0 - THERE IS NO RELATIONSHIP BETWEEN EFFECTING CONSTRUCTION OF THE UPPER ATHI DAM AND ANTICIPATED CHANGES/INCREASES IN VISITING FREQUENCIES INTO NAIROBI NATIONAL PARK.

H_1 - THERE IS A RELATIONSHIP BETWEEN EFFECTING CONSTRUCTION OF THE UPPER ATHI DAM AND ANTICIPATED CHANGES/INCREASES IN VISITING FREQUENCIES INTO NAIROBI NATIONAL PARK.

All the three hypotheses were tested through statistical or inferential analysis.

In an attempt to achieve the first objective, it was demonstrated that Athi River town has a very high growth potential in as far as industrial development is concerned. This apparent potential is however hampered by the presence of an acute water shortage due to the absence of bulk water supplies to the township, hence the need for the proposed project.

The environmental setting of the proposed project site was discussed with an emphasis on the fauna and avifauna of the area. It was stated that a wide range of the same would be affected by the inundation of the area. It was further found out that while the project environment is relatively free of agro-based industrial activities, it may be speculated that an inevitable rapid growth in population will be paralled by an equally rapid growth in agriculture and industries, leading to heavy pollution of waterways upstream of the proposed site. The effects of such pollution were exhaustively discussed in chapter five.

The second objective analysed impacts on the physical, biological, cultural and purely ecological sub-systems and was supported by hypothesis number one.

Among the variables related to this objective and hypothesis werethat on effects accruing from sedimentation, the presence or absence of birds, and effects on aquatic and terrestrial flora and fauna. These were discussed within the sub-theme of biological/physical conditions and/or characteristics. Effects on tourism and scenic appeal of the dam environment were highlighted within the spectrum of cultural factors while pollution was identified as an important factor and was treated within the ecological dimension.

Important findings were made regarding the second objective. These were:

(i) That the proposed dam's economic life would be shortened by as much as a half by factors largely exogenous to the dam but bearing an indirect relationship. Siltation due to erosion of the catchment was found to be the main cause while the role of macrophyte populations was found to be significant;

(ii) Speaking in a strictly economic sense, the dam would provide the basis for bird watching and photography-based tourism, an event that is likely to be manifested in increased utility of Nairobi National Park.

However, the same variable was found to have an associated negative effect on ecologic stability in that it would most likely affect most biological characteristics of wildlife adjacent to the area due to excessive human interference;

(iii) The presence of the dam would exert a stress on the carrying capacity of Nairobi National Park and thereby further distabilising the delicate ecological balance of Nairobi National Park; and

(iv) It was predicted with a fairly high level of certainty that a macrophyte population would emerge soon after inundation, an event that would lead to problems of siltation, eutrophication, water potability, and aquatic weeds.

An exhaustive discussion of facts and information geared towards the satisfactory achievement of this objective revealed that the proposed Upper Athi dam site is only part of a larger ecosystem - the Nairobi National Park ecosystem - whose presence would be manifested by negative effects within a wider spatial area. Predictions and projections based on available information and data confirmed this fact leading to a rejection of the null hypothesis purporting that such a dam would not bear negative ecological effects on the rest of its environment.

The alternative hypothesis that "ANY WATER DEVELOPMENT ALONG THE MBAGATHI RIVER WOULD BE INCOMPATIBLE WITH THE ECOLOGIC STABILITY OF NAIROBI NATIONAL PARK" was therefore accepted in view of the above findings.

In the third objective, information on reasons for visit, major areas of attraction, adequacy or otherwise of amenities provided within the park, frequencies of visits into the park and their adequacy or inadequacy as perceived by the visitors was collected.

Further, the objective was achieved by use of information on perceived current value of park in the aesthetic and ecological sense, perceived enhancement or inhibition of the dam on the above, the implications of the dam on satisfaction and range of attraction levels, and the role of the proposed dam on the continued economic viability of Nairobi National Park. The achievement of this objective facilitated the testing of the second and third hypotheses.

It was discovered that the old myth that tries to explain the advent and growth of tourism to the presence of wildlife was no longer necessarilly valid. The study found out that while wildlife viewing attracts the highest percentage of resident visitors to Nairobi National Park (26.25%), photography and love for scenery was equally important with responses of 23.75% and 22.5% respectively.

This clearly points out the fact that planning for Nairobi National Park must shift from the 'Planning for Wildlife' prototype to a more broader planning perspective that incorporates not only wildlife per se, but wildlife and its environment in totality.

This study further confirmed the impression that almost 50% of Nairobi National Park is either underutilised or not utilised at all. All the respondents indicated on a map of the park that they had not bothered to visit the western and eastern parts of the park. Continued discussions with visitors inside the park confirmed that the areas were felt to be undeveloped, disinteresting and sometimes dangerous due to the poor condition of roads in the area. Some visitors indicated to the researcher that the area would enjoy greater use if they were to be developed.

