Monitoring Health in African Dams

The Kamburu Dam (Kenya) as a Test Case

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE GENEESKUNDE
AAN DE ERASMUS UNIVERSITEIT ROTTERDAM
OP GEZAG VAN DE RECTOR MAGNIFICUS
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Without man development has no meaning;
without health development can have no secure basis.

A.A.Quenum

Once the proper questions are asked and the relevant facts collected,any sensible person can reach the correct conclusions.

M.D. Greenwood

Limitations are fundamental to understand the human predicament. Resources, information, intelligence, rationality and sympathy are the limiting factors.

G.J. Warnock

Contents

Preface

Dams are among the obvious efforts to improve the economic situation in a developing country. They aim at using locally available natural resources. At present they are among the most popular means for promoting socio-economic development. A significant number of these programmes have been undertaken in Africa during the past two decades, and it is to be expected that many more will follow in due course.

Dams are anything but natural. They do not fit into the old balance which nature established between climate and environment. Man responded to this ecological situation by creating systems of food production, by rigidly adhering to their routine, by constructing shelter fitting the needs of his household, and by developing customs and rules to guide his daily life. These conditions of human living, also called subsistence economy, still prevail in many parts of Africa, and we usually consider them as belonging to a traditional life-style.

But technological progress tends increasingly to disrupt the old ways of life by promising a different and brighter future. Obstructing the natural flow of rivers on a previously unprecedented scale, and subjugating them to the strivings of man is just one of them. For growing food where this was formerly scarce, and for multiplying power which formerly depended on man's muscles only, this procedure is very efficient.

As, however, only the sun rises for nothing, such gigantic efforts have to be paid somehow in gigantic currency. A dam creates a crisis situation in a given ecological setting. It does more than throwing up another physical gradient. It creates a new environment not only for flora and fauna, but also for man.

Especially the history of the great seas-connecting canals is full of calamities following such interventions. Of the more recent history of numerous larger and smaller dams it can be confidently stated that every one was followed by undesirable or unforeseen effects. In recent years the attention for those effects has rapidly grown, and is still expressing itself in relevant documentation.

Water and development in Africa are items very different from those in temperate climates. They have much more to do with health and wellbeing of the people involved. Those people are far less prepared for the implications than in economically advanced societies. That means that much more attention and efforts should be spent on planning, monitoring and evaluating the health effects at the introduction of dams and irrigation.

The author himself was confronted with the consequences of dam construction on two different occasions. First, at Yelwa (Northern Nigeria) when he was a local doctor near the newly created lake behind Kainji Dam. Second, as a lecturer in Community Health at the University of Nairobi (Kenya). At that time the Kamburu Dam was already well underway in construction. The necessity to look into future health problems of the people concerned came as an afterthought, for which provisions had not been made. Only "modest" means were made available to Professor Odingo, who was in charge of the project. This lead to a pluridisciplinary ecological survey in 1974, followed by a repetition in 1977.

Later on, in discussions with experts of WHO, FAO, UNDP and the World Bank the absence of more comprehensive documentation was often deplored. Many incidental reports and documents existed but they were hardly accessible, and reliable guidelines were not established.

In view of the many dams yet to come, and the gigantic investment needed, this pilot study will attempt to demonstrate that it is possible to document the health effects of development without an elaborate research organisation. In PART I a frame is presented in which to fit the manifold aspects of health planning. Such a frame is necessary for selecting the components of health monitoring. In PART II a factual account is given of the conditions encountered, methods employed and results obtained during our trials to monitor health in the development of the Kamburu Dam. Our research was guided by the belief that health problems related to dams and irrigation are more of an especial chapter in intelligent rural development, than a mere problem of waterrelated diseases.

PART I

Development of waterresources and health

Chapter 1

A review of development of waterresources in the African continent

1. INTRODUCTION

Africa is the second largest continent and has nearly one quarter of the world's land surface to support one tenth of the world population. It contains the Nile, the longest river of the world and the Congo or Zaire, the second largest; Lake Victoria, the second largest fresh water lake with the longest lake-shoreline; Lake Tanganyika, the second deepest lake; the imposing lake system of the Great Rift Valley; several inland lake basins like those of Lake Chad, Lake Rudolf and others. Combining all these evokes a vision of abundance of waterresources, and wealth.

At the same time, however, the African continent contains the largest deserts in the world, the Sahara, to the North of the Equator and the Kalahari in the South. The climate in extensive parts is arid or semi-arid, and distress and devastation caused by prolonged droughts in the Sahel, but also in other parts, are a source of increasing concern. There is an ever rising need for the essentials of living; for human and animal food and the basic domestic amenities such as drinking water and sanitation.

The African land masses straddle across the Equator extending from latitude 37 degrees North to 35 degrees South. Its geologic structure is formed by deposits of sedimentary rocks alternating with massive outcrops of crystalline rocks. The whole forms a table land bordered by broken terraces and escarpments. The continental island of Madagascar is a relic of a former land connection with the main continent. The relief of Africa has been classified in three divisions:

1. A ring of plateaux, elevated somewhat above the interior, falls abruptly to the sea on the outer side. The highest point of the rim is in the South East, where the Drakenburg Mountains rise to 3400 m . The plateaux of Northern and Central Africa are comparatively low, averaging 400-600 m above sea level, which contrasts with the high plateaux to the East and South, which average 900-1200 m . In East Africa gigantic fractures in the earth crust have affected relief formation, and constitute the Great Rift Valley, flanked by the continent's highest mountains of Kilimanjaro, Kenya and Ruwenzori.
2. The Atlas region in the North West is composed of parallel mountain chains roughly running South West to North East and enclosing a high plateau.
3. The Southern ridges and valleys are formed by mountain folding, and are cut by rivers flowing along the softer outcrops.

The general configuration of the continent is responsible for the characteristic features in river drainage. The dividing lines between the headwaters of rivers are sometimes ill-defined, and in their middle courses the streams flow sluggishly and often spread over wide floodplains, or form swamps such as the Sudd of the Nile, the Inland Delta of the Niger or the Okavango. In their lower courses the rivers enter wild gorges and descend by falls to the sea. The drainage pattern of the continent is outlined on the map.

The African climate is influenced by the position of the continent in relation to the Equator, crossing subtropical and tropical belts. This, combined with great variations in altitude causes an enormous variety in climatic conditions. The common factor nearly all over is the high insolation and hence the high evaporation. Average rainfall, however, ranges from 5 mm/ annum in Wadi Halfa (Sudan) to over 4000 mm/ annum on the West Coast of the United Republic of the Cameroons. There is perpetual snow on mounts Kilimanjaro, Kenya and Ruwenzori, while large parts of Northern Africa have a mean day temperature of over 40 degrees centigrade on 100 or more days each year.

The African population is small in proportion to that of other continents. In no other part of the world does the influence of high temperature and deficient rainfall create such serious problems for man's survival and fitness. The soils in many areas are eroded, limiting the use of land to nomadic pastoralism. Adverse climatic conditions and soil erosion may partly explain why Africa, with about 17% of the world's arable land, and 23% of the pasture lands, produces no more than 4% of the world's agricultural output.

With an annual population growth of 2.5-3% or more, as reported by many countries, the population of Africa was estimated to number 370 million in 1980, and the figure may approach 600 million by the year 2000. In 1979 Africa's health situation was crudely assessed (WHO, 1974) by the following mortality indices: neonatal mortality 50-80 per 1000 births; infant mortality 100-200 per thousand; and cumulative mortality from 0 to 5 years of age 300-500 per thousand. Childbirth in these areas is often attended by high maternal mortality. The growing medical establishment and the expansion of immunization, antimalarial and antibiotic treatment will most likely reduce mortality from infectious diseases considerably in the coming years, thereby further enhancing the already high population growth. The supply of food and other basic amenities to the rapidly growing population therefore is an urgent problem to the African governments.

2. WATERRESOURCES IN PERSPECTIVE

(The information in this section derives from: Economic Commission for Africa, 1976)

The assessment of waterresources in Africa has been crude and incomplete so far. It has been estimated that 2481 cubic km of water is available per year from surface runoff through the main river systems. In addition enormous supplies are present as underground water. Further studies would be needed to indicate what quantities could be considered as economically exploitable resources, and what quantities could be available for different purposes such as domestic water supply, irrigation, livestock and industrial uses, and for the generation of hydropower. So far known the available quantity of water is liberal and compares to that of China, with a much larger population, and Canada. It was estimated that at the present time the total water utilization and consumptive use of water for the community water supplies and irrigation is of the order of 80 to 90 cubic km . The consumptive use of water in industry is taken as insignificant in comparison with this quantity. On this basis only about 2% of the water wealth of Africa may be considered as being used at present for consumptive purposes.

The principal uses of water to be considered in the perspective of an expansion of the utilization of waterresources are:
(1) Community water supplies and waste water disposal
(2) Use of water in agriculture
(3) Use of water for the generation of hydropower
(4) Uses in industry
(5) Inland water transport

Water Supplies

A survey on water supply and sewage disposal was conducted by the World Health Organisation in 1970. Surveys covered a population of 280 million of whom 70 million were living in urban centres. According to the survey findings 73% of the urban and 19% of the rural populations studied, had reasonable access to safe water. The goals set for the Second United Nations Development Decade call for the extension of water supplies to serve 100% of the urban and 25% of the rural populations in the year 1990. Similar findings and targets apply to the sanitary situation. Although the targets for the year 1990 are not realistic and need to be redefined regularly against the progress made, these figures nevertheless indicate the scope for expansion of water consumption in the domestic sector.

Agriculture

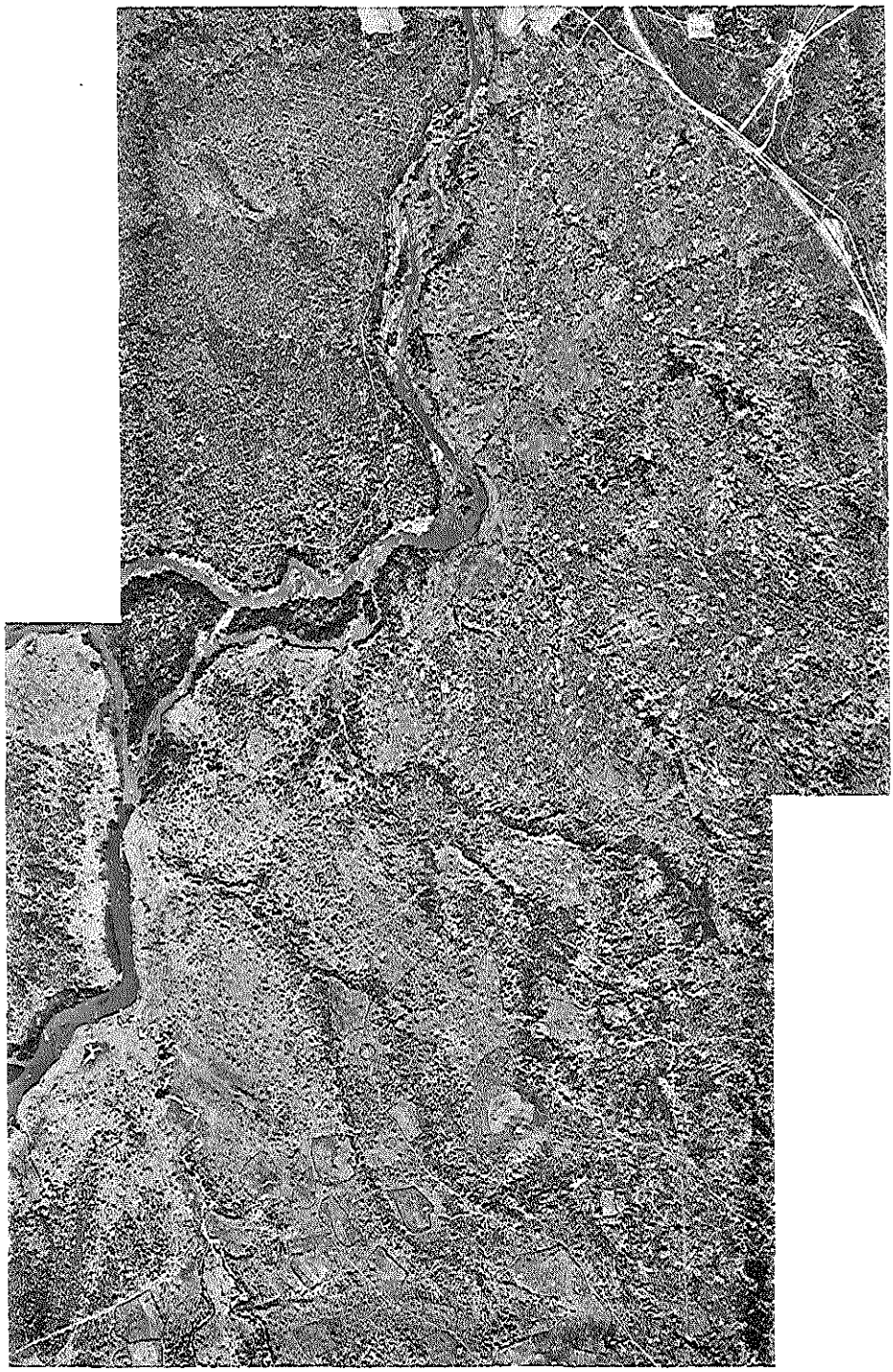
Water use in agriculture is closely linked to land use. For the total area of Africa, measuring 30,310,000 sqkm, land use is as follows:

- Arable land, including land under permanent crops	7%
- Permanent meadows and pastures	26%
- Forest and woodland	21%
- Other land (mostly desert and uncultivable)	46%

The proportion of arable land to the total area of Africa is lower than in other parts of the world (average 11%). The latter is also the case for the lands classed as forest and woodland (world average 30%). The fact that nearly half of all the land is classified as 'other' brings out the importance of proper land use and management for food production and agricultural productivity. Optimum land use is closely dependent on the use and management of waterresources.

Between 1970/75 food production had increased to an index level of 121-127, taking the level of the period 1960-65 as the 100% baseline. Though these figures suggest an improvement in the food situation, the opposite is true.Because of the rapid increase in population the level of food produced per caput actually decreased during the period to 93-101%. The figures for agricultural output are very similar. To improve this situation and increase the per caput food production and agricultural output there are basically two approaches. The first is to expand the area of cultivated land and the production area. The second is to increase the yield per unit of land. The single most essential requirement for both approaches is the provision and control of water. This may be relevant to irrigation,drainage,flood protection,stock watering, fisheries production, supply for domestic or rural industrial purposes, the control of water breeding insect vectors of disease, and usually is directed at a combination of these activities.

It has been estimated that the total cultivated area is about 150 million hectares, and that the area under irrigation is of the order of 8 million, a 5% share. Since proportionally more of the irrigated areas are in Egypt and the Sudan, the area irrigated in countries South of the Sahara is much less and may be of the order of 2% of the total cultivated area. However, also in these countries there is an increasing interest in the development of irrigation. Irrigation projects commanded about 2 million hectares in 1965, against 3 million in



• Aerial view of the Kamburu Dam area before inundation in 1974 showing the sparse vegetation. On the left the confluence of Tiba and Tana Rivers. At the top the main road and construction site. The area to the right of the river belongs to Machakos District, and forms part of the Lakeside area.

1975, an increase of roughly 50%. In the event of actual development of the projects currently in various stages of execution, the irrigated area would measure 4.3 million hectares.

Hydropower

The per caput hydropower potential in Africa is known to be more than three times the world average, while expressed per unit land area the ratio is one and a half. According to the presently available information on the hydropower potential, nearly a third of the world's hydropower is located in this continent.

The installed capacity of all the hydro-electricity projects in Africa represents a mere 5.6% of the potential. And the energy generated in 1974 by the hydropower stations was 34 billion kWh, out of an exploitable amount of 1,630 billion kWh, which works out to about 2%. These figures show the enormous potential which could be expected for the coming years.

The share of hydropower in the total electricity production has been continuously increasing, from 22.9% in 1962 to 28.4% in 1974. This trend towards increased emphasis on hydropower generation in preference to other forms of water use, is likely to continue as a result of the emerging trend in oil prices. The governments of Nigeria, Uganda, the Cameroons, and Zaire have accorded priority to hydropower development in their preference to other forms of electricity generation.

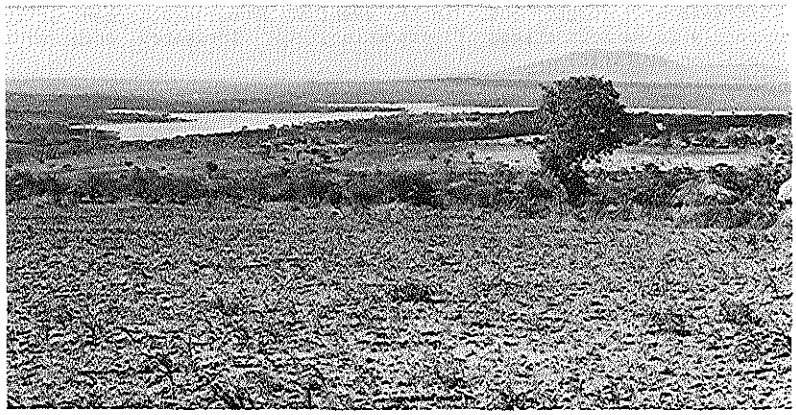
Industry and Transport

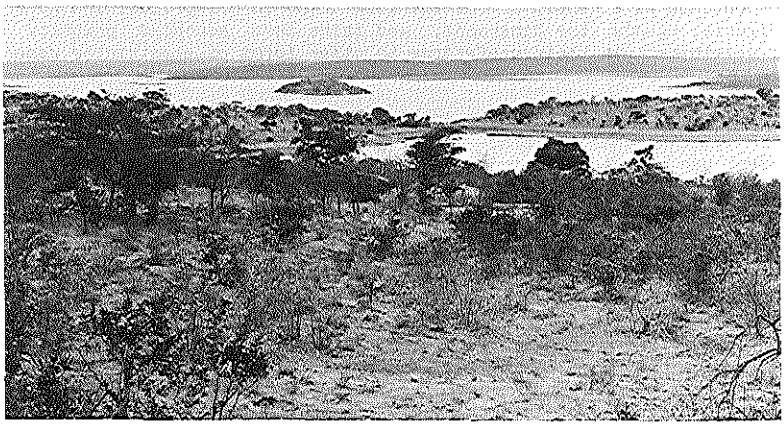
The present use of water for industrial purposes is insignificant, but will increase in coming decades. Industrial production is expected to treble in the course of the next two decades. Industrial growth will make proportional demands on suitable water. Although decisions on the location of new industries will depend on market conditions, the availablity of raw materials and transport, the factors relating to the quantity and quality of water may often become important.

Historically inland water transport was an important element in the communication network of the continent. At present it still plays a vital role in the economic life of a number of countries. Nearly all the major rivers and lakes are used for passenger and commercial transport. There still is an immense potential to be developed as an integral part of multipurpose development projects.

Conclusion

The preceding pages briefly indicate the great wealth in water and non-consumptive waterresources of the African continent, and contrast these to the urgent need for their development. There can be little doubt that in coming decades development of waterresources will continue at a steady , if not fast, rate. The economic investment required is gigantic. From an economic point of view, and even more for humane reasons, there is the imperative demand that such investment is spent efficiently. Optimal economical results and improvements in human living conditions must be realised.





●● View of the Kamburu Lake as seen from the Machakos side since 1974.
● All vegetation had been cleared from the area before inundation.

3. A SHORT REVIEW OF EXPERIENCES IN AFRICA

The dams at Kariba (Zambesi River), Akosombo (Volta River), Kainji (Niger River) and Kossou (Bandama River) were built for the generation of hydro- electricity mainly. In the case of the Aswan Dam (Nile) both hydro-electricity and irrigated agriculture were the main motives. Recent development at Kafue (Kafue River) and Cabora Bassa (Zambesi River) appears to have electricity production as their main objectives.

Pre-construction surveys mainly concerned the collection of technologically relevant information. Restricted socio-cultural surveys were conducted at the last minute in view of resettlement (Scudder, 1975). Baseline health surveys were done on a limited scale at Aswan and Volta. In fact no good baseline data exist. Post construction studies were undertaken at Kariba, Volta, Kainji and Aswan by local research institutes with emphasis on hydrology and limnology. Post construction studies were conducted by UNDP at Kariba, Volta, Kainji, Nasser and Kossou with more emphasis on health problems, mainly schistosomiasis, and fishery development.

Resettlement constituted the least satisfactory aspects of dam construction (Scudder, 1973). About half a million people were involved in resettlement schemes, many more were also affected but were not displaced. Resettlement proved much more costly than estimated ($ 2,000.-/person at Aswan, $ 600.- at Volta and Kainji, $ 150.- at Kariba). The logistical problems of resettlement, as well as the psychological and social effects were grossly underestimated. As a consequence, the disruptive effects extended over many years.

Health problems increased at an alarming rate since impoundment was effected. As health problems take a longer time to develop, they may eventually overtake resettlement as the least satisfactory aspect of waterdevelopment. Documented evidence indicates a staggering increase of schistosomiasis (Deom, 1976).

The negative impact of river basin development on downstream populations has been overlooked, as is well illustrated by the Kainji Dam Project. Adeniyi (1973) found that termination of the annual flood seriously reduced the dry season harvests of downstream farmers and the yields of fishermen. No longer flooded, thousands of hectares went out of cultivation, with over 20,000 households among the Nupe alone affected. The annual income of fishermen decreased after cessation of flooding by 50-70%. Adverse impacts, however, extended much further downstream reaching to the apex of the Niger Delta. According to Awachie (1979) the lower Anambra Basin Northeast of Onitsha, which had hitherto been responsible for 70% of freshwater fish and yam production for Eastern Nigeria, had lost 60% of its fish output and yam produce running into 100,000 tonnes.

The management arrangements were not adequate to deal with a very complex task. Planners and decision makers did not have sufficient understanding of the ecological implications of this type of development in Africa. Planning arrangements were ambivalent in that dam authorities had a limited responsibility and had to compete or co-operate with government ministries. There was a lack of co-operation between ministries of health and development authorities. The infrastructure and manpower needed to conduct the necessary research was insufficient (White, 1972; Ackermann, 1973).

Governments experienced difficulty in obtaining sufficient funds to finance the projects and the resulting uncertainty until the last minute, interfered with planning activities. Economic considerations presumably dominated in financial deals, with little attention to ecological impacts (Jackson, 1970; Rouse Jones, 1968).

A number of international meetings on the subject focussed attention on the adverse effects on health and the resettlement problems:

(1) The Economic Commission for Asia and the Far East
Regional Symposium on Dams and Reservoirs
Tokyo, September 1961
(ECAFE, 1962)

(2) Man Made Lakes
The Royal Geographical Society
London, October 1965
(Lowe-McConnell, 1966)

(3) Man Made Lakes, the Accra Symposium
Accra, November 1966
(Obeng, 1966)

(4) Man Made Lakes: their problems and environmental effects
American Geophysical Union
Knoxville, May 1971
(Ackermann et al., 1973)

(5) Arid Land Irrigation in Developing Countries: environmental problems and effects. International Symposium
Alexandria, February 1976
(Worthington, 1976)

MAP 1 DEVELOPMENT OF WATERRESOURCES IN AFRICA

1 Lake Nasser/Nubia, Egypt/Sudan
2 Jebel Auliya Reservoir, Sudan
3 Sennar Reservoir, Sudan
4 Roseires Reservoir, Sudan
5 Khashm ek Girba, Sudan
6 Koka Reservoir, Ethiopia
7 Sevenforks Scheme, Kenya
8 Owen Falls, Uganda
9 Kagera Basin Project, Ruanda Burundi
10 Nyumba ya Mungu Reservoir, Tanzania
11 Kidatu Ntera Reservoir, Tanzania
12 Mwadingusha/Tchangalele Reservoir, Tanzania
13 Nzilo Reservoir, Zaire
14 Kafue Flats, Zambia
15 Kariba Lake, Zambia
16 Cabora Bassa Dam, Mozambique
17 Tsiazompaniry Reservoir, Madagascar
18 Mantasoa Reservoir, Madagascar
19 Loskopdam Reservoir, South Africa
20 Vaaldam Reservoir, South Africa
21 Hendrik Verwoerddam Reservoir, South Africa
22 Baragem Salazar, Angola
23 Baragem do Gove, Angola
24 M'Bakaou Reservoir, Camerouns
25 Tiga Dam, Nigeria
26 Kainji Lake, Nigeria
27 Sokoto Dam Reservoir, Nigeria
28 Volta Lake, Ghana
29 Bui Dam, Ghana
30 Ayame Reservoir, Ivory Coast
31 Kossou Lake, Ivory Coast
32 Forty Dams Porject, Upper Volta
33 Senegal Basin Project, Senegal

Chapter 2
Aspects of human intervention

1. IMPACT OF DAMS ON THE ECOSYSTEM

1.1 Perspective

The closure of a dam is a dramatic event. From that moment water in the old river bed starts to rise within a short time beyond levels that people have ever known before.

Lake Kainji was filled within a year and a water expanse of 1250 km2 created. In the case of Volta Lake this took nearly 5 years and for Lake Nasser it may take 15 years or longer. From a naturalistic point of view the event is even more significant for, within a time space of a few years, conditions in a river basin have been changed on a scale, which in the past might have taken several thousands of years.

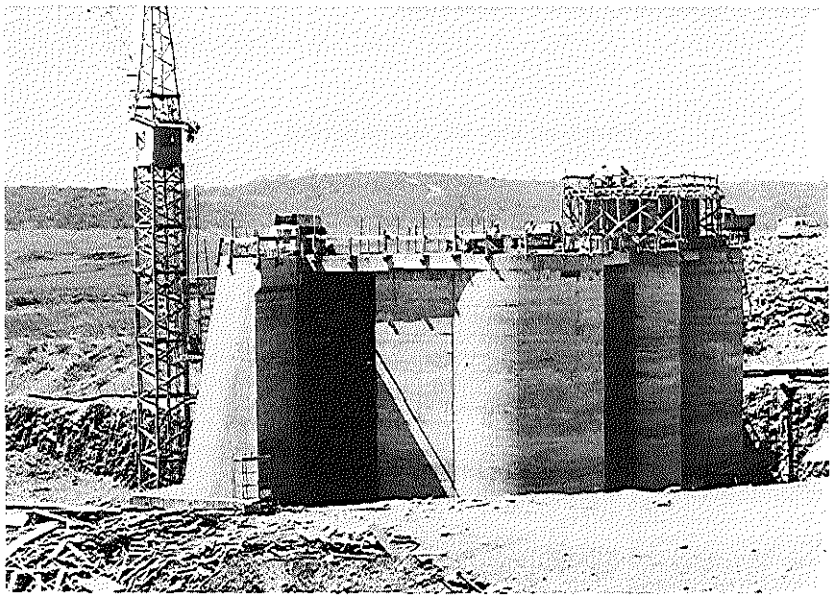
Geological events created the Rift Valley of East Africa and the Victoria basin and a considerably changed aquatic and terrestrial environment resulted. The original "Soudanian" fauna and flora of a riverine environment was forced to adapt to a lacustrine environment and then many new species evolved. In contrast the fauna of the waters of Northern and Western Africa has remained much closer to the original (Beadle, 1974). The diversification of fish, molluscs, insects, birds and mammals, and of the surrounding vegetation in this tropical environment contributed to the diversity of water-related health problems encountered today. Whether the change, which will be induced by waterdevelopment on the scale of the last 30 years could be compared with prehistoric events, is only an academic argument. The fact remains that waterdevelopment is undertaken with the intention to induce socio-economic change.

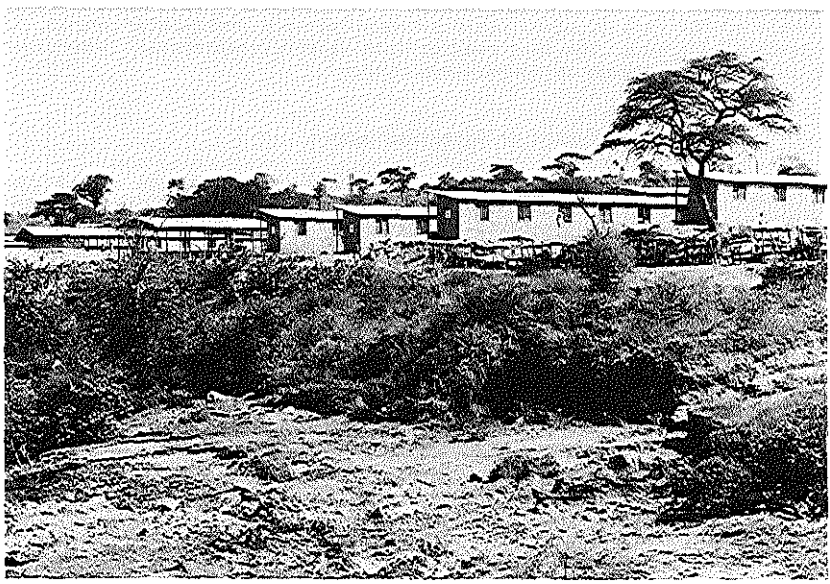
1.2 Impact of Waterdevelopment

A dam lies as a solid mass but also as a seemingly fragile device across the riverbed. It controls the river by the rate of discharge through its gates and turbines and can be adjusted according to definite rules or needs. Many of the biotopes and niches of the previously riverine ecosystem are drowned, modified or simply disappeared. Also below the dam the riverine ecosystem undergoes significant change because of the change in the waterregime and quality of the water. At times a stretch of the old river becomes completely dry and the water is conducted underground to emerge at a distant place.

Where previously the conditions for human habitation were rather limited within the river basin ecosystem, the modification is intended to broaden the human niche by making available more water, more food and more energy. Waterdevelopment in biological terms results in gains and losses and the balance between the two will take considerable time to reach a new equilibrium.

In biological terms the evaluation of the new equilibrium will depend on parameters such as biomass and number of species which finally establish themselves in the new ecosystems. In human terms the ultimate criterion is welfare. As it is difficult to define, it usually is described by socio-economic parameters such as per capita income, employment levels, income distribution, or in socio-cultural parameters referring to type of housing, standard of agricultural practice, educational level, communal organization. Human welfare requires an acceptable standard of health and the relative absence of disease and disability.





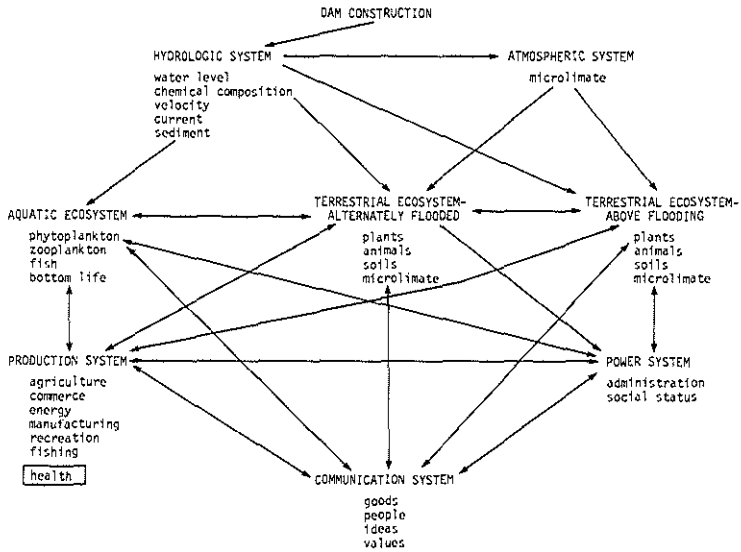
- Intake for Gtaru power plant under construction in 1977. Water will be channelled into three vertical dropshafts to a depth of 140 m, where the turbines are located.
- Camp for labourers at Gtaru construction side in 1977. At the peak of construction nearly 3000 workers were engaged.

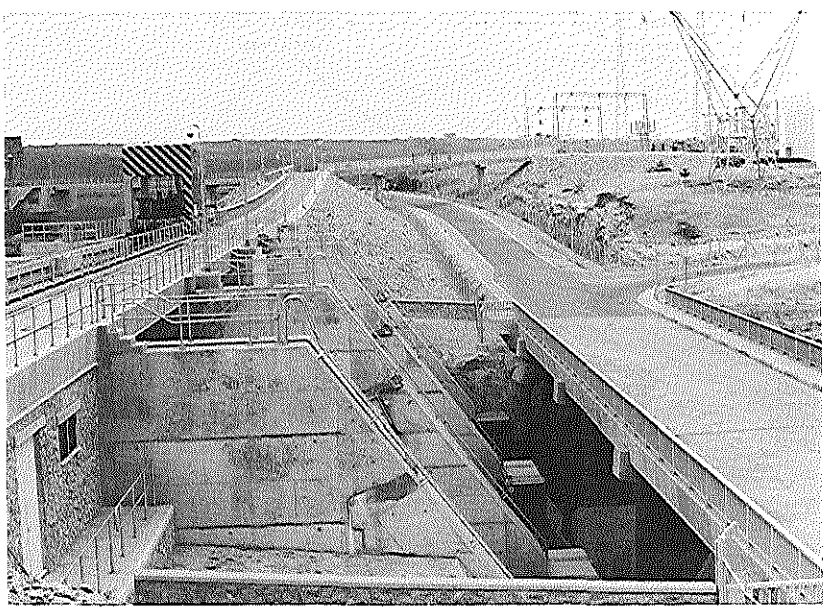
Because the decision to undertake a waterdevelopment project is of great political significance and requires major investments, in reality planners and decisionmakers pay one-sided respect to tangible economic consequences and tend to disregard the less tangible socio-cultural and health aspects.

Waterdevelopment upsets aquatic and terrestrial ecosystems, but these also form part of wider ecosystems to which ultimately man belongs himself. As a result of this interference a chain of reactions and interactions develops, which to some extent can be predicted in qualitative and quantitative terms, provided sufficient is known on the processes involved. The use of ecological models is of great significance in making predictions. Quite advanced models are available describing physical and biological systems. Including man in these ecological models requires the introduction of socio-cultural components and eventually determinants of the political and administrative agencies which are in charge of waterdevelopment.

In general the effects of water impoundment can be classified as positive or negative impacts. The first constitute opportunities, and the last new problems and unwanted disturbances. Accumulated experience of industrialised countries of temperate zones exposes pollution as the main problem . However, in tropical and subtropical countries many problems appear side by side: displacement of large populations, water-related diseases, sedimentation, problems of soil salinization and abundant growth of aquatic weeds (Falkenmark, 1977; Kovda, 1978; Ackermann et al., 1973).

FIGURE 1: Diagram on the Possible Effects of Reservoir Impoundment (source: White, 1972)





- View of Gtaru Dam spillway under construction in 1977.
- Kamburu Dam had been completed since 1974. In front its spillway. In the right upper corner the Control Station. The main road crosses the dam.

1.3 Impact in the Ecosystem Model

The diagram in Figure 1 by White (1972) lucidly illustrates the ecological nature of reservoir impoundment. Within the large ecosystem of the river basin two physical systems, three biological ecosystems and three aspects of human activity are distinguished. For each system some of its components are also indicated. The eight systems are all related and the majority of the relationships are reciprocal.

If we could stop the continuous flow of interactions in this very dynamic lake ecosystem for a moment, and study the effects of human activity, we find that impacts can be further classified, for instance according to their directness or their predictability.

The decision to practice fishery is directly influenced by the water level, but also by the number and species of fish. Terrestrial ecosystems influence the fish production in a less direct way, because decomposing plants and minerals may be washed into the lake and provide more abundant nutrients but this depends on vegetation, soil composition and conditions governing rainfall. Vectorborne water-related diseases also are examples of impacts which require many intermediate steps.

As for predictability the average amount of electricity to be generated per year, or the average area of land that can be irrigated, can be accurately predicted. However, although it can be predicted that in a region where schistosomiasis is endemic, the disease frequency will increase as a result of the lake, the magnitude of the impact will be uncertain. This would require accurate guesses on human sanitary behaviour, the type of snail which will find a suitable habitat in the lake, the adaptation of the wormparasite to the human host and to the snailhost.

Predictability of impact could be a powerful tool in the hands of planners if translated in consequent action. Unfortunately this last step often has not been taken. For instance the rapid increase of water-related disease was accurately predicted for Lake Volta by McDonald (1955), but little action was undertaken.

2. INTEGRATED RIVER BASIN DEVELOPMENT

2.1 Definition

An Expert Panel of the United Nations (UN, 1970) described Integrated River Basin Planning as meaning: "The orderly marshalling of waterresources of river basins for multiple purposes to promote human welfare". This definition mentions three aspects which are central to the whole issue. The orderly exploitation of waterresources requires advance consideration for what purpose they should be used. The use of alternative resources for the same purpose should be carefully weighed against using waterresources. Electrical energy for instance can be generated by means of hydropower, by burning coal, gas or oil, or by nuclear fission. Optimal use of water may be quite different for a country with large mineral resources (Nigeria), or a country which economy relies mainly on agricultural produce (Egypt).

Development of waterresources, because of their economic significance, introduces new forces in the national economy and requires adjustment of National Development Plans. International coordination of development may be needed, as

- Vegetation is being cut down for firewood and charcoal production. Deforestation and eventually erosion ensues.
- Charcoal in bags awaiting transport to the city.

Africa's major rivers nearly all cross several national boundaries.

The main purposes for which waterresources can be exploited comprise: the production of hydro-electricity, expansion of irrigated agriculture, inland fishery, facilitation of transport and tourism. To this list a less tangible but most realistic purpose could be added: the opportunity to accelerate an orderly change in a traditional rural society (Scudder, 1977; Brokensha, 1968).

It is clear that for whatever purpose waterdevelopment is undertaken, additional opportunities will be created by the positive impacts mentioned in the previous paragraph. For instance construction of a reservoir to develop irrigated agriculture, automatically creates opportunities to generate electricity and to develop fishery.

Objectives of development ultimately concern human welfare. In referring to specific projects, development objectives will have to be tailored to the limits of available funds. Considerable care has to be taken to formulate objectives such as:

- Tangible: measurable, eg. in monetary terms or epidemiological rates
- Intangible: referring to the quality of life or environment
- Complementary: synergistic in their targets
- Conflicting: antagonistic in their targets

For instance the objective to improve nutrition is tangible and is complementary to improve labour productivity, but the effect of nutrition on labour productivity is rather intangible. On the other hand the objective to maximize the GNP will conflict with another objective, to control urbanization and keep farmers in rural areas (Odingo, 1979).

2.2 Application

Of the recent African superdams all except one had one single main purpose, to produce hydro-electricity. Information on their pre- and postconstruction which is available from a number of publications, shows that in the planning and construction phases of these great projects only one subject received adequate attention, that is the technical feasibility. This occurred despite the fact that the World Health Organization and the Food and Agriculture Organization had warned on a number of occasions for the consequences of such an approach. The sometimes disastrous events which followed, or still are developing forcefully emphasized the need for a more integrated approach. The dams delivered their quota of electricity according to expectation to the benefit of the national economies. However, people in the dam region itself suffered and still continue suffering misery without having received a fair share of the benefits.

There is an urgent need to correct these mistakes through the approach of Integrated River Basin Development. Outside Africa this approach has been used with great succes by the Tennessee Valley Authority of the U.S.A. More recently the approach is being applied in Africa for the development of the Senegal River Basin (UNDP, 1979).

The following table is an attempt to indicate the requirements for Integrated Development with sufficient attention to the regional population.

TABLE 1: National and Regional Aspects of Integrated River Basin Planning for a Hydro-electric Dam

Aspects	National Level	Regional Level
Objective	Increase G.N.P.	Compensate Displaced Population Guarantee Share in G.N.P.
Primary Activity	Hydro-electricity	
Secondary Activity	Electro-intensive industries	Positive Impacts: opportunities to promote agriculture, fishery, transport "development", health
Problems created	Disparity Income Distribution Urbanization	Negative Impacts: Stress of resettlement, water-related diseases, health, social and environmental effects
Planning Required	Create optimal Cost-Benefit Ratio Adjust Nat.Developm.Plan	Limited development of positive impacts Prevention or maximal control negative impacts
Information needed	Political goals Nat.Developm.Plan Hydrogeological data Monitoring economic param.	Pre- and postimpoundment studies on: population - sociology, public health environment - biology, soc. geography Monitoring social, health, biological, geographical parameters
Management	National Level Mainly economical, technical	Regional and Local Level Multi-disciplinary
Costs	Construction and Resettlement	Additional Cost Integrated Development

Chapter 3

The concern of human health and welfare in integrated river basin development

1. AN OVERVIEW OF WATERDEVELOPMENT AND HEALTH

1.1 Demographic Features

Waterdevelopment projects are closely associated with population movements. River valleys, often more fertile and populated than land away from water courses, are flooded by man-made lakes. The Bandama Valley of Ivory Coast provided good farmland and had a relatively high population density (120 /km2), but 120,000 people had to move when Lake Kossou was filled. Though the Nile Valley south of Aswan comprises mainly desert lands, still about 100,000 people were displaced by the waters of Lake Nasser. On the other hand man-made lakes do attract people. We have seen that around Volta Lake, within 2 years of its completion, nearly 60,000 people had immigrated into the area to exploit the rich fishing grounds. In general water bodies in dry climates, as long as economic opportunities are present, attract subsistence farmers, fishermen and nomadic cattle herders.

In irrigation aiming at development the emphasis is somewhat different. Barren land is made fertile and water becomes available in more ample quantities. Apart from the already settled population a more or less controlled (Chambers, 1969) influx of new settlers is stimulated. In well planned irrigation projects prospective settlers are submitted to a selection procedure. However apart from this easily identifiable group there is a less well-defined group of migrants, composed of relatives and people seeking to exploit incidental opportunities. Also for instance seasonal laborers, employed temporarily during the harvest, may contribute a sizable portion to the local population. In Gezira each year nearly half a million people will move onto the Scheme, coming from all over Sudan, and return home after the harvest. In many parts of Africa the movement of herdsmen and fishermen is governed by the changes of season and floods.

Finally the construction of dams and canals requires large numbers of laborers and professional workers. These accrue to 5,000 - 10,000 or more and remain present for a period of 3-5 years. Accompanying this credit-worthy group is a selection of relatives, traders and womenfolk filling in for their domestic needs. Also a selection of government officials employed in administration, education and health services will be new in the area.

1.2 Time Trend

Health problems associated with waterdevelopment also can be classified according to the time needed to reach their full impact.

Short term health problems are mostly related to the process of migration itself, especially the forced migration of resettlement. The various types of stress as well as the conditions of housing, crowding, feeding and sanitation in the period immediately after the move may have serious health implications but are basically temporary. According to Scudder (1975) a minimum period of two years is required for people to become adapted to the new situation under optimal conditions. In practice often a much longer time is involved. Medium- and longterm medical problems mostly arise due to the spread of water-related parasitic diseases. These are of special significance to the people more or less permanently settled in the area. The rapid or gradual development of health impacts interact with the pre-impoundment health status of the community. As a

result of this interaction, an initially very dynamic element is added to the forces governing the health status of the people in the area during the post-impoundment stages.

The Health Aspects Proper

The relationship between waterdevelopment, or man-made lakes and irrigation, and health has been the subject of an ever increasing number of publications (Deom, 1976).

A variety of African experiences clearly shows that negative effects on health are of such severity that they may jeopardize the economic viability of projects. In Upper Volta for instance onchocerciasis (river blindness) presents, besides schistosomiasis and trypanosomiasis, a risk to development activities. A rice irrigation scheme of 1600 ha was started in the valley of the Tiao river in 1955. The water conservation structures provided excellent new breeding sites to the existing local vector of onchocerciasis, Similium damnosum (Le Berre, 1971). As a consequence transmission of onchocerciasis, which had a low endemicity prior to 1955, rapidly became very intense. In 1962 virtually the total project population was infected with eye lesions already present in children of 10-14 year old, which is unusual. Of people above 30 year 22% had become blind and of those above 40 year 50%. As a result the scheme was neglected and small dykes and spillways collapsed. Although transmission decreased as a result of the neglect, the disease problem, being of a chronic nature, continued. Only in 1969 effective control measures were instituted. The author stresses that the scale of the devastating impact could not have predicted by health workers nor by engineers.

In Egypt Farooq (1967) estimated that as a result of construction of the Aswan High Dam 2.65 million people would become victims of schistosomiasis in addition to the 14 million Egyptians who were already infected. Farooq also estimated that the economic loss in Egypt due to the schistosomiasis problem amounted to the order of $ 560 million per year.

Despite the obvious relevance of water-related diseases, it nevertheless appears that health aspects have been studied in a piecemeal fashion. For instance the problems created by schistosomiasis transmission are relatively well documented in terms of increasing prevalence rates, and these may be extrapolated to numbers of cases. In Africa alone more than 91 million people are affected by the disease (McJunkin, 1975). Despite the significance of the figure itself, existing knowledge on schistosomiasis in general is very fragmentary and imcomplete if the public health implications are considered. It is not known what the specific mortality of schistosomiasis is, or how it affects life-expectancy, nor is there any sound information how large a burden the disease implies to health services or how many labour days are lost. In relation to development projects it would be desirable that such information is available not only in general, but also, in view of geographical variability, under the conditions of the project situations.

As for malaria, the number of cases is impossible to estimate due to the complexities of the disease, though the number of deaths can be estimated together with the influence on infant mortality . But also for malaria the actual public health assault can only roughly be predicted because of important geographical variations.

The valuable book by Stanley and Alpers (1975) pictures the various disease problems against a broad etiological background and allows an understanding of the complexity of factors involved. A series of publications by anthropologists (Scudder, 1973, 1975) not only draws attention to cultural and social health factors affecting the displaced people but also points at the difficulty to arrange organised control efforts. Economists (Prescott, 1979) try to determine the nature and size of the economic benefits derived from control of disease.

This knowledge would serve as an implementation incentive to decisionmakers by making possible economically sensible allocations of scarce resources, but concludes that some basic data on the distribution of schistosomiasis in population groups are lacking, as well as observations on the effect of disease severity on labour output.

Although the need for a multidisciplinary approach also to health problems is basic to Integrated River Basin Development (United Nations, 1970), and is mentioned in many publications, few such studies have been carried out. The Kamburu Ecological Survey of which this report considers the health aspects is one of these.

The abundant literature on health and waterdevelopment provides insight in the cause of the problems as they exist today, but there is a need to provide imformation that can serve as implementation incentives for the allocations of resources, and above all to those who have to implement the objectives set, and who need practical tools to guide them in this process.

The information required should describe health problems of individuals and the community in a "real life" situation in such a way that this information can be linked to the functioning of health services, and to the impact of disease on economic activity, social life and political forces (Hunter et al., 1979). The conceptual framework to decide which data are needed is provided by the concept of "Community Health" (Kark, 1974; Bennett, 1979).

2. DEFINING THE HEALTH SECTOR

The object of Integrated River Basin Development is the geographical region in which the waterworks are located, including its population and the sociopolitical structure of the society. Although development impacts presumably can be registered over a wide area, their intensity, like that of the tremors of an earthquake around the epicentre, rapidly diminishes. It should then be possible to define an area around the epicentre of the geographical impact of waterworks, observing both the expectation of impact and the regular administrative boundaries. The society in the region so defined will be the target community for the integrated development objectives.

Management of development (see Table 2) requires the activation, coordination and control of a large number of interrelated activities. Using the concept of Integrated River Basin Development, it is possible to outline the structure of management by sectors and subsectors.

Although management sectors and subsectors each fullfill a special function, quite a few decisions and actions undertaken by one sector are relevant to others as well. This is particularly true because of the ecological nature of waterdevelopment. To avoid conflicting decisions and actions in one sector which are incompatible with those of other sectors it is necessary that areas of interaction are identified during the planning stages, and suitable solutions found. An example to illustrate conflicting interests is the need for management of the reservoir level. Whereas irregular wateruse resulting in frequent fluctuation of the reservoir level could be desirable from the point of view of electricity generation and also health, this practice would be less desirable from the point of view of agriculture, fishery and water transport.

TABLE 2: An Outline of Integrated River Basin Development Management

National Government / River Basin Authority	Management Sector	Management Subsector
Primary Management Activities	Hydro-electricity	Dam construction & operation
		Electrical installations
		Transmission of electricity
		Marketing electricity
		Electro-intensive industries
	Resettlement	Indemnification
		Relocation & land
		Housing
		Transport
		Food relief
Secondary Management Activities	Agriculture	Landuse & cash crops
		Extension work
		Marketing
		Agric.industries
	Fishery	Commercial fishery
		Fish conservation
		Marketing
	Social Development	Socio-economic organisation
		Water supply and sanitation
		Education
		Communication
		Vocational training
	Health	Resettlement and migration
		Waterrelated diseases
		Basic health care
	Tourism	Hotels, touristic attractions

Management of planning and operation requires knowledge and understanding of the existing situation in various sectors, but also anticipation of change and prediction of effects. Objectives have to be defined on the basis of priorities and resources allocated for different purposes. A prerequisite for management therefore is sufficient and appropriate information. To each management sector ideally an information unit should be attached.

This brief outline of the complexities involved in the Management of River Basin Development seems to lead to a conclusion. Large scale waterdevelopment poses a series of managerial problems which could benefit from application of the system analysis approach. The River Basin society constitutes a socio-politico-economic system, which however is part of a larger national system. The construction of waterworks sets a development process in motion which is of considerable regional and national significance, and is guided by specific goals and objectives. Also the construction activities, the resettlement of the dislocated population and the management of the ensuing impacts constitutes a time-limited series of activities designed to bring about social change, and can be characterized as a project. The implementation of such a project brings about a mass of valuable experience which can be used to refine the project and improve future planning within the region, but particularly also elsewhere in the national system.

Viewed in terms of the system, health status may be seen both as a result of and as a contributor to the social and environmental complex. The health sec-

tor, the health services for resettlement and migration, the control of water-related disease and the provision of health care, as well as the health management and planning may be regarded as progressively smaller subsystems (WHO, 1976).

3. ASSESSMENT AND PREDICTION OF CHANGE

3.1 Shoe-leather Epidemiology

The dynamic nature of ecosystems sets in motion a continuous state of change, of reactions and interactions within and between the physical, biological and human components of the reservoir environment. The premise of Integrated Development requires that adequate predictions concerning health impacts are made and that preventive or control measures form an integrated part of planning, execution and operation of waterdevelopment projects. This implies that epidemiological studies are undertaken during all phases of development to monitor developments and to evaluate the effect of planned control measures and other interventions. It is now clear (Hughes and Hunter, 1970; Deom, 1975; Waddy, 1975) that neglect of this aspect of project development has created severe health problems among several million people in Africa who are living in the immediate vicinity of man-made lakes or take part in irrigation projects. Moreover it is expected that waterdevelopment in Africa will continue at a rapidly accelerating pace.

With regard to the environmental and health costs the view has been expressed (McJunkin, 1975) that they are inevitable and therefore must be absorbed in order to secure overall benefits. Also that the application of a reasonable part of project investments for adequate utilization of the land, geographically and economically influenced by the lake, will generate a more equal distribution of economic benefits and indirectly provides a controlling influence on health deterioration.

Health protection as part of Integrated Development requires an active ongoing surveillance programme by which disease risks should be estimated with sufficient precision and the causal relationships identified. This information has to be used to identify and institute appropriate measures for protection and control. The effectiveness of control measures can be gauged through the ongoing surveillance, and necessary adjustments and alteration can then be made.

Few if any examples of the application of this principle can be found in the literature and therefore there is a need to develop the necessary multidisciplinary methodology. It is however obvious that in order to be useful under the conditions of rural Africa, this methodology should avoid sophistication, yet provide the down to earth information required with sufficient accuracy.

The term "shoe-leather" epidemiology was used to describe the down to earth surveillance and control measures used to eradicate Anopheles gambiae from Brasil, where this mosquito, after its accidental introduction in 1930, caused a devastating epidemic of malaria. A characteristic of the methodology required for Integrated River Basin Development may be that it resembles Soper's "shoe-leather" epidemiology.

A remarkable inconsistency between the consequences of development in industrialized and non-industrialized countries should be signalized. In both technological development creates serious human problems. Environmental Health Impact Assessment is a subject rapidly gaining priority in industrialized countries (WHO, 1979), but also here a suitable methodology still has to be developed. While in industrialized countries the prevailing attitude is that the polluter pays for the costs to control damages, and environmental impact

studies are now required by law in Sweden and the United States, a similar attitude seems to be missing in non-industrialized nations, or with the funding agencies who help to finance their projects, despite the fact that the damage to health in tropical countries as a result of waterdevelopment must amplify unto a severalfold larger magnitude.

3.2 Assessment and Monitoring Health Aspects

The apparently adequate provisions for technological information needed for the implementation of the primary engineering ojectives in dam projects contrast with the relative lack of such data concerning the secondary objectives including health. Hydrological and geophysical data are essential for the design and operation of dams. Their collection is initiated often many years ahead of dam construction, and continues throughout its lifetime. The experiences of at least five major African dams demonstrate that from technological point of view their programme could be implemented successfully and the primary objectives for energy and irrigation fulfilled. If the implementation of secondary objectives of these programmes appears,despite the investment of considerable resources, to have been less successful, it is justified to consider the lack of an adequately functioning information system for this purpose as a major reason for the failure.

To control the medical implications of water management in the Volta River Project, MacDonald (1955) advised that an epidemiological unit should be established within the Health and Safety Division of the Dam Authority, to carry out baseline and recurring medical surveys. Though this advice was formulated before any of the major African dams had come into existence, it received only limited attention by the Volta Dam Authority, neither was it heeded by other dam authorities. It is to be hoped that the experiences gained since that time will have positive repercussions for the future of health planning in these projects. As recommended by MacDonald a health information system remains basic for the purpose, and in contemporary terminology could be referred to as health monitoring.

Lwanga (1978) defines health monitoring as: "An integrated system of making observations on health and environmental factors, and of scrutinizing, storing and retrieving these data for specific purposes of protecting and improving health". Health monitoring is closely related to surveillance for specific health problems. In the light of resettlement policies and considering the standard of living in rural areas of the tropics the protection and enhancement of human health stands for the provisions and improvementof Primary Health Care, which apart from basic health care includes measures of environmental improvement and communicable disease control.

Health planning for these waterdevelopment projects requires an integral approach aimed at the improvement of health in general, rather than the application of control measures for the water-related diseases. Though there need to be little uncertainty about the severe impact on public health of the latter, nevertheless health conditions are mainly the result of more ubiquitous environmental and other factors. According to the Health Policy Paper (World Bank, 1980) the main determinants of the incidence of disease in developping countries are demographic factors, malnutrition, insanitary conditions of housing and water supply. And though health care itself can do little about the incidence of infectious and parasitic diseases, immunization and other measures of basic health care can do much about improving health. It is generally accepted that the improvements in the standard of health in Europe and North America, but also in South America and certain African and Asian countries were brought about by improved living standards rather than by medical care per se.

Primary Health Care has been defined in the Alma Ata Conference Joint Report for WHO and UNICEF (1978) as: "Essential health care based on practical, scien-

tifically sound and socially acceptable methods and technology, made universally accessible to individuals and families in the community through their full participation, and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self- reliance and self-determination. It forms an integral part both of the country's health system of which it is the central function and main focus and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and the community with the national health system, bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process". As for the content and scope of Primary Health Care this usually includes: maternal and child health as well as family planning, nutrition, communicable disease control, health education, environmental improvement and the treatment of simple and common complaints. In the case of waterdevelopment programmes the specific ecological factors probably warrant a more than average attention for communicable disease control and environmental improvement. Apart from these factors however, more universal aspects of Primary Health Care remain equally important. It could be concluded that Primary Health Care provides the background into which the scope and content of a health monitoring system for these programmes should be blended. In addition the system has to fit in with information requirements by other sectors of Integrated Development.

In his paper Lwanga discusses three critical components for health monitoring:

(1) The health effects: these may concern vital events such as mortality ,morbidity and fertility rates, or other types of "health indicators".
(2) The environmental factors: these concern the aspects of the environment which are subject to change, and might influence health. Observations should include the intensity, duration and frequency of exposure.
(3) The target group: observations can be made at the aggregated level, that is on groups (families, villages) or various types of samples.

These recommendations are very basic and need further elaboration in order to become practicable for use in Integrated Development.

4. HEALTH MONITORING FOR INTEGRATED DEVELOPMENT

4.1 Designing a Basic Model for Information Planning

From reports on waterdevelopment in Africa during the last two decades it becomes clear that very little attention was given to the integrated development concept. All efforts were directed at realizing the primary objectives of power production or irrigation, and little attention was given to ecological impacts and opportunities. As a consequence significant problems and shortcomings emerged, amongst others in the health sector, and disfigure the achievements. Lack of experience and expertise, the prevailing socio-political conditions and incorrect use of the available scanty resources could explain some of the shortcomings.

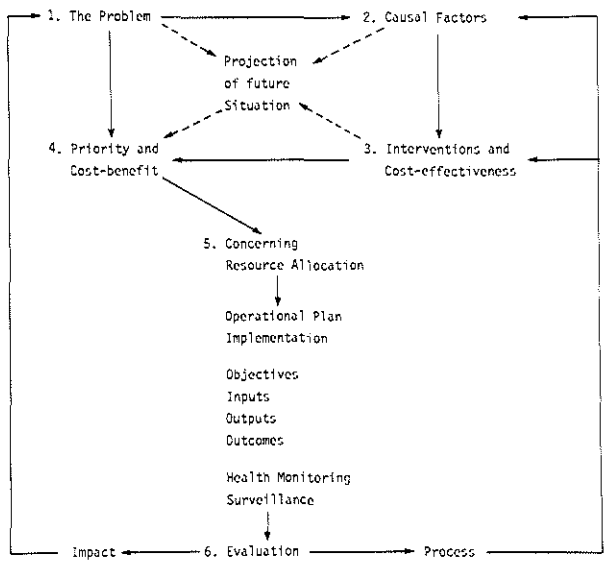
"Why is it that comprehensive studies of alternatives, and the possible significance and character of impacts from each alternative, have never been carried out?". White (1972), who poses this question, assigns the responsibility to a multiplicity of very human elements:

- Unawareness on behalf of decisionmakers
- Lack of foresight due to ignorance and stupidity, but also by lack of orientation and training to deal with such problems
- The tendency of advisors and technicians to minimize the hazards until it is too late, and to treat ecological problems as unimportant
- A variety of economic considerations among which shortterm benefits outweigh longterm prospects.

There are indications to show that a different attitude and practice of planning is taking form. Examples of the latter are the Blue Nile Health Project of Gezira, which is an undertaking of the Sudan Government and the WHO ; and the Integrated Development Plan for the Senegal River Basin being prepared by the countries concerned with assistance of the UNDP.

Information is essential to rational planning. The information that is available, or can be generated for planning in the health sector is limited in quantity and in quality. This is especially true in rural areas of the tropics where health services are thinly distributed and few if any health surveys have been carried out. The active collection of health data through specially designed surveys is relatively costly and restricted by financial constraints, but also by constraints concerning manpower and facilities, communication and transportation. There are therefore good reasons why planners should be selective in their decisions as to what epidemiological data should be collected. Such data should be of known accuracy and should facilitate the more important decisions which require major allocation of resource, or are expected to have a major impact on the living conditions. The experience gained in waterdevelopment so far provides some guidance as to which these items of information are.

FIGURE 2 A Model of Basic Information Needed for Health Planning



Haro (1979) postulates that an intentionally collected item of information is primarily serving one purpose, that is, to be of use for a model that enables evaluative considerations to be made. Only rarely is it possible to construct a valid formal model to which quantitative measurements can be fitted. In most cases the basic models are mental ones, which help to solve the problem of how to establish the information requirements.

For describing the information requirements of the three health sector subsystems we shall make use of a simple logical model which allows for the estimation of the priority of a problem taking into account the causal background and the impact of different forms of intervention. Besides we shall consider parameters for the evaluation of project impacts during and after implementation.

The first half of the model relates aspects which are underlying the formulation part of the system analysis approach, while the second half concerns the implementation phase. In our analysis we shall only consider the most relevant aspects which have been numbered (items 1-6).

4.2 Definition of the Problem

Basic demographic information and vital statistics are essential for the definition of health needs. Population composition and the size and distribution of mortality over population subgroups are significant indicators of general health conditions. Initially the reduction of mortality especially of younger age groups is the goal of the provision of health care. But also other demographic and vital statistics allow for a projection of needs and estimation of the type of services required. For the latter information on morbidity and disability is needed. Besides demographic information being essential for the calculation of incidence and prevalence rates.

General and disease-specific mortality rates, and if available morbidity rates, provide for insight in the nature of disease problems and the groups most seriously affected. Specific morbidity data allow for the estimation of the relative importance of different disease problems. This statement needs further qualification. A characteristic feature of African health conditions is the co-existence of various infectious, but also non-infectious, disease problems in the same population, and particularly in the same individuals. According to Buck (1978) the term poly-parasitism has epidemiological and clinical implications; epidemiologically it is synonymous with the co-endemicity of parasitic diseases in a population and clinically with the presence of multiple infections of the individual. The occurrence of poly-parasitism is of significance both to the epidemiologist and to the clinician. The diagnostic significance of signs and symptoms of infection may be altered by the interaction between infections, and the diagnostic capacity of immunological tests decreases. On the whole little is known at present of the effect of poly-parasitism on morbidity. However certain patterns of poly-parasitism may suggest that common host factors influence the extent, distribution and type of multiple infections in the community.

Next to death, degree of disability and its duration are the most serious social consequences of disease. Though several degrees of disability may be distinguished, the most important information regards the restriction of social activities resulting in food production and income, domestic duties and schooling. Such information allows for an estimation of the social importance of diseases.

Conventionally socio-economic state and other social parameters are included in morbidity surveys. Though such parameters may be used as explanatory variables, their incorporation is usually justified by the facts that facilitate the identification of groups with a higher risk, which could be the target group for active measures. For similar reasons observations are often related to families.

Perceived ill-health requires some therapeutic action to be undertaken by the individual or the community. The description of the health situation therefore is not complete without an assessment of the health services and health behaviour of the population. Distance and transport influence the utilization of medical institutions. But so does the quality of care received as for instance indicated by the waiting time, personal attention and effectiveness of treatment received. Home treatment and the services provided by traditional healers usually cover a considerable part of the medical consumption.

Problem Projection

A dynamic force underlies the natural history of disease. Within the community the pool of susceptible hosts constantly changes, as does the group of diseased persons. But similarly the force of various causally related factors in the interaction between host, agent and environment may be modified in the course of time. Health conditions therefore are not static, but are characterized by periodical fluctuations or, particularly under the influence of socio-economic development, by short-, medium- and longterm trends.

4.3 Aetiology of Ill Health

In developing countries the most important health problems are due to either infectious disease or inadequate nutrition or both (Cruickshank et al., 1976). For practically all of them the present scientific literature provides at least a basic, but for many also a very complete understanding, of their cause and the causal factors involved. However the pattern of causation may vary from one place to another, and different causal factors may dominate. For instance the classical waterborne infections of typhoid and cholera may also be transmitted due to a lack of hygiene, or a waterwashed mechanism. It then becomes important to know which mode of transmission prevails in a particular situation, in order to design the most efficient forms of intervention. It therefore is the aim of operational epidemiological field studies to provide basic information on the local pattern of transmission or causation.

Causal factors forthcoming from the human environment may be based in its physical, biological or social components. Disease causation usually comprises a combination relating to all three components. Information on causal factors which may be manipulated by interventions and control activities is most relevant to the health planner. Examples are the physical design of irrigation canals, the biological quality of domestic water and the social customs concerning food production, consumption and nutrition. Particularly the social environment contributes to health problems in many ways, related to socio-economic status, the quality and quantity of health services and the regulating influence of human behaviour.

Next to immune response, behaviour probably is the most relevant human host characteristic in relation to major health problems. Human behaviour in the daily life of a family (nutrition, water collection, excretion, body and domestic hygiene), in occupational activities (practices of agriculture and fishery, nomadic way of life), and on the occasion of social gatherings (markets, festivities, funerals) may all have significant implications for disease transmission. So far research on the transmission of parasitic and other infectious diseases has been largely concentrated on describing the biological and biomedical behaviour of parasites, vectors and hosts, including the human host. Dunn (1979) observed that human behaviour as determined by cultural, social and psychological factors, has largely been neglected in studies on parasitic disease transmission. Many aspects of human behaviour influence the transmission, but also the control measures of parasitic diseases. Such forms of

behaviour may be disease specific, but others can affect the transmission of a variety of parasites and other agents. Buck (1976) has emphasized that behavioral epidemiological studies should follow a holistic trans-disease approach regarding the multiple problems of the community rather than a single disease, because poly-parasitism is the rule in many parts of the tropics. Dunn (1979) recommends that human health related behaviour should be classified in four major divisions:

- Deliberate and consciously health related types of behaviour by individuals or groups that serve to promote or maintain health
- Deliberate behaviour that contributes to ill-health and mortality
- Non-deliberate behaviour, i.e. behaviour not perceived to be health related, that nevertheless influences the health of individuals, groups or populations favorably, either by enhancing or maintaining the level of health
- Non-deliberate behaviour that contributes to ill-health and mortality

Each of these types of behaviour should be divided once more to take account whether such behaviour originates from within the group of community, or is stimulated or imposed from the outside, such as for disease control or treatment and health promotion.

4.4 Intervention and Cost Effectiveness

Interventions may interrupt the sequence of causal interactions with varying degrees of directness, and at the level of different environmental and host factors, or the agent. The specific effect of an intervention depends on such characteristics. Immunization against measles interrupts transmission through its specific effect on the host. But the application of an insecticide to interrupt malaria transmission by killing its vectors may incidentally reduce the transmission of filariasis or viral infections as well. The improvement of socio-economic conditions or the installation of water supplies have still more widespread effects. The measurement and evaluation of effect becomes more difficult as interventive measures are less specific.

The value of interventions is judged according to their efficacy, effectiveness and efficiency. Efficacy refers to the intrinsic ability to reduce disease, effectiveness to the potential to reach individuals in the population, while efficiency or cost-effectiveness weighs the cost of intervention against the reduction of disease, death and disability.

Cost-effectiveness is the critical characteristic of interventions and has a decisive influence in planning. Cost-effectiveness is determined by comparing the total costs of the intervention programme with the number of deaths and cases prevented, and the result is commonly expressed as the cost per case prevented. Though broad generalizations can be made for comparing strategies of intervention, from its definition it must be concluded that cost-effectiveness is programme specific. Buck (1976 and 1978) demonstrated that poly-parasitism is the rule in many tropical areas rather than the exception. Cost-effectiveness (and cost-benefit) calculations which fail to take this into account will substantially underestimate the impact of communicable disease programmes. Both costs and effectiveness are influenced by the local situation. According to Cvjetanovic et al. (1978) cost-effectiveness analysis of control programmes shows that many factors influence the cost-effectiveness relationship. A decrease in per capita cost may be achieved by (Cvjetanovic, 1976):

- The use of cheaper vaccine, sanitary facilities, drugs and other materials and supplies
- The use of smaller doses, simpler and yet effective sanitary facilities, drugs, categories of staff, transport etc.

An increase in effectiveness of control measures, which implies a decrease in per capita cost may be achieved by:

- Better, faster and cheaper techniques (jet-injectors, tests, etc.)
- Combined activities such as simultaneous administration of vaccines and antigens, the combination of water supply and sanitation, combining health education with programme activities
- Efficient organization of sessions, staff, transport
- Good public relations
- Selective application of preventive measures to high risk groups
- Application of preventive measures at the most strategic and for the population convenient time
- Sound planning of action which implies a good understanding of the local health situation and its background.

From this discussion it may be concluded that cost-effectiveness is a dynamic variable, its components may change to the worse or to the better during programme operation. Through monitoring and regular evaluation of control programmes their weakness can be identified and improvements introduced.

4.5 Cost Benefit and Priorities

Cost Benefit Analysis

The determination of health priorities is based on obtaining the maximum benefit for a given expenditure, including the use of staff and other resources. The application of the theory of cost-benefit to health matters is of relatively recent date. According to this concept the main contribution of a health programme to the economy is its ability to generate more economic value than costs during its estimated lifetime. Cost-benefit analysis therefore is concerned with measuring the benefits (or costs of illness prevented) and relating these to the costs of producing them. It is assumed that benefits can be quantified in economic terms. Direct benefits are assumed to be the costs otherwise incurred due to illness by individuals, families and the nation as a whole; while indirect benefits refer to more general economic losses prevented.

Direct benefits

Costs of curative and/or preventive services
Additional costs incurred by households

Indirect benefits

Labour productivity losses - loss of workers, working time, productive capacity
Non-labour product losses - Unused land, other unexploited resources
Reduced incentive to investment of capital
Accumulation of capital

If feasible, cost-benefit analysis may provide an efficient tool to health planners to decide whether to allocate resources to a specific programme, e.g. immunization, or rely on curative services alone. Similarly cost-benefit may provide a forceful incentive for the implementation of preventive programmes, as opposed to the habitual allocation of resources to curative services. Despite such important advantages, the use of cost-benefit analysis in health planning is hampered by fundamental disadvantages. Cost-benefit assessment based on economic criteria fails to take into account the less tangible, but not less realistic, aspects of ill-health, such as human suffering and human dignity. The perceived priority of health needs therefore may disagree with the importance as assessed by cost-benefit.

The background document of the World Employment Conference organized by ILO in 1976 contained proposals to adopt a strategy for development aiming at the achievement of certain minimum standards of living through fulfilment of basic needs, rather than using economic gain as the sole criteria. Basic needs are defined as the minimum standard of living which a society should set for the poorest of its people. Basic needs concern food, shelter and clothing, safe drinking water and sanitation, health services, communication and education, the right of employment and other communal services. Though the relationship between health services and health is evident, as a matter of fact all basic needs have a bearance upon human health, and health status of the community. Some measure, for instance cost-effectiveness, is therefore needed to compare the impact of health services to that of other basic needs, for the efficient allocation of health resources. The equitable distribution of resources for the satisfaction of basic needs has now become a basic principle in the philosophy and strategy of development. This approach was further pursued at the World Water Conference of 1977, and the World Health Organization Conference on Primary Health Care of 1978.

Priorities

According to Schwarz (1975) decisions on the priority of health problems should weigh two components, that of magnitude of the problem and secondly that of manageability or vulnerability of the problem in case of intervention. Besides, impacts of disease should be considered at the social levels of the individual, the family and the community.

Component	Elements
Magnitude	Occurrence : incidence, duration, case-fatality Humanitarian value: psychological, patho-psychological and social aspects (three levels) Economic value : direct costs of illness, indirect costs (three levels)
Manageability or Vulnerability	Efficacy, effectiveness and efficiency of interventions; available resources including management capability

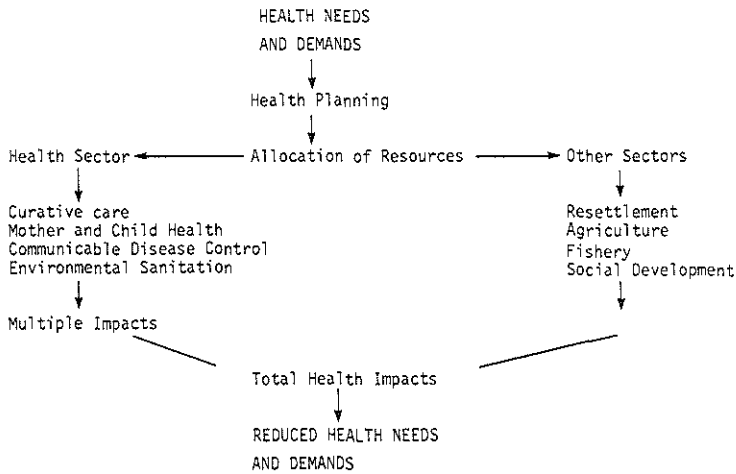
4.6 Concerning the Allocation of Resources and Intervention Strategies

Between 4-6% of the national budgets of African countries is allocated to health. Considering that the average Gross National Produce per capita was less than US$ 400 for a majority of African countries in 1977 (mean US$ 209), the resulting per capita health budgets are small, and this observation is further reaffirmed by considering the important health needs. Besides financial constraints, a shortage of manpower and facilities, but also of management capabilities, limits the delivery of health services. Against this background careful allocation of resources according to well-defined priorities is indicated.

Public health planners in African waterdevelopment programmes have to operate against this background of scarce resources with the goal of at least satisfying basic health needs. They constantly face the choice of optimal allocation of resources. Because rural areas of the tropics are as far as the distribution of health services is concerned practically virgin lands, there is the opportunity and challenge to build up the health sector along lines which guarantee optimal health benefits. This implies exploiting to the full potential of preventive and promotive measures without disregarding the real and perceived needs for curative services. In order to implement this philosophy or goal of development it is essential that allocation decisions are made using sound, but basic, epi-

demiological information in setting priorities, which includes the consideration of cost-effectiveness and cost-benefit or different strategies. This approach contrasts with the tendency to develop the health sector along the standard pattern, which in many formerly colonized countries was founded on the principle of high quality health care for the urban elite with little left for the rural masses. Rosenfield (1977) stated: "Frequently the decision making process is implicitly carried out. With active competition for scarce resources in developing countries, the process may only reach optimal results (in terms of achieving certain stated goals) if decision making is undertaken within an explicit framework". This explicit framework involves, besides the setting of measurable goals, the definition of measurable objectives which are to be achieved by strategies selected because they promise an optimal contribution according to quantitative, or at least qualitative criteria. The problem solving approach to health planning is at the heart of this explicit framework.

FIGURE 3: The Allocation of Resources and Total Health Impacts



A critical stage in the planning exercise concerns the allocation of scarce resources. The distribution of resources for the purpose of improving health and obtaining maximal health benefits is a complex task for several reasons.