This was emphasised through responses by visitors to the effect that the park was lacking in attractions. 62.5% of the resident (Kenya) visitors felt that the range of attractions within the park was clearly inadequate.

This study also found out that a high percentage (55%) would like to visit the park more often but are hindered by a wide range of factors. Of those, it was found out that lack of a wider range in attractions accounted for 28.75% as compared to time and economic constraints which only accounted for 13.75% and 11.25% respectively.

These findings add weight to the need to re-evaluate the objectives governing the continued existence of Nairobi National Park and indeed most other National Parks in Kenya.

This research found out that 75% of the total resident visitors felt that the proposed upper Athi Site held positive aesthetic value as opposed to only 20% who saw nothing of significant aesthetic value in the site. This emohasises the tremendous potential that most parts of the country bear towards the promotion of both internal and external tourism since this country is not lacking in areas of similar geologically natural formations.

Similarly, a significantly high percentage of the sample (65%) was found to associate the site with a lot of ecological/environmental importance. The finding that 70% of the resident visitor population associated the site with positive aesthetic and environmental/ecological importance is a clear indication that the decision as to whether or not to ge ahead with the project must take into account the feelings of one of the impactees - the visitors.

The above finding was however molified by the perceptions of the visitors on the role of such a dam towards changes in aesthetic and ecological/environmental values, its influence on the visiting frequencies and perceived levels of satisfaction attainable.

It was found that 41.25% of the visitors felt that the dam would enhance the aesthetic value of the proposed site as opposed to 21.25% who felt it would decrease the aesthetic value. While 25% of the visitors could not perceive any changes on the environmental value, 22.5% were of the opinion that the dam would increase the value, while an equal number perceived a decrease in the ecologic/environmental quality of the park towards the attraction of the visitors. This latter aspect was not investigated although the implications of the above perceptions should be considered fully before construction of the Upper Athi dam is sanctioned.

This study found out that the proposed Upper Athi dam would help provide a wide diversification in range of attractions. 46.25% of the resident visitors at least perceived an increase in such a range. Earlier on, this study made the finding that over 50% of those visitors who felt they were not visiting the park as often as they would have liked to were in part dissuaded from making more visits by the lack of a sufficient range of attractions, and would by implication visit the park more often if the attractions were diversified.

This implication has been confirmed by the fact that 50% of the respondents said they would visit the park more often if a wider range of attractions was provided. It is therefore reasonable to assume that the construction of the dam would at least lead to a 50% increment in number of resident visitors to Nairobi National Park.

A related finding was the observation that 43.75% of the respondents perceived themselves as achieving higher satisfaction levels as a result of the presence of the dam. The finding on a possible increment in resident visitor numbers is therefore rendered more valid by the above finding.

A finding related to the continued economic viability of the park after construction of the dam was the fact that 67.5% of the resident visitor population was willing to pay more as park entrance charges due to advantages associated with the project. The finding is of importance in that it reveals the fact that visitors are not unwilling to pay more as long as there is a corresponding increase in the utility of any resource.

The above findings were summarised by a statistical test of hypotheses two and three. It is closely related to the range of attractions offered, levels of satisfaction achieved and percieved value of aesthetic and environmental resources within such areas.

It was demonstrated that the higher levels the above variables attain, the higher the perceived utility of a resource. In view of this, the null hypothesis (of hypothesis two) was rejected and the alternative hypothesis stating that "LEVELS OF SATISFACTION ACHIEVED DURING VISITS INTO NAIROBI NATIONAL PARK AND WILLINGNESS BY VISITORS TO PAY MORE AS PARK ENTRANCE CHARGES ARE STATISTICALLY DEPENDENT" was accepted at the .50 probability level.

In achieving the same objective, it was demonstrated that there is always a desire by users of any recreation facility to achieve maximum satisfaction from such use. Users of such facilities are therefore hardly opposed to modifications which the, perceive as bearing a positive relationship with their satisfaction. Users were in fact found willing to make optimum use of such modified recreation areas, a factor that was found to bear implications on the continued social and economic viability of such resources. It was with this in mind that the null hypothesis (of hypothesis three) was rejected and the alternative hypothesis stating that "THERE IS A RELATIONSHIP BETWEEN EFFECTING CONSTRUCTION OF THE UPPER ATHI DAM AND ANTICIPATED CHANGES/INCREASES IN VISITING FREQUENCIES INTO NAIROBI NATIONAL PARK" was accepted at the .01 level of probability.

7.3 CONCLUSIONS

This thesis has been an attempt to provide an insight into some of the environmental problems that normally occur with the initiation of technologically sophisticated economic development projects.

It has been emphasized that secondary and tertiary impacts bear more relevance than primary effects in that they are more difficult to discern at a glance. Such effects interlink to produce systemic effects whose temporal and spatial dimensions are more diverse than they were originally..