Firstly, if health planning has as its objective to satisfy basic health needs, it follows that the object of planning is the whole scale of health problems, including those of low priority. Though in theory probably even more benefit could be attained by concentrating on only the major causes of death, such an approach would socially be unacceptable. The dilemma of health planning

therefore is to satisfy the basic demand for high-cost but low-effectiveness curative care, while at the same time exploiting the potential of low-cost but high-effectiveness health promotion and prevention.

Secondly, the satisfaction of basic needs other than the provision of health services is not within the competence of the health sector. Therefore health planning extends to decisions on the use of resources in other sectors of planning and management, in order to optimalize benefits also from their side.

Thirdly the programmes for which resources are utilized usually cover a range of health problems. Disease specific programmes such as for malaria, schistosomiasis or tuberculosis, in reality have a beneficial effect on other problems as well.

In order to obtain optimal results, resource allocation should be guided by explicit information on resource requirements in different sectors and programmes, and on estimates of the health impacts.

Different preventive and/or curative forms of intervention can be incorporated in health programmes in varying proportions. Therefore alternative strategies can be designed to meet community health needs either by using equal resources, or by using more or less. The design of such strategies requires inventiveness and ingenuity, as well as a business instinct how to realize the maximum in profits from investment. The explicit value of various intervention strategies can be evaluated by considering their impact on high priority health needs and the corresponding cost-effectiveness and cost-benefit. Such a procedure promotes the optimal use of resources by different sectors of management, and within these sectors. Through the use of computers and the development of resource allocation models for simulating the effects of intervention strategies the health planning process may gain both in precision and accuracy, and ultimately in realizing the maximum health benefit. Rosenfield (1977) considers the investment of resources for this purpose justified, or in other words cost-effective.

Once the choice of a strategy for implementation has been made, specific programme planning regarding technical methods and operational details proceeds. Dunn (1979) states that in this final analysis the selection of control methods should not only depend on technical considerations and operational analysis. Two other elements ought to be brought into the decision process: a sound knowledge of the cultural-ecological setting (the control sector) in which control is assumed to be needed, and a control philosophy. The latter concerns the relationships between control methods, persons who act as agents of control, and the control sector. Control can be imposed on the control sector from the outside and the necessary operations being carried out by out-siders. On the other hand a programme may be implemented with the active cooperation of the control sector, and with direct involvement of persons belonging to the sector. Similar extremes exist in respect of the responsability for programme operations.

4.7 Health Monitoring and Evaluation

Health Monitoring

The planning and implementation of health programmes requires a certain amount of information to assure optimal utilization of the available resources. The profound disturbance of the ecological relationships between host, agent and environmental factors in waterdevelopment and the difficulty to predict precisely the eventual impact, impart more urgency to this requirement. Even the use of scarce resources for health monitoring is considered to be justified and recommended by many authors.

Health monitoring can be defined as the timely collection of information on community health and health programmes. Ideally monitoring should be commenced during the earliest stage of development planning and continue till after its

implementation. Monitoring requires a simple system that provides continuous information and feedback on key-indicators for project planning and the assessment of project progress. It is preferable that monitoring provides reliable information on few but appropriate indicators.

The type of indicators on which information is required and their use in programme planning has been elaborated on in the previous paragraphs. From the time that implementation of health plans commences, selection of indicators should be guided by the goals and objectives of the programme and related to outputs, activities, effects and impacts. The latter information is used for surveillance and evaluation.

Evaluation

Evaluation is performed for a number of reasons of which the most pertinent concern improving the programme and its effectiveness.

Has the programme accomplished its task?

How has the programme accomplished this?

Evaluation then is based on comparing the programme outputs, effects and impacts against the established plans.

Evaluation research using retrospective data generated by a multipurpose healthmonitoring system precludes the use of a rigorous experimental design with randomized control groups. Such a design might be built into the programme however. With a possible exception in case of the latter, judgment is made by studying the trend of treatment variables, or by comparing groups in the target population with different degrees of exposure or intensity of interventions delivered. Whichever approach is applied suitable statistical procedures will have to be employed to eliminate the effect of non-treatment variables.

Summative or impact evaluation attempts to answer the first questions which concerns the programmes effects and impacts. It can only be performed when a programme has been in operation for some time, and determines the extent to which the stated goals and objectives have been achieved. The type of indicators needed for this purpose are those directly measuring problems with a high priority. The ultimate purpose of impact evaluation is to provide policy-makers with information for future programmes and projects.

Formative or impact evaluation is more concerned with operational aspects of programme performance; the delivery of interventions, their utilization by the target population and immediate effects. Ongoing evaluation is a form of process evaluation which closely resembles surveillance. It is a continuing exercise analysing indicators of project outputs and effects. The main purpose of process- and ongoing evaluation is to provide the programme management with information enabling them to assess and if necessary adjust programme policies, objectives, resource allocation and organizational arrangements . Cvjetanovic (1976) stresses that ongoing evaluation is essential for the successful implementation of immunization programmes and should concentrate on indicators of cost-effectiveness and cost-benefit.

Programme planning and evaluation are interactive. The one supports the other, and if either is missing, the other's role and meaning are greatly diminished (Sahn and Pestronk, 1979). This statement equally applies to information needed for either purpose, and indicators suitable for evaluation should be included in the monitoring system at an early time.

5. MAN MADE HEALTH FACTORS

The health problems of waterdevelopment cover a wide range and man-made causal factors invariably are important in their etiology. This is generally accepted for parasitic diseases such as malaria and schistosomiasis, which depend on water in the community environment for their transmission. For instance the design and operation of irrigation for agriculture may enhance or reduce their transmission. It is not equally emphasized that many other aspects of the community and the domestic environment have an impact on infectious and non-infectious disease, and may be used for their control. Integrated Development regularly offers the opportunity to redesign the community, when new settlements are being created, or improve the existing situation through for instance installing a water supply. The incorporation of such environmental control measures for health problems in the planning and implementation of development has important advantages:

(1) They are effective to various degrees
(2) They have long term effects and once implemented remain effective
(3) They have considerable side benefits

If the various opportunities for environmental control are to be fully utilized in resettlement, an impression should be formed about the extent to which various design components of planning contribute to the local health problems. For this reason the most pertinent aspects of the community environment should be included in any health research (Oomen, in preparation). A sample of socalled man-made health factors deriving from the design components of settlement plans is given in table 3. Factors which are more specifically related to parasitic infections are not considered separately here.

TABLE 3: Man-made Health Factors to be Considered for Information Planning in Integrated Development

Design Component	Man-made Health Factor
1. Village design	Health services
	Educational facilities
	Transport and communication
	Village environment
2. Housing	Crowding and contact
	Crowding and ventilation
	Building materials
	Fire and other hazards
	Domestic environment
3. Water supply	Watersources
	Quantity
	Quality
	Collection journey
	Water uses
4. Excreta disposal	Place of excretion
	Latrines and their usage
	Anal cleaning
	Hygiene behaviour
	Faecal habits of children
5. Nutrition	Foodstuffs and diet
	Food customs and behaviour
	Weaning and breastfeeding
	Land for food production
	Labour inputs for food
	Woman's role in food production
	Food storage
	Food or cash crops
	Foodstuffs from markets/shops
6. Fuel supply	Type of fuel
	Collection journey
	Cooking facilities
7. Occupation	Income and wealth
	Cash crops, crafts
	Occupational hazards of infection/ trauma
	Occupational behaviour and discipline
	Male out-migration
8. Population density	Population distribution
	Population growth
	Level of natural/ artificial immunity
	Land erosion
9. Migration	Type and origin of migrants
	Seasonal aspects and duration of stay
	Diseases carried by migrants
	Social problems

PART II

The Kamburu Dam Project as a test case

Chapter 4

The Kamburu Dam Study: Application of health monitoring in an African dam

1. WATERDEVELOPMENT IN KENYA

A brief outline of the progress of water conservation in Kenya is instructive. Population growth and scarcity of agricultural land characterizes the economy of rural areas in Kenya, where 90% of the population lives.

A traditional type of irrigation is practised in some parts by the use of 'hafir dams' along the lower slopes to retain water. Before 1939 the area of irrigated land was small and confined to places where water could be easily directed. By 1972 the total area under irrigation still was less than 7300 hectares. The country however has substantial area suitable for this purpose. There are 150,000 hectares in the Lower Tana River Basin, and 28,000 hectares in Western Kenya (Highton, 1974). An impression about the progress and significance of irrigation until 1976 can be obtained from table 4.

Much of the investment in waterdevelopment in Kenya centers on the Tana River. This river drains an area of 100,000 sqkm (16% of the country) comprising regions of widely different nature and developmental potential. In an Appraisal Report made for the Tana River Development Authority it was estimated that by the year 2000 it will provide for:

- Public water supplies for a population of 9 million (3 million in the City of Nairobi)
- Expansion of the irrigated area to 90,000 hectares
- Hydro-electric power up to 800 MW

Under the 1978-83 Agricultural Development Plan a total of 9350 hectares is to be developed for so called smallholder schemes. Apart from these developments in various parts of Kenya, a major development will take place in the Lower Tana Basin. A scheme of 6700 hectares will be constructed at Bura. Pending dam construction in the Upper Tana River this scheme may eventually cover over 50,000 hectares with a population of over 100,000.

While before 1966 only a few minor hydropower stations were in operation, three dams were constructed in the Upper Tana River between 1966 and 1980, under the Sevenforks Hydro-electric Scheme. Together these dams have a generating potential of 370 MW, sufficient to make Kenya independent from foreign electricity. The reservoirs created by these dams are small (1500-2000 hectares), and do not provide sufficient storage capacity for optimal use of the available water. A fourth dam is under construction which will create a large storage reservoir (120 sqkm, 1560 million cubic m) to serve electricity production, and the irrigation scheme at Bura.

Small dams are common all over the country but particularly so in the Machakos area. In Western Kenya 10,000 fishponds were constructed by the population between 1957/1962 (Lockhart et al., 1969).

TABLE 4: An Overview of Irrigation Development in Kenya
(source: National Irrigation Board, 1975-1976)

SCHEMES		YEARS 1965/66	1975/76
Mwea			
Area cropped	Hectares	2,593	5,609
Plotholders	No	1,484	2,972
Gross Cropvalue	Kpound	318,662	1,857,235
Ahero			
Area cropped	Hectares	-	1,236
Plotholders	No	-	519
Gross Cropvalue	Kpound	-	184,335
Bunyala			
Area cropped	Hectares	-	381
Plotholders	No	-	131
Gross Cropvalue	Kpound	-	58,572
Hola			
Area cropped	Hectares	499	856
Plotholders	No	276	586
Gross Cropvalue	Kpound	43,312	249,240
Perkerra			
Area cropped	Hectares	231	195
Plotholders	No	403	340
Gross Cropvalue	Kpound	70,837	77,444
Total			
Area cropped	Hectares	3,323	8,277
Plotholders	No	2,163	4,548
Gross Cropvalue	Kpound	434,811	2,427,006

2. THE KAMBURU ECOLOGICAL SURVEY

The Sevenforks Hydro-electric Scheme of Central Kenya, called after the seven channels and tributaries of Tana River at this point, has the potential to produce 350 MW of electricity when finally completed. Its development will make Kenya less dependent on foreign energy supplies and will contribute considerably to the economic progress of the country.

Works on Kindaruma Dam, the first of the scheme, commenced in 1963 and the dam was commissioned in 1968. Kamburu Dam followed in 1975 and Gtaru Dam, situated in between the latter two, in 1979. These three dams are layed out over a stretch of approximately 40 km of the river course, where it leaves the Central Plateau. Each makes use of so called tailrace tunnels, which conduct the water underground to a point between 3-8 km below the dams. By this design the available hydro-power is extracted to virtually the last kw. It implies however that the reservoirs are relatively small (1500 ha for Kamburu Dam at maximum water level), and do not provide sufficient storage capacity to capture the marked fluctuation by seasonal flow of Tana River. Consequently construction of a

fourth dam, at Masinga, was started in 1978. This dam will not serve for electricity production, but will create a reservoir ("century storage") of considerable proportions (length approx. 90 km), sufficient to provide over the year storage. Masinga Dam will guarantee optimal utilization of the potential generating capacity of the other dams, and will create a more stable water regimen further downstream. A large irrigation scheme at Bura, near Garissa, will be feasible because of the more stable water regimen. Because of the latter the Sevenforks Scheme may be considered multipurpose, serving power production as well as irrigation.

In 1973 the International Federation of Institutes of Advanced Study and the Nobel Foundation convened a workshop in Stockholm (IFIAS, 1973). The main subject of discussion was the schistosomiasis problem in developing countries. The increased incidence of the disease as a consequence of dam construction had been noted in these countries. Whereas waterdevelopment projects could be justified on economic grounds there was unquestionable evidence that they undermined health conditions through the spread of waterrelated disease. One of the most important recommendations of the Workshop concerned their control and prevention by a transdisciplinary approach to planning and watermanagement.

As a follow up of the conference the Kamburu Ecological Survey (later on Kamburu/Gtaru Ecol. Survey) was conceived by Dr.R.S.Odingo, a participant from the Department of Geography of the University of Nairobi. The International Bank of Reconstruction and Development, one of the financiers of Kamburu dam, had insisted that baseline studies should be conducted to assess its ecological impact. The Swedish International Development Agency (SIDA), another financier , was prepared to sponsor the project financially. Initially a modest sum of $50,000 was made available, an amount insufficient to carry out the project in a conventional way, that is with the assistence of external experts with high salaries and traveling costs.

Dr.Odingo, who had been appointed as the Director of the project, however, succeeded in bringing together a team of scholars from different departments of the University of Nairobi. By using experts in various disciplines locally available, it proved to be possible to carry the project through and conduct a series of integrated transdisciplinary studies. The active involvement of staff from the national university in these problem-oriented studies, and over the year of many university students as well, has the additional advantage that a team of local experts is created which can be used for other development projects.

The terms of reference for the project were prepared in close consultation with Dr.Bengt Lundholm of SIDA. The project was conceived in 1973 and the plans were taking form by the end of that year. As Kamburu dam approached completion at that time it was not feasible to make true baseline observations, before inundation. It was argued however that the ecological impacts would need time to take effect and it was still timely enough to send the research team into the field. The study proposals emphasized the following areas for research:

- Hydrology, climatology, erosion and sedimentation
- Vegetation and Wildlife
- Aquatic ecology
- Epidemiology
- Land use and agriculture
- Demography and sociology

Baseline studies for each of these subjects were carried out in late 1974 and 1975, and were published in a transdisciplinary report (Odingo, 1977 and 1979). The document prepared by Lundholm contained the following guidelines for the studies in epidemiology:

(1) The main effort should be concentrated on the water-associated diseases of schistosomiasis, malaria and onchocerciasis
(2) A detailed study should be made of the vector snail populations of schistosomiasis, both within the inundated area and further upstream
(3) Attention should be given to waterborne enteric diseases
(4) Information should be collected on the effect of the dam on local food supplies, and the nutritional status of the people.

As the Kamburu Ecological Survey was initiated at a late stage in the construction of the Dam, there was little time for preparation of elaborate survey protocols. It was clear that baseline observations needed to be made as soon as possible as the lake was already filled up. It was also realised that whatever baseline observations were going to be made, these would form the basis, and constraints, for any conclusions at future evaluation. In this respect the reports on the Zaina Scheme had a cautioning influence.

This Scheme concerned the installation of a gravity fed, chlorinated rural water supply for a community in Nyeri District of Central Kenya. It was intended to evaluate the impact of safe water supply on public health by comparing observations in the area to ones in a similar area without safe water. This attempt was probably the first of its kind in Africa. Sanitary and medical surveys were carried out in both places before the installation, and again four years later. The baseline survey was reported by Strudwick (1962), and the later one by Fenwick (non-dated report). Unfortunately the report by Fenwick showed that the very extensive data were difficult to interprete, and hardly any valid conclusions could be made. Responsible for this failure were differences in the survey, and lack of competence of the field staff. These were non-professionals and had relatively little supervision. The sampling procedures were inadequate and, though evidence is given that data varied in completion, this was not accounted for in the analysis. Some of the items of information collected were rather subjective, such as the definition of gastrointestinal, diarrhoeal and respiratory illnesses. The uncertainty introduced by such technicalities overshadow the apparent positive impact of water and sanitation on health in the area. A full discussion of this study is given by White et al. (1972).

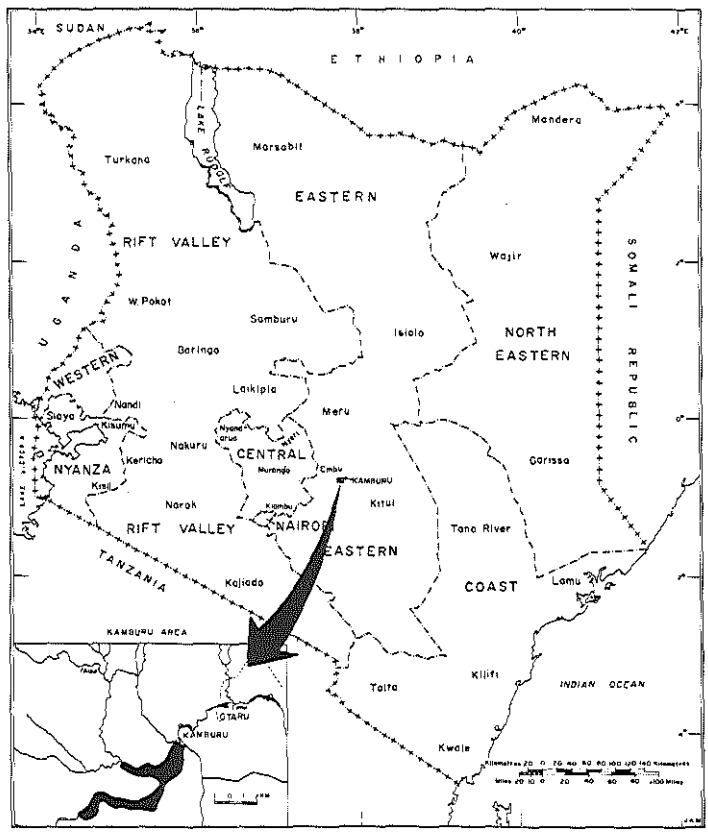
Apart from the admonition by the Zaina Scheme there was little other evidence offering guidance in the design and implementation of a multipurpose study on the effects of man-made lakes on human health. Studies which had been done in this field all concerned observations on specific diseases, mostly schistosomiasis, and concentrated more on prevalence and incidence aspects than on the significance of disease to the community. For designing the study protocol for the baseline studies on health we had to rely on the practice and experience on this matter in the Department of Community Health, University of Nairobi. At the time of planning for Kamburu a longitudinal study on various problems related to Mother and Child Health was in progress in a nearby area of Machakos District (Muller et al., 1977). This study was being conducted by staffmembers of the Medical Research Centre, Nairobi (project leader: Dr. A.S. Muller). On several aspects of the Kamburu protocol valuable advice was obtained from staffmembers of this project.

The quintessence of studies on health in waterdevelopment is to make policy relevant observations. This applies to baseline studies related to the initial health planning, and to later follow-up observations and the implementation and adjustment of health plans. For this type of evaluative research the scope and and limitations are determined by the baseline variables and various technical points. It is therefore urgent that research design is technically sound, but

especially that items for information are included which are relevant against the background of Integrated Development. Though, as a matter of fact, by being involved with the subject and project we gradually developed more pertinent ideas on this type of research, these could only be to a limited extent useful in our work at Kamburu.

In comparison to some of the truly major African Dams, and also to large irrigation projects, the Kamburu Ecological Survey covered only a minor population group. Moreover the Survey was not directly concerned with a policy of development for the area. In so far the project had a more academic than practical background. But possibly because of its limited scope, and therefore being more easy to manage, and because the project was carried out by staffmembers of the University of Nairobi, did the project become a pilot study for how multidisciplinary research could contribute to more optimal planning and management of the real big projects.

MAP 2 THE LOCATION OF THE SEVENFORKS HYDRO ELECTRIC SCHEME AND KAMBURU DAM IN KENYA



province boundary
district boundary

- View of the local market during the rainy season. Shops and houses are built in a rectangle. The central open space is used as a market once a week.
- Simple hotels provide accomodation, food and drinks to travellers and market visitors.

Chapter 5
The human element in the Kamburu ecosystem

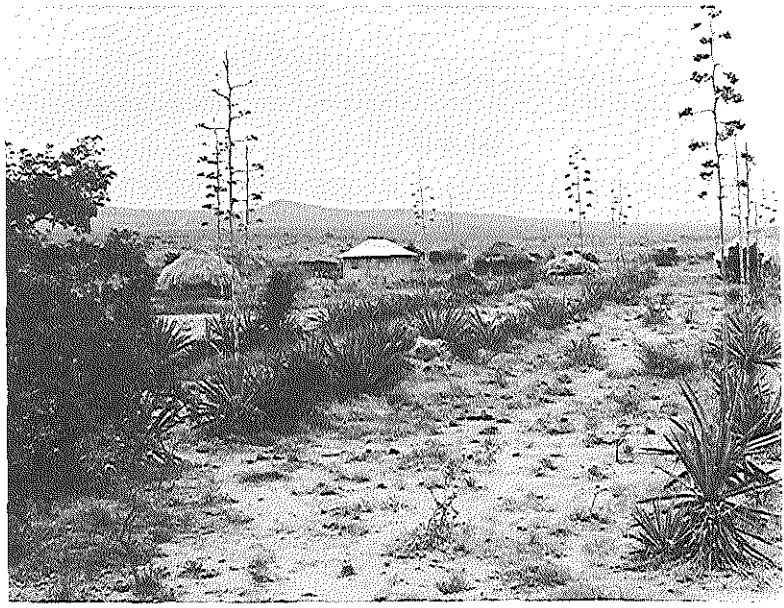
1. THE AREA

The Sevenforks Scheme area is situated at an altitude between 900-1000 m and is part of the foreland plateau of Eastern Kenya. From a human ecological viewpoint it is unattractive and comprises arid and semi-arid lands both on the northern Embu side of the river, and on the southern Machakos side. But whereas the land to the north rapidly changes to moist grassland and woodland at higher altitudes near Mount Kenya, on the Machakos side the land remains arid except in the immediate vicinity of rivers and streams. The ecological potential of the land is that of zone V (National Atlas of Kenya, 1970): "land only very locally suited for agriculture, the wooded vegetation being dominated by Comniphora's, Acacia and allied genera, mostly of shrubby habit".

The mean annual rainfall is between 500-750 mm, while the probability of obtaining 750 mm of rain during one year is less than 30% (rainfall at Kamburu for 1974: 570 mm). There are two rainy seasons, the long rains in March-May and the short rains in November. The long dry season from May to October covers the three coolest months of the years, which is fortunate from an agricultural viewpoint. The nearby Machakos area has an evaporation rate of 1000-2000 mm per annum. The mean annual minimal temperature is between 14-18 degrees centigrade, and the maximum temperature 26-30 degrees centigrade. The period from January to March is the hottest of the year.

In this area the Tana river forms a natural boundary between the Embu and Machakos Districts, inhabited by distinct ethnic groups. Before 1960 it was only sparsely inhabited, because of its low agricultural potential but also because it was known as a tse-tse area. The ongoing construction activities since the 1960's , combined with increasing population pressure in the densely populated parts of Machakos district, produced a flow of migrants moving into the area. The land on both sides of the river where the dams are located however belongs to the Tana River Development Authority, which forbids settlement but does not strictly enforce this rule. In 1974 a group of about 100 families had settled, partially illegally, immediate to the Machakos side of Kamburu dam. They all belonged to the Kamba ethnic groups. As on the Embu side of the lake human settlement did not start until about 8 km inland, it was decided to conduct the epidemiological studies among people living in Machakos District. These were all Kamba people. Against this background it should be evident that at Kamburu there was no question of forced migration. All those who had settled in the area, had come voluntarily. This aspect will be different for the lands to be inundated when Masinga Dam is completed. The observations on health conditions in Kamburu, however, probably may be considered representative for those groups as well.

The Kambas form the third largest ethnic group in the Kenyan population with approx. 1 million people. They, like their neighbour Kikuyu, Embu and Meru people, speak a Bantu language. The extended family and the clan are the basic elements of their social organization, and leadership comes forth from these collective units rather than from individuals or families. Marriage may be monogamous or polygamous according to preference and ability to furnish a bride price (Ndeti, 1972). Though at present the majority belong to various christian denominations, traditional beliefs influence religious behaviour. In Kamburu about 20%, probably more the older people, indicated to adhere to traditional religion. According to their concepts on health, diseases are either inflicted by man, through witchcraft and sorcery, or sent by God. For the first category



- Compounds are dispersed in a semi-arid landscape. Sisal plants are planted around the compound for fencing and utility.
- Typical view inside a compound.

relief and cure can be obtained through the help of a herbalist-diviner, who identifies the type of sorcery and the sorcerer. For the latter herbal medicines are usually administered. Traditional health behaviour plays an important role (Maina-Ahlberg, 1979). Kamba's have a long tradition in agriculture and cattle holding, though the last seems to have declined in recent decades due to shortage of pasture land. They are well-known artists, craftsmen and traders. Sizable Kamba communities can be found in various parts of Kenya.

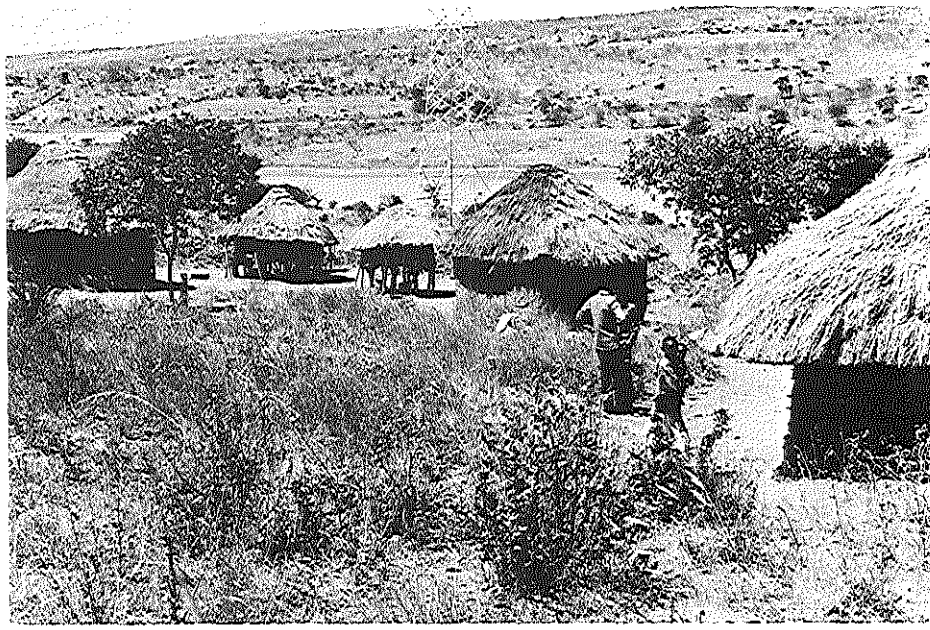
Endemic Diseases

Diseases and other health problems characteristic of various parts of Kenya are reviewed in "Health and Disease in Kenya" (Vogel et al., 1974). The potential health implications of water development on the Tana River were assessed earlier by a WHO mission (Derryberry et al., 1966).

Schistosome infections, both the intestinal and the urinary form, are prevalent in various parts of Machakos District. They have a focal distribution. In the Mwea-Tebere Irrigation Scheme, at some 60 km upstream from Kamburu, S.mansoni caused serious public health problems. Malaria, mainly the malignant form caused by P.falciparum, is endemic along the course of Tana river and in areas below an altitude of 1700 m. In this part of Kenya transmission is rather unstable and may take place between 3-6 months of the year, especially so along the river. In particular the transmission and incidence of malaria and schistosomiasis are likely to be affected andereased by in the waterworks going on in the area.

Intestinal helminth infections are prevalent throughout Kenya. Their incidence mainly depends on local factors favoring their transmission. Visceral leishmaniasis is sporadically reported from Northern Machakos, Kitui and Meru Districts. Major outbreaks have occurred in the recent past, and the disease is notifiable since 1957. Since 1975 an increasing number of cases was reported from adjacent areas and the disease appears to be spreading also in the area in which Kamburu is located. Human trypanosomiasis is a health problem of Western Kenya near Lake Victoria. Animal trypanosomiasis however has a wider distribution, though epizootics are infrequent. The Masinga area also used to be called Tse-tse Area, indicating that animal trypanosomiasis has been a problem in this region in the past. Little information is available on its present importance, but Glossina pallidipes, one of the vectors, is known to be about. Arbo-viral infections are known to occur or to have occurred in Kenya. Little is known about their importance in these parts of Machakos and Embu Districts. Plague and rabies are enzootic in the area. If introduced bancroftian filariasis, endemic along the lower reaches of Tana river and the coastal area, and onchocerciasis, formerly endemic in Western Kenya, might initiate a local cycle of transmission.

The diseases listed above have been selected because their transmission may be affected by the water development activities. It should be stipulated however that they constitute only part of a wider scala of health problems, amongst which measles and other respiratory infections, diarrhoeal disease, malnutrition and undernutrition, tuberculosis, accidents and venereal diseases are the most important.



- Traditionally built houses are round and have a thatched roof. A compound near the lake.
- The house in this picture shows a more square building style, walls are still mud and wattle, but the roof is iron-sheeted. Signs of transition. Tobacco snuff, a valuable product, is being prepared under the tree.

2. STANDARD OF LIVING AND THE DOMESTIC ENVIRONMENT

In this section some of the field observations made as part of the epidemiological studies are presented. They are summarized in Tables 5-8. Details about their collection are given later on. The remaining information has been taken from the contributions of other participants in the Kamburu Ecological Survey (Odingo, 1979), from the findings in the Joint Project Machakos in a nearby area of Ukambani (Muller et al., 1977), and other sources.

Administration, Population density and Migration

The Kamburu area is part of Masinga Sublocation and Location (lower administrative units of government) of Machakos District. The sublocational offices are at Masinga, while the location headquarters are at Matuu (35 km). A sublocation is further divided in 4-8 utui, whose elder, or headman, holds a honorary position. The population density of the Masinga Sublocation is between 10-19 persons per sq. km. Before 1950 population density was very low, probably 1-2. The area immediate south of the lake, however, measures about 10 sq. km and had about 500 inhabitants at the time of the surveys.

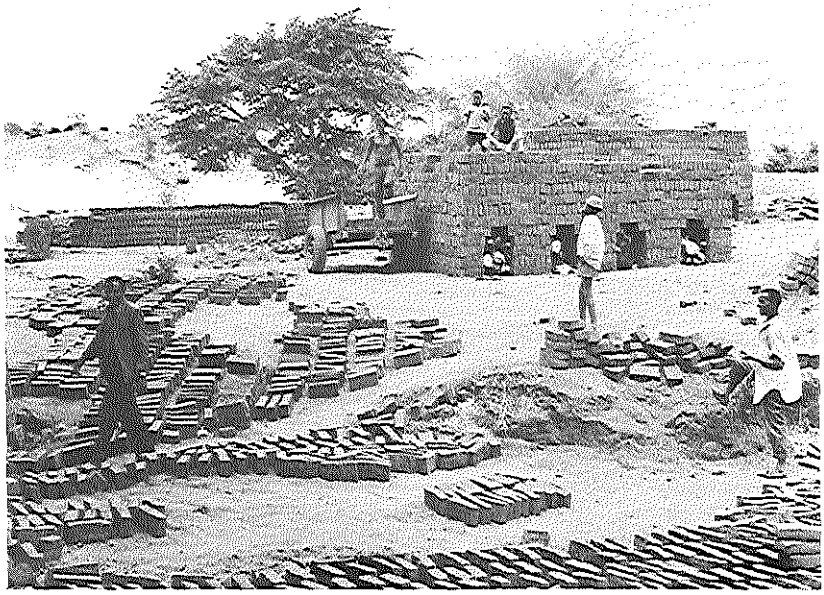
Several forms of migration are important. A more permanent element in the population is formed by rural-to-rural migrants. This type of migration is motivated by the desire to acquire land for farming and domestic animals. Movements are more intense in the vicinity of the lake than in the remaining part of the sublocation (see Demography). Migrants mostly come from densely populated areas in the district around Machakos town, Masii and Mwala, where an increasing population and accompanying soil erosion are responsible for shortage of arable land.

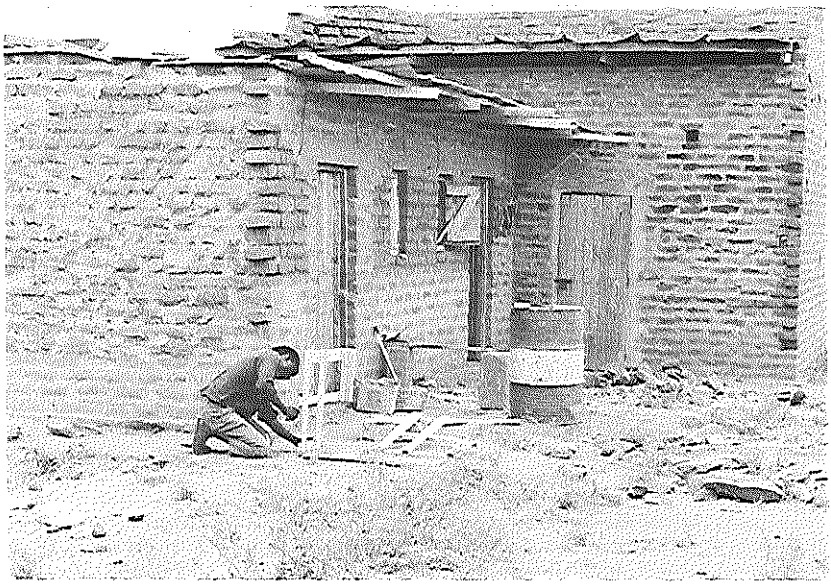
An important group of temporary residents in the area is constituted by the unskilled or semi-skilled laborers employed at the construction sites. Particularly this group may introduce various infections to the local population. Schistosome infections were prevalent among the workers employed for Kamburu dam (Roberts, pers. communication). A limited health survey carried out among a sample of the workers of Gtaru dam in 1977 showed that they belonged to nine different ethnic groups from all over Kenya. Few pertinent health problems could be detected among these people, who had already been receiving health care from their employer for some time. The labor force is usually constituted by single men and few women. Their families stay behind in the home areas (Department of Community Health, 1977).

A third mobile group in the population is formed by men who are employed in urban areas, but whose families stay behind on the farm. These may come home once a month or less often. They remit a proportion of their earnings. Occasionally the wife and small children may go to stay with the father for a while.

Settlement Pattern and Social Services

As in other parts of East Africa the settlement pattern is scattered, each family occupying their own plot, and houses and farms being spread all over the land. Shopping centres with 20-30 shops built in a characteristic style, are the social and economic heart of a given area. The main shopping centres for Kamburu are at Kivaa (Lakeside group) and Masinga (Inland group). Here an open air market is held weekly. Minor shopping centres are at Kaewa and Mukusu. Shops offer meat, bread and a variety of mainly commercial foodstuffs for sale, as well as clothing and essential technical services. Fresh produce is sold in the weekly market, which accurately reflects what is being cultivated in the area. Near the shopping centres one or more churches can be found, as well as bars and a school. Each of the centres mentioned has a primary school. A government secondary school is located at Masinga, but the people of Kivaa en-





- Bricks are formed and burnt locally if conditions are suitable.
- A modern shop under construction. Cemented brick walls. Doors and windows made by the local carpenter. Sloping iron sheets on the roof, and cemented floors.

deavoured to start one on self-help basis in 1977. Primary education is free up to standard IV, parents have to contribute however to the building and maintenance of the school and other special expenses. From standard VI on a school fee is charged in the order of Ksh.100/- per annum (approximately US$ 12).

Several traditional medical practioners have their practice in the area, their homes are sometimes marked by a white flag. The only government clinic is at Masinga. This is a dispensary staffed by an enrolled nurse and a midwife, a married couple. Health centres are located at Matuu in Machakos (35 km), and Kiritiri (25 km) in Embu. The quality of care provided is seriously restricted by a regular shortage of drugs in these places. General hospitals are at Embu (60 km) and Machakos town (135 km). Despite the distance Kamba's prefer to seek medical care within their own district however. Kivaa used to be served by a Mobile Clinic once a month, but services were discontinued in 1976. At government centres medical outpatient care is provided free of charge, and a nominal fee has to be paid for admission.

All-weather roads connect Kivaa and Masinga with urban centres and Nairobi. As all construction materials have to be transported along these roads, they are kept in a reasonable state of service. Private transport companies maintain, daily or at the most twice daily , bus services. Transport from the farm to shopping centres is along a network of tracks and foodpaths. Also because of the accidented terrain few of these admit fourwheel vehicles. Travelling is on foot and for some by bicycle. Loads are transported by oxcart, owned by a few, sometimes by donkey, but mostly on the backs of the housewives, who are phyically able and culturally accustomed to carrying almost any load by a headband. When traveling without a load these women often weave sisal rope or baskets while on their way.