This study has proved that apart from a few scattered benefits, the presence of the Upper Athi dam at the proposed site would be ecologically, socially and economically disastrous to Nairobi National Park. Its very existence as a viable ecologic and economic entity is already threatened by a host of largely exogenous factors. Further disruptions to this already delicate system will bear untold consequences to an area that provides the backbone of wildlife-viewing-based tourism in this country.

This does not imply that economic development is undesirable. Rather, the thesis tries to shed light on the fact that it is not possible to separate economic development from the environment (natural) and social context in which it is proposed.

It is therefore imperative that technically and economically viable mitigating measures be undertaken before such development projects are sanctioned. Only after such an action has been taken can we be sure of the continued existence of a resource base upon which all life forms are eventually dependent on, - the environment in its totality.

7.4 Recommendations

These are addressed to two interest groups:

(i) Planners and policy makers; and

(ii) Scholars:

For the latter group, the recommendations are in the form of suggestions for further lines of research that could be undertaken by scholars interested in the field of environmental impact assessment of water resource development projects.

7.4.1 Proposals for the introduction of economic development related projects within public recreation areas.

Conclusions drawn from this research carry significant policy implications. These have been divided into two sections - general and site specific.

7.4.2 General Planning Considerations

Recreation areas are protected by an Act of Law. This has largely been done to reduce external interference to such areas for purposes of ensuring the existence of such areas in as near their natural state as is practically possible.

Such areas are important not only as recreation areas but often bear great scientific, educational, archaeological and cultural values.

While the purpose here is not to argue against economic development, it has been the thesis of this study that development near recreation areas must be based on ecologically sound principles. The system of linkages governing natural and social phenomena within such areas of wide diversity are too complex and should not be overshadowed by seemingly attractive economic arguments.

It has been demonstrated in this study that the proposed upper Athi dam is interlinked with the entire Nairobi National Park ecosystem. It follows therefore that any primary impacts within and without the impoundment are bound to lead to secondary impacts within the adjoining environment. Apart from the general displacement of species, disruptions on various behavioural traits such as reproduction, feeding and recruitment are bound to occur. Proper mitigation measures must be undertaken by policy makers before such plans and proposals are endorsed.

User opinions are important in planning for development projects which might directly or indirectly infringe on the utility levels of recreation areas, more so when such areas are part of a larger national economic framework.

User perceptions have been incorporated in this research. It has been demonstrated that amenity users are very sensitive to changes that result in modifications of their environments. Disregard of such perceptions is likely to lead to erosion or total collapse of some or all institutions associated with the system. Such perceptions must however be considered, hand in hand, with ecologic considerations; in other words, planners must harmonise the two.

7.4 3 The Upper Athi dam: Proposals for Nairobi National Park.

The above proposals, though broad-based, are applicable to specific situations. The first proposal based on eco-development is relevant to Nairobi National Park in view of the fact that the park is in real terms an 'Island ecosystem'. Coupled with the existence of other external threats to the park, a situation that would bring about an ecological imbalance must be viewed with due caution.

This research has demonstrated that the dam would be associated with a wide range of negative impacts on the ecology of the park. Of particular importance is the effect on the carrying capacity of the park.

The ultimate dimensions of such an eventuality must be fully considered when making the decision as to whether to sanction the project or not. This research has demonstrated the fact that the carrying capacity would likely be exceeded by between 10-25 per cent. Whether such levels are ecologically permissible must be taken into consideration by planners in the formulation of policies geared towards the management of Nairobi National Park in future.

This study has argued that nearly 50% of Nairobi National Park is currently under-utilised or unutilised. The construction of the upper Athi dam will noticeably reduce the spatial area of the park. This is relevant in the light of the fact that the proposed site lies within the already overused central portion of the park. Management planners for the park must seriously consider the 'opening' up of under-utilised areas to absorb the 'displaced' visitor population.

Moreover, this study has proved that the dam would attract a larger number of visitors. Such visitor influxes cannot be accommodated within the central portion of the park. Any attempts to do so would only result in serious denudation of the park due to vehicle and visitor pressure, further leading to a deterioration in the ecologic system of the park.

This research has confidently proved that Nairobi National Park is seriously lacking in recreation-related amenities. This has been shown to affect the number of visitors wishing to visit the park more often. This partly explains the decrease in annual visitor returns over the last eight years. To arrest the deteriorating utility of the park, planners must consider the introduction of extra amenities. This can partly be achieved by the introduction of new picnic spots, observation points and walking trails, among others.

7.4.4 Lines for further research

The continued sustainability of economic development is largely dependent on the 'wise use' of natural resources which after all provide the inputs to such development. It is in the light of this fact that the following suggestions in the field of impact assessment with particular reference to activities within the environment of natural or man-made recreation areas have been made.

(i) It is necessary to formulate assessment models relevant to the country's local situation. The methodologies applied in this study have largely been developed outside this country. In real terms, this study should not have been undertaken due to the absence of relevant analytical models.