Thanks to the vicinity of the construction camp, the centre of Kivaa has benefitted from increased business by the dam-workers.

The Household

The household was defined as people habitually eating and sleeping together. According to this definition the Kamba household has on the average 6 people. A larger homestead is often occupied by more than one family. The extended family may be composed of the head of the household and his wife or wives, older children or brothers and sisters, and newly married couples. Each couple usually having their own off-spring as well. For the larger family van Steenbergen (1978) found an average of 9 persons.

Among the Kamburu population the Inland group complied with the pattern of 6 persons per household. Households on the Lakeside were quite smaller in 1974. By 1977, however, also here households had increased to an average of 6 persons. In the period between 1974-77, 20 households departed from the Lakeside area altogether, as opposed to 10 from the Inland group. On the whole these families had only spent a few years in the area, exploring its possibilities. The increased size of Lakeside households apparently reflects a true increase in the number of persons, and indicates a stabilization of households having decided to remain after a trial period.

- One or more grainstores are found in every farm compound. Stores are raised off the ground and well ventilated. Here some gourds are being dried underneath.
- Traditional Kamba house interior. A three-stone fire centrally. A cupboardlike structure is used for keeping food and cooking utensils. The sleeping section is screened off. Domestic animals have free access (picture HAPC Oomen)

TABLE 5: A Profile of Households and Housing in the Lakeside and Inland groups in 1974 and 1977

Households with	1974 Inland (n 108)	1974 Lakeside (n 103)	1977 Inland (n 106)	1977 Lakeside (n 91)
Average nr. persons	6.2	4.8	6.6	5.9
More than 10 persons, %	10	8	23	11
More than 3 rooms (excl. kitchen) %	13	13	37	30
One room only %	58	62	33	32
Separate kitchen %	35	39	37	29
Latrine present %	7	8	5	9
Iron sheet roof %	17	16	35	20
Cemented walls %	11	4	21	9
Property more than 3 units * %	29	29	58	49
Property a single unit %	34	47	21	29
Animal husbandry more than 4 units ** %	24	43	29	34
No animals or only goats %	34	26	17	26

*Legend: 1 unit per/ room, iron sheet roof, cemented wall, radio, bicycle each.
**Legend: 4 units represent more than 49 animal-points on the basis of 5 points for a cow or bull, and 1 point for goats and sheep each.

Housing

The Kamba homestead is commonly composed of several building structures which serve the family or extended family. The house is surrounded by a garden beyond which a mostly thorny fence or a hedge of sisal is encountered. The leaves of the latter are cut and pulled over a sharp device to separate the fibers for making ropes and baskets. Traditional houses are round and have a thatched roof. Walls are constructed from mud and wattle or mud and bricks. Baked bricks are manufactured locally. The framework of the roof is supported by poles. A fire dominates the centre of the interior, while household items and sleeping facilities each have their own customary place. Furniture is simple, consisting of a few stools and a wooden framed bed or their more modern modifications. Larger compounds may have a separate hut for cooking. One or more granaries supported by large rocks to elevate them, and a circular area to enclose cattle complete the compound. Few of them possess a latrine, or a secluded place for bathing. When people can afford this, the thatch of the roof is replaced by sheets of corrugated iron or flattened tins or drums. Modern houses are built with bricks and natural stones, using cement as mortar. Such houses are rectangular and contain several rooms. Traditional houses sometimes have wooden-framed windows while smoke from the fire has to force its way out through the thatch or various openings. Modern houses on the other hand often have steelframed windows and a chimney. Various openings, for instance the open space between the roof and the wall may provide additional ventilation. Except for modern houses all have pounded earth floors. Small locally made oil lamps

- Water for domestic use is taken mostly from surface watersources. The picture shows a large pond near Kaewa, from which households in the vicinity draw water.
- Near Masinga water is pumped from a deep borehole into a cemented reservoir. Though not shown, most watersources are also used for watering animals.

are used for lighting, while some shops may possess more sophisticated paraffin lamps.

According to the information contained in Table 5, about one in five households have at least one room covered by corrugated iron, while about half of these have walls built with cement. Housing conditions in the Lakeside area did not change between 1974-77, but in the Inland area the quality of buildings had improved.

Meals are taken around the cooking fire or outside the hut. In one-room households (60% in 1974, 30% in 1977), or households without a separate kitchen, the same room serves for cooking and sleeping. Sometimes small animals may be kept inside the room during the night also. For sleeping each wife normally has her own room, where she stays with her smaller children. Older children build their own room. Sleeping density, which is a function of the number of people and the size of the room, has not been assessed. Crowdedness expressed as the average number of people per room was calculated instead (see Demography).

Water Supply

A single deep borehole and dieselpump supplies a number of Inland households near Masinga. The remainig households both Inland and on the Lakeside depend on various sources of surface water. These include the lake, a few open wells, pools of rainwater during that season, and during the dry season waterholes which are dug in the dry bed of seasonal rivers. The latter is especially characteristic for the arid and semi-arid parts of Machakos. Season therefore influences the type of water source employed. Few houses make use of rain catchment.

TABLE 6: Type of Water Source used by Households during the Dry and Wet Seasons

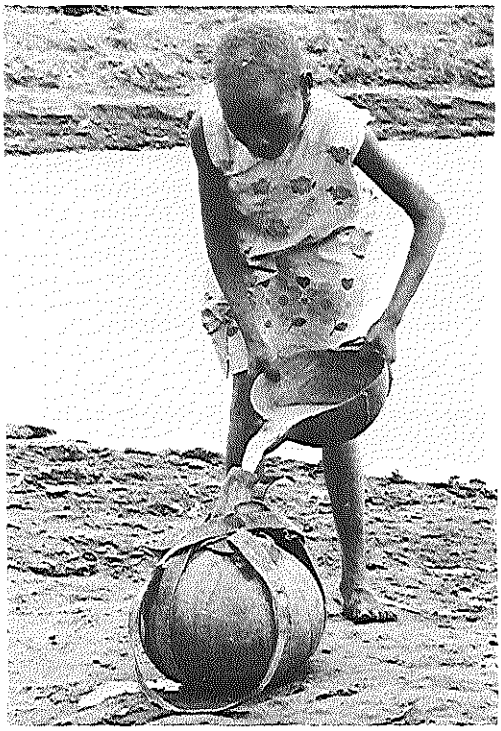
	1974				1977			
	Inland		Lakeside		Inland		Lakeside	
Water source/season	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
The lake	9	4	72	68	10	4	79	59
Other surface sources	84	89	38	42	81	93	29	46
Borehole	36	28	0	0	35	25	0	0
Raintank	0	2	0	0	0	4	0	4

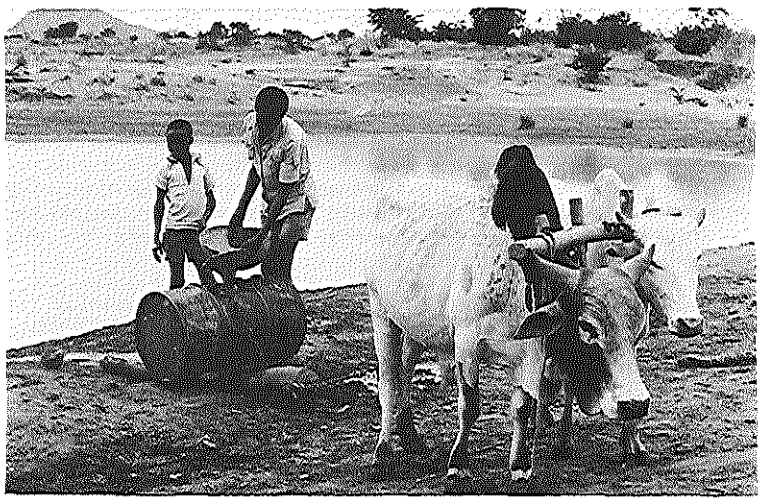
* A household may use more than one source at the same time

The type of water supply changed very little between 1974-77, except that a few more houses were able to install rain tanks. Observations on water quality have not been made. The table clearly demonstrates the different pattern of water sources used by the two groups.

Water collection is the duty of women and children. A varying number of "water collection journeys" are made each day. At the source water is scooped up with a small calabash into the carrying vessel. These are large gourds, but many women use a small type of drum, holding 20-30 liters, nowadays. They are carried by a headband on the back. Traditionally water is stored in the house in large clay pots, however containers may vary from buckets to oil drums.

In the dry season when water sources near the house have dried up, water collection becomes more arduous for many housewives. The significance of time and energy expenditure of the water collection journey during the dry season was assessed for a sample of Inland and Lakeside households before the long rains of





- The traditional water collection vessel, a large calabash, being filled with a calabash scoop. Sisal sling for carrying is fastened with a special knot around the round object.
- Water for a local hotel is collected in an oil-drum. Transport is on a primitive sled drawn by oxen.

1975.

These figures are based on a rough assessment especially of the distances involved. Some of them may appear incredible. Similar observations however were recorded by White et al. (1972) for the Masii area not far away. On the whole these data indicate that the time and energy cost of domestic water is very much lower for households situated near a dependable source, both Inland and on the Lakeside. The Lakeside group has a major advantage over the Inland families in this respect, having to spend "only" about a third of the time and energy. The significance of these findings could probably also be demonstrated by the observation that Inland women in the sample, weighed less ($P<0.05$) and had a lower weight for height ($P<0.01$) than their Lakeside counterparts.

Average water consumption is about 10 litres per person per day, it is slightly higher for the Inland people, despite the extra efforts involved. This apparently contradictory finding is explained by the fact that Inland people perform more activities for which water is needed at home. At home water is used for cooking and drinking, washing kitchen utensils and clothes, and for bathing. Smaller animals are sometimes watered at the farm, cattle however is always taken to watering points for drinking. Some information on domestic water use indicates that bathing and clothes washing, though done less often, is more often done at home by the Inland people. It could be expected that body-hygiene is less satisfactory in these households.

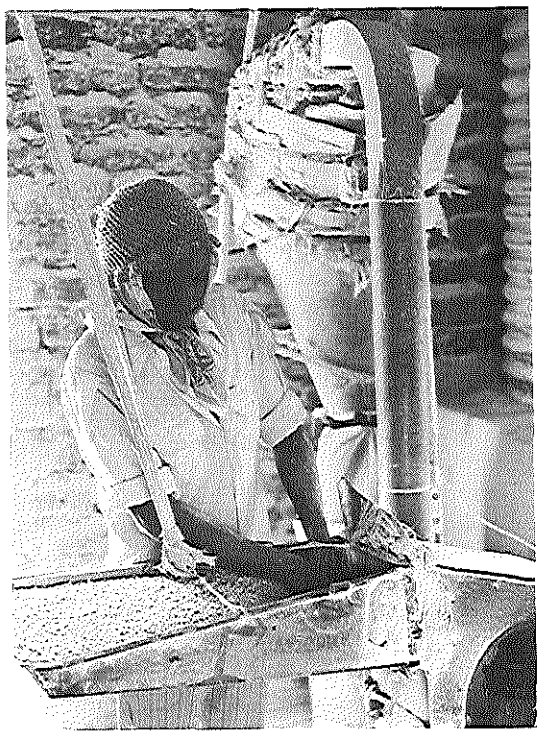
TABLE 7: The Water Collection Journey and Average Consumption per person during the Dry Season for Inland and Lakeside Households

	Item	Range	Median	Mean
Lakeside Group (n 31)	Distance both ways (m.)	441-3780	1313	1375
	Time both ways (min.)	5-68	24	24
	Nr. of collections/day	1-5	1.8	1.9
	Energy/woman/day (cal.)*	31-571	154	186
	Av. consumption/person/day (litres)	4-24	8.6	9.6
Inland Group (n 40)	Distance	316-11,900	4750	5207
	Time	6-203	82	90
	Nr. of collections	1-4	1.9	2.5
	Energy	49-1227	536	524
	Av. consumption	4-23	9.9	10.8

* Calculated as indicated by White et al. 1972

TABLE 8: Some aspects of Domestic Water use during the Dry Season for Inland and Lakeside Women and Men

	Sex	Av. times Bathing/wk	Bathing at home	Av.times Laundry/wk	Laundry at home
Inland Group	Males (n 27)	3.0	48%	-	-
	Females (n 41)	3.5	49%	2.1	37%
Lakeside Group	Males (n 18)	4.9	11%	-	-
	Females (n 30)	4.9	40%	2.8	32%



- A dieselpowered mill for grinding maize can be found near any of the market centres. The service is being paid for in kind.
- Factory produced maizemeal and flour can be purchased from most shops. Simple but important medicines, such antimalarials and analgesics are usually sold as well. (picture HAPC Oomen)

Excreta Disposal

Fewer than 10% of all households have a latrine at their disposal. Existing facilities are all pit-latrines with dry pits. A rectangular hole of about 3 m deep is covered by a simple wooden squatting frame and superstructure. Smell appears to be the main nuisance. Some of the latrines appeared not to be used regularly. Of the remaining the hygienic state was reasonable. This statement should be qualified for latrines used by a single household. Unhygienic and often offensive conditions prevail in places where latrines have a mixed group of users, such as in shopping centres and schools. Non-latrine owners use the open field, which has the relative advantage of being usually sunlit and well-ventilated.

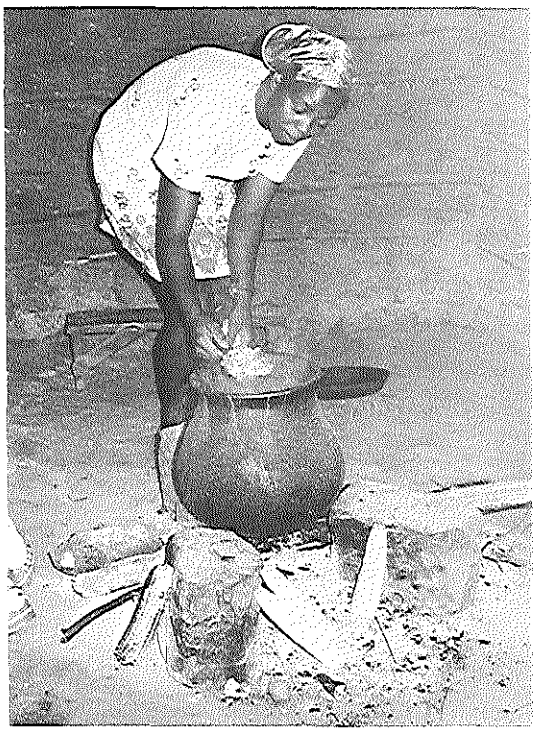
Mothers are rather careless about the excreta of their infants. These are wiped off with a cloth or removed with a leaf or piece of wood. Excreta of small children are removed in a similar way from the living area. Few other details are available on hygienic behaviour.

Nutrition

Under normal circumstances the Kamba family uses three meals per day. The main ingredients are maize (used 220-240 times per 100 consumer days), legumes (85-145 times), milk (60-90 times), vegetables (35-85 times), sugar (50-65 times) and fat (25 times). Other foodstuffs consumed are sorghum, millet, rice, wheat, bread, fruits and onion. Except for onions and salt, these items are consumed only occasionally, and contribute a minimal share to the diet. Diet composition is influenced by the season and this influence is marked for the frequency and amount of legumes and vegetables consumed. Fruits are mainly eaten by children. The main dishes recurring on almost every day of the year are isiyo (a mixture of maize and beans or peas) and ngima (a solid maize flour porridge served with stew or milk). More well-to-do households add more fat and meat, but essentially eat the same diet (van Steenbergen et al., 1978). This diet based on the staples of maize and legumes, and the Kamba feeding habits are considered nutritionally sound by these authors.

These observations were made in the neighbouring location of Mbiuni, some 90 km to the southwest, a site which has been studied extensively. Here the ecological potential of the land is higher (National Atlas of Kenya, 1970: Zone IV) and prospects for agriculture better. Harvest failure due to shortage of rain is expected 33 out of 100 years. The altitude is 1200 m, and population density 165 per sq. km. Farming households cultivate about 1.2 ha of land, and own several cattle, goat or sheep and a few chickens. Ploughs are owned by 35% of the farms. Of the foodstuffs needed, sugar, tealeaves and fat are wholly purchased from shops, and of the remaining about 40% or less is purchased mostly from the market. Onchere (1976) estimated that an average family needs Ksh. 182/- per month for food, representing 75% of their total income in years with a satisfactory harvest. For feeding 45% of the families rely exclusively on farm income, while the other 55% have additional sources of income. The authors conclude that the situation in this area is vulnerable. Whereas people can feed themselves adequately in good harvest years and have a small surplus, this may not stretch to overcome seasons with a poor harvest. Years of starvation are the consequence, and are a familiar occurrence in the area.

By contrasting the findings at Mbiuni with the situation in Kamburu an insight can be gained in the conditions of nutrition. The ecological potential (zone V) is less than for Mbiuni, and harvest failures are expected to occur 40-50 years out of every 100 (Odingo, 1979). Landholdings average 1.4 ha per family of which 75% is under cultivation. Ploughs are owned by 10-20% of the farms, the remaining relying on the traditional hoe for cultivation. Maize represents 75% of the crops under cultivation, and produces a meagre 20 bags (90



- Maize, beans and peas, and cooking fat are the basic ingredients of the local diet. Simple cooking utensils are used for preparation. (picture WM van Steenbergen)
- Isiyo (a mixture of maize and beans) being cooked in a earthen pot on the fire. This dish is eaten daily most of the year. When available fresh corncobs are eaten roasted (foreground) as a snack. (picture HAPC Oomen)

kg) per ha. Other crops are mainly beans (Phaseolus vulgaris), cowpeas (Vigna unguiculata) and pigeon peas (Cajanus cajan). An average family holds about 4-5 cattle and 5-10 goats and sheep, but about 20% of the families have no domestic animals at all or only a few goats. It may be concluded that conditions for nutrition are even more precarious than at Mbiuni, unless significant non-farm sources of income are available to the people.

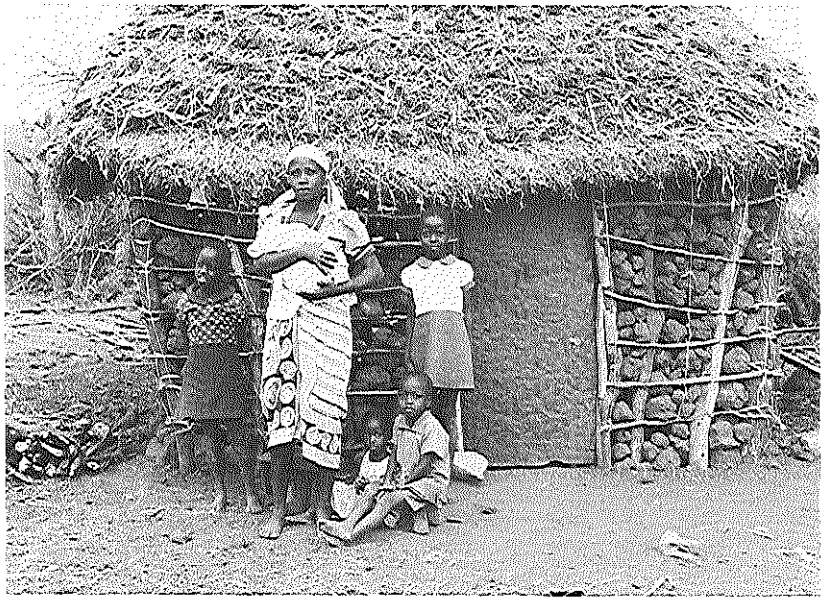
No information is at hand comparing farming and farm produce of the Inland and Lakeside groups. It could perhaps be expected that the Lakeside farms are able to maintain irrigated gardens at the water side. This is now not the case, and is precluded by the rapid fluctuations of the water level in the lake during these years. In general Inland and Lakeside farms have the same appearance and similar crops are grown. The cattle index (table 1) indicates that more animals are kept by the Lakeside farms. This could be explained by the ease of watering cattle in this area. On the other hand in semi-arid areas cattle is kept as a kind of insurance for years when the harvest fails. For this reason pioneering farmers may keep more than the usual number of animals. Cattle ownership, however, declined between 1974-77 in the Lakeside area, but increased Inland. The rains largely failed in 1974 and 1975, the following years however had quite satisfactory rainy seasons. The more favorable property index of 1977 could be the reflection of two good harvest years.

The lake has a potential for supplying the population with fish. Since its filling early 1974 commercial fishing was carried on by a few immigrant families from Western Kenya. Catches are sold fresh or smoked, mostly in the construction workers camp. The local people have no tradition of fishing or fish consumption. Though in theory at least the Lakeside group could have a ready supply of fish, in practice its significance is negligible.

The Role of Women

That locally women are involved in many and varied activities strikes even the casual observer. They are the managers of the homestead, prepare food, collect water and fuel, care for the children, clean utensils and clothes and at times can be seen repairing or thatching the roof. Besides they contribute significantly to food production and farm management, and are responsible for grazing and watering cattle. They visit the market at least weekly, take children for treatment when needed, visit church and self-help groups. Van Steenbergen et al. (1978) lists seven categories of activities, which women regularly take part in. According to their observations mothers of children under 3 years spend about 2 hours per day in the farm and with cattle, five hours on domestic duties and child care, two hours collecting water and firewood, and 2 hours for going to the market and social visits.

Apart from the labour they contribute, it is important to consider the influence of women on decisions concerning the farm, the home, health care and education. Traditionally Kamba's distinguish between male and female tasks and duties, which implies certain responsibilities. Tradition however is progressively modified by outside influences. Corkill Redlich (1971), who studied the role of Kamba women in the household, classifies households in traditional, transitional and divergent. The first are the large (traditional) extended family households. Here it is the "mother" of the house who takes the women's decisions. The last is the independent nuclear family of which the husband has regular employment, and often lives separated from his family. In this case the wife is left at the farm to care for the children, the house, the fields and animals. She will take decisions on daily affairs alone, and for instance also decides when to take a child to the clinic, without waiting to consult with the father. In the Kambura area about 10-20% of the households are of the extended family type, and about another 20% of the divergent type, with the husband staying away from home. The remaining households may be considered as transitional



- Child-bearing and child-rearing are central in a women's life. Large families are common also because at present fewer children die prematurely.
- The water collection journey is made several times a day by most housewives. Here water is being carried in the traditional way, on the back by a sling around the forehead.

between these extremes. We had the impression that housewives of the Inland group had more conservative attitudes, while in the Lakeside group they tended to be more modern, and probably divergent.

Fuel Supply

For cooking and heating a simple open fire is used with very few exceptions. The fire is contained by three stones which support the cooking pots. Charcoal burners are seen rarely in farmhouses, but they are regularly used in the shopping centres. Kitchen arrangements of this type are of course a source of accidents.

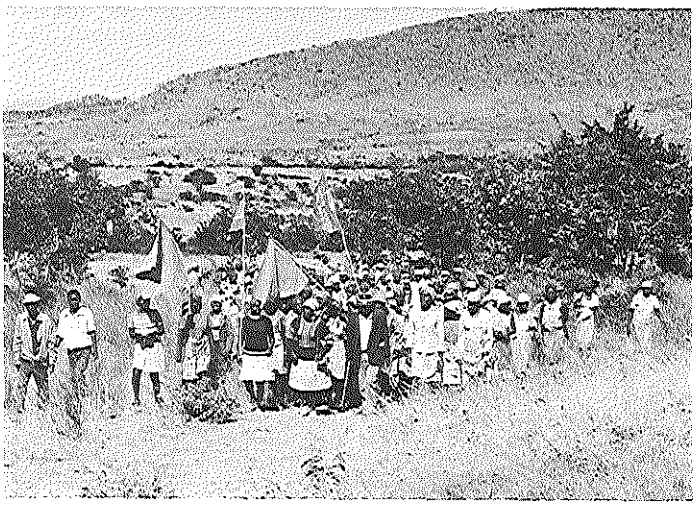
Women collect the firewood. Though the cutting down of trees is mostly done by men, women can be seen cutting the branches and chopping up the logs. At the present time firewood is still available relatively near the homes. Firewood is carried in large bundles by the usual headband. Though charcoal is rarely used a number of women take part in charcoal burning as a source of income. Charcoal is being sold to urban centres at about Ksh. 7/50 per bag. The demand imposed on the local vegetation, especially on the slow-growing hard wood species used for charcoal, exceeds the natural supply. The effects of deforestation during the last 10-15 years are visible everywhere in the form of deep erosion gullies.

Occupation and Income

More than 90% of the households derive their livelihood from agriculture. There are a few larger farms near Masinga, growing for instance mung beans (Phaseolus radiatus) as a commercial crop. Near Kivaa a single cattle farm with approximately 75 animals is managed by a few men, employed by the owner who resides in the town of Thika. Apart from such exceptions households farm at the subsistence level, and produce is used for private consumption, while some of it is sold to obtain cash to purchase necessary foodstuffs and pay for school charges.

Muller et al. (1977) estimated the total annual income in Mbiuni at between Ksh. 1700-2250 for the year 1973 (1 US$ = aprox. 10 Ksh.). However, only part of this amount may be actually received in cash and the remainder in natura. Kune et al. (1979) stated that out of this amount Ksh. 750 derives from the sale of farm produce, the remainder coming from the sale of cattle and additional sources of income. From an agro-economic survey in 1976 in the area Onchere (1976) arrived at an total income of Ksh. 2800 for that year with a particularly good harvest, of which amount 75% was spent for the purchase of foodstuffs. Income in the Mbiuni area, which is situated in an ecologically more fertile zone, is considered to be near or below the subsistence level. It could be concluded that income in the Kamburu area is even more precarious and that the people depend to a significant extent on sources of income other than farm produce.

Few men of the area are employed in dam construction (see Demography). Apart from these it could be ascertained that 15-20% of fathers of children under 3 years were not staying with their family, and probably were employed outside the area. Such men transfer about 25% of their earnings. Further additional income may be generated by various types of self-employment. Farming is markedly seasonal and during 6 months of the year people have little farmwork on hand. Particularly during this period men and women may engage in bee-keeping, charcoal burning, tobacco and snuff preparation, woodcarving, basketry and other crafts and trades, includig poaching on the wildlife beyond Kindaruma. Some people do quite well even here. An example of these is a locally well-to-do and enterprising farmer-business man who besides his farm keeps a small bar- restaurant annnex shop at Mukusu, and owns curio-shops at Nairobi and Malindi.



- After having separated the grains from the cob this housewife is collecting them in a bag to await consumption, or sale in the market.
- Women often fill spare moments, or while walking somewhere, with weaving sisal fibres into bands and baskets. The sisal is usually homeproduced and prepared.
- Harambee (self-help) groups take an important place in social life. The group in the picture is mustering support for a secondary school at Kivaa market. Women take a prominent part in such activities.

Chapter 6
Survey methods and quality control

1. DESIGN AND SAMPLING

For reasons indicated earlier the epidemiological surveys were restricted to the Kamba people who live on the southern or Machakos side of the lake. To distinguish between changes in health conditions due to exposure to the effects of the newly created lake, and those which would have occurred in any case, it was considered necessary to make observations in an Inland group (or control group) and a Lakeside group (or study group). The Lakeside people inhabit an area of about 10 sq. km extending about 4 km Inland from the southern shore of the lake. All households living here were included in the sample. The Inland group was settled in a territory, part of Masinga Sublocation, between 4-11 km Inland from the lake and adjacent to the Lakeside territory. From the households a random cluster sample was drawn to match the Lakeside group. The names of six heads of households were drawn randomly from the taxregister at Masinga. The households so selected were taken as the starting point of six clusters of households, each having a minimum of 100 individuals (see Map 3).

Each area could be geographically defined using roads and tracks, the Kamburu Power Station transmission line, and the boundaries of Masinga as landmarks. The area is transsected by a seasonal stream, the Kithambui river. Some people (Lakeside 81, Inland 43) were missed at registration of the sample populations in 1974, however they were included in 1977. Households located in the market centres of Kivaa, Masinga, Mukusu and Kaewa were excluded from the samples, because it was assumed that they were less representative for the truly rural households of the area.

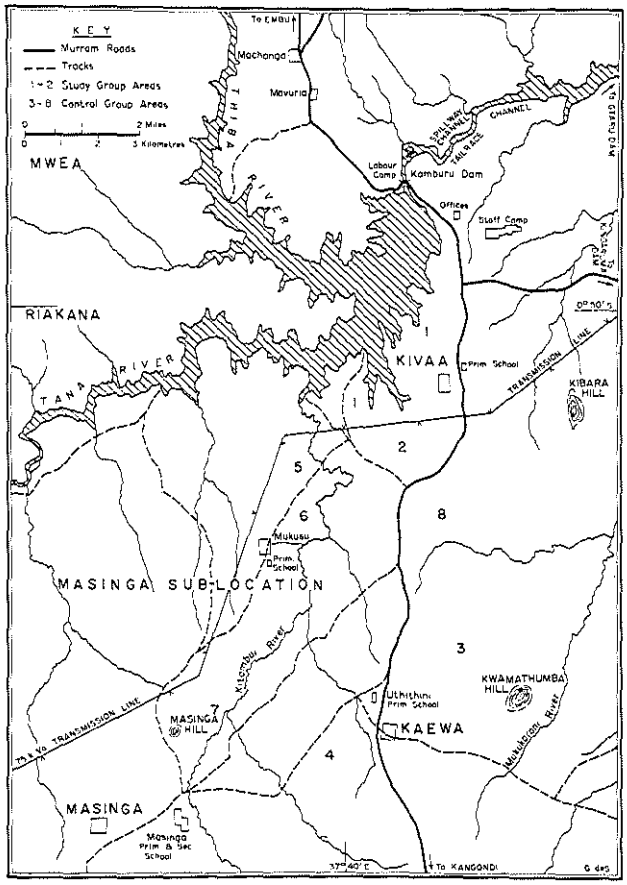
The surveys were carried out between October 5th - December 11th 1974, and between July 8th- September 14th 1977. The first survey therefore took place during the 'short rains' of 1974, which however were poor during that year. The second took place after a good 'long rainy season' in 1977. Ideally both surveys should have been carried out during the same season of the year. This unfortunately was for technical reasons not feasible. Annual rainfall recorded at the Kamburu construction camp was in the order of 550mm for 1974 and 1975. The following two years had more ample rain, no figure is available for 1976, but for 1977 this was 750mm.

With an exception for some minor details, survey procedures were identical in 1974 and 1977. Initially all households were visited at home. Persons belonging to the households were individually registered (Individual Form), and certain characteristics of housing and environment assessed (Household Form). Also anthropometric measurements were taken from children under 3 years of age, and information about their diet and health recorded (Nutrition Form).
Households, and items on the survey forms have been defined previously (Oomen, 1977). Registration of all households in this fashion took between 3-4 weeks.

After registration of all households had been completed a second round was started. Now people were requested, with 2 days advance notice, to report to one of the four centrally located schools on a specific day for the health interview and physical examination, and to supply specimens of blood, urine and stool (Health survey Form 1 and 2). Households of which individuals failed to report, were reinvited at least once.

Apart for the two health surveys reported here, all households were visited again in May 1975 and November 1975. During these visits any changes in house-

MAP 3 GEOGRAPHICAL DEFINITION OF INLAND AND LAKESIDE AREAS



hold composition were recorded and the nutritional status of children reassessed. In April 1975 details on water collection were measured for a 1 in 3 household sample. These surveys have been reported on elsewhere (Oomen, 1977; Oomen 1979).

Fieldwork for the Kamburu Ecological Survey was executed with permission of the Office of the President of Kenya, and of the Provincial Commissioner of Eastern Province. Chief and Assistant Chief were informed well in time, and baraza's (meetings) were held to inform people about the purpose of the survey and about the cooperation required. People were not rewarded for their cooperation, but minor complaints were treated on the spot and more serious ailments referred for treatment elsewhere. Cases of schistosomiasis were treated after the diagnosis had been made. After the 1977 survey had ended an immunization and nutrition education campaign was conducted by medical students of the Department of Community Health of the University of Nairobi.

None of the households included in the samples refused information during the home visits. However at the time of the health survey some people could not be examined because they were absent (having been away from the house for less than 4 weeks and expected to return within the next 4 weeks) or failed to report for other reasons. Table 9 specifies the "de jure" population (see also Chapter 7), those who were absent, failed to report, and those who reported and could be examined. Of the persons under 15 years of age 80-96% of the 'de jure population' were examined. Response rates were lower for persons older than 15 years (40-87%) and any conclusions from survey findings should be treated with reservation. In general response rates were lower for males, while fewer people responded during the second survey.

TABLE 9: The "de jure" Population of Inland and Lakeside groups, Absentees, Non-reporters and Reporters for the Health Examination Survey, by age and sex in 1974 and 1977.

	Under 15 years				Over 15 years			
	Inland		Lakeside		Inland		Lakeside	
	M	F	M	F	M	F	M	F
				1974				
De jure No *	186	196	132	118	112	176	109	137
Absent	3	5	2	2	27	12	16	8
Non-reported	13	8	5	3	19	25	17	10
Reported **	170	183	125	113	66	139	76	119
Reported %	91	93	95	96	59	79	70	87
				1977				
De jure No *	179	201	141	131	143	176	122	145
Absent	5	5	7	8	46	16	24	17
Non-reported	31	14	8	6	39	35	32	16
Reported **	143	182	126	117	57	125	66	112
Reported %	80	90	89	90	40	71	54	77

* : De jure Numbers are denominator for vital rates
** : Numbers Reported are denominator for morbidity rates

- During the health survey two landrovers were constantly needed to carry the survey team back and forth, to liaise with the field laboratory and to transport people from remote households.

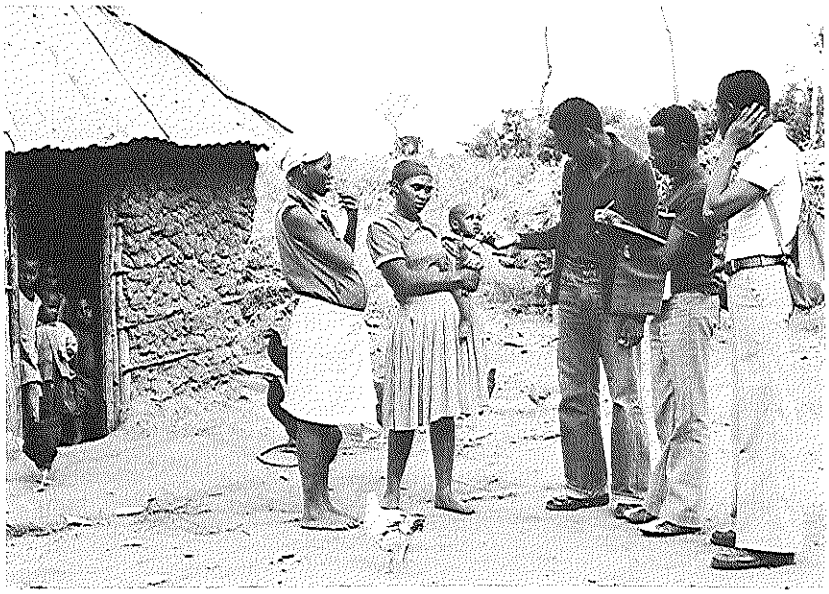
2. METHODS AND PROCEDURES

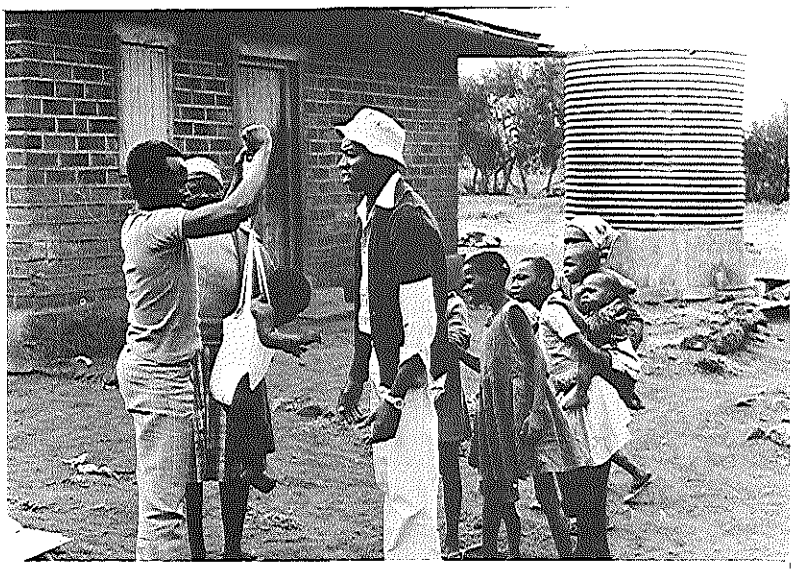
TABLE 10 Survey Forms and the Items of Information Recorded (more detailed information in Oomen, 1977)

Household Form	Individual Form	Nutrition Form 1)	Health Form
*Name of the head	*Name	*Age in months	*Age
*Nr. of people	*Sex	*Nr. deciduous teeth	*Specific complaints 2) about ill-health
*Nr. of rooms	*Date of birth	*Weight	*Frequency of lake contact 2)
*Kitchen	*Place of birth	*Height	*Disability, duration 2)
*Roof materials	*Relationship to the head of the household	*Arm-circumference	*Blood pressure 3)
*Wall materials	*Religion	*Vaccination scars for BCG and Smallpox	*Weight 4)
*Water source: dry season wet season	*Length of stay in this area	*Any complaints today	*Height 4)
*Persons collecting water	*Years schooling	*Diet: 24 hour recall	*Arm-circumference 4)
*Frequency of water collection	*Occupation 2)	*Breastfeeding	*Triceps skinfold 3)4)
*Nr. cattle/goats	*Parity for women 2)	*Fish consumption	*Nr. permanent teeth 5)
*Luxury goods (radio, bicycle)		*Parity of mother	*Liver enlargement
*Fuel used			*Spleen enlargement
			*Haemoglobin conc.
			*Packed Cell Volume
			*Assessment bloodfilms for micro-/macrocytic changes 6)
			*Malaria parasites
			*Stool: consistency helminths
			*Urine: protein S.haematobium
			*Other observations

* Item
1) Children under 3 years
2) Persons over 15 years
3) 1974 only
4) Children under 3 years were measured at home
5) Children 5-14 years only
6) Only if Hb less than : 11.0 G% (1974)
10.0 G% (1977)

Firstly the selection of survey methods and procedures was guided by the overall aims of the Kamburu Ecological Survey: to assess the impact of the lake on health, with special attention to schistosomiasis and nutritional state (Lundholm, 1973). A wider range of variables was included, however, primarily because the author believed that a more balanced form of assessment was indicated and observations should lead to a form of community diagnosis. Surveys aimed at a limited community diagnosis are regularly carried out by medical students in Kenya as part of their training in Community Health. Basic guidelines for these surveys have been laid down in a field work manual (Christensen and Dissevelt, 1974), which addresses the collection of information on demography, assessment





- Survey team visiting household for registration of the members. During the same visit environmental features are noted, and nutritional status of young children assessed.
- Infant suspended in a sling trousers for weighing. Note raintank in the background, which can provide a significant part of water needed. Buildings are those of a well-to-do farm near Masinga.

of nutritional status and mother and child health. These guidelines also form the foundation of the epidemiological surveys at Kamburu. Additional variables were selected on the basis of the expected health impacts of the lake. The final choice of variables and survey methods depended on available finances, laboratory facilities, and manpower for fieldwork. The selection of survey methods and procedures therefore was made using practical considerations rather than scientific or operational criteria. Variables included on the various survey forms are listed in the table 10. As a rule standard methods were used, and a detailed description has been published in a preliminary report (Oomen, 1977).