However, this country cannot afford the luxury of postponing decisions until such a time when models of reality with a high potential for accurate prediction have been developed. There is a need to make decisions now. Scholars must therefore start from where this study has left off and develop a more suitable model for the analysis of effects of economic development related activities within recreation areas with particular reference to water resource development activities.

(ii) This research has only analysed the perceptions of visitors who can be classified as residents of the country. While the justification for such a bias in sampling is rational, there is a need to incorporate the feelings of non-residents in subsequent researches into the problem.

(iii) There is a need to better understand the nature of ecological relationships within Nairobi National Park. It will be necessary to collect quantitative information on such relationships before final decisions on impacts are made.

(iv) This research would have benefited from an application of cost-benefit analysis. Indices from such analysis would have provided sufficient justification to the conclusions of this study.

As it is, the study has fallen short of giving a decision as to whether the project should be allowed at the proposed site. Planners and policy makers have been left with the task of making the final decision after careful consideration of all the facts and information contained in this study. The need for a cost-benefit analysis of the problem is unquestionable. In particular, a problem that will have to be faced by scholars in future should be the assignment of values to costs (and returns) which are basically non-pecuniary (i.e. have no financial value). This is essentially a problem of assessing the value of environmental amenities which are not readily identifiable with a market value, such as scenic beauty.

Due to logistical, financial and time constraints, this problem was not effectively addressed in this study. However, the study has provided valueable information that would greatly facilitate the undertaking of such an exercise.

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APPENDIX A

QUESTIONNAIRE ADMINISTERED TO NAIROBI NATIONAL PARK VISITORS

Dear respondent,

Good day. I am conducting a survey on the Nairobi National Park and its various attractions. The survey is intended to collect data for a research project which is part of M.A. degree in Geography at the University of Nairobi.

Your cooperation in answering these questions will be highly appreciated. All information will, of course, be treated confidentially.

May I take this opportunity both to thank you in advance for your cooperation and to wish you a pleasant safari into the park.

Thank you.

CHEGE KANIARU

INSTRUCTIONS:

1. Unless otherwise stated, put a tick alongside the answer of your choice.

2. Questions 8 to 22 require personal observation and can only be answered if you happen to visit the southern end of the park along the Mbagathi river, an area which offers several unique attractions.

   In particular observe the area around Sosian and Mokoyeti gorges, Leopard Cliffs and baboon escarpment.

Questionnaire number _____

Date and time given out _____

Date and time received back _____

Status: Citizen _____

Resident Non-Citizen _____

1. Are you a regular visitor to this park?

   (1) Yes _____

   (2) No _____

2. If yes, roughly how many times do you visit this park in a year?

   (1) One to two times _____

   (2) Three to four times _____

   (3) Five to six times _____

   (4) Seven or more times _____

3. Do you think you are visiting this park as often as you would want to?

   (1) Yes _____

   (2) No _____

4. If no, what is the reason?

   (1) It is too expensive _____

   (2) It is too time consuming _____

   (3) The park is lacking in a wider variety of attractions _____

   (4) Others (specify) _____

5. Why did you visit this park today?

(1) To kill boredom _____

(2) For recreation _____

(3) Love for scenery _____

(4) Photography _____

(5) To overcome urban stress _____

(6) To admire wildlife _____

6. How would you rate your over-all experience of visiting this park today?

(1) Very satisfying _____

(2) Satisfying _____

(3) Dissatisfying _____

(4) **Very** dissatisfying _____

7. In your opinion, do you think the various attractions being offered in this park are adequate?

(1) Yes _____

(2) No _____

8. From a broad point of view, could you try to evaluate the southern part of the park (along the Mbagathi river valley) in terms of its scenic value. Do you think it is:

(1) Very attractive _____

(2) Fairly attractive _____

(3) Of no particular attraction _____

(4) Don't know _____

9. Do the same as in question number (8) for environmental/ecological value. Do you think it is:

(1) Very important/valuable _____

(2) Fairly important/valuable _____

(3) Of no particular importance/ value _____

(4) Don't know _____

NOTE:

Let us assume a large dam (covering 180 ha) were to be constructed along the southern end of the park across the Mbagathi river submerging Sosian, Mokoyeti and Mbagathi gorges. Using such an assumption, answer the following questions.

10. In your opinion, would the construction of such a dam . . .

(1) Decrease the ecological/environmental value of the area _____

(2) Not change the ecological/environmental value of the park _____

(3) Increase the ecological/environmental value of the park _____

(4) Don't know _____

11. Do you think the presence of such a dam would

(1) Decrease the scenic beauty of the area _____

(2) Not change the scenic beauty of the area _____

(3) Increase the scenic beauty of the area _____

(4) Don't know _____

12. In particular, what would you say is attractive (aesthetically) about the southern end of the park?

(1) Its vegetation (Riverine) _____

(2) Birds _____

(3) Mammalian wildlife _____

(4) The gorges _____

(5) The river valley _____

(6) The general landscape _____

13. Having visited the area proposed to accommodate the dam, do you think the area bears any attraction worth preserving?

(1) Yes _____

(2) No _____

14. If yes, what kind of attraction?

(1) Animals _____

(2) Birds _____

(3) Vegetation _____

(4) Scenic beauty _____

15. Would the construction of such a dam

(1) Increase the variety of attractions within the park _____

(2) Not change the variety of attractions within the park _____

(3) Decrease the variety of attractions within the park _____

16. If such a dam were to be constructed, do you feel you would

(1) Achieve a higher level of satisfaction from visiting the park _____

(2) Experience no change in levels of [illegible] visiting the park

16.

(3) Experience decreased levels of satisfaction from visiting the park _____

17. In the event of the construction of such a dam, do you feel you would

(1) Visit the park more often _____

(2) Not change your frequency/pattern of visit to this park _____

(3) Visit the park less often _____

18. By how many times would you like to either increase or decrease your frequency of visits to this park as a result of the construction of such a dam?

(1) One time _____

(2) Two times _____

(3) Three times _____

(4) Four or more times _____

19. In view of the various attractions found within the park, do you think the entrance charges are

(1) Too low _____

(2) Moderate _____

(3) Too high _____

20. With the construction of such a dam, would you be willing to pay more as park entrance charges?

(1) Yes _____

(2) No _____

21. How much more would you be willing to pay?

(1) Kshs. 1-4 _____

(2) Kshs. 5 - 9 _____

(3) Kshs. 10 - 14 _____

(4) Kshs. 15 - 19 _____

(5) Kshs. 20 - 24 _____

(6) Kshs. 25 - 29 _____

(7) Kshs. 30 or more _____

22. Finally, would you be opposed to the construction of such a dam on that particular site?

(1) Yes _____

(2) No _____

That is all. Thank you for your cooperation.

APPENDIX B

SUMMARY OF RESPONSES ON A QUESTIONNAIRE ADMINISTERED TO A SAMPLE OF NAIROBI NATIONAL PARK VISITORS

Question No.	Answer/choice No.	No. of Responses	% of Responses
1	1	53	66.25
	2	27	33.75
2	1	8	10.00
	2	33	41.25
	3	27	33.75
	4	12	15.00
3	1	36	45.00
	2	44	55.00
4	1	9	11.25
	2	11	13.75
	3	23	28.75
	4	1	1.25
5	1	4	5.00
	2	12	15.00
	3	18	22.50
	4	19	23.75
	5	6	7.50
	6	21	26.25

.....cont'd

APPENDIX II (Contid)

Question No.	Answer/Choice No.	No.of Responses	% of Responses
6	1	15	18.75
	2	27	33.75
	3	29	36.25
	4	9	11.25
7	1	30	37.50
	2	50	62.50
8	1	27	33.75
	2	33	41.25
	3	16	20.00
	4	4	5.00
9	1	19	23.75
	2	33	41.25
	3	18	22.50
	4	10	12.50
10	1	18	22.50
	2	20	25.00
	3	18	22.50
	4	24	30.00
11	1	17	21.25
	2	24	30.00
	3	33	41.25
	4	6	7.50

APPENDIX B (Cont.)

Question No.	Answer/Choice No.	No. of Responses	% of Responses
12	1	10	12.50
	2	3	3.75
	3	2	2.50
	4	25	31.25
	5	8	10.00
	6	12	15.00
13	1	48	60.00
	2	32	40.00
14	1	5	
	2	14	
	3	15	
	4	14	
15	1	38	47.50
	2	26	32.50
	3	16	20.00
16	1	35	43.75
	2	30	37.50
	3	15	18.75
17	1	38	47.50
	2	26	32.50
	3	16	20.00

APPENDIX B (CONT.)

Question No.	Answer/Choice No.	No. of Responses	% of Responses
18	1	9	11.25
	2	29	36.25
	3	12	15.00
	4	4	5.00
19	1	32	40.00
	2	34	42.50
	3	14	17.50
20	1	54	67.50
	2	26	32.50
21	1	0	0
	2	4	5.00
	3	9	11.25
	4	11	13.75
	5	17	21.25
	6	9	11.25
	7	4	5.00
22	1	35	43.75
	2	45	56.25

APPENDIX C

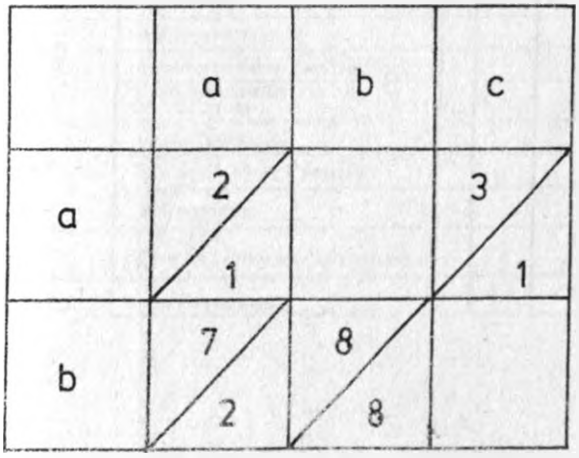
INSTRUCTIONS TO THE LEOPOLD INFORMATION MATRIX FOR ENVIRONMENTAL ASSESSMENT.