Blood was collected by fingerprick. Only a few mothers of small children objected to the procedure. Two capillaries were filled for the determination of the haematocrit (Hawksley Centrifuge), a thick and a thin bloodfilm for malaria parasites were prepared, and the haemoglobin concentration measured on the spot (Spencer haemometer). People were requested to supply stool and urine in standard containers. On submission urine samples were tested for the presence of albumin (Albustix, Amesz) immediately. A significant number (see Chapter 11) of people failed to submit stool and urine.

A small field laboratory was maintained near the construction workers camp, where electricity was available. Here the haematocrit was determined, after which the plasma containing part of capillaries was separated, sealed, labelled and preserved by freezing. Urine samples were examined for Schistosoma haematobium ova and discarded. A sample of stool specimens was preserved in 5-10% formalin. Each day stool and urine containers were desinfected, cleaned and prepared for reuse.

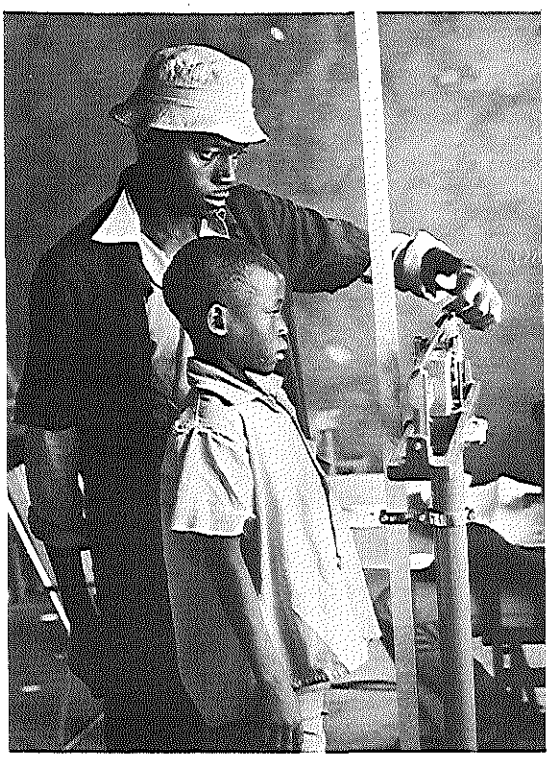
Because in 1977 cases of kala-azar (visceral leishmaniasis) had been diagnosed in nearby areas, it was considered necessary to perform splenic punctures in all people with an enlarged spleen grade 3 or higher. Splenic punctures were done with the patient lying down on a camp bed, after having checked the bleeding time. Aspirates were inoculated unto a culture medium and smears were made. Of 39 aspirations performed, only one case was detected, a 12 year old girl from a household near Kivaa. Patient was treated elsewhere.

Bloodslides for malaria, stool specimens and splenic aspirates were examined by the Division of Vector-borne Diseases of the National Public Health Laboratories in Nairobi, under the supervision of Dr.T.K.Arap Siongok. Though blood plasma specimens were available for serological studies, these unfortunately could not be implemented.

Fieldworkers and Supervision

Home visiting for demographic registration (Individual form, Household form) and assessment of nutritional status of children (Nutrition form) were carried out by three fieldworkers in 1974, two of whom were Kamba's. The good public relations established by these fieldworkers contributed greatly to the successful completion of the 1974 survey, and probably also in 1977. Fieldworkers had a minimum of three years secondary education. One of them participated in the 1977 survey also, which introduced an important element of continuity. At that time he was assisted by two second year medical students. The group could handle 8-12 homevisits per day, depending also on distances to be covered and size of the households.

For the second part of the survey (Health survey form 1 and 2) a team was assembled comprising two senior medical students of the 4th year, one senior laboratory technologist and three laboratory assistants (belonging to the Division of Vector-borne Diseases). Two fieldworkers (later junior medical students) assisted in the health survey, while the third was fully occupied by visiting and revisiting homes to inform households on their appointment dates. The latter proved to be the 'kingpin' of the health surveys. The survey team could handle a maximum of 50 people per day, but progress of the surveys was mainly dependent



- Households were invited to report to a nearby primary school for the health examination. Here women and children are waiting outside the classroom for their turn to be called and make their tour along the examining stations.
- Weight and height are useful health indicators also in older children and adults.

on the number of people turning up.

The author participated in the fieldwork continuously in the initial stages, and about half the time later on. Supervisory visits were at times carried out by Dr.Arap Siongok.

Transport

For home visiting fieldworkers were supplied with bicycles, but if available motorized transport was used also. During the health survey two landrovers were constantly needed to carry the survey team to the survey stations and back, to liaise with the field laboratory, but also to bring in people from more remote households and take them back. Each vehicle covered at least 5000 miles during each of the surveys. Roadworthiness and petrol supplies were a regular source of concern. Adequate transport arrangements are a prerequisite for conducting the surveys.

Records and Analysis

All individuals eligible for registration were identified by a five digit number, based on the cluster or area, the household and the person. During the survey separate forms were used for each person.

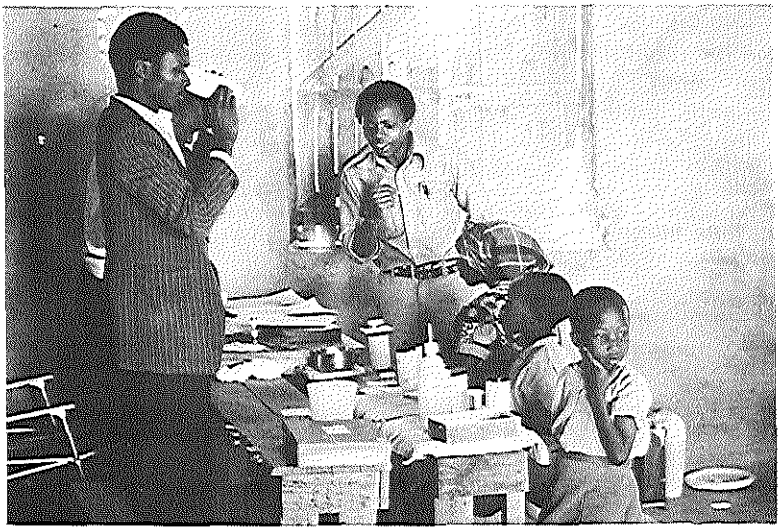
After the first survey suitable codes were designed to transfer the data to IBM punch-cards. Care was taken to design the code for ordinal data in such a way that a reasonably normal distribution resulted. Data were then transferred to punch-cards and checked for errors. After the second survey a linked record was prepared for each individual, combining data, if available, from both surveys. Except for the nutrition survey data on children under 3 years, which were analysed by hand, all analysis was performed by computer.

3. REPRODUCIBILITY OF THE RESULTS

A more elaborate consideration of the reproducibility of observations and measurements made under conditions which preclude full control of factors affecting their accuracy and validity is necessary and justified. For the interpretation of the findings these will have to be taken into account. Reproducibility of results depends on the measuring instrument or survey method, the observor variation, and whether the phenomenon measured changes.

Personnel had been instructed and trained in the survey procedures. In addition each survey was preceded by a day of trial practice on households not belonging to the sample populations. Procedures were carried out in a standardized fashion and always by the same person, in some cases two persons. The latter did not apply to the examination of malaria slides and stool samples in the central laboratory at Nairobi, where examinations were part of the routine duties of laboratory personnel.

Reproducibility was assessed by doing replicate measurements, interviews or tests. A system was developed whereby respondents who had gone through the full health examination procedure were requested to do another round. Their completed survey forms were then taken in, and they were given blank forms of a different colour instead. Between the first and the second round about one hour had passed, sufficient time to erase the recollection of details from the memory of observer and interviewer. Duplicate collections of the various specimens was considered to be too disturbing and not necessary. On an average survey day about 30-40 people were seen, of whom 2-3 were requested to submit to a second round. In this way undue extra work was avoided, while it at the same time helped to keep teammembers aware of the need to work conscientiously and stick



- The bloodtaking station in the health examination room. After bloodtests have been done, containers (on the bench) for submitting stool and urine specimens are handed out.
- Searching the ventilation shafts of a termite hill for sandflies, the vector of kala-azar.

to the prescribed routine. Respondents for a second round were selected mostly by the author, and in 1977 care was taken to include sufficient persons of different ages, and with abnormal findings.

Measurements

Table 11 gives the reproducibility of anthropometric measurements, blood pressure and the counts of teeth in children. The latter were used as a check on stated age. Except for blood pressure, variation mostly concerns within-observer variation. In 1977 more attention was paid to the need to include different age groups.

TABLE 11: Reproducibility of Measurements on a Continuous Scale

Measurement	Age y.	No pairs	Mean diff.	S.D. diff.	Student T	Relative error %
			1974			
Weight (kg)	> 15	29	-0.24	0.24	5.61	0.6
Height (cm)	> 15	29	-0.14	0.64	1.18	0.1
Arm circumf.	> 5	34	-0.07	0.41	0.92	0.3
Triceps skinf.	> 5	34	-0.19	0.98	1.14	2.2
B.P.syst.	> 15	24	-0.83	9.74	0.42	0.8
B.P.diast.	> 15	24	-4.58	8.06	2.72	6.2
No perm. teeth	5-14	16	0.12	1.46	0.34	0.7
			1977			
Weight (kg)	> 15	31	-0.29	0.22	7.4	0.6
	5-14	33	-0.14	0.28	3.0	0.5
	< 5	29	0.32	0.45	3.8	3.6
Height (cm)	> 15	31	-0.11	0.62	1.0	0.07
	5-14	33	-0.08	0.49	0.9	0.05
	< 5	29	1.28	1.93	3.6	1.8
Arm circumf.	> 15	31	0.13	0.33	2.2	0.6
	5-14	33	0.06	0.26	1.3	0.4
	< 5	29	-0.18	0.76	1.2	1.3
No perm.teeth	5-14	29	-0.45	1.30	1.9	4.3
No decid.teeth	< 3	30	0.43	1.28	1.9	4.1

These results show that measurements were taken with acceptable to good accuracy. Observer variation is somewhat larger for weight measurements. For older children and adults this can be explained by the fact that a stool and urine specimen had been supplied in between, and therefore some weight was lost. For children under 3 years there was a period of about two weeks between the measurements.

Clinical Assessments

Though in 1974 replicate palpations had been done, reproducibility could not be evaluated because only two times an enlarged spleen and no liver enlargement was found. For 1977 the reproducibility of palpation, and assessment of vaccination scars is given in table 12.

TABLE 12: Reproducibility of Clinical Assessments (1977 only)

Item	Observer variation	No of pairs	No positive			Agreement %	Correl. coeff.
			1st	2nd	1st+2nd		
Spleen *	intra	64	28	25	18	51	0.73
	inter	70	34	25	24	68	0.92
Liver **	intra	64	6	7	2	18	0.23
	inter	70	15	20	9	35	0.52
BCG-scar***	intra+inter	29	7	10	6	54	0.61
SP-scar***	intra+inter	29	6	7	4	44	0.51

* : Hackett's classification grades 0 - 4
** : in cm below costal arch, 0, 1-3, 4-7, over 8.
***: scar observed yes/no

For palpation both within-observer and between-observer variation were evaluated, though in the survey all palpation was done by the same examiner. It is remarkable that the observer who did all the palpating during the survey had more difficulty in reproducing his own results, than his colleague. This suggests a systematic bias, most likely that the second examiner had had information on the findings of the first. From the contingency tables for spleen and liver enlargement, which are not reproduced, it is clear, that the lower level of reproducibility is almost wholly due to variation in the assessment of minor degrees of enlargement. It can be concluded that a considerable degree of uncertainty is attached, as expected, to the assessment of minor degrees of enlargement (spleen grade 1), but that more significant enlargements are diagnosed with fair accuracy.

The figures on the identification of vaccination scars of smallpox and BCG show that this simple observation proved to be more difficult than anticipated. The low figure of reproducibility is disturbing. The left arm had to be inspected for these scars. Though, if a scar was present, there might have been some uncertainty about it being from a vaccination or a wound, reproducibility of the observation should have been better than 50%. It can be concluded that instruction on this point was inadequate.

Haemoglobin and Haematocrit Measurements

It was considered unacceptable to repeat the fingerpricks, while the amount of blood collected was insufficient to serve for replicate measurements. During the 1974 survey no special precautions for validating the measurements were taken. Moreover, because it had been impossible to obtain the appropiate haemolysers for measuring the haemoglobin with the Spencer meter, saponin powder had to be used instead. As a consequence some problems were encountered during the survey and a number of Hb-records had to be discarded. The haematocrit was measured in the same way as in 1977, the only difference being that capillaries were flamed-sealed in contrast to the second occasion, when capillaries were sealed

with plasticine.

In 1977 care was taken to calibrate the apparatus used in the field against the readings of a Coulter Counter used by the Department of Haematology, Kenyatta National Hospital. Readings on the same blood samples with the field equipment were highly correlated (corr. coefficient PCV 0.99; Hb 0.98) with the Coulter counter readings, however deviated systematically. Values obtained by the field equipment need therefore to be corrected, which can be best done with the following regression formulae:

$$\text{Hb (Coulter)} = 0.90\ \text{Hb (Spencer)} + 0.96$$
$$\text{PCV (Coulter)} = 0.95\ \text{PCV (Hawksley)} - 1.8$$

During the survey 8 venous bloodsamples could be obtained from men, with which replicate measurements were done on the Coulter counter. Results behaved closely as predicted by the regression formula.

All haematological determinations in the field were performed by the same medical student. The intra-observer error was assessed by blind double readings for Hb (mean difference 0.1, range plus or minus 0.5) and PCV (mean difference 0; range plus 1 to minus 2).

Laboratory Examinations for Malaria and Intestinal Helminths

These examinations were done in the Central Laboratory in Nairobi. Replicate examinations were included in 1977 only. After all malaria slides had been examined by several technicians, the examination was replicated in a set of 76 slides by a more experienced technologist. During the first examination infections by Plasmodium malariae were diagnosed in excess of those by P. falciparum (table 13). These findings were "suspect", as P. malariae infections do not constitute more than 5-10% of malaria infections. The results of the second examiner are in agreement with expectation in this respect. Agreement on the diagnosis of the two malaria species was negligible, and was still low when considering the presence of malaria parasites without species indication. Regarding the obvious inexperience of the first examiners, and taking the results of the second examination as more reliable, the presence of malaria parasites were misdiagnosed by nearly 100%, but included 15 of the 19 "true" malaria infections. It can be concluded that for each 2-3 cases of malaria diagnosed, only one actually had malaria parasites in the bloodfilm. Though after these findings all slides should have been reexamined, this was for practical reasons impossible.

TABLE 13: Reproducibility of Blood- and Stool Examinations (1977 only)

Item		No	No positive 1st	2nd	1st+2nd	Agreement %
Blood -	P.falciparum	76	13	17	4	15
	P.malariae	76	24	1	0	0
	"Malaria" parasites	76	37	19*	15	37
Stool** -	S.mansoni	101	4	1	0	0
	other helminths	101	3	4	0	0

* P.vivax one

** Ritchies concentration method

Hundred and one stool specimens were preserved in duplicate and submitted for examination to the same laboratory, where they were examined by several technicians. Analysis for reproducibility of the findings is hampered by the low prevalence of intestinal parasites, which usually implies low egg counts as well. Reproducibility of the positive findings was nil. As replicate examinations were carried out as part of the same routine, and though there is no reason to doubt the presence of helminth eggs if seen by a technician, it can be concluded that helminth infections were seriously underdiagnosed, and the real figure could be severalfold that found. The reliability of urine examinations for Schistosoma haematobium infections has not been assessed.

Answer to survey questions

Persons older than 15 years were questioned about morbidity, disability, and water contact. Mothers were asked, concerning their small children, about the frequency of fish consumption, complaints about the child and a 24-hour recall of what the child had eaten.

TABLE 14: Reproducibility of Answers to Questions of Morbidity, Lake Contact and Fish Consumption (Persons older than 15)

Item	Affirming			Agreement %	Correlation coefficient
	1st	2nd	1st+2nd		
	1974, No of replicates 25				
Being unwell	21	21	21	100	0.93
Fever	2	1	1	50	0.69
Headache	5	6	3	38	0.40
Abdom.pain	12	12	11	92	0.68
Diarrhoea	0	0	-	-	-
Dysentery	2	2	2	100	0.94
Painful mictur.	0	0	-	-	-
Haematuria	0	0	-	-	-
Other complaints	14	12	12	86	0.82
Lake contact	5	6	5	83	0.78
	1977, No of replicates 31				
Being unwell	23	20	19	79	0.81
Fever	11	13	11	85	0.81
Headache	17	20	17	85	0.77
Diarrhoea	2	2	2	100	1.00
Dysentery	2	2	2	100	1.00
Painful mictur.	3	3	2	50	0.63
Haematuria	2	3	2	67	1.00
Other complaints	10	10	8	67	0.74
Lake contact	12	13	13	100	0.99
Disability	17	17	16	89	0.66
Family fish consumption *	9	6	5	50	0.47
Child fish consumption *	7	4	3	38	

* : No was 28

All the questions to adults were replicated, but from the nutrition survey only the one on fish consumption. Questions were asked by a standard formula in the Kikamba language. It is presumed that reproducibility is mainly affected by variations in the subject.

With few exceptions, e.g. for fish consumption, answers obtained proved to be reproducible and had a correlation coefficient of 0.60 or more (table 14).

Those who stated to have been restricted or disabled by their complaints recorded the duration with fair accuracy (mean difference - 1.2 days; range plus 4 to minus 14 days).

In 1977 only information was obtained on the presence of infirmity and degree of disability. The presence of this information allows the assessment of an aspect of internal consistency, as persons disabled should coincide with those having complaints. The presence of different complaints has been correlated with presence and degree of disability. For the complaints listed in table 15, correlation was significant to high. Coefficients for males are about twice those of females, presumably because females on the whole had more, but minor, complaints.

TABLE 15: Consistency of the Presence of Various Complaints with Person Being Disabled (1977 only; persons older than 15).

	Correlation Coefficients	
Complaint	Males n=123	Females n=237
Unwell	0.64	0.33
Fever	0.63	0.31
Headache	0.49	0.28
Abd. pain	0.60	0.29
Diarrhoea	0.34	0.17
Other complaints	0.31	(0.11)NS

Concluding remarks

In this section some of the observations made have been qualified, and an indication given of the reliability of results. The latter has to be taken in account when interpreting the results. Attempts to assess reproducibility were initiated when the first survey was in progress, and were extended and improved in the second survey. Still only part of the observations have been so qualified. Notable exceptions are the demographic information on individuals and the observations on the domestic environment. Though replicating this type of survey procedures is more laborious, it is feasible and worthwhile in surveys of this kind.

On the whole, field personnel readily appreciated the value of replicate observations, they did not feel threatened by this form of control and accepted the extra work. Little difficulty was encountered in persuading respondents to submit to a second interview and examination. Some resistance however had to be overcome with the staff of the Central Laboratory in Nairobi. These workers, who had no direct involvement with the fieldwork, were more reluctant and more suspicious of the use which could be made of such a comparison. Our findings unfortunately confirm that they had little reason to feel very confident about the quality of their work.

Chapter 7
Demography

INTRODUCTION

The collection of demographic information has been included in the health surveys because such data are not available from other sources in this region. The demographic description of the population is essential for the determination of the denominators for vital and health statistics; and the estimation of mortality, fertility and migration is needed for the planning and evaluation of primary health care. In addition the socio-demographic data, which were included in the demographic survey forms, help in defining the social environment, and provide for understanding of conditions underlying the health situation and the identification of high risk groups.

RESULTS

Population size and composition (table 16 and 17)

Both in 1974 and 1977 a population census was carried out. The selection procedures for households to be enumerated have been mentioned earlier. Any person normally eating and sleeping in these households since at least 4 weeks, and if not having slept there during the previous night, expected to return within 4 weeks, was considered eligible for registration. According to these criteria those present, absent, emigrated and immigrated could be defined. Persons staying in households but since less than 4 weeks were considered as visitors and not registered. By this definition the 'de jure' population was sufficiently identified for use in the demographic analysis. The size of the 'de facto' population was also known and is presented in table 9. Age and sex of the sample groups are shown in table 16.

For demographic analysis the sample sizes were very small and therefore sampling variation affected the results. Based on the 'de jure' definition one would expect sex ratios of the under-15's to be even. However, generally females preponderated, but the disproportion was larger in the Inland group. The distribution of sexes by age-groups is irregular and the relative deficiency of males affects mainly those over 15 years. Some irregularities are due to misclassification of age, a well-known problem in census taking in areas where people do not record their date of birth and no population register is kept. We tried to avoid misclassification of age by using a "calendar of local events", and by comparing with dental age in children.

Analysis of the proportions and sex-ratios in table 17 warrants the following observations. Except for females in the Lakeside group there is no evidence for underenumeration of under-fives. For the 1977 Inland group the 5-9 and 10-14 male groups appear to be inflated at the expense of older ages. For females of the 10-14 year Inland group and the 5-9 year Lakeside the trend is reversed. For older age-groups the sex ratios demonstrate that especially the 15-45 year old males leave for elsewhere. The use of dental age resulted in a rather crude assessment of the age in children. The table shows that 50-57% is less than 15 years old. This result is ascribed to high fertility and decreasing mortality but also to out-migration of adults.

TABLE 16: Age and Sex Composition of the 'de jure' Inland and Lakeside Population Groups in the years 1974 and 1977

Age, y.	Males				Females			
	Inland		Lakeside		Inland		Lakeside	
	%	No	%	No	%	No	%	No
				1974				
0- 2	4.9	33	7.7	38	7.5	38	5.0	25
3- 4	4.8	32	3.2	16	4.9	33	3.0	15
5- 9	11.6	78	7.5	37	9.0	60	9.7	48
10-14	6.4	43	8.3	41	7.9	53	6.0	30
15-24	5.4	36	8.5	42	10.1	68	9.7	48
25-34	2.8	19	3.0	15	6.1	41	5.4	27
35-44	4.2	28	3.4	17	3.9	26	4.0	20
45-54	1.8	12	1.8	9	2.2	15	4.8	24
55-64	1.2	8	2.8	14	1.0	7	2.6	13
65+	1.3	9	2.4	12	2.8	19	1.0	5
total	44.5	298	48.6	241	55.5	372	51.4	255
				1977				
0- 2	6.0	42	6.1	33	6.7	47	6.1	33
3- 4	2.6	18	4.8	26	4.0	28	2.8	15
5- 9	7.9	55	7.2	39	10.7	75	8.9	48
10-14	9.2	64	8.0	43	7.3	51	6.5	35
15-24	9.2	64	8.3	45	8.9	62	8.5	46
25-34	2.6	18	5.8	31	7.0	49	7.6	41
35-44	3.1	22	3.5	19	3.7	26	3.7	20
45-54	2.7	19	2.2	12	2.7	19	3.2	17
55-64	1.1	8	1.1	6	0.6	4	2.6	14
65+	1.7	12	1.7	9	2.3	16	1.3	7
total	46.1	322	48.8	263	53.9	377	51.2	276

TABLE 17: Proportions of age-groups by Sex, and Sex-ratios of the Sample Population groups in 1974 and 1977 (percentages and ratio)

	Inland						Lakeside					
	1974			1977			1974			1977		
Age-group	M	F	R	M	F	R	M	F	R	M	F	R
0- 4	22	19	92	19	20	80	22	16	135	22	17	123
5- 9	26	16	130	17	20	73	15	19	77	15	17	81
10-14	14	14	81	20	14	125	17	12	137	16	13	123
15-24	12	18	53	20	16	103	17	19	88	17	17	98
25-34	6	11	46	6	13	37	6	11	56	12	15	76
35-44	9	7	108	7	7	85	7	8	85	7	7	95
45-54	4	4	80	6	5	100	4	9	38	5	6	70
55+	6	7	65	6	5	100	11	7	144	6	8	71
All	100	100	80	100	100	85	100	100	94	100	100	95
% < 15	57			54			50			50		

R = sex ratio: M/F x 100

Vital Events and Migration. (Table 18)

Vital events affecting any person registered in 1974 could be checked in 1977. Thus deaths, births and migratory movements could be identified in a period of 33 months. It was then discovered that a number of people belonging to the Inland and Lakeside groups in 1974 had been missed. They now were registered and have been accounted for in the calculated rates.

Apart from emigrants and immigrants, and births and deaths affecting them, the category of persons who both immigrated and emigrated in that period add to the complexity of the situation. Some could be identified because at a 6-months interval in 1975 all households had been visited. But for this, their existence would have been missed in 1977. Double migrations after November 1975 may also have escaped enumeration. Therefore the number of migrants should be considered minimal. Other details may be derived from the table. A full acccount on demographic changes in the first 12 months has been given previously (Oomen, 1979).

Ascertaining births and deaths in migrants was less precise than in residents. Newborn children dying soon after birth proved also to be a delicate category. Fieldworkers had been properly instructed on acquiring such socially sensitive information. Though some may have been missed, their number is considered small.

Of 699 people of the Inland group in 1977, 548 had been there in 1974; of the Lakeside respectively 539 and 353. Except for some non-registered persons still remaining in the area it can be concluded that 85, respectively 80% had a stable residence over a period of 33 months.

TABLE 18: Vital Events and Migratory Movements registered for the Period 1974 - 1977 (33 months) by Sample Group.

Sort	specified	Inland	Lakeside
Residents in 1974		670	496
Deaths	residents	7	10
	newborns	1	3
	immigrants	0	1
	not registered	0	1
subtotal		8	15
Emigrants	residents	115	133
	newborns	3	4
	newb.immigrants*	0	2
	immigrants	25	42
subtotal		143	181
Births	residents	81	53
	newborns died	1	3
	newb.emigrated	3	4
	newb.immigrants	1	10
subtotal		86	70
Immigrants	residents	29	46
	emigrated	25	42
subtotal		54	88
Non-registered**		40	81
Permanent residents***		548	353
Residents in 1977		699	539

* Born between 1974-77 but not necessarily in the area, not included under immmigrants
** Failed to be registered in 1974, but were resident
***Resident in 1974 as well as 1977

Changing Population Elements (tables 19, 20 and 21)

Over one third of all deaths occurred in under-fives, about one third in over-55 years olds. Notable in the in-between group were two girls of 8 and 9 years old on neighbouring Lakeside farms whose cause of death could not be detected. Three under-fives were stated to have died of measles in 1975 in the Lakeside area but none in the Inland area. It was found that a Government immunization team had been active in Masinga dispensary the previous year. In general malaria was thought to be a probable cause of death.

TABLE 19: Deaths, Emigrants, Immigrants and Non-registered (see Table 18**) Persons of the Sample Groups by age and sex (in brackets Newborn-immigrants)

Age, y.	Deaths		Emigrants		Immigrants		Non-registered	
	M	F	M	F	M	F	M	F
				INLAND				
0- 4	1*	1**	5	7	0	4(+1)	1	2
5-14	-	-	30	21	7	8	4	9
15-24	-	-	16	17	17	3	4	5
25-34	1	-	6	17	4	6	3	2
35-44	-	-	5	6	1	0	2	0
45-54	-	2	2	2	0	2	2	2
55-64	-	3	2	3	1	0	0	1
Total	2	6	69	74	31	23(+1)	19	21
				LAKESIDE				
0- 4	4***	2****	3	8	2(+6)	5(+4)	3	1
5-14	-	2	25	26	16	15	15	10
15-24	-	-	32	24	14	8	6	12
25-34	-	-	12	16	11	7	8	11
35-44	1	1	5	5	3	2	4	4
45-54	-	-	3	4	4	0	2	2
55-64	-	-	5	5	0	0	0	1
65+	5	-	5	3	1	0	1	1
Total	10	5	90	91	51(+6)	37(+4)	39	42

* age 12-17 months ** age 6-11 months *** age 0- 6 months 6-11 months 6-11 months 30-35 months **** 6-11 months 24-29 months

Emigration affected sexes equally, and 35% were children. Often complete households departed. Among immigrants also complete households moved in. Males predominated among immigrants by about 15% and children accounted for 40%. Migrants were a socially mixed group with varying levels of education and property, and included residents of over 5 years.

For calculating rates of vital events and migration two approaches were used. For 'total population' rates the mid-period population was estimated including non registered people in 1974. Birth- and death rates could also be determined for those people who had been registered in 1974 and remained resident throughout the 33 months period.

TABLE 20: Rates of Vital Events and Migration, and of Population Growth for the Inland and Lakeside Population groups expressed per 1000 person-years Midterm Population

	Total population		Resident population*	
	Inland	Lakeside	Inland	Lakeside
Mid-period no	704	558	690	531
Crude Death Rate	4	10	4	10
Infant Mortality **	12	57	12	67
Crude Birth Rate	44	46	45	41
General Fertility Rate ***	252	229	-	-
Age-standardized GFR ****	206	172	-	-
Natural Growth Rate	40	36	41	31
Emigration Rate	74	118	62	94
Immigration Rate	26	57	-	-
Netto-migration Rate	-48	-61	-	-
Actual Growth Rate	-8	-25	-	-

* see text for explanation
** estimated by dividing infant deaths by total births over 33 months
*** total births divided by mid-period no of women aged 15-44 years
**** indirect standardization of General Fertility Rate using Kenya Census age-specific fertility rates (Ominde, 1974)

TABLE 21: Average Parity of Females by age (1977 only)

Age	Inland n = 139	Lakeside n = 175
10-14	0	0
15-24	0.55	0.81
25-34	4.58	3.61
35-44	7.58	4.52
45-54	8.05	5.78
55-64	7.00	5.89
65+	5.94	7.17
Overall mean	4.45	3.75
St. error	0.27	0.28

Mortality was 4 per thousand in the Inland versus 10 per thousand in the Lakeside group. The difference was significant at the five percent level (Chi square test). Infant mortality suggested the same difference. Crude birth rates were about 45 per thousand in both groups, higher in the Lakeside group but less in the 'resident population' rates. The difference was explained by 10 immigrant newborns, of whom two subsequently emigrated, who may have been born outside the area. The lower fertility of the Lakeside group was confirmed by the general fertility rates, and especially by the figure on average parity ($p<0.05$, not standardized for age, see table 21).

The natural growth rate was assessed at 36-40 per thousand implying a doubling of the population in under 20 years. Despite this the population decreased at an average rate of 0.8, resp. 2.5% per year. Annually 7 resp. 12% emigrated and were only partially replaced by immigrants. The pattern of migration differed significantly for Inland and Lakeside groups. The netto-migration rates were minus 48 and 61 per thousand per year and thereby the high natural growth rate was cancelled out.

Socio-demographic characteristics (tables 22 and 23)

As part of census taking, data were collected on various socio-demographic characteristics of the individuals. Of these data information concerning socio-economic aspects derive from household characteristics, as it was assumed that these were similar for all members of the household. Social aspects however were assessed on individual basis. The reproducibility of this part of the survey has not been tested. But the results which are presented in this section appear to be consistent with each other and with impressions gained from field experience. This unfortunately did not apply to data obtained for occupation of the adults. Under the prevailing subsistence type of situation, occupation is a difficult subject to assess. Results proved to be incompatible with the reality, partly because of faulty coding, and were omitted from the analysis. For the remaining variables the results are summarized in table 22 for adults and table 23 for children. Differences between and within groups have been tested by the Chi-square method. Where in the text a difference is indicated, the significance has a probability of 0.01 or less. In a few cases with a lesser probability this is indicated.

TABLE 22: Social Characteristics of Persons over 15 years (percentages)

	Inland				Lakeside			
	Males		Females		Males		Females	
	1974	1977	1974	1977	1974	1977	1974	1977
No of people	112	143	176	176	109	122	137	145
Resident in area>5 y.	86	71	80	59	68	84	63	52
Educated>4 y.	36	47	15	28	40	55	26	32
*Household/property>3 u.	33	68	32	66	32	52	39	46
*Household/cattle>4 u.	31	37	30	37	55	37	52	41
*Household<3 pers/room**	29	39	33	40	36	30	39	27
Lake contact*** daily	9	9	1	8	54	79	61	87
weekly	15	9	14	1	33	14	23	4
never	56	70	80	83	8	2	10	4

* ie. from a household with ..
** Household/persons/room: no information 10-15%
*** Lake contact: information only for those who 'reported', see table 9
For legend Household/property units: see table 5
Household cattle units : see table 5

TABLE 23: Social Characteristics of Children 0 - 14 years old (percentages)

	Under 5 years				5 - 14 years			
	Inland		Lakeside		Inland		Lakeside	
	1974	1977	1974	1977	1974	1977	1974	1977
No of chlidren	148	135	94	107	234	245	156	196
Resident in area>5 y.	-	-	-	-	99	74	64	73
Going to school	-	-	-	-	54	62	62	60
*Household<3 pers/room	17	30	28	24	19	29	16	25
*Household/property>3 u.	22	63	43	56	27	60	36	52
*Household/cattle>4 u.	25	32	40	36	35	31	53	44
Father staying at home	76	68	55	57	-	71	-	59
Mother educated	18	33	35	56	-	16	-	38
First born**	-	14	-	17	-	-	-	-
Parity mother>6***	-	46	-	29	-	-	-	-

* ie. From a household with ..
** First born: only for children 0-2 years
*** Parity mother: 10-15% no information
For legend Household/property units: see table 5
Household cattle units: see table 5

Education

Generally 50-60% of men and 30-40% of women have had some form of education. Males were more often and longer educated than females in both groups. Educated adults mostly belong to the age groups between 15-35 years. Of school aged children 50-60% are attending primary schools in the area. Though boys are sent to school more often the difference is not significant. Probably as a result of several age cohorts of schoolchildren in 1974 having become registered as adults by 1977, the educational experience of the population as a whole has improved significantly. Both in 1974 and 1977 the educational status of the Lakeside group appeared to be somewhat better than for the Inland people, but the difference was not of significance. As a separate group, however, adult women of the Lakeside were better educated in 1974 ($P<0.05$). This distinction was no longer evident in 1977, possibly because a number of educated women had emigrated from the area.