1. Identify all actions (located across the top of matrix) that are part of the proposed project.

2. Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.

3. Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greates magnitude of the impact and 1, the least,(No.Zeroes). Before each number place+ if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e.g. regional versus local); 10 represents the greates importance and 1, the least (no Zeroes).

SAMPLE MATRIX



APPENDIX D

INFORMATION MATRIX FOR ENVIRONMENTAL IMPACT ASSESSMENT

ACTIVITIES WHICH MAY CAUSE ENVIRONMENTAL IMPACT

EXISTING CHARACTERISTICS AND CONDITIONS THAT MIGHT BE AFFECTED

	OTHERS	ECOLOGICAL RELATIONSHIPS				CULTURAL FACTORS						BIOLOGICAL CONDITIONS									PHYSICAL AND CHEMICAL CHARACTERISTICS			
						AESTHETIC AND INTERESTS			RECREATION		LAND USE	FLORA					FAUNA				PROCESSES		WATER	
	COMMUTATIONS	STRESS - STRAIN	FOOD CHAINS	DISEASE - INSECT VECTORS	EUTROPHICATION	RARE AND UNIQUE SPECIES OR ECOSYSTEMS	UNIQUE PHYSICAL FEATURES	LANDSCAPE DESIGN	SCENIC VIEWS	FISHING / HUNTING	GRAZING AND [illegible]	ENDANGERED SPECIES	AQUATIC PLANTS	GRASS	SHRUBS	TREES	AQUATIC MAMMALS & REPTILES	FISH	LAND ANIMALS INCLUDING REPTILES	BIRDS	DEPOSITION (SEDIMENTATION)	EROSION	QUALITY	TEMPERATURE
ALTERATION OF GROUND COVER																								
RIVER CONTROL AND FLOW MODIFICATION																								
EXOTIC FLORA AND FAUNA INTRODUCTION																								
ROADS AND TRAILS																								
DAMS AND IMPOUNDMENTS																								
BARRIERS																								
OPERATIONAL FAILURE																								
COMPUTATIONS																								

APPENDIX E

KEY OF THE DELPHI PROBABILITY ESTIMATE FIGURES

A. Vertical axis

This represents temporal forecasts/estimates (in years after the project commencies) of occurrence of particular events under considerations in round 1. There are no estimates (temporal) for round 1 since the respondents were only required to predict events that are likely to occur with the construction of the Upper Athi dam. Rounds 2,3 and 4 involved the forecasts of time occurrence of predicted events.

B. Horizontal axis

The axis represents the questionnaire/round/iteration number. Four questionnaires were administered to the respondents and are represented on the horizontal axis as questionnaires 1,2,3 and 4.

C ———

This line segment represents the flow in estimates of times of occurrence by respective respondents. Most lines start at the intersection between questionnaire number 2 and the time estimated (vertical axis) by a respondent. The line segment then flows on to the intersection between questionnaire number three and the revised time estimate of occurrence of event under consideration and then on to questionnaire number four. The numerals on top of the line segments indicate the respondent (number) who made that particular estimate. More than one numeral on top of a line segment indicates that more than one respondent made the same time estimate for the event under consideration.

D. ———

The 'line' indicates that the respective respondent had given a 'never' response in the previous iteration. For example, in figure ∞, a similar 'line' appears on top of

Cont.... APPENDIX E

questionnaire three with a numeral three alongside it. This indicates that respondent number three had indicated in round 2 that the event under consideration would never occur. The respondent later indicated (in questionnaire number 3) that the event would occur on or after the first year after inundation.