Property

The property index intended to assess the possession of capital goods by households. Individuals belonging to the same household were all assigned the same household property index. The number of buildings and rooms in the homestead were taken to represent capital goods as well. In practice it turned out that the index heavily depended on this aspect of housing. Measured by this index, Inland persons belonged to households with less property in 1974. Between 1974 and 1977 the property holding significantly increased for both groups. but considerably more Inland than at the Lakeside. As a result of this disproportionate growth the Inland group scored higher for property in 1977. Such a growth in capital goods could have been resulted from a good harvest season in 1976 from which the Inland group gained more than the Lakeside people.

Cattle holding

Cattle holding is related to the type of subsistence practised, but at the same time animals represent capital value as well. Cattle holding was significantly correlated with the property index (coeff. 0.3-0.4). Also the pattern of cattle ownership and property was similar. In 1974 Inland households owned fewer animals. In the following years cattle holding decreased in the Lakeside group, but increased in the Inland group.

This reverse trend is similar to that for property and further supports the evidence that a shift in socio-economic conditions took place. We did not analyse to what extent emigration could be responsible for such a shift.

Crowdedness of Households

This variable is closely correlated (coeff. 0.45 - 0.60) with the one for property holding, since both take into account the number of buildings and rooms in the homestead. On the other hand there is a minimal correlation (coeff. 0 - 0.36) between this variable and the one on cattle holding.

In 1974 crowded living conditions were more prevalent amongst the Inland group. From 1974-1977 crowding decreased in this group, while it aggravated in the Lakeside area. By 1977 crowded living conditions had become more prevalent in the Lakeside area.

Duration of Residence

From the demographic analysis it became clear that migratory movements are more intensive in the Lakeside area. This characteristic is reflected in the present variable.

Inland people have resided for a longer period in the same place than in the Lakeside area. The period of residence is nearly equal for men and women. The average duration of residence decreased between 1974-1977 in the Lakeside area but remained the same Inland. Consequently the original pattern persisted.

Frequency of Lake contact

From adults information was requested on the frequency of their coming near the shore of Kamburu Lake, either for collecting water, watering cattle or for other reasons. As expected the majority of the Lakeside people visit the lake often, but despite the distance this is true for a few Inland individuals also. For the former lake contact became more frequent in 1977. Lake contact is highly correlated with the use of the lake as domestic water source, while it is negatively correlated with the use of other surface- water sources.

Special Variables of Children

For children, especially those under five, a few characteristics relating to their parents were noted. Fathers of Inland children reside at home more often than Lakeside fathers. This is a remarkable observation in view of the low Inland adult sex ratio. Apparently, though more men are present in the Lakeside area, these are not all husbands and fathers.

More Lakeside mothers have been educated than Inland. The average parity of mothers, though slightly higher Inland, does not differ between the groups.

DISCUSSION

The United Nations Economic Commission in Africa (1974) has recommended the use of an internationally standardized definition for the 'de facto' and the 'de jure' population. When the collection of demographic data is part of a multipurpose survey, we believe, these definitions are less practical to use. In a health survey for instance attention should focus on people who actually live in the area and are exposed to any of its hazards, rather than cover individuals who belong to the population for more formal reasons. Therefore we have used a more direct definition of the 'de jure' population in our surveys. The population so defined is less complete than according to the officially recommended definition, and therefore constitutes a smaller denominator for the calculation of rates. We estimate that the use of the official 'de jure' definition would have resulted in a 5-10% larger population size, and a more balanced ratio, but lower estimated rates.

The ascertainment of births, deaths and migratory movements by surveys with an interval of three years is supposedly crude, and biased by underreporting. Annual or more frequent surveys give probably a more complete coverage, but are also affected by underreporting. In the course of the Danfa Project in Ghana (1979) it could be estimated that ascertainment by annual surveys covered under optimal conditions between 65-80% of births, and 50-80% of deaths. In general the underreporting of deaths, in particular of infant deaths, is more marked than for births (Marks et al., 1974). Comparison of the data previously reported for the year 1974-75 (Oomen, 1979) with the present ones does not provide evidence that the three year interval markedly affected the number of events recorded. During the first twelve and a half months (Oomen, 1977) 10 deaths were recorded, which gives an expected number of 26 deaths for the 33 months period, against 23 having actually been observed. In a similar way 114 births would have been expected to occur, against 156 observed.

The overall annual crude death rate of 7 per thousand and birth rate of 45 per thousand found for the Kamburu population are lower than expected by the figures of the National 1969 census (death rate of 17 per thousand, and births 50 per thousand). Local health conditions do not justify the finding of a lower mortality in the area. However, lower mortality figures were found also in two more recent national demographic sample surveys in 1973 (death rate 13 per thousand, birth rate 49-52 per thousand; CBS, 1975) and 1977 (death rate 14 per thousand, birth rate 53 per thousand; CBS, 1979). These results provide evidence for a nationally declining mortality, but for a constant or even slightly higher fertility. Even more convincing support for a low mortality is provided by demographic results of the Machakos Joint Project for the Locations of Mbiuni and Kangundo (van Ginneken et al., 1980a). Here births and deaths were ascertained by a dual reporting system, including biweekly home-visits. Over the period from 1973-78 an average annual crude death rate of 6 per thousand and birth rate of 44 per thousand were found. In particular living conditions of the Mbiuni Location resemble those of Kamburu. We conclude that correction for the denominator population definition is to some extent counterbalanced by underreporting, and that the rates provide realistic estimates of mortality and fertility. The most important implication of this observation is the high natural growth rate.

For the period under consideration migration was the most important determinant of population size. The figures presented on permanent in- and outmigration are not directly comparable to those from elsewhere, but they are of the same magnitude. As persons who both immigrated and emigrated may have escaped attention, the figures are minimum figures. Their main implication is the negative netto migration rate which cancels the effects of natural population growth. Van Ginneken et al. (1980b) also found a negative netto migration of

minus 6% in the Mbiuni area, which is a fraction of our findings in Kamburu. The observation that 85 resp. 80% of the population maintained their residence during three years further demonstrated that some immigrants do not stay very long. At the time of each survey it was found that about 15% of adults, but only a few children, were absent. A form of temporary or circular migration, characteristic for Kambas, is possibly responsible for this level of absenteeism.

Demographically the Lakeside and the Inland groups are heterogeneous. Mortality and migratory mobility are greatest in the Lakeside population, while they have a lower fertility. The higher mortality exists despite the Lakeside group being better educated and economically superior, and it could for instance be due to inferior health conditions or the existence of specific health risks. The pattern of fertility and migration is rooted in the social characteristics of the two groups and the economic potential of the area. The negative-nett migration perhaps should be interpreted as an indication that as result of deforestation and erosion the carrying capacity of the land was not sufficient to support the people resident by 1974.

The socio-demographic data give a qualitative impression of the main characteristics of the two groups. Educational status is somewhat better in the Lakeside group, on the whole the level of education improved since 1974. The free primary education policy of the Kenya Government appears to be effective also in this rural area.

In terms of the socio-economic index units observed there was in general a trend to increase property holding, but for cattle this was only in the Inland while the number of cattle on the Lakeside actually decreased. The property trend favoured the Inland group disproportionally. Thus, although the Lakeside group appeared to be economically superior in 1974, this pattern reversed during these three years.

Finally the location of the Lakeside group near Kamburu Lake has several relevant implications. The most significant probably is the ease with which Lakeside households can obtain domestic water. On the average these households need to spend only one third of the time and energy needed by Inland households for this purpose. In terms of lake-contact, or water contact, the vicinity of the lake could well have less advantageous implications. The information on lake contact of adults indicates that Lakeside women, but also men, come to the lake shore almost daily, while such exposure is rare in the Inland group. Such a difference in the general behavioural pattern could have implications for the transmission of several of the waterbased and waterrelated infections.

Chapter 8
Immunization status

INTRODUCTION

Information on the level of immunization of preschool children is important as an indicator of protection against common childhood infections, but also as evidence of the adequate functioning of mother and child health services in the area. Conclusive evidence on immunization of a child is difficult to obtain if permanent records are not issued or kept. According to the practice of the Ministry of Health in Kenya BCG vaccination is given at any age from birth, while smallpox (SP) vaccination is done after the first month of life. Either one is administered on contact with the health services and is always combined with the administration of DPT- and oral polio vaccin. Measles vaccination is not given before the age of 9 months. If such a policy is strictly adhered to, which we assume, it implies that a child with both BCG and SP scars has had at least two doses of DPT and polio-vaccin, and if one scar is present at least a single dose.

RESULTS

Immunization Status (table 24)

By the end of the third year of life between 45-70% of the children have one or two immunization scars. While in 1974 the percentages in older age groups increase gradually, by 1977 this pattern has become less distinct. Immunization status is better, though not significantly, in the Lakeside group. Here also one third of the children under 6 months have been vaccinated in contrast with very few Inland children. The level of immunization decreased between 1974-1977.

Socio-demographic Characteristics of Immunized Children

To assess whether any variables were associated with being vaccinated the data of the two groups were pooled. Both in 1974 and in 1977 were the children of fathers not staying at home found to be vaccinated more often ($P<0.05$ and $P<0.01$). Such an association was not present with the educational standard of the mother, nor with any of the other variables recorded.

DISCUSSION

For the whole of Machakos district in 1974 around 50% of the infants received BCG and SP vaccinations as well as 2 doses of DPT and oral polio vaccin. Only around 25% of the infants received a third DPT injection and a polio dose, and were vaccinated for measles (Dept. of Community Health, 1976). In comparison with the coverage figures of the district the level of immunization was low in the Kamburu population of 1974 and further declined since that time.

The availibility of mother and child health services at a convenient time and distance is the most significant determinant for immunizing infants and young children. As mentioned before the Inland group is served by a dispensary at

Masinga, where essential supplies are often out of stock, and the kerosene refrigerator for stocking vaccines often out of order. The nearest functioning health centre is at a distance of 35 km. On the other hand the Lakeside people were served by a Mobile Clinic once a month, until 1976, when this service was discontinued. For them the nearest health centre is in Embu District at a distance of 25 km. The 1974 survey results demonstrate that the monthly Mobile Clinic apparently functioned quite well, but not better than the Dispensary.

Though not very helpful, it is a typical observation that children whose father does not normally stay at home, and therefore is assumed to be employed elsewhere, are more often immunized than others whose fathers stay and work at the farm. The wives and small children of the first will visit them in their urban centre of employment once or twice a year. Most likely these opportunities are utilized to make up for the lack of health services at Kamburu.

TABLE 24: Immunization Status of Pre-school Children of the Inland and Lakeside groups in 1974 and 1977, Assessed by the Presence of BCG and/or Smallpox Vaccination Scars.

Group	Year	Nr. and Vacc. Status	AGE in months 0-5	6-11	12-23	24-35	Total
INLAND	1974	No	24	12	26	20	81
		1 scar	0	3	14	7	24 (29%)
		2 scars	1	1	2	7	11 (13%)
		% vaccinated	4	33	61	70	(42%)
	1977	No	17	13	31	27	88*
		1 scar	0	1	4	5	10 (11%)
		2 scars	0	3	5	7	15 (17%)
		% vaccinated	0	31	29	44	(28%)
LAKESIDE	1974	No	11	10	24	17	62*
		1 scar	2	1	3	5	11 (17%)
		2 scars	2	1	9	6	18 (29%)
		% vaccinated	36	20	50	65	(46%)
	1977	No	6	16	19	22	63
		1 scar	0	0	2	3	5 (8%)
		2 scars	2	3	2	9	16 (25%)
		% vaccinated	33	19	21	54	(33%)

* Information missing for 1 child

Chapter 9
Nutritional status of children

INRTODUCTION

The measurement of weight and height was routinely included for all survey respondents. These data, together with additional information on children under three years collected separately, form the material for studying the nutritional status of the people. Except for some information on weaning practices, none was collected on diet and foodstuffs.

It is widely agreed that the nutritional status of the preschool-child is the most sensitive indicator for the nutrition situation in the community. Therefore we concentrated on this group, in particular on those under three. Some attention was given to older children. In a following section nutritional status of the population is evaluated by the Quetelet index. The analysis aims to contribute to the following questions:

- Quantify the problem of malnutrition
- Assess whether there is a difference between Inland and Lakeside groups which could be related to agricultural and socio-economic factors or, from a different angle, to the impact of infections as malaria and schistosomiasis
- Study the habits of fish consumption

RESULTS

For the analysis of anthropometric measurements in relation to a growth standard the correct determination of age is necessary. Misclassifications due to faulty age recordings affect mainly the parameters of weight for age (W/A) and height for age (H/A), but weight for height (W/H) is more or less age independent. It has been stated in the section of Demography that age assessment has been crude, but did not result in underenumeration of preschool children. For this reason we defined the nutritional status by using the weight for height index. The relatively small number of children combined with the effect of unreliable age did not justify the subdivision of the data into age groups by months or even by 3 months, nor separation by sex.

Weight for height as an indicator of the growth pattern (Tables 25 - 28)

The distribution of the W/H in the first, second and third year of life is very typical. At birth and for the following 6 months well over half of the babies have a W/H of 100% or more of the Harvard Standard. In the second half year the proportion exceeding the standard decreases, and further drops during the second year to stabilize itself in older age groups (table 25 and 26).

The weight for height relationship derives from the growth pattern for weight and height. For the first 35 months we present this growth pattern in table 27, in which the mean percentage values of the standard are given for W/A, H/A and W/H, by half yearly age groups. The development of these growth indicators reflects a similar trend. The weight and height of the newborn lie between 90-100% of the standard, they commence to decrease in the second half year and reach their lowest value in the second year. However, this decline as usual, is much steeper for weight, which falls from an average of 90-100% to between 80-

85%, than for height (from 95-100% to 90-95%).

The distribution of W/H of older children (table 26) shows that the pattern is constant from the third year onwards in both groups. Though similar proportions classify below 85% W/H, the median value of the Lakeside distribution is somewhat above that for the Inland group.

For the assessment of malnutrition attention is usually focussed on the lower range of the distribution. Children who do not measure up to a certain level of the standard are designated to be nutritionally at risk, and are mildly or seriously undernourished. In table 28 the proportions of children under three who do not meet 80 or 70% of the W/A standard, 90 or 85% of the H/A or 95 or 85% of the W/H standard are given.

TABLE 25: Distribution of Weight for Height Percentages (Harvard Standard) in 6 months age groups for Children under 3 years in Inland and Lakeside groups in 1974 and 1977

Harvard W/H Standard	Inland				Lakeside			
	0-5	6-11	12-23 (months)	24-35(%)	0-5	6-11	12-23 (months)	24-35 %
				1974				
> +20 %	1	0	1	0 (2)	1	0	0	1 (3)
+10 - +19 %	5	1	0	1 (9)	4	1	0	2 (12)
+0 - +9 %	11	4	3	5 (29)	0	0	6	4 (17)
-1 - -10 %	5	6	9	7 (34)	4	6	14	6 (51)
-11 - -20 %	0	0	12	6 (22)	1	3	3	3 (17)
< -20 %	0	1	1	1 (4)	0	0	1	1 (3)
Total*	22	12	26	20(100)	10	10	24	17(100)
				1977				
> +20 %	2	1	0	0 (4)	0	0	0	0 (0)
+10 - +19 %	6	1	1	1 (11)	0	1	0	1 (3)
+0 - +9 %	4	7	7	4 (26)	3	5	4	8 (33)
-1 - -10 %	1	1	7	9 (21)	2	9	6	7 (39)
-11 - -20 %	0	3	10	14 (32)	0	1	7	6 (23)
< -20 %	0	0	5	1 (7)	0	0	1	0 (2)
Total*	13	13	30	29(100)	5	16	18	22(100)

* Inland 1974 total 80, no information 1; 1977 total 85, no inf. 4
Lakeside 1974 total 61, no inf. 2; 1977 total 61, no inf. 2
In brackets (): percent of Weight for Height rubrics

TABLE 26: Proportions of Children 0-14 years according to Various Classes of the Harvard Standard for Weight for Height in the Inland and Lakeside groups in 1977 (% of total)

Harvard	Inland (age years)				Lakeside (age years)			
Standard %	0-2	3-4	5-9	10-14	0-2	3-4	5-9	10-14
No	85	42	110	99	61	40	75	70
> 95 %	53	36	30	28	54	56	52	59
86 - 95 %	34	56	57	62	33	38	45	35
76 - 85 %	13	7	13	10	13	5	1	6
< 75 %	0	0	0	0	0	0	1	0

TABLE 27: Mean Weight for Height, Weight for Age, Height for Age as % of the Harvard Standard, for Inland and Lakeside Children by age group in 1974 and 1977

	Inland				Lakeside			
Age, months	No	W/H	W/A	H/A	No	W/H	W/A	H/A
				1974				
0- 5	22	105	98	96	10	104	100	98
6-11	12	98	81	92	10	94	86	96
12-17	16	91	80	94	8	92	84	94
18-23	10	92	78	92	16	96	84	94
24-29	19	94	84	93	16	100	87	93
30-35	1	-	-	-	1	-	-	-
				1977				
0- 5	13	111	96	95	5	100	86	96
6-11	13	102	92	96	16	98	86	96
12-17	14	94	84	92	10	92	80	92
18-23	16	88	76	90	8	92	81	93
24-29	13	93	81	91	9	96	81	90
30-35	16	90	76	92	13	97	83	91

TABLE 28: Proportions of Children under 3 years with low Weight for Height, low Weight for Age and low Height for Age among Inland and Lakeside groups in 1974 and 1977 (cut-off Harvard Standard)

	Inland		Lakeside	
	1974	1977	1974	1977
No subjects	80	85	61	61
W/H < 85%	8	14	11	10
< 95%	44	46	47	46
W/A < 70%	11	13	3	10
< 80%	34	43	26	41
H/A < 85%	2	2	3	6
< 90%	19	20	15	23

There are no gross differences in nutritional status of children under three between the two groups. This is evident from comparing the proportions in the lower range of the distributions, as given in table 28. A similar conclusion could be derived from studying the higher range values, such as are given for W/H in table 25. In 1974 11% of Inland children and 15% of Lakeside children had values above 110% of the W/H standard. In 1977 these percentages were lower (15% resp. 3%). Both approaches suggest a small degree of advantage in the Lakeside group. The lower median value for W/H in children from 3-15 yrs in the Inland area is consistent with such a suggestion. In the latter age groups the W/H Inland is significantly lower ($P<0.001$). We are unfortunately unable to give a similar distribution based on 1974 survey data, due to technical reasons. However, we were able to trace the W/H value of children who were under three in 1974 and between 3-6 yr in 1977. Of the Lakeside cohort with 42 children, 22 scored at the same level in 1977, the remainder scoring either lower or higher (mean difference -0.23%). Of 61 Inland children only 20 scored at the same level and the remainder tended to score lower (mean difference -1.6%). The trend in each group, though not differing significantly, is in the direction of the W/H pattern of older children, mentioned already.

Though a comparison of the 1974 situation with that of 1977 also does not demonstrate big differences, the figures may suggest that the nutrition situation in 1977 had declined. This trend is particularly suggested by the lower W/A in both groups. In addition in the Lakeside group growth of height appears to have been retarded. It has however been stipulated before that the surveys did not take place during the same season of the year, and therefore variations as those concerned could be due to a seasonal factor. Indeed the period immediately preceding July, the time of data collection, is sometimes referred to as the hunger season. People still subsist on produce of the previous year and are awaiting the new harvest. During the month May 1975 a nutrition survey had been carried out together with a demographic resurvey. The results of this survey, which have been reported (Odingo, 1979) suggest that a seasonal factor affects growth in weight and height at the same time of the year.

The Weaning diet

Information on the weaning diet obtained in November 1974 and during the resurveys of 1975 have been reported elsewhere (Odingo, 1979). Weaning prac-

tices and weaning foods had not changed substantially by 1977, and therefore do not need to be documented again. Childfeeding and weaning practices may be briefly described as follows. Virtually all children are breastfed till the age of 18 months, being nursed four or more times per day. After 18 months the numbers decline until between 24-29 months all children have been weaned. Inland mothers tended to breastfeed longer in 1974, and also in 1977. In addition to breastmilk about two thirds of the infants received bottle feeds, either milk or a thin porridge or both. Bottle feeding is stopped between 12-18 months when most children can be fed by cup and spoon. Bottlefed Inland infants are fewer, and they continue for a shorter period.

Solid foods are first introduced around the age of 6 months. Initially a cereal porridge is added to breastfeeding. The frequency of supplementary feeding gradually increases to 3-4 times per day by the age of 24 months. Fully weaned children are fed at least four times a day. Maize is the most important cereal, followed by millet. Tubers are rarely included. Legumes and vegetables are introduced after the age of 12 months and then only about once every two days. Fruits are given infrequently and only to Lakeside children. Milk is given daily or more often to all children under three. Consumption of other animal products, including eggs, is low.

Fish consumption

Also fish consumption in 1977 had not materially altered from the pattern recorded in 1974 and 1975 (Odingo, 1979).
About 50% of the families in the Lakeside area state that they eat fish once a week or more often, as opposed to only 15% of families Inland. Lakeside families indicated that children under three are regularly given fish to eat. The latter information could not be confirmed from the data on the weaning diet. We therefore suspect that fish consumption is rather overstated, showing the intention rather than the practice.

Factors Associated with Weight for Height

In order to identify potential factors influencing nutritional status the data of the two groups were pooled. Variables, of which reasonably could be assumed that they influence nutrition, were tested by the Chi square method. The following relationships were investigated (table 29).

TABLE 29: Variables Associated with low Weight for Height among Preschool and Schoolchildren in 1974 and 1977

	1974	1977	
Variable	under 3 yr.	under 3 yr.	5-14 yr.
Property score	P<0.05	P<0.05	*
Cattle score	ns	P<0.1	*
Crowdedness score	P<0.05	ns	*
Residence of father	ns	ns	*
Education of mother	trend?	ns	*
Immunization status	ns	ns	*
Malaria parasites	trend	trend	trend
Spleen enlargement	ns	ns	ns
S. haematobium	*	*	P<0.05

* not available
* not available

DISCUSSION

The results obtained in each of the surveys demonstrate the important characteristics of the growth pattern in relation to the weaning process. They tally with more fully documented reports in adjacent Machakos (Oomen et al., 1979; van Steenbergen et al. 1978; CBS, 1977).

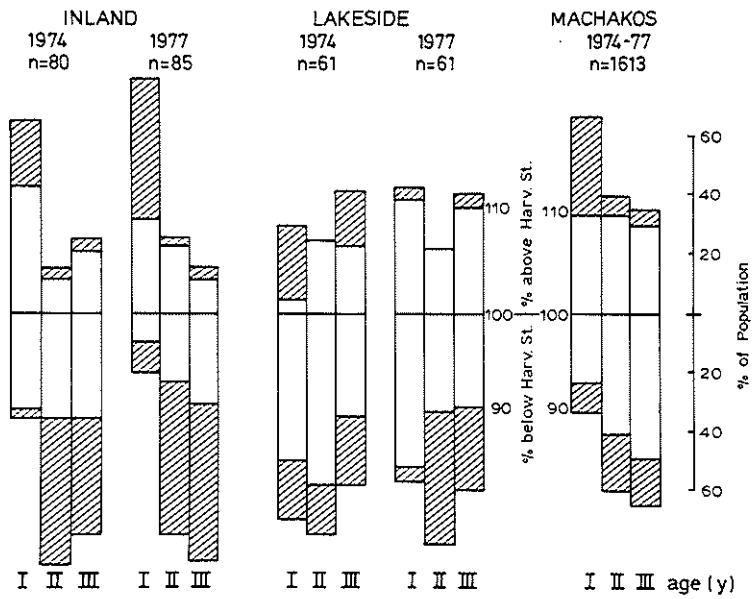
Taking into account the rather limited numbers and the point of time of the measurements, the W/H rates suggest the following conclusions (see Figure 4):

(1) W/H rates in the Inland babies in the first year of life are better than in the Lakeside babies. This applies to both observation periods in 1974 and 1977. At a closer analysis this is most evident in the first half year which suggests a more successful breastfeeding period.

(2) In the second and third year the majority is substandard, and a considerable proportion is below 90% of the standard, perhaps more so in the Inland than in the Lakeside population. There are more well-of infants in the 2d and 3rd year in the Lakeside population than in the Inland one.

(3) Compared to a longitudinal study in the same years of a Machakos District child population the same general trends are discernible. A closer tallying at 80% of the W/H rates (not indicated in the graph) would indicate the subjects at risk.

FIGURE 4: The Distribution of Weight for Height Scores for the Harvard Standard in Children under 3 years among Inland and Lakeside groups in 1974 and 1977



For the interpretation of the growth pattern, comparison to the Harvard Standard has been used. The nutritional diagnosis is based on the proportions which do not measure up to a specified level for H/A, W/A or W/H. Commonly children under 80% of the standard for W/A are designed as wasted or undernourished, and those below 90% H/A as stunted. Oomen et al. (1979) argue that the use of an arbitrary standard and cut-off points results in an artificial inflation of malnutrition; or, the creation of anthropometric malnutrition which cannot be corroborated by clinical signs and symptoms. According to their, and also van Steenbergen et al. (1978) observations, is the Kamba child at 80% W/A or 90% W/H a reasonably healthy child. They recommend that for community surveys children below 75% W/A or 90% H/A are considered nutritionally at risk, and those below 70% resp. 85% as actually suffering from clinical malnutrition. Using these well founded criteria malnutrition does not constitute a serious problem. From a more pragmatic angle, Blankhart (1974) considers areas with 40% or more of the children showing an underweight of less than 80% W/A as high risk areas, where the shortage of food and socio-economic factors have contributed to the high prevalence of PCM. According to such criteria the 1977 situation suggested the existence of a more significant nutritional problem than before. Describing the nutritional state in terms of statistical parameters however remains a simplification of the real situation. Clinical cases of malnutrition were observed during both surveys and not necessarily had a W/A of W/H below the cut-off points mentioned. Unfortunately figures are not available, as they have not been systematically recorded. The fact that over the three years of observation infant mortality appeared to be low provided indirect evidence that malnutrition did not constitute a serious problem. These findings also reflect more favorably on the local socio-economic conditions of subsistence economy, than some of the figures and facts mentioned in the introduction.

In the previous report (Odingo, 1979) we concluded with the following observations about the qualitative aspects of the weaning diet and practice:
- That solid foods were introduced relatively delayed and at a low frequency
- That maize flour and milk form the backbone of the weaning diet and are included soon more than once daily
- That fat and sugar, convenient sources of calories, though included regularly, are given in small or too small quantities
- That legumes and vegetables only contribute significantly after the age of one year
- That sources of animal protein other than milk are few

These observations are in agreement with the more complete information on the qualitative and quantitative aspects of the diet of the Kamba child, given by van Steenbergen et al. (1978). The caloric intakes reported by them increased from 86% of the Recommended Intake in the first half year, to 96% after the age of 18 months. A particularly critical period affecting the calorie intake occurs around the age of 4-6 months when breastmilk yield declined and only a thin maize porridge was given as additional food. The main constraining factors in the diet appeared to be energy, iron and riboflavin. Protein consumption was adequate in all age groups. The authors considered the pattern of childfeeding relatively favorable.

We enquired specifically after the frequency of fish consumption. This is more frequent in the Lakeside area (about 50% of the households indicate to eat fish at least weekly) where it is easier available. We have reason to believe, however, that this is an overstatement. In 1977 the figure was nearly the same. Commercial fishing is being carried on by fishermen from Western Kenya, as Kamba's themselves have no traditions in this respect. By 1977 a few local men could be found on the waterside trying to catch fish with simple rods. Another reason why consumption presumably did not increase could be its costs. Fish

remained expensive, and most catches were sold in the contractor's camp.

So far, few indications have been found in the local ecology of nutrition that the burden of childhood infections is a major cause of deterioration of nutritional state in general. Under these conditions factors affecting the adequacy of the diet are the main determinants of nutritional state.

On what other factors does nutritional state depend?

For the Kamburu children the property level of the household was correlated with W/H, indicating that socio-economic differences exist between households and have implications. The precise meaning of this association is difficult to evaluate because of the dependence of the property index on the number of rooms in the house. Presumably childfeeding is better in the larger homesteads with more rooms and a larger extended family. The fact that W/H correlated to a lesser extent with crowdedness, and not at all with cattle holding, appears to confirm the property score as a more or less independent socio-economic indicator.

Though the educational level of the mother appeared to coincide with better nutritional state, the effect was minimal and not significant. In a similar way the presence of malaria parasites appeared to be associated with somewhat lower W/H values. Urinary schistosomiasis was diagnosed only in a small group of children, it nevertheless appeared to affect the level of W/H in this group.

Chapter 10
Observations on ill health

INTRODUCTION

In this chapter features of health will be reported which reflect ill-health but are not strictly related to a single disease. The main items are: the subjective perception of ill-health by adults, the occurrence of splenic enlargement and anaemia, the distribution of the Quetelet index as a measure of nutritional status, and others. Some are related to one or more infections (e.g. splenic enlargement by malaria or schistosomiasis), others have a more complex causal background to which infections, but also nutrition and environmental factors contribute. The description of these signs of ill health and especially also the interpretation of their possible origins under the local conditions contribute to the understanding of the natural history of endemic disease. Elsewhere, in chapter 12, we have called this the "structure if ill-health". This understanding aids in the determination of priorities for health planning and eventually the evaluation of a communicable disease control programme. Besides it is of importance to interprete the relationship of these signs of ill-health relating to certain social and other environmental characteristics of communal life. The understanding of relationships between environmental conditions and health assists in the identification of the most effective ways of improving health in the course of development.

In the course of two surveys socio-demographic and health data were registered on an individual basis. All this information therefore can be used to identify the underlying factors of ill-health in the community. The preparation of tabulations and cross tabulations from such a large data base would be very laborious without the aid of computer facilities. Moreover the analysis of often mutually interacting variables requires the application of sophisticated forms of statistical analysis, more than the preparation of cross tabulations and contingency tables.

On the use of Multivariate Analysis

Is has been said that health problems are multicausal by nature. A variety of factors contribute to their occurrence. Common ones are infections, nutritional imbalances or deficiencies, behavioural characteristics, the organization of the community, and other aspects of environment. In the context of this chapter health problems are referred to as the dependent variable, while information on the individual characteristics of persons or on aspects of the environment are referred to as independent variables. The statistical analysis of the health survey data aims at identifying statistical associations between a dependent and independent variables. If such relationships do not necessarily indicate causality at least they will help in identifying from among a mass of information those variables which contribute to the distribution of the dependent variable and are worth to be interpreted.

Traditionally such analysis was done by studying the dependent variable in relation to each independent one separately. As a matter of fact this approach has been employed in chapters 7-9. If a mass of data is to be processed and interpreted the approach is cumbersome, and the validity of the conclusions may be confounded by the interrelationships between the variables. As in health studies the latter is usual, extra needs for standardization arise to improve the

validity of conclusions.

The use of high speed computer hardware and the appropiate software makes the application of multivariate techniques for the analysis of health survey data possible. These constitute sophisticated analytical tools. The main advantage of their use is that in a single analysis the relationships between a dependent variable and two or more independent ones can be described qualitatively, and to some extent also quantitatively. The confounding influence of the interrelationships between variables is also taken care of.

The main techniques of multivariate analysis are multiple regression, discriminant and factor analysis. Of these multiple regression is best suited for dealing with the problem of interpreting health survey data. By this method "related" variables can be identified and "unrelated" ones discarded. The method makes use of models to describe the situation, and several models may fit a single problem. It may then be difficult to determine the best choice. Also, these models are abstractions and their meaning to the real life situation may be difficult to determine. Such drawbacks, however, do not diminish their usefulness for an orderly evaluation, and eventually interpretation.

In the following sections multivariate techniques have been applied to the distributions of the "disability score", the Quetelet index, packed cell volume, spleen, and malaria parasitaemia. The dependent variable, according to Kleinbaum and Kupper (1978), should in multiple regression analysis be of a continuous type, while the independent variables can be of any type. In our study this was the case for the distributions of the Quetelet index, packed cell volume and the "disability score". On the other hand the technique of "discriminant analysis" is appropiate where the dependent variable is assessed on a nominal scale. Though spleen status was originally measured semi-quantitatively, it was thought better to reduce this information to nominal values. In the case of analyses for malaria and schistosomiasis also a nominal scale was used. Unfortunately these analyses were less productive than the ones with multiple regression.

Multiple regression analyses aim at fitting a simple linear model to the data, which is described by the following equation:

$$Y = B0 + B1\ x1 + B2\ x2 \ldots + Bk\ xk + E$$

where	y	the dependent variable
	x1-k	the independent or "indicator" variables
	B0	the intercept
	B1-k	the regression coefficients
	E	the unexplained residual

Several statistical parameters are available for assessing the fit of the model and the contribution by each indicator. The main ones needed for interpretation are:

R	the multiple correlation coefficient.
R-square	the square of the multiple regression coefficient (value range 0-1). The figure indicates the proportion of the total variance explained by the model.
R-square change	this is a fraction of R-square, and refers to the contribution of each indicator variable in explaining the total variance.
Regression Coeff.	this is the weight by which each indicator variable in the equation is multiplied. The sign of the coefficient indicates whether the contribution is to be added or subtracted from the "basic value", represented by the intercept, B0.

The value of the contribution by any of the regression coefficients can be assessed by a significance test to assure that the coefficient differs significantly from zero.

The model used in discriminant analysis resembles the multiple regression equation. Though the assumptions for discriminant analysis and multiple regression are quite different, they have quite similar goals. Both attempt to describe by a linear model the relationship between a dependent variable, and various independent variables. The first for the primary purpose of discrimination, the latter for prediction. In the discriminant model a value L is determined which can be used to assign each individual to one, or the other, category of the dependent variable. The equation for L is:

$$L = b1\ x1 + b2\ x2 \ldots\ldots + bk\ xk$$

where	L	the discriminant function
	x1-k	the independent or "indicator" variables
	b1-k	the discriminant coefficients

The discriminant coefficients can be derived from the multiple regression coefficient, through multiplying by a constant. The parameter for assessing the discriminatory power of the model, D-square, relates to the multiple regression model, and equals R-square times a constant. The significance of the discriminant coefficient is tested, as for the multiple regression coefficient, for its being different from zero.

In describing the various analyses we have relied on the parameters mentioned. In these parts we have used the terms "analysis" and "model" interchangably, and as referring to the regression or discriminant equation. As in multivariate analysis a large number of significance tests are carried out the number of "chance-significances" increases, if significance is taken at the usual $P<0.05$. It could be assumed therefore that more definite associations should have a significance level of $P<0.01$ or less.

For fitting the data to the multivariate models, Inland and Lakeside groups were taken as a single population, assuming that indicator variables operate in the same fashion in both groups. As, however, age profoundly influences the causes behind health problems we thought it wiser to perform separate analyses for adults, school- and preschoolchildren.

Reasonably reliable and complete information was available on an individual basis for 13 variables. Details about these, and the various scores employed, are provided in Appendix 1. In selecting from these 13 indicators for the different multivariate models, only those variables were considered which "a priori" implied a logical explanation or possibly a causal relationship. For instance PCV was not used as an indicator of the Quetelet distribution, though the two are associated, because anaemia may be the product of poor nutrition, but poor nutrition usually is not the product of anaemia. After a number of trial runs only one variable was identified which never contributed to the explanation of variance. This variable, the cattle index, subsequently was dropped. In the different analyses the same set of indicator variables for adults, school- and pre-schoolchildren, was always used.

The regression analyses were performed separately for 1974- and 1977-data sets. The results reflect the situation in each year on a crossectional basis. As for persons staying in the area throughout the period the pattern of individual change could be identified, a longitudinal element could be introduced in the analysis. "Change variables" were created on an individual basis by subtracting the 1974 value from the 1977 value. The changes having occurred in the dependent variables were then studied on the basis of baseline information, ob-

tained in 1974, and changes having occurred in the independent variables.

A specification of the technique employed for the multiple regression analysis is given in Appendix 1. Where the discriminant analysis had to be performed, the computer programme for multiple regression analysis was used, and the results corrected as indicated above. It should be observed that under the specifications of the multiple regression programme used, a complete or nearly complete output is obtained, including all variables specified in the prediction list. We were satisfied by this rather exploratory approach, because our main aim was exploration of the "structure of morbidity", rather than designing models with a minimum number of variables giving a maximum of prediction. Neither the aims of the Kamburu study, nor the available resources warranted more extensive use of these complicated techniques.

The reporting on the results of multiple regression analyses is not easy, and there is the risk to obscure the main conclusions in a wealth of secondary details. For this reason we have choosen to present the main conclusions deriving from each model in a tabular form in the text. In the different sections of this chapter tables are given with the regression or discriminant coefficients and their standard errors. This information enables the reader to study the contribution by each of the indicator variables, and to construct the predicting equation. For those less familiar with interpreting these models, an example is spelled out in detail in Appendix 2. Finally the percentage of the variance explained by each indicator variable is specified in the summary tables 49 and 50. For readers wanting to have full information on the different analyses a complete print-out is available from the author (see Appendix 2).