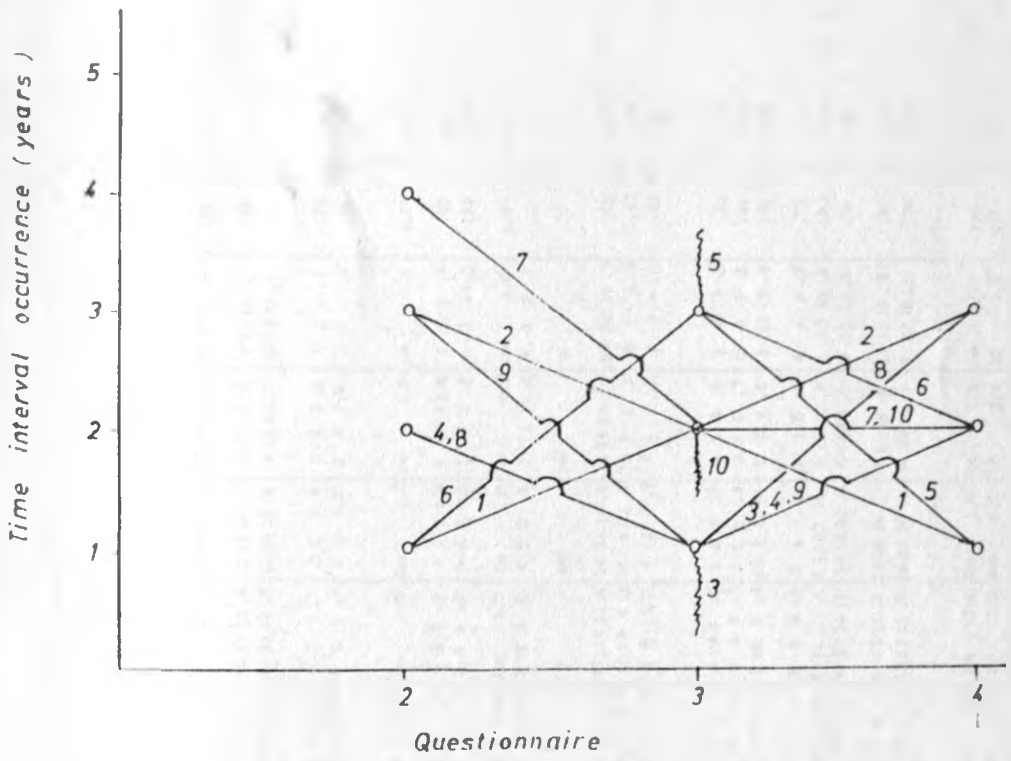


Fig. ∞ key to the Delphi probability estimate figures

APPENDIX F

RESULTS OF THE DELPHI EXERCISE

RESPONDENTS, ITERATIONS, TEMPORAL ESTIMATES AND PROBABILITIES OF OCCURENCE

Elements/Effects Sedimentation	1 2 3 4 p(i)	2 2 3 4 p(i)	3 2 3 4 p(i)	4 2 3 4 p(i)	5 2 3 4 p(i)	6 2 3 4 p(i)	7 2 3 4 p(i)	8 2 3 4 p(i)	9 2 3 4 p(i)	10 2 3 4 p(i)	Mean p	Median p
1. Shorten lifespan	20 34 25 .6	28 26 26 .5	25 25 25 .7	23 23 23 .6	25 25 24 .6	30 27 24 .5	26 26 25 .7	20 25 24 .6	23 24 25 .7	30 27 27 .4	.59	.60
2. Accelerate eutrophication	12 11 12 .8	16 10 11 .7	14 11 12 .7	15 12 11 .8	10 12 12 .6	8 11 11 .7	10 11 12 .6	12 12 11 .7	6 10 11 .6	8 10 12 .8	.70	.70
3. Reduce productivity	14 15 14 .6	20 15 13 .5	16 13 14 .6	18 12 14 .5	10 14 13 .7	10 13 13 .4	14 13 13 .8	12 15 12 .6	8 12 13 .7	10 13 12 .6	.62	.60
Birds												
1. Elimination	1 2 1 .5	3 2 3 .8	N 1 2 .6	2 1 2 .7	N 3 1 .9	1 3 2 .9	4 2 2 .7	2 1 3 .6	2 1 2 .9	N 2 2 .5	.79	.80
2. Introduction	4 6 4 .9	3 4 4 .9	6 6 5 .9	3 5 4 .6	2 3 4 .9	4 4 3. 9	6 4 5 .8	5 5 4.8	2 4 5.8	5 3 4 .9	.86	.90
Fauna (terrestial)												
1. Elimination of feeding/ browsing ground	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	2m 1.0	1m 1.0	1.0	1.0
2. Displacement of animals	3 2 21.0	1 3 2 .9	2 3 3 .9	2 2 2 .8	1 2 21.0	3 2 3 .9	5 2 2 .9	3 2 2 1.0	4 3 32.0	2 3 2 .8	.92	.90
3. Increment of stress	3 3 2 .7	1 3 3 .6	3 2 3 .9	7 4 3 1.0	4 4 3 .9	5 3 4 .7	2 4 2 .8	5 4 3 .8	3 3 3 .8	4 3 31.0	.82	.80
4. Elimination of shade and cover	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1.0	1.0
5. Reduced animal range	2 4 2 1.0	1 3 2 .5	4 4 4 .9	6 3 2 .9	3 3 3 1.0	3 4 21.0	1 2 2 .8	4 2 3 .9	1 2 21.0	4 3 2 .7		
6. Destruction of migration patterns	1m	1m	N	1m	1m	N	N	1m	1m	N		
Fauna (Aquatic)												
1. Population explosion	16 16 15 .6	10 14 14 .4	15 14 15.6	12 13 14.7	18 15 15 .5	12 14 14 .8	17 14 15 .4	14 14 14 .6	13 13 15 .4	10 14 15 .5	.55	.55
2. Land-use conflict	14 7 5 .8	10 6 6 .9	16 8 5.7	14 5 4.8	16 8 6 .6	15 7 5 .8	10 6 6 .3	16 6 6 .7	12 8 5 .5	8 5 4 .6	.67	.70
Flora (terrestial)	5 3 4 .7	3 3 5 .7	3 5 5 .8	6 4 41.0	5 4 4 .8	3 5 5 .6	4 6 5 .7	4 5 4 .9	5 4 4 .9	3 5 41.0	.81	.80
1. Decreased due to stress												
Flora(Aquatic)												
1. Introduction	4 3 31.0	6 2 31.0	5 3 31.9	3 3 31.0	6 3 3 1.0	3 3 3 .8	5 4 4 .9	2 3 4 .9	4 3 3 .8	2 2 3 .9	.92	.90