1. SYMPTOMS OF ILL-HEALTH AND RESTRICTED ACTIVITY

1.1 Introduction

At the time of the baseline survey it had been decided to use the potentially most important endemic diseases of malaria, and mansoni and haematobium schistosomiasis as the focus for enquiries on symptoms of disease. Nine questions, because of the reason stated a somewhat unusual combination, were formulated in the Kikamba language to identify the presence of the following symptoms and signs: being unwell or weak, having fever, headache, abdominal pain, diarrhoea, dysentery (diarrhoea with blood), dysuria, haematuria, and the presence of any other complaint. Of these the first and the last are of a general nature while the remaining questions referred to more or less charcteristic symptoms of the infections mentioned. Only persons of 15 yr and older were interviewed, and it was ascertained whether the complaint was present on the previous day, or during the last two weeks. Even though the initial results had not been very informative, the same set of questions were included in the 1977 survey procedures. However, now, in addition to the nine questions, it was asked whether the person had been restricted in his/her activities by the illness or even had been completely disabled. The duration of incapacity was recorded. Because of an unfortunate oversight the information on restricted activity and disability was combined into a single code early on in the data processing. Due to this mistake it proved impossible to distinguish between the two on final analysis.

1.2 Results

Table 30 summarizes the results of the interviews on ill-health. A different interviewer conducted the second round of questions. On both occasions most of the symptoms were of a general nature ("being unwell", other complaints), or concerned fever, headache and abdominal pain (the common presenting symptoms of an attack of malaria). For the remaining questions very few people confirmed the presence of these symptoms. Both in 1974 and 1977, a higher percentage of women gave positive answers. Though to a lesser degree, a similar observation can be made in respect of Lakeside men and women who both share a higher prevalence of symptoms. In 1977 the percentage of people suffering from fever, headache and abdominal pain had substantially increased, while no such trend was detected in respect of other problems.

The modifications in coding introduced in 1977 allow a closer examination of the results of that survey. Forty eight resp. 62% of men, and 73 resp. 88% of women reported the presence of one or more symptoms. Despite the fact that women reported illness more often, they reported fewer symptoms than men (1.5 symptoms/woman, and 2.0 symptoms/man). Also here Lakeside men and women reported more illness.

Finally, of those who reported the presence of illness, nearly three quarters indicated to have been restricted in their activities or completely invalidated. The average period of restricted activities lasted 2.5 and 4.2 days for men, and 4.8 and 6.0 for women per two week period. If the average duration is taken as a quantitative measure of the degree of ill-health than once more it may be concluded that Lakeside people are more seriously affected ($P<0.001$), and within the population groups, women ($P<0.001$). On the basis of the data provided it can be calculated that altogether 360 adults suffered 951 days of restriction or complete disability during a two week period, or on the average 2,6 persondays out of every fourteen.

TABLE 30: Symptoms of Ill-health during the Last Two Weeks for Inland and Lakeside Groups in 1974 and 1977

		Inland				Lakeside			
		Males		Females		Males		Females	
Symptoms		1974	1977	1974	1977	1974	1977	1974	1977
Persons interviewed	No	66	56	140	124	75	68	118	112
Symptoms	%								
Unwell		21	20	21	22	33	32	22	18
Fever		8	28	13	35	13	34	13	35
Headache		12	25	16	32	9	35	12	27
Abd.pain		3	11	11	15	13	15	20	21
Diarrhoea		1	0	0	4	0	6	2	3
Dysentery		1	5	2	4	4	3	4	9
Dysuria		2	2	0	1	1	0	1	2
Haematuria		1	4	0	0	0	0	0	0
Other		14	2	12	7	21	5	9	9
Persons with symptoms	No	-	27	-	91	-	42	-	98
	%		48		73		62		88
Total No symptoms		-	54	-	149	-	88	-	137
Average No sympt/pers.		-	2.0	-	1.6	-	2.0	-	1.4
Persons restricted or disabled	No	-	15	-	70	-	29	-	76
	%		27		56		43		69
Average duration (days/2 weeks)			2.5		4.8		4.2		6.0

TABLE 31: Indicator Variables of Ill-health of Adults in 1977. Discriminant coefficients with the Standard Error in ()

Indicator	Discriminant Coeff.	Variance expl. (R2-change)
Lakeside living	0.51 (0.16) xx	1.8%
Sex	0.57 (0.18) xx	3.4%
Age	0.19 (0.08) xx	7.8%
Education status	-0.21 (0.10) x	1.1%

x P<0.05 xx P<0.01

The duration of being restricted or disabled by ill-health was used as the dependent variable for the multiple regression analysis of ill-health. By exception is, in this case, the model based on selected contributing variables only (Lakeside living, sex, age and education), rather than on the more extensive set used in other models. The discriminant model indicates that females and people on the Lakeside experience more ill-health, and that the latter is influenced positively by increasing age, and also by being more educated (see

Table 31). Unfortunately, only 14.2% of being restricted or disabled can be explained by these variables.

1.3 Discussion

The design of the morbidity interview was influenced by the desire to identify the effects of malaria and schistosomiasis. As was stated in chapter 6 the questions had been translated and were asked in such a way that answers were reproducible. Except for the "general" questions on weakness and other complaints, most positive answers were obtained for the cluster of questions aimed at malaria, i.e. fever, headache and possible abdominal pain. The fact that this coincides with the occurrence of malaria in this population, and also that an increased prevalence of malaria in 1977 is accompanied by an increase especially of these symptoms, is suggestive of an association. More objective evidence of this association, however, could not be produced.

Viewed from the same angle the deficit in symptoms potentially relating to the two forms of schistosomiasis tally with their low prevalence locally. Also in this case however the value of the symptoms for the diagnosis of schistosomiasis is quite doubtful. Siongok et al.(1976) studied the pattern and impact of Schistosoma mansoni in a heavily infected Kamba community. According to their findings, referring to one two week period, 18% mentioned symptoms of weakness, 15% abdominal pain, 3% diarrhoea and 13% dysentery. These figures are of comparable magnitude with ours. However the authors found that of the complaints only abdominal pain was significantly associated with schistosoma infections in patients with a heavy wormload. For the remaining complaints no such relationship could be demonstrated.

The additional question on restricted activity, posed in 1977, allows a little better definition of ill-health. For the population as a whole 72% reports the presence of one or more complaints, and 53% states to have been restricted in daily activities or disabled by the underlying condition in the last two weeks. Illness is used here, in a broad sense, as perceived ill-health by the respondent. In the neighbouring study area of the Joint Project Machakos, Schulpen and Swinkels (1980) found that 25% of the population (including children), out of a sample of 800 households, reported to have been unwell during the past two weeks. The attending restriction and disablity is not mentioned. However, of people with complaints 21% visited a clinic or traditional healer, 35% relied on selfmedication and 38% did not undertake any remedial action.

Belcher et al. (1976a) recorded an illness rate of 21% per two week period in a household morbidity rate of rural Ghana, including all age groups, in a population of 14,729. The exact figure for adults is not stated but is of the order of 25%-35%. Females reported 50 per cent more illness than males. On the average 0.5 days/2 weeks were lost due to complete disability. These authors comment that their figures are low compared to findings elsewhere. The average duration of a bout of illness in Ghana was 5.6 days which compares with our findings ranging 2.5 - 6.0 days. Frerichs et al. (1980) reporting a similar survey from Bolivia stated an illness rate of 47% per two week period.

The multiple regression model indicates the characteristics of persons more prone to suffer ill-health. We believe the guarded conclusion could be drawn that the level of ill-health was relatively high in the area in 1977, and possibly an increase had taken place since 1974. The Lakeside people perceived considerably more illness, and so did the women if compared to men. Perception was also more in the older persons, and less among the better educated. It is of interest to note in this context that persons with more than 4 years education had less often an enlarged spleen, and had higher PCV levels (see following sections). In addition it could be estimated that for the adult population as a

whole some degree of illness was perceived during 2.6 out of every fourteen days, but unfortunately the time lost from productive work could not be determined.

In retrospect we do not think it was a good starting point to focus the morbidity interview on a few infections. The approach as described by Belcher et al. (1976a) and used in the Danfa project is more useful. Here enquiries were directed towards the presence of illness and the type. In addition enquiries were made about the nature and cost of any remedial action and treatment. The same authors (1976b) compare the result of health interviews with those of a health examination survey. Their conclusion is: "Although the health examination survey is conducted at 8x the cost of interviews it produced far more useful disease- and age specific information for use in planning and evaluating health programs."

1.4 Conclusion

A possibly somewhat higher level of perceived ill-health was found among the people of Kamburu, than reported by some authors from elsewhere. On the average every adult had some complaint during two to three days out of a two week period. The discriminant analysis confirmed that Lakeside people experience more ill-health, and also women. The reporting of ill-health was influenced positively by age, and negatively by education.

2. DISTRIBUTION AND CHANGES IN THE QUETELET INDEX

2.1 Introduction

In the course of the two surveys body weight and height were recorded for all people reporting for the health examination survey. In a previous paragraph the nutritional status, mainly of preschool children, was described with the for this purpose more usual anthropometric measures. From a different angle, and focussing on the population as a whole, this subject is once more described here. It will not be the intention to assess the prevalence of malnutrition, but to identify differences in nutritional state between the Inland and Lakeside groups, and between 1974 and 1977.

Among the various weight/height relationships the Quetelet Index (weight divided by the square of height x 100,000) is most consistently correlated with body density or relative adiposity (Billewicz et al. 1962); it gives a crude assessment of the nutritional state in the community at an aggregated level (Florey, 1970); because of its independence of height it is relatively independent of age (Benn, 1971); among Ethiopian children the index is within age groups of two to three years almost constant (Kusin, 1973), and correlates closely with weight and upper arm circumference.

The Quetelet Index is less suitable for routine use in nutrition surveys because of the more complicated arithmetics involved. Such aspects are no longer a barrier where data processing is done by computer.

2.2 Results

A log-transformation was used to normalize the distribution and calculate the statistical indices. The results presented in table 32 have been retransformed into the original form of the Quetelet Index. This table allows the assessment of differences between the Inland and Lakeside groups, and between 1974 and 1977. The age groups have been chosen broad enough to simplify the comparisons, but at the same time guaranteeing some degree of uniformity of distributrion within each age group.

In 1974 Lakeside people with a minor exception had higher Quetelet indices than Inland people. The distribution of the differences is independent of sex and age, and the difference significant ($P < 0.001$). In 1977 the pattern of differences again was independent of sex, but not so of age. The overall evaluation therefore becomes more difficult. However on inspection of the distribution of differences it will be noted that between 3 and 24 years Lakeside people still have superior values, though the magnitude of the differences decreased. For the two extreme age groups of 0-2 yr and over 25 yr the difference has changed more, so that now a minor advantage exists Inland, except for Inland men.

The Quetelet values of Inland people improved uniformly between 1974 and 1977. The picture of the Lakeside group is more mixed in this respect, while some age groups show a minor increase, others manifest a lowering of values in 1977. It is evident that the differential changing taking place in Inland and Lakeside groups are responsible for the lowering of the advantage of Lakeside people regarding the Quetelet index.

TABLE 32: Distribution of the Quetelet Index* of the Inland and Lakeside Population in 1974 and 1977, grouped according to Age and Sex

	Inland				Lakeside			
	Male		Female		Male		Female	
Age, yrs	No	QI**	No	QI**	No	QI**	No	QI**
				1974				
0- 2	20	161 140-185	35	157 141-175	27	161 142-181	14	162 137-191
3- 4	38	152 138-169	41	150 136-166	25	163 144-185	22	155 136-177
5- 9	72	143 133-154	55	141 130-154	33	145 130-161	45	147 134-161
10-14	35	148 133-164	51	151 138-165	40	161 146-178	26	155 137-176
15-24	20	171 149-197	58	193 177-209	31	182 163-204	43	200 182-220
> 25	47	191 175-210	82	195 182-209	45	192 175-211	75	198 184-213
				1977				
0- 2	23	171 150-195	28	170 151-192	18	166 143-193	19	165 143-190
3- 4	26	154 136-174	44	151 137-166	39	158 143-175	21	154 134-176
5- 9	41	148 134-164	69	144 134-155	34	155 140-173	41	148 134-163
10-14	54	151 139-164	45	153 139-168	38	160 145-177	32	160 143-178
15-24	31	177 158-198	47	193 176-212	35	183 164-203	32	197 177-211
> 25	25	192 169-218	76	205 191-220	32	198 177-221	78	201 187-216

* Quetelet Index = Weight/height2 x 100,000
** QI : mean and estimated 95% confidence interval

The relationship between the Quetelet index and various independent variables, or indicator variables, were studied among adults, school- and preschool-schildren. With regard to the multiple regression model it is important to note that the relationship between the Quetelet index and age is non-linear with the lowest values being recorded in the age range 5-9 yrs. Though a linear relationship may be assumed to exist in the preschool-age and adult groups this is not wholly true in the school-age group.

A number of indicator variables contribute to the explanation of the Quetelet distribution by the regression models (Tables 33 and 34, and 49 and 50). Between 14 and 23% of the total variance could be explained. Age, sex and Lakeside living are the most consistent indicators, and recur in the various analyses. The contribution by other variables, property, education, spleen status and malaria is more irregular and concerns mainly the adult group.

Between 31 to 61% of the variance of the pattern of change from 1974-1977

could be explained by the regression models. The variables contributing to the explanation of the individual change in Quetelet value from 1974 to 1977 are fewer,however. Here the main indicators are the baseline Quetelet value in 1974, and also age. Of the other variables change in property and crowdedness, and migrant status appear to contribute in adults. The influence of other variables is less important. Though only indicator variables with a significant regression coefficient have been mentioned here, it is nevertheless worthwhile to study the direction and magnitude of the contribution by other variables.

TABLE 33: Indicator Variables of the Quetelet Index in 1974 and 1977 for Adults, School- and Pre-schoolchildren. For each Variable the Regression Coefficient is given with the Standard Error in ()

	Adults	Schoolchildren	Preschoolchildren
Indicators	Regression Coeff.	Regression Coeff.	Regression Coeff.
		1974	
	No 359	No 291	No 184
Lakeside living	3.75 (2.67)	5.05 (1.56) xxx	7.12 (2.78) xx
Sex	8.25 (2.90) xx	0.43 (1.49)	-2.13 (2.62)
Age	-0.16 (0.11)	1.97 (0.27) xxx	-3.57 (0.87) xxx
Migrant status	6.91 (4.55)	1.95 (2.87)	4.93 (4.91)
Education I	-5.44 (4.21)	na	na
Education II	-7.86 (3.89) x	na	na
Property status	5.04 (1.21) xxx	-0.34 (0.74)	1.58 (1.28)
Crowdedness	-0.37 (0.73)	-0.53 (0.46)	0.07 (0.72)
Spleen	-9.25 (4.35) x	4.38 (3.06)	-9.15 (5.75)
Malaria par.	-2.22 (7.55)	-0.25 (2.89)	17.7 (6.21) xx
Intercept	187	130	161
		1977	
	No 313	No 308	No 183
Lakeside living	7.96 (2.87) xx	6.01 (1.55) xxx	0.33 (2.40)
Sex	13.07 (3.10) xxx	-1.77 (1.49)	-5.14 (2.32) x
Age	-0.06 (0.13)	1.49 (0.27) xxx	-5.36 (0.79) xxx
Migrant status	-3.38 (5.33)	2.07 (3.11)	5.05 (5.30)
Education I	-0.40 (4.48)	na	na
Education II	-6.42 (4.20)	na	na
Property status	3.42 (1.26) xx	0.08 (0.72)	0.64 (1.19)
Crowdedness	-0.16 (0.84)	-0.50 (0.48)	0.02 (0.75)
Spleen status	-10.67 (4.02) xx	0.60 (2.22)	-3.99 (4.30)
Malaria par.	-4.09 (3.16)	-0.60 (1.58)	1.35 (2.42)
Intercept	184	138	174

na not applicable
(x) 0.05<P<0.1 x P<0.05 xx P<0.01 xxx P<0.001

TABLE 34: Indicator Variables of Quetelet Index Change from 1974-1977 for Adults, School- and Pre-schoolchildren. For each Variable the Regression Coefficient is given with the Standard Error in ()

Indicators	Adults	Schoolchildren	Pre-schoolchildren
	Regression Coeff.	Regression Coeff.	Regression Coeff.
	No 159	No 183	No 129
Lakeside living	1.66 (2.57)	-2.25 (1.51)	2.33 (2.22)
Sex	-2.58 (3.21)	2.20 (1.41)	-1.64 (2.06)
Age	-0.35 (0.10) xxx	2.60 (0.29) xxx	-1.22 (0.67) (x)
Migrant 1974	-9.82 (5.07) (x)	0.50 (4.18)	2.76 (3.90)
Education I-1974	2.21 (3.98)	na	na
Education II-1974	-3.39 (3.57)	na	na
Property 1974	1.64 (1.20)	0.87 (0.77)	-0.49 (1.09)
Crowdedness 1974	0.15 (0.80)	-0.55 (0.49)	-0.42 (0.65)
Spleen 1974	-6.51 (5.45)	0.51 (4.39)	8.70 (6.96)
Malaria 1974	-5.47 (9.53)	-1.59 (2.95)	-4.90 (6.01)
Quetelet 1974	-0.26 (0.05) xxx	-0.17 (0.06) xx	-0.74 (0.07) xxx
Change property	5.37 (1.55) xxx	-0.03 (0.92)	-0.04 (1.30)
Spleen increase	-6.05 (5.01)	-1.28 (2.01)	-2.81 (3.50)
Spleen decrease	4.29 (7.07)	-0.75 (5.95)	4.67 (9.06)
Change malaria	-0.61 (3.02)	-0.54 (1.46)	-0.47 (2.13)
Change Crowdedness	1.85 (0.78) x	0.36 (0.50)	0.27 (0.72)
Intercept	65	11	114

na not applicable
(x) $0.05<P<0.1$ x $P<0.05$ xx $P<0.01$ xxx $P<0.001$

2.3 DISCUSSION

The distribution of the Quetelet index was studied with the intention to evaluate any change in nutritional status of the population during the period under consideration, and to obtain an understanding about local determinants of nutrition. Biologically the Quetelet index is influenced by age and sex, and the relationship with age is nonlinear with the lowest values occurring between 5-9 yr. On the other hand within a limited age range, the Quetelet index is relatively age independent, which makes it an attractive parameter for use in nutrition studies when age is not accurately known. We therefore assumed that by including broad age groups in the evaluation the confounding effect of age was sufficiently taken care of. As a matter of fact also sex was considered separately. It was shown elsewhere that the measurements of weight and height were quite reproducible especially in older children and adults.

By comparing Inland versus Lakeside groups it was demonstrated that Lakeside individuals had superior values for the Quetelet index in 1974. By 1977, however, the level of superiority had become less marked especially in the very young (0-2 yr) and adults (25 yr and older). The relative change between the two groups appears to be mainly due to the fact that the Inland group passed through a period with considerable and uniform improvement of this index, while in the Lakeside group the situation remained more or less stationary, or even deteriorated in a few age groups. The pattern of change observed between the

1974 and 1977 observations could have been influenced by seasonal fluctuations, which certainly are important locally. There is, however, no obvious reason why such seasonal changes would affect one group more than the other, indeed why at a time of the year when food is scarce one of the groups shows uniformly an improvement in the index used. The pattern of change therefore appears to fit in with a larger pattern of change. The period from 1974 till the second survey, or at least part of it, appears to have been marked by a positive trend Inland, whereas a more negative trend prevailed on the Lakeside. A similar pattern of differential development was noted earlier in respect of the few socio-economic observations available, such as property, crowding and cattle holding. It is attractive to assume that the two trends are related, but more detailed observations would be required to demonstrate this more convincingly. Some support for this thesis, however, is found in the role of property as indicator variable for the Quetelet index in various agegroups.

It proved possible to explain a limited amount of the Quetelet variance observed on the basis of available information, through the application of multiple regression analysis. For the pattern of individual changes taking place this figure was higher, mainly because of the high predictive value of the baseline observation for this purpose.

Among the indicator variables of the regression models age, sex and Lakeside living play a prominent role. The latter are by their nature not subject to change in time, while age changes by a constant amount for all. Age proved to be a significant indicator among children, but did not play an important role above the age of 15 yr. Sex to the contrary is important among adults and less so in children. Among the three groups Lakeside living is significantly and positively correlated with the Quetelet distribution, indicating that there is a nutritional advantage in belonging to this group. The meaning of this relationship cannot be precisely defined, and can relate to environmental, socio-economic and morbidity aspects. It is not unlikely that there is an environmental advantage in living near the lake. For instance it was shown that for housewives the costs in energy and time of obtaining domestic water is much lower (see Chapter 5). It was shown in Chapter 9, that Weight for Height declines more rapidly in older children Inland than at the Lakeside. An explanation for this phenomenon was not available.

Of the three remaining indicators property, spleen status and malaria, the first gives a significant contribution among adults and in 1974 also among preschool-children. The property index was intended to measure an aspect of socio-economic standing of households. In practice, however, as was mentioned earlier, it heavily depended on the number of rooms in the compound. More extended households therefore might have scored higher, not so much because of their economic superiority, as because such houses tended to be bigger and the households more stable. Though it may be unfortunate that this variable was not very well defined, it nevertheless is of interest that it has such a clear determinant function in the explanation of the Quetelet distribution of adults.

Spleen status and malaria were significant determinants for the Quetelet distribution of adults and preschoolchildren. As will be shown later the presence of splenomegaly should be treated as an indication of malaria, and it is not unlikely that persons with an inadequate level of premunity against malaria, and harboring an infection, loose weight as a consequence. In underfives the presence of malaria parasites is associated with children with a higher Quetelet index, while for schoolchildren this is the case with splenomegaly. An explanation for these apparently contradictory findings is not directly available, but without doubt can be found in the complex natural history of malaria. The negative influence of infections, including malaria, on nutritional status is generally acknowledged (Jelliffe, 1966).

Of other variables migrant status and education had quite large regression

coefficients. In 1974 migrant adults and underfives appeared to have had a nutritional advantage over others. For adults this advantage had disappeared in 1970. As was outlined previously, immigration probably had reached its peak in 1974, and after that emigration prevailed (Chapter 7). Also the Lakeside group with more migrants appeared more prosperous in terms of property and cattle holding. The reversal of migratory movements between 1974 and 1977 could be partially responsible for these changes. It is not clear why educated adults should have a lower Quetelet index.

The longitudinal models explaining the individual changes between 1974-77 confirm the trends noted in the crossectional analyses. Here the main indicators are the 1974 Quetelet value and age. Socio- environmental variables only reach significant proportions in adults (migrant status, property and crowdedness). The direction of the coefficients, and the large size though not significant, of variables concerning the spleen and malaria, together represent the influence of that infection on nutritional status.

2.4 Conclusion

By analysing the distribution of the Quetelet index over a three year period it was possible to identify a shift to lower levels in the Lakeside group, which should be interpreted as a sign of decline of nutritional status. Through the regression analysis the following determinants of Quetelet status in this population could be identified:

(1) Age is a basic determinant of the Quetelet status. The influence of sex is only evident for adults. Individual change is mainly dependent on the starting Quetelet value, expressing an individual trend in growth.
(2) Lakeside living is persistently associated with an advantage in Quetelet distribution. Though the position of the Lakeside group declined, this deterioration apparently was not due to the Lakeside living factor per se.
(3) The Quetelet distribution is positively influenced by the level of property and crowdedness of households. The variables migrant status and education do not give consistent influences.
(4) The Quetelet distribution is influenced negatively by spleen enlargement and malaria infection. This influence is strong enough to cancel the advantage of Lakeside living.

3. PACKED CELL VOLUME AND ANAEMIA

3.1 Introduction

In Africa anaemia is a common problem. Particularly nutritional deficiencies due to iron and folate are responsible for this situation, but there is a close relationship with parasitic infections. Where malaria is endemic, chronic low-grade haemolysis contributes to the problem (WHO, 1970 and 1976). The prevalence and type of anaemia in a community is therefore a mirror of some important health conditions. Though mild degrees of anaemia do not have any direct implications, their presence constitutes a risk factor for the development of serious anaemia especially in pregnant women and children. The underlying deficiencies of iron and folate may play a role in the ability of the individual to resist infection. Anaemia, especially the more severe degrees, reduces the working capacity and possibly the normal feeling of vitality and vigour.

For practical reasons we have chosen the Packed Cell Volume (PCV) as the parameter of haematopoietic status, rather than the more usual haemoglobin concentration. The two are closely correlated, but PCV has the advantage of being better reproducible with the methods used. Graitcer et al. (1981) compared the outcome of screening for anaemia by either the Hb or PCV as screening parameter in a large group of school-children. Their findings indicate substantial differences between the two methods. In general the use of PCV tended to underrate the prevalence of anaemia according to the more usual Hb criteria.

3.2 RESULTS

The same apparatus was used for measuring PCV in 1974 and 77, but the microcentrifuge was only calibrated against an official standard in 1977. The calibration formula was then, retrospectively, applied to the 1974 results. The reproducibility of PCV was quite satisfactory.

The distribution of PCV is given in table 35. It is wellknown that the level of PCV varies with age and sex, and is inluenced also by pregnancy and lactation. In our data the relationship with age appears to be linear, although in females values decline somewhat after the age of puberty. For the purpose of the present report we are mainly concerned with the pattern of difference between the Inland/Lakeside groups, and changes occurring in the course of time. We shall in addition consider the presence of iron deficiency in this area.

The pattern of differences between Inland and Lakeside groups is quite consistent. Except for female children under five, a higher value is observed for all age and sex groups of the Lakeside population in 1974. The pattern of differences is independent of age and sex, and Lakeside individuals have on the average 0.78% PCV more (<0.01). This pattern was radically changed in 1977 when Lakeside people had, in all age and sex groups, lower mean PCV levels. Now Inland persons had on the average 3.00% PCV more ($P<0.001$).

The background of the paradoxical reversal of the situation is shown by comparing the results for both surveys of each group. From 1974 to 1977 PCV levels declined for all age and sex groups of the Lakeside area, whereas Inland the opposite occurred. The opposite trend to change between Inland and Lakeside groups resembles that observed for the Quetelet index.

TABLE 35: Distribution of Packed Cell Volume (%) by Age and Sex for Inland and Lakeside Groups in 1974 and 1977 (estimated overall St.Dev. 4.4)

	Males		Females		Males		Females	
Age	No	Mn	No	Mn	No	Mn	No	Mn
				1974				
0- 2	20	28	34	30.2	26	29.2	16	29.5
3- 4	38	31.5	41	32.4	23	32.1	20	31.5
5- 9	69	33.4	53	32.3	33	34.5	45	33.6
10-14	33	34.5	47	34.1	41	34.6	28	34.8
15-24	20	36.2	57	33.4	27	38.0	42	33.9
> 25	44	38	80	33.9	42	39.6	66	34.9
				1977				
0- 2	20	29.0	22	31.1	15	26.2	17	27.2
3- 4	22	34.3	42	31.9	39	28.9	20	30.5
5- 9	38	34.8	66	34.1	32	32.0	40	30.8
10-14	54	35.9	43	36.8	37	33.3	32	32.5
15-24	29	36.8	45	35.7	35	35.3	32	32.8
> 25	25	40.9	79	34.8	31	37.8	74	32.2

TABLE 36: Prevalence of Low Packed Cell Volume in the Inland and Lakeside Groups in 1974 and 1977 by Age and Sex
(% of PCV's below 30% and between 30-34%)

	Inland				Lakeside			
	Males		Females		Males		Females	
Age/PCV	<30%	30-34	<30%	30-34	<30%	30-34	<30%	30-34
				1974				
0- 2	60	40	44	47	58	31	50	44
3- 4	29	53	20	58	13	74	30	55
5- 9	14	54	21	58	15	36	18	44
10-14	18	21	11	47	12	32	4	50
15-24	0	30	17	42	4	22	14	36
> 25	5	23	18	36	2	7	12	33
All	18	39	20	47	16	31	17	41
				1977				
0- 2	50	45	32	50	67	3	59	41
3- 4	9	45	29	45	44	51	40	40
5- 9	16	24	15	32	25	53	45	32
10-14	13	22	5	21	19	43	16	56
15-24	7	21	9	22	14	29	25	38
> 25	0	8	11	35	10	16	23	49
All	14	26	15	33	26	39	31	44

The levels of the PCV in the different groups are relatively low, indicating that anaemia is prevalent in this population, and increasing by 1977 (table 36). Deviating from the normal practice to define anaemia in terms of haemoglobin concentration, we had to use criteria based on PCV here. We defined a more serious degree of anaemia as presented by PCV of less than 30% (less than 10.0 g% Hb), and a mild level of anaemia by PCV values of 30-34% (approximately 10.0-11.5 g%). According to these criteria nearly all children under three years and about 80% of those between 3 and 5 yr are anaemic, and more than a half of them falling in the more serious category. The prevalence of anaemia declines gradually in older children, and sharply after puberty in males. From about the age of 10 yr onward anaemia is more prevalent among females. Especially in the older age-groups the degree of anaemia is mostly mild.

The mean corpuscular haemoglobin content (MCHC) could be calculated for 1977 only. Low MCHC values are an indication of iron deficiency. In accordance with normal practice we defined low MCHC values as those of 30% or less. The percentage of the persons in each group with low MCHC is given in table 36. The highest prevalence is seen in children under five (17-35%). Generally low MCHC occurs more in females (19-22%) than among males (12-13%). In the course of the health examination survey thin blood films were usually made if respondents had a haemoglobin of 10 g% or less. These films were examined by an experienced technologist. In 1974 a total of 60 slides were made of which 46 (77%) showed changes suggestive of iron deficiency, and in 1977 these figures were 53 slides out of 132 (40%). There may have been considerable observer variation between the two surveys.

TABLE 37: The Occurrence of low Mean Corpuscular Haemoglobin Content (MCHC < 30%) in the Inland and Lakeside Groups in 1977 (%)

	Inland				Lakeside			
	Males		Females		Males		Females	
	No	Low MCHC	No	Low MCHC	No	Low MCHC	No	Low MCHC
0- 4 yr	42	17	64	34	54	26	37	35
5-14	92	8	109	13	69	4	72	10
15-24	29	20	45	24	35	11	31	25
> 25	24	13	79	25	31	3	74	18
All	187	13	297	22	189	12	214	19

Also here the multiple regression analysis was performed for adults, school- and preschool-children. The models explain between 14 and 37% of the total variance crossectionally, and 48 to 60% longitudinally (tables 38 and 39, 49 and 50). For the haematopoetic status age and Lakeside living are important indicator variables. The influence of sex is restricted to adults. Spleen status, and malaria, play a major role. The contribution by the indicators crowdedness, migrant, education and the Quetelet varies. The pattern of indicators from the crossectional data is closely reflected in the indicators for longitudinal individual PCV change. Here, like in the case of the Quetelet index, the baseline PCV is the main determinant. Other variables contribute as well, especially spleen status and spleen change, and Lakeside living.

TABLE 38: Indicator Variables of PCV in 1974 and 1977 for Adults, School- and Pre-schoolchildren. For each Variable the Regression Coefficient is given with the Standard Error in ()

	Adults	Schoolchildren	Pre-schoolchildren
Indicators	Regression Coeff.	Regression Coeff.	Regression Coeff.
		1974	
	No 336	No 282	No 178
Lakeside living	1.55 (0.51) xx	1.56 (0.44) xxx	0.13 (0.63)
Sex	-4.49 (0.56) xxx	-0.61 (0.42)	0.60 (0.58)
Age	0.04 (0.02) (x)	0.30 (0.09) xxx	0.66 (0.20) xxx
Migrant status	-0.15 (0.89)	1.45 (0.81) (x)	-2.08 (1.12) (x)
Education I	0.25 (0.81)	na	na
Education II	0.74 (0.74)	na	na
Property status	-0.34 (0.23)	0.30 (0.21)	-0.05 (0.29)
Crowdedness	-0.02 (0.13)	0.23 (0.13) (x)	0.06 (0.16)
Spleen status	-1.49 (0.83) (x)	-3.85 (0.85) xxx	-3.63 (1.33) xx
Malaria par.	-3.62 (1.40) xx	-1.27 (0.80) (x)	-1.63 (1.40)
Quetelet Index	0.01 (0.01)	-0.03 (0.02) (x)	-0.00 (0.02)
Intercept	36	33	29
		1977	
	No 305	No 297	No 170
Lakeside living	-2.52 (0.51) xxx	-2.93 (0.48) xxx	-2.23 (0.66) xxx
Sex	-3.29 (0.56) xxx	-0.73 (0.45)	0.17 (0.64)
Age	0.04 (0.02) (x)	0.31 (0.09) xxx	1.02 (0.25) xxx
Migrant status	0.92 (0.93)	-0.83 (0.93)	0.86 (1.50)
Education I	-1.25 (0.78)	na	na
Education II	1.87 (0.74) x	na	na
Property status	-0.11 (0.22)	-0.06 (0.22)	0.45 (0.32)
Crowdedness	-0.20 (0.15)	-0.28 (0.14) x	-0.20 (0.20)
Spleen status	-3.53 (0.71) xxx	-4.96 (0.67) xxx	-4.67 (1.18) xxx
Malaria par.	-0.26 (0.55)	-0.50 (0.48)	-2.35 (0.66) xxx
Quetelet index	0.01 (0.01)	-0.02 (0.02)	0.02 (0.02)
Intercept	35	35	26

na not appicable
(x) $0.05<P<0.1$ x $P<0.05$ xx $P<0.01$ xxx $P<0.001$

TABLE 39: Indicator Variables of PCV-change from 1974-77 for Adults, School- and Pre-schoolchildren. For each Variable the Regression Coefficient is given with the Standard Error in ()

	Adults	Schoolchildren	Pre-schoolchildren
	Regression Coeff.	Regression Coeff.	Regression Coeff.
	No 148	No 176	No 122
Lakeside living	-3.22 (0.74) xxx	-2.56 (0.68) xxx	-2.02 (0.78) xx
Sex	-2.34 (1.01) x	-0.92 (0.60)	-0.95 (0.73)
Age	-0.04 (0.03)	-0.02 (0.15)	0.33 (0.24)
Migrant 1974	-0.41 (1.50)	2.64 (1.94)	-0.88 (1.66)
Education I -1974	-0.83 (1.11)	na	na
Education II-1974	1.00 (1.01)	na	na
Property 1974	0.28 (0.34)	-0.39 (0.32)	0.45 (0.38)
Crowdedness 1974	-0.28 (0.23)	-0.21 (0.21)	-0.05 (0.23)
Spleen 1974	-1.39 (1.60)	-5.02 (1.84) xx	-1.63 (2.39)
Malaria 1974	-2.70 (2.78)	2.04 (1.24) (x)	1.26 (2.17)
Quetelet 1974	-0.01 (0.02)	-0.03 (0.03)	0.01 (0.03)
PCV 1974	-0.65 (0.08) xxx	-0.68 (0.10) xxx	-0.91 (0.08) xxx
Change Property	-0.12 (0.46)	-1.00 (0.42) x	0.26 (0.46)
Change Crowdedness	-0.28 (0.23)	-0.48 (0.22) x	0.05 (0.25)
Change Malaria	-0.29 (0.87)	0.53 (0.62)	-1.59 (0.74) x
Change Quetelet	-0.00 (0.02)	0.04 (0.03)	0.05 (0.03)
Spleen increase	-3.36 (1.46) xx	-3.67 (0.87) xxx	-4.25 (1.21)
Spleen decrease	2.30 (2.15)	5.94 (2.47) x	-0.70 (3.30)
Intercept	30	31	29

na not applicable
(x) 0.05<P<0.1 x P<0.05 xx P<0.01 xxx P<0.001

3.3 DISCUSSION

The haematological status of the population has been described in terms of PCV, because of difficulties encountered in measuring haemoglobin. PCV is a highly reproducible parameter, and also in our survey reproducibility was good. Calibration of the equipment used for Hb and PCV estimation in the field was overlooked in 1974, but included in the preparations for 1977. As the equipment used was the same on both occasions, we thought it permissible to apply the calibration formula retrospectively to PCV estimations of 1974. Any error introduced by this procedure may affect systematically the comparison between 1974 observations and of 1977. However, comparison between Inland and Lakeside groups is not influenced.

The main conclusion from the haematological information obtained is that the Lakeside group, which had higher PCV values in 1974, had lost this advantage by 1977. By comparing the group average for 1974 and 1977, it can be demonstrated that generally a lowering of PCV took place on the Lakeside and an increase Inland. While it is not unlikely that such a differential pattern of change could represent a seasonal trend, it is on the other hand possible that it is interwoven with more permanent changes mainly affecting the Lakeside group. In any

case the change in PCV appears to be part of a larger pattern, also concerning the Quetelet index and spleen enlargement.