2. Reduce Shore Erosion	7 5 6 .6	10 6 6 .5	8 7 5 .6	6 6 6 .8	7 5 6 .7	6 7 7 .5	6 6 7 .7	5 6 6 .8	5 7 6 .7	5 6 7 .5	.64	.65
3. Act as filter	12 10 8 .5	14 11 9.5	10 8 9 .5	13 10 10 .7	8 8 10 .4	5 9 9 .3	7 10 9 .6	10 8 8 .4	5 8 9 .5	5 10 9 .4	.46	.45
4. Source of nutrients/ energy	6 6 6 .6	7 6 6 .8	6 6 6 .7	5 5 6 .8	8 6 6 .6	5 5 5 .7	8 6 6 .8	5 5 6 .8	7 5 6 .6	4 6 5 .7	.71	.70
5. Impediment to flow	14 12 12 .7	17 12 11 .9	13 13 13.5	15 11 12 .6	12 12 12 .7	9 14 11 .9	8 11 11 .6	8 12 13 .6	6 13 12 .8	7 10 11 .8	.71	.70
6. De-oxygenation	13 10 12 .9	15 12 12 .6	15 13 12 .8	14 14 13 .9	15 11 13 .9	12 13 13 .7	13 12 12 .7	11 13 12 .8	8 14 14 .9	9 12 12 .6	.78	.80
7. Increase sedimentation rate	15 13 14 .8	10 14 14 .8	17 15 15 .9	16 16 14 .7	16 13 15 .8	14 16 16 .9	15 15 15 .8	13 16 14 .7	10 14 14 .8	12 15 15 .9	.81	.80
8. Increase Eutrophication	14 14 14 .7	18 16 16 .9	13 15 15 .7	15 16 15 .8	15 15 15 .9	16 16 16 .6	17 15 15 .8	16 16 16 .7	14 16 16 .7	17 15 16 .8	.76	.75
Tourism(Selic attraction)												
1. Destruction	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1m 1.0	1.0	1.0
2. Creation	50 1.0	1m 1.0	1m 1.0	1m 1.0	50 1.0	50 1.0	1m 1.0	1m 1.0	1m 1.0	50 1.0	1.0	1.0
3. Attraction of more visitors	5 5 4 1.0	4 4 4 .7	5 4 4 .8	4 4 4 .9	3 5 5 .7	6 4 5 .7	5 5 5 .9	6 4 5 .9	3 5 4 1.0	4 5 4 .9	.85	.90
4. Attract less visitors eventually	16 16 14 .9	14 15 15 1.0	13 15 15 .9	13 16 15 .7	16 15 14 .9	15 15 15 .8	16 15 15 .7	12 15 15 .7	10 16 15 .9	15 15 16 1.0	.85	.90

APPENDIX F CONTINUED

RESPONDENTS, ITERATIONS, TEMPORAL ESTIMATES AND PROBABILITIES OF OCCURENCE

Elements/Effects Sedimentation	1	2	3	4	5	6	7	8	9	10	Mean p	Media p
	2 3 4 P(i)	2 3 4 p(i)	2 3 4 p(i)	2 3 4 p (i)	2 3 4 p (i)	2 3 4 p (i)	2 3 4 p (i)	2 3 4 p (i)	2 3 4 p (i)	2 3 4 p (i)		
Pollution												
1. create alieu tastes and orocurs	19 2o 20 .4	21 21 21.6	18 21 20.6	20 20 21.4	18 19 20.5	19 19 21.3	20 19 20.5	18 21 21.4	20 20 20.6	24 21 21.5	.48	.50
2. Render water unpotable	20 21 21 .3	23 22 22.5	22 22 22.4	20 23 23.6	22 22 22.4	24 22 23.4	23 23 22.7	28 21 22.6	21 23 22.5	26 23 22.6	.50	.50
3. Discourage tourism	22 24 24 .9	26 23 25.3	27 25 25.5	27 24 25.4	25 26 24.7	28 24 25.5	27 23 25.6	26 24 24.5	23 25 24.7	29 26 25.5	.61	.60

APPENDIX G

VISITORS GUIDE MAP OF NAIROBI NATIONAL PARK