Anaemia is a common problem in this population and its prevalence might further increase in the Lakeside group. It is in the first place a condition of children and adult women, suggesting the presence of iron deficiency as an etiological factor, because iron requirements are highest in these groups. Analysis of the MCHC distribution shows that about 12% of males (mainly children) and about 20% of females (both children and adults) have a MCHC below 30% which is a sign of iron deficiency. The presence of iron deficiency was further confirmed by examining blood slides of anaemic subjects. Anaemia is a significant public health problem in Kenya and it generally ranks with the first ten causes of hospital deaths and admissions (Bonte, 1974). It is especially prevalent in the coastal areas where Foy (1952) measured a mean haemoglobin of 9.0 g% among 100 normal adults, which signifies that 100% of the population is anaemic. Low iron intake, associated with iron losses due to helminth infections, and folic acid deficiency, associated with chronic haemolysis of malaria and haemoglobinopathies, are the main factors. More recently Greenham (1978) demonstrated the presence of a serious anaemia problem in the nomadic people of the Northeastern province of Kenya, with as main determinant low iron intake from a diet consisting largely of milk. The anaemia problem is less serious in the high altitude parts of Central Kenya (Levine, 1969), but reliable population based information is not available. Both iron deficiency and megaloblastic anaemias are regularly seen in hospitals (Young et al., 1974). The marginal type of subsistence characteristic for Kamburu, most likely will not provide for ample supply of essential nutrients for haematopoiesis. It is therefore not unexpected that a moderate nutritional anaemia problem exists. The situation may rapidly become more serious if helminth infections increase in prevalence. On the other hand haemolysis, due to malaria, appears to be a second factor responsible for the anaemia in Kamburu.

Haematopoietic status was slightly more predictable by the regression analysis than the Quetelet index. In crossectional models Lakeside living and age were the main personal indicators, the influence of sex being quite important in adults. Lakeside living was responsible for 1-3 PCV%, but the direction of its effect changed from positive in 1974 to negative later. The change most likely was connected with the increasing prevalence of spleen enlargement, but cannot be pinpointed precisely. Increasing age may also add several PCV% to the readings, while women have 3-4 PCV% less than men. The effects of age and sex were conform to what is normally expected.

A second quantitatively important group of variables concern the spleen and malaria. Spleen enlargement in Africa is usually associated with lower Hb and PCV. The role of the spleen as a factor of anaemia, by trapping red blood cells, is wellknown (Edington and Gilles, 1976). It will be shown later on that spleen enlargement in Kamburu was mostly due to malaria. The mechanism for malarial anaemia are several (WHO,1968), and anaemia is often disproportional to the degree of parasitaemia (WHO, 1975). In the Kamburu population the presence of splenic enlargement or malaria parasites lowered the PCV level by about 4-7 PCV%.

A third group of indicators concerns the variables migrant status, property and crowdedness, education. These contributed generally less than 1 PCV% and the direction of their influence was not always consistent between the groups and the two survey years. Evidently they did not constitute important determinants, and their influence is indirect. An exception should possibly be made for education. Adults with more than 4 years primary education had consistently 1-2 PCV% more than others. It is attractive to suppose that these persons were socio-economically better off, or took treatment and prophylaxis for malaria more readily than others did.

The influence of the Quetelet index, representing the influence of nutrition, amounted to 1-3 PCV%, but was inconsistent in direction. The index apparently insufficiently identified the nutritional factor of anaemia.

In the analysis of the longitudinal changes, the baseline PCV reading and Lakeside living were the dominant predictors. Both had negative coefficients. Whereas for Lakeside living this reduction concerned 2-3 PCV%, in the case of baseline PCV this effect was as high as 25-30 PCV% for persons with high readings. The negative effect of indicators involving the spleen and malaria amounted to 3 or more PCV%. It is striking to note that for all groups, developing splenomegaly is accompanied by a reduction of the PCV, and its disappearance by a rise. Children who had malaria in 1974 also showed a rise. Their immunity acquired in the meantime could possibly have a promotive influence. The effect of socio-environmental variables was mixed and not very strong, like in the cross-sectional models.

3.4 Conclusions

On the basis of the observations on PCV it was demonstrated that a moderate degree of anaemia is common in Kamburu. Its prevalence, initially highest Inland, shifted significantly to the Lakeside, and increased. The regression analysis resulted in the identification of the following determinants of PCV:

(1) Age, and for adults sex, are basic determinants. In addition the individual baseline PCV level proved to be the strongest predictor.
(2) The effect of Lakeside living changed in the course of three years from positive to negative. The cause responsible for the change therefore must have been closely related to Lakeside living.
(3) Factors associated with spleen enlargement and malaria appear to have been instrumental to the change.
(4) Socio-environmental indicators and the Quetelet index did not influence PCV distribution significantly, nor consistently, with exception of a more advanced level of education.

4. ENLARGEMENT OF THE SPLEEN

4.1 Introduction

Both spleen and liver are organs easily accessible to palpation during field surveys. The prevalence of splenomegaly thus is used as an indicator for the endemicity of various infections (Edington and Gilles, 1976): malaria, schistosomiasis, visceral leishmaniasis and trypanosomiasis. Liver enlargement may accompany splenomegaly in all types of malaria (Russel et al., 1963) without adding an indication of the severity of the disease. On the other hand liver enlargement alone, or accompanying splenomegaly, is considered as a sign of the severity of the infection in Schistosomiasis mansoni (Arap Siongok et al., 1976). Liver enlargement is also present in some forms of infantile malnutrition.

Assessment of the spleen rate in community surveys therefore, is usually intended as a diagnostic tool. However, splenic enlargement itself may be an expression of ill-health, and as we have seen, an indicator of anaemia. A standardized and reproducible method for spleen assessment is nowadays commonly used (WHO, 1963), but in respect of hepatomegaly this has not been the case (Sullivan, 1976).

4.2 Results

In the Kamburu population splenic enlargement (table 40) in 1974 was associated with age-group ($P<0.05$) and sex ($P<0.1$), and this was also the case in 1977 ($P<0.01$ resp. $P<0.1$). For interpreting the distributions the effect of age and sex therefore should be accounted for. During the baseline survey of 1974 all Lakeside age- and sex groups, except for males of 25 yr and older, had higher spleen rates than Inland groups. A similar pattern prevailed in 1977 but now the differences between Inland and Lakeside groups had increased. Though formal significance testing has not been done, it is obvious that there is a systematic and persistent difference in this respect between the two groups.

Inland, splenomegaly was rarely encountered in 1974, but showed a prevalence of around 20% in 1977. If only major degrees of splenic enlargement are considered (Hackett grade 2 and more), there appears to have been little change. The situation is quite different on the Lakeside. Here a spleen rate of 15-20% was registered in 1974 and these figures increased to around 40-60% in 1977. If only major degrees (grade 2 and more) are considered there also is a significant increase ($P<.01$) both for males and females. If only the largest degrees of splenomegaly (grades 3-5) are considered, 12 cases were registered on the Lakeside in 1974 and 1 Inland. In 1977 these numbers had become 22 resp. 12, which further illustrates that a general trend to more splenic enlargement was observed during the latter year.

Summarizing the observations on the distribution of splenomegaly it can be concluded that spleen enlargement is occurring more in the Lakeside population and it became more prevalent at the end of the three year period.

TABLE 40: Distribution of Splenomegaly in 1974 and 1977 by Age and Sex
(% - Hackett's classification)

	Inland						Lakeside					
	Males			Females			Males			Females		
Age, y.	No	>1	>2	No	>1	>2	No	>1	>2	No	>1	>2
						1974						
0- 2	22	9	9	34	6	3	28	18	11	17	12	6
3- 4	40	2	2	41	5	2	23	22	13	21	10	5
5- 9	72	4	1	56	4	2	34	18	15	46	9	6
10-14	35	3	3	51	4	4	41	32	27	28	21	4
15-24	20	5	0	57	4	4	31	16	13	43	5	5
> 25	47	11	11	83	11	10	45	11	11	76	18	18
All	236	6	4	322	6	5	202	19	15	231	13	10
						1977						
0- 2	21	5	5	27	7	4	18	22	22	20	10	5
3- 4	26	19	4	42	26	5	39	44	15	21	29	10
5- 9	42	19	10	70	19	7	34	59	12	41	56	20
10-14	55	29	9	45	29	7	38	76	26	32	50	16
15-24	32	28	6	49	14	4	35	83	31	32	44	12
> 25	27	11	0	80	14	9	32	53	16	80	38	19
All	203	21	6	313	18	6	196	59	20	226	40	15

The results of the discriminant analysis have been summarized in the tables 41 and 42, 49 and 50. The most important indicators in 1974 were Lakeside living, malaria, and for adults advanced education and the Quetelet index. Property and sex were important only in the group of schoolchildren. In 1977 the same variables, except education, contributed. Property now influenced preschoolchildren.

In the analysis of the pattern of longitudinal change, concerning spleen increase, few determinants were found apart from Lakeside living. Judged from the size of the discriminant coefficients of variables concerning spleen and malaria, these were next in importance.

TABLE 41: Indicator Variables of Spleen Status in 1974 and 1977 for Adults, School-, and Pre-schoolchildren. For each Variable the Regression Coefficient is given with the Standard Error in ()

	Adults	Schoolchildren	Preschool-children
Indicator	Discriminant Coeff.	Discriminant Coeff.	Discriminant Coeff.
	1974		
	No 359	No 291	No 184
Lakeside living	0.34 (0.16) x	1.70 (0.54) xx	0.90 (0.76)
Sex	-0.06 (0.18)	-0.94 (0.51) (x)	-0.78 (0.70)
Age	-0.00 (0.01)	0.03 (0.10)	-0.09 (0.25)
Migrant status	0.08 (0.08)	-0.72 (0.99)	-1.50 (1.32)
Education I	-0.35 (0.26)	na	na
Education II	-0.73 (0.24) xx	na	na
Property status	0.04 (0.08)	-0.63 (0.25) x	-0.33 (0.35)
Crowdedness	0.00 (0.04)	-0.21 (0.16)	-0.14 (0.19)
Malaria par.	0.44 (0.46)	5.37 (0.94) xxx	9.71 (1.55) xxx
Quetelet index	-0.07 (0.03) x	0.03 (0.02)	-0.03 (0.02)
	1977		
	No 313	No 308	No 183
Lakeside living	1.17 (0.37) xxx	0.73 (0.37) x	0.42 (0.61)
Sex	0.09 (0.41)	-0.12 (0.35)	-0.54 (0.60)
Age	0.01 (0.02)	0.09 (0.07)	0.06 (0.23)
Migrant status	-0.52 (0.68)	-0.21 (0.73)	0.12 (1.36)
Education I	-0.06 (0.57)	na	na
Education II	0.34 (0.54)	na	na
Property status	-0.15 (0.16)	-0.07 (0.17)	-0.65 (0.30) x
Crowdedness	-0.05 (0.11)	0.04 (0.11)	-0.13 (0.19)
Malaria par.	-0.32 (0.40)	0.79 (0.37) x	1.65 (0.61) xx
Quetelet index	-0.02 (0.01) xx	0.00 (0.01)	-0.02 (0.02)

na not applicable
(x) $0.05<P<0.1$ x $P<0.05$ xx $P<0.01$ xxx $P<0.001$

TABLE 42: Indicator Variables of Spleen Increase from 1974-77 for Adults, School-, and Pre-schoolchildren. For each Variable the Discriminant Coefficient is given with the Standard Error in ()

	Adults	Schoolchildren	Pre-schoolchildren
Indicators	Discriminant Coeff.	Discriminant Coeff.	Discriminant Coeff.
	No 148	No 178	No 125
Lakeside living	2.13 (0.79) xx	0.90 (0.52) (x)	-0.39 (0.80)
Sex	0.48 (1.01)	-0.37 (0.49)	-1.08 (0.74)
Age	0.02 (0.03)	0.16 (0.12)	0.04 (0.25)
Migrant 1974	0.53 (1.65)	0.88 (1.43)	1.34 (1.39)
Education I -1974	-0.59 (1.27)	na	na
Education II-1974	0.25 (1.11)	na	na
Property 1974	-0.37 (0.38)	-0.16 (0.27)	-0.65 (0.39) (x)
Crowdedness 1974	0.24 (0.25)	0.02 (0.17)	-0.12 (0.23)
Spleen 1974	-2.25 (1.68)	-2.05 (1.50)	0.40 (2.52)
Malaria 1974	-3.10 (4.71)	1.40 (1.03)	0.06 (2.47)
Quetelet 1974	-0.03 (0.02)	-0.00 (0.02)	-0.01 (0.03)
Change Property	-0.20 (0.52)	0.15 (0.32)	0.35 (0.47)
Change Crowdedness	-0.02 (0.25)	0.07 (0.18)	0.01 (0.26)
Change Malaria	1.19 (0.99)	0.68 (0.50)	1.66 (0.76) x
Change Quetelet	-0.03 (0.03)	0.02 (0.03)	0.03 (0.03)

na not applicable
(x) $0.05<P<0.1$ x $P<0.05$ xx $P<0.01$ xxx $P<0.001$

4.3 Discussion

During the period under observation the prevalence of enlarged spleens and livers considerably increased in both population groups. For spleen enlargement the increase was higher in the Lakeside group, but not for liver enlargement (data have not been given). Such a pattern of change may be the result of observer variation. The examinations were done by different fieldstaff whose performance could not be compared. Though similar considerations concerned the results of the haematocrit measurements, a systematic deviation was less likely in that case, because of the peculiar opposing trend in Lakeside and Inland groups. Reproducibility of spleen assessment (51 and 68%) was shown much superior to that of the liver (18 and 35% agreement) at the time of the second survey. This suggests that the spleen rates are more reliable than the result of liver assessment. As especially in the case of spleen palpation observer variation was rarely more than 1 grade according to Hackett, the spleen rate for grades 2 and more represents a minimum estimate of the true occurrence of spleen enlargement. The latter was less for liver enlargement, and on the whole major degrees of hepatomegaly were rarely observed. Because of the apparent unreliability of the information on liver enlargement, and as it did not suggest the presence of significant liver pathology, we did not pursue further analysis of its distribution.

More splenomegaly was found at the time of the second survey, both among Inland and Lakeside groups, but especially prominent in the latter. Such a change could be the result of seasonal fluctuations in the transmission for instance of

malaria. On the other hand the increase could represent a more permanent change. A definite conclusion is impossible to draw without additional information. The involvement of splenomegaly with the local pattern of anaemia, and even nutritional status, however, is suggestive that a longterm trend towards more splenomegaly affected at least the Lakeside group.

Locally the following diseases deserve consideration as a possible cause of splenomegaly: malaria, schistosomiasis, visceral leishmaniasis. Of these malaria deserves first consideration as the Kamburu area falls within a region with known, though limited, malaria transmission. The contribution of malaria as a cause of splenomegaly is further suggested by the observation from the discriminant analyses, that malaria parasitaemia was associated with spleen enlargement in children. Although the diagnosis of malaria in 1977 was quuite inaccurate the association with splenomegaly still remained evident. Of the two types of schistosomiasis, it is mainly Schistosoma mansoni infections which may be the cause of endemic splenomegaly. As will be shown later, few cases of this infection were diagnosed and locally the infections appear light. Under such conditions S. mansoni infections will not produce sufficient cases of splenomegaly to be relevant locally. Also among the few cases there was no preponderance of splenomegaly.

Visceral leishmaniasis is endemic in an area to the north east of Kamburu (Wijers, 1974). Here a major outbreak occurred between 1952 and 1954. Since that time the infection has slowly spread into adjacent areas, also in the northern parts of Machakos where Kamburu is situated. In recent years a increasing number of clinical cases was noticed at the hospital of Machakos. In April 1977, a few months prior to the present survey, several adjacent locations were surveyed by medical students of the University of Nairobi, examining a total of 11,436 people (Wasunna, 1977). Among them 1.9% had splenomegaly of sufficient degree to allow for splenic puncture and 22 cases of kala azar were identified by culturing the splenic aspirate (point prevalence 1.9 per thousand). During our Kamburu survey splenic punctures were done in 39 people (4.2%). One case was detected, having a positive culture and smear, which gives an estimated prevalence (1 per thousand) like that reported by Wasunna. As the methods used are reliable for the diagnosis of kala azar, it is unlikely that the disease contributed significantly to the local splenomegaly situation.

With the aid of discriminant analysis a small part of the variation in the occurrence of spleen enlargement could be explained. In terms of the total variance explained by the multiple regression analysis this would have been 7-14%. The indicator variable which gives the most significant, and largest, contribution to the discriminant function is malaria parasitaemia in pre-school- and schoolchildren. In adults the acquired premunition against malaria may have masked the association. In 1977 the association was less strong, but this is due to inaccuracy of diagnosis and misclassification.

In adults the Quetelet index may influence the occurrence of spleen enlargement. This association has been viewed from the other side in the section about the Quetelet index. It is not possible to distinguish the two, but probably the latter effect is stronger. Educated adults tend to have less enlarged spleens. This applies particularly to people with a more advanced level of education. Similar relationships were reported for PCV, and it was speculated that these people are more well to do, or take antimalarials more readily.

Among children the occurrence of splenomegaly is negatively influenced by property. Possibly large spleens occurred less often in the larger households with a higher property score. Though the discriminant coefficients of sex and migrant status were not significant, they nevertheless were quite large, signifying that boys tend to have more enlarged spleens, and migrants less.

The analyses to explain the occurrence of spleen increase were not very productive. Spleen increase was positvely correlated with Lakeside living. In pre-

schoolchildren the property, and becoming positive for malaria, were positively associated. Judged from the size of the coefficients spleen increase had a malarial aetiology.

4.4 Conclusions

The prevalence of splenomegaly increased considerably from 1974 to 1977 in both Inland and Lakeside groups, but mostly in the latter. It proved impossible to decide whether the increase was due to seasonal fluctuations, or was of a more permanent nature. Schistosomiasis mansoni, visceral leishmaniasis and malaria (infections occurring in the area) could each contribute to the incidence. The available evidence however, indicates that malaria is the main causal agent. The discriminant analysis demonstrated the following relationships:

(1) Enlarged spleens are more frequent in the Lakeside group in all analyses, showing that these people are more prone to have them, irrespective of any changes in prevalence.
(2) The discriminant analysis confirms the aetiological role of malaria.
(3) Socio-environmental indicators are of secondary importance. Education appears to have a preventive influence.

5. OTHER OBSERVATIONS

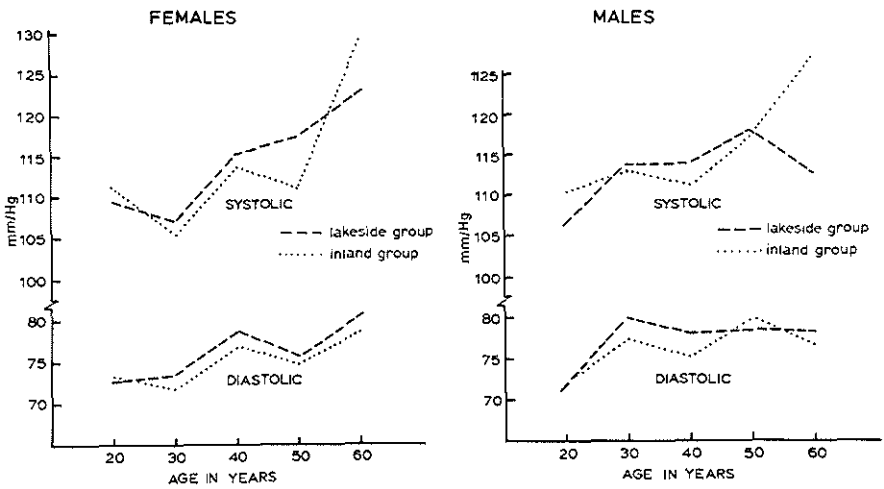
To conclude this section on general aspects of ill-health we briefly report on the distribution of blood pressure and hypertension, the occurrence of proteinuria and diarrhoeic stool.

5.1 BLOOD PRESSURE AND THE PREVALENCE OF HYPERTENSION

Nutritional and social factors, and the pattern of endemic infections probably are the main determinants of blood pressure in rural African population. Hypertension, including essential hypertension and hypertensive heart disease are relatively common causes of illness and disability in some parts. Renal pathology as a result of endemic infections contribute to this situation. The contribution by Schistosoma haematobium infections to hypertensive disease is inconclusive and under investigation. Ojiambo (1974) observes that hypertension and hypertensive heart disease is in Kenya a problem of urbanized people.

Blood pressures were included in the baseline survey of 1974, but not repeated in 1977(see figure 5). Measurements were taken in a sitting position after a few minutes rest, the diastolic pressure being recorded at the fourth phase of Korotkof. A single observor measured the blood pressures on each occasion, but for 1974 and 1977 different observors were involved.

FIGURE 5: The Distribution of Systolic and Diastolic Bloodpressure of Persons over 15 years in Inland and Lakeside groups by age



On the whole the distribution of blood pressure is very similar in Inland and Lakeside groups. The values for females tended to be somewhat higher than for males. The mean systolic pressure rises from between 105-110 mm Hg in the 15-24 yr old to a level of about 125 mm Hg in the oldest persons. For diastolic blood pressures these values are respectively 72 and 80 mm Hg. The pattern of blood pressure is therefore characterized by low readings, and a moderate rise in blood pressure with age. Comparable information from other areas in Kenya is scanty. Shaper et al. (1969) reported on blood pressure in three nomadic tribes from northern Kenya. Their blood pressure distribution was also marked by low average readings, and an absence of rising systolic blood pressure with age. Williams (1969) studied Kikuyu males and females from Central Kenya and found that mean values were higher than those reported by Shaper, and at the present from Kamburu, and increased with age.

Hypertension is rare in this population. According to WHO criteria, hypertension is defined as a blood pressure of systolic 160 or diastolic 95 mm Hg or more or both. Two men (1.4%) and three women (1.0%) were hypertensive according to these criteria. Using less stringent criteria of 140 and/or 90 mm Hg, still only 8 men (5.6%) and 17 women (6.0%) classified as hypertensive. Clearly hypertension did not constitute a problem of any significance in 1974, and the observations were not repeated in 1977.

5.2 PROTEINURIA

Proteinuria is a cardinal sign of pathology of the urinary tract and kidneys, which is often associated with infections. Urinary schistosomiasis itself is usually accompanied by proteinuria, as are acute attacks of malaria. Besides, both diseases may cause parenchymal pathology of the kidneys. It is for these reasons that testing the urine for the presence of protein was included in the procedures. Urine was tested using either Bili-Labstix or Albustix paper strips (Amesz). Results were scored according to the grade of color change of the strip. Though tests for reproducibility of the results were not done, we had the impression that minor color changes indicating protein 'trace' were not reproducible. For this reason results are only reported for definite degrees (1-4) of proteinuria.

The results for 1974 and 1977 are given in table 43. There is no clear pattern linking urinary protein either to certain age or sex groups, nor were there obvious differences between Inland and Lakeside groups. Generally between 5-10% of people had a positive test.

The occurrence of proteinuria could not be associated with any specific condition. In the Inland area a limited number of cases of urinary schistosomiasis were diagnosed, mostly in schoolage children and young adults, which nearly all had a positive test. It is further not unlikely that attacks of malaria in the population account for another number of positive tests. With the aid of multiple regression analysis a limited 6% of the total variance could be explained, not including schistosomiasis. Both splenomegaly and anaemia appeared to be weak indicators of proteinuria.

In areas where the infection is highly endemic, proteinuria especially in school-children is closely correlated with the infection, and may be used as a screening device (Oomen, 1974). The relative absence of proteinuria from this population is a positive observation. As a baseline datum it may prove useful in case Schistosoma heamatobium infections will become more common.

TABLE 43: The Distribution of Proteinuria* in Inland and Lakeside groups in 1974 and 1977 (percentages)

	Inland				Lakeside			
	Males		Females		Males		Females	
Age	No	% positive	No	% positive	No	% positive	No	% positive
				1974				
0- 4 yr	47	4	50	0	44	7	27	4
5-14	102	11	98	4	72	4	72	12
>15	61	8	133	8	74	11	116	13
All	210	9	281	5	190	7	215	12
				1977				
0- 4 yr	34	3	50	4	45	4	34	12
5-14	91	9	111	7	72	1	66	6
>15	55	11	119	2	64	9	104	5
All	180	8	280	4	181	5	204	6

* protein 1-4+ using Albustix (Amesz).

TABLE 44: The Occurrence of Diarrhoeic* Stool in Inland and Lakeside groups in 1974 and 1977 (cases)

	Inland				Lakeside			
	Males		Females		Males		Females	
Age	No	Diarrhoea	No	Diarrhoea	No	Diarrhoea	No	Diarrhoea
				1974				
0- 4 yr	46	3	56	9	36	1	26	4
5-14	88	1	92	0	68	0	65	0
> 15	59	2	126	2	73	0	107	3
All	193	6(3%)	274	11(4%)	177	1(<1%)	198	7(4%)
				1977				
0- 4	30	3	46	2	44	2	34	6
5-14	80	0	98	0	69	0	65	0
> 15	51	0	107	0	64	2	100	2
All	161	3(2%)	251	2(1%)	177	4(2%)	199	8(4%)

* Watery consistency only

5.3 DIARRHOEIC STOOL

In developing countries diarrhoea is a major cause of morbidity and mortality. Usually information on diarrhoea is obtained from hospital cases which represent only part of the total cases occurring. Diarrhoea studies are difficult to perform because of problems of subject and observer variation. The incidence of diarrhoea is subject to periodic fluctuations: for instance for a different part of Machakos Leeuwenburg et al. (1978) report that most diarrhoea deaths occurred in the period March to July. Enteric infections of bacterial or viral origin are probably the main source of diarrhoea, but other systematic infections (measles, malaria) and malnutrition are important causal factors also. Consequently diarrhoeal disease varies greatly in severity of the symptoms, in stool frequency and duration of the attack.

For all stool specimens collected in 1974 and 1977 the consistency was recorded either as formed, loose or watery. Watery stool was defined as stool which would 'run' in the tilted container. In 1974 52% of stools were formed, 45% loose and 3% watery. In 1977 these percentages were 58%, resp. 40% and 2%. Because of the bulky nature of the local diet stools often appear to be loose and unformed, and no special significance should be attached to this observation. Therefore only watery stools could be considered as an indication of the occurrence of diarrhoeal disease. The observations are recorded in table 44. The prevalence of diarrhoea at the time of the survey ranged between 1-4% in 1974, and in 1977. There were no clear sex differences, but most cases of watery stools were in children underfive. In 1974 10% of this group had diarrhoea, and in 1977 8%. Without any additional information on the duration of the attacks it is difficult to give an estimate of the incidence. Leeuwenburg et al. (1978) report an incidence of 10.5% in children underfive per two-week period. This rate is based on information given by the mothers of the children, and not on inspecting their stools, though in a smaller sample reliability of the reports were checked by obtaining and inspecting stool samples. Moreover the authors state that the mothers tended to overreport diarrhoeal episodes. Our observations of a point prevalence of watery stool of 10% resp. 8% in children underfive therefore appears to be of similar magnitude. These figures strongly contrast with the virtual absence of diarrhoeal stools in schoolage children and with a rate of 2 resp. 1% in adults. It is not unlikely that some of the older children with diarrhoea and also adults failed to submit their stool for reason of inconvenience in collecting diarrhoeic stool, or because of shame.

Chapter 11
Parasitic infections

Previous sections of this report analysed health problems without tracing them to their aetiological roots or identifying their basic cause. Such an approach provides more depth to the understanding of health conditions than information which mainly concentrates on the incidence or prevalence of certain infections. The aim of the present section, however, is to record our observations on the occurrence of specific diseases, and will concern malaria, schistosomiasis and other helminths. Apart from malaria, the prevalence of these parasitoses was low and they do not appear to constitute the main problems at present. Our attention was directed to these diseases because of their potential to spread especially in the lakeside population. Their diagnosis was feasible and specimens of stool, urine and blood could be collected. Unfortunately the sensitivity and reproducibility of the laboratory examination proved to be poor (see chapter 6). There would have been the possibility to include other infective diseases in the observations as capillary tubes with plasma were available for serological studies. Regretfully these could not be examined.

1. MALARIA

1.1 Introduction

Roberts (1974), who has long experience with the disease in Kenya, states that malaria is prevalent at meso-endemic level in the Districts of Machakos and Embu below an altitude of 1300 m. Malaria transmission takes place during 6-12 months of the year in a narrow strip along the Tana river, and beyond these limits for a shorter period of 3-6 months. All four types of malaria have been observed in Kenya. Plasmodium falciparum is the most common (80-85%) agent, followed by P.malariae (10-15%). The other parasites are reported infrequently. For the region of which Kamburu is part Anopheles gambiae is stated to be the main vector, followed by A.funestus.

1.2 Results

Entomological Survey

Siongok, a member of the research team, (1979) reported on a brief entomological survey carried out in the area in November and December of 1974. Mosquito larvae were collected from a variety of potential breeding sites, and adults were caught inside a random sample of houses either early in the morning or late in the evening. Among the larvae samples the mosquito species of Anopheles, Aedes and Culex were represented. Larvae of A.gambiae were found in almost any of the water collections examined. Adult specimens included the species of Anopheles and Culex, but not Aedes. Again A. gambiae was found in many houses, but A. funestus was not found. The sporozoite rate was zero.

Malariometric Indices

Information of the occurrence of splenic enlargement and its distribution has been given in chapter 10.4. The occurrence of malaria parasites in thick blood films is recorded in table 45.

On both occasions malaria parasitaemia was found more frequently on the Lakeside, and the parasite rates were higher in 1977 than in 1974. Because of the very poor quality of malaria diagnosis in 1977 due to the observor fault, very little value can be attached to this finding. The following very preliminary observations could be made, noting that the observer error could be as high as 100%.

Except in the Lakeside group in 1977 the highest rate was observed between 5-24 yr. For the Lakeside group in 1977, however, this concerned the 0-1 yr olds.

TABLE 45: Distribution of Malaria Parasitaemia for Inland and Lakeside groups in 1974 and 1977 (percentages)

	Inland				Lakeside			
	Males		Females		Males		Females	
Age	No	Parasite Rate	No	Parasite Rate	No	Parasite Rate	No	Parasite Rate
				1974				
0- 1	22	0	33	3	28	7	16	0
2- 4	39	8	40	5	23	4	19	11
5- 9	72	3	56	5	33	15	46	11
10-14	34	9	49	6	40	12	28	7
15-24	21	0	58	2	31	10	43	12
> 25	44	5	82	0	43	2	76	1
Total	232	4	318	3	198	9	228	7
				1977				
0- 1	21	24	25	20	18	56	20	55
2- 4	27	26	41	37	36	33	22	55
5- 9	39	33	68	31	33	30	40	38
10-14	54	35	43	35	38	34	32	34
15-24	31	29	46	24	32	25	34	38
> 25	23	30	78	22	28	25	77	22
Total	195	31	301	28	185	32	225	35

The differences between Inland and Lakeside groups were not associated with age or sex in 1974, so that it is permissible to compare percentages. In 1977 there was a weak association ($P < 0.1$) with sex. Ignoring the latter, and allowing for very broad confidence intervals, the overall parasite rates can be compared as follows:

Group	Year	Inland	Lakeside
All	1974	3.6%	7.5%
	1977	29.0%	33.9%
0 - 1 yr	1974	1.8%	4.5%
	1977	22.2%	55.3%
2 yr and older	1974	3.8%	7.9%
	1977	29.7%	31.7%

The total group differences in parasite rates for 1974 and 1977 are similar. In 1974 the Lakeside rate was more than twice the Inland one, however, as proportion of the 1977 prevalence, the difference did not amount to more than a fraction. Moreover closer examination reveals that in 1977 for babies the difference amounted to 33% while in the remaining age groups it was 2%. Parasite rates therefore were significantly higher ($P < 0.05$) on the Lakeside in 1974, but a similar conclusion cannot be made for 1977.

An attempt was made to find indicators of malaria transmission by applying the multiple regression analysis to the information on malaria. Both in 1974 and in 1977 less than 4% of the total variance could be explained by age, sex, lakeside living and migrant status. Among these variables lakeside living was the only one which more consistently explained 1-2% of the variance.

1.3 Discussion

The reliability of the observations on spleen enlargement has been discussed before and it was concluded that the spleen rates showed an acceptable standard. Observer variation, however, could have enhanced or reduced artificially the real increase in spleen rates between the two surveys. However, the diagnostic accuracy of the examination of blood films for malaria parasites was at least in 1977 very poor and biassed the estimate of the occurrence of parasitaemia.

Table 46 summarizes the malariometric information. According to the criteria of the spleen rate in children 2-9 yr old (WHO, 1963) malaria was hypo-endemic resp. low meso-endemic in Inland and Lakeside areas in 1974. In 1977 the situation had changed to low- resp. high meso-endemic. The highest spleen rates were observed in older children (10-14 yr) which is consistent with light and unstable malaria transmission, when it takes longer for protective immunity to develop. The irregular pattern of the average spleen size and parasite rates also fit this situation.

Arguments were given before substantiating why it can be assumed that in the Lakeside area splenomegaly is mostly due to malaria infections, and that therefore splenomegaly identifies persons with malaria, and that the spleen rate reflects malaria transmission. According to the multiple regression analysis of the distribution of spleen status it is evident that malaria transmission is more intense on the lakeside than inland, and that the risk of infection is possibly associated with the age of children, and with sex. Of these indicators only lakeside living remains if the malaria parasite rates are studied, while contributing only a minor proportion of the total variance. This most likely is

due to the poor diagnostic quality of blood film examination.

It was hypothesized in the planning stages of the Kamburu ecological studies that malaria would increase in the population exposed to lake formation. Conclusive evidence to support this hypothesis could not be produced. Even if more reliable information on the occurrence of malaria parasites would have been available, seasonal influences would have precluded a definite conclusion. A more elaborate series of surveys would have been necessary to separate the seasonal effects from more longterm trends. Alternatively the IFA (indirect fluorescent antibody) test may be a more sensitive indicator of malaria transmission in such surveys (Lelijveld, 1980) and a mathematical model has been developped by van Druten (in press) by which a trend in the transmission of malaria during a period preceding the survey can be estimated.

It has been stressed that it is not the occurrence of endemic infections, but their impact on community health, which is relevant to the health planner. It is noteworthy that in this survey the association between malaria and the occurrence of anaemia could be established in a qualitative, but in principle also in a quantitative way, through the multivariate analyses. In these models splenomegaly represented the link between malaria transmission and anaemia. A less dramatic but nevertheless interesting relationship was demonstrated between malaria (again using the spleen status as link) and the Quetelet index. This relationship appeared to represent the impact of malaria on nutrition status.

Finally the increased prevalence of malaria coincided with an increase in complaints about fever and headache among adults, and in 1977 disabling ill-health was also more frequent in the Lakeside group. Though these observations may be suggestive, a direct relationship between morbidity experience and malaria could not be established.

TABLE 46: Summary Malariometric Information* on Inland and Lakeside groups in 1974 and 1977 (figures in brackets are based on less than 4 observations)

	Inland				Lakeside			
	Males		Females		Males		Females	
Age-group	Spleen Rate(%)	Av.Spl. Size	Spleen Rate(%)	Av.Spl. Size	Spleen Rate(%)	Av.Spl. Size	Spleen Rate(%)	Av.Spl. Size
				1974				
0 - 1 yrs	(9)	(2.0)	(6)	(1.5)	18	1.8	(12)	(1.5)
2 - 9	4	1.5	4	1.5	19	1.7	9	1.7
10 -14	(3)	(1.0)	(4)	(2.0)	32	2.2	21	1.2
>15	9	2.0	8	1.1	13	2.2	13	2.4
				1977				
0 - 1 yrs	(5)	(2.0)	(7)	(1.5)	22	2.0	(10)	(2.0)
2 - 9	19	1.6	22	1.3	51	1.4	46	1.5
10 -14	28	1.4	31	1.2	76	1.5	50	1.6
>15	12	1.0	14	2.1	64	2.0	39	1.5

* Parasite rates have been omitted because of unreliability

2. INTESTINAL AND URINARY SCHISTOSOMIASIS

2.1 Introduction

Schistosomiasis has a wide distribution in Kenya (Highton, 1974), however, S. mansoni and haematobium infrequently occur in the same area. An exception to this rule is found in the Districts of Machakos, Kitui and Taveta. The main snail vectors for S. mansoni are Biomphalaria pfeifferi and B.sudanica, while for S. haematobium the important vectors are Bulinus africanus, B. globosus and B. nasutus. Several other snail species may transmit the disease but they are of less practical importance.

2.2 Results

Malacological Survey

On three occasions between 1974 and 1976, Kinoti (1979) conducted snail surveys of the river systems upstream from Kamburu lake, and of the lake and its shores. The upstream river systems come from four different districts where schistosomiasis is endemic. The main snail vectors in these areas are B. pfeifferi, B. africanus, B. globosus and B. nasutus. Snails of these species therefore can easily invade the Kamburu area once the right ecological conditions become established. Kinoti found that B. pfeifferi and B. africanus were established in several smaller rivers upstream from the lake. Though specimens of B. pfeifferi were found in the lake, the snail did not appear to be breeding here. Surprisingly a different snail, and potential vector of S. haematobium, B. truncatus was found to be breeding in the lake. Another less common vector of S. haematobium, S. nasutus, was found to have established itself and transmit the infection in a small earthen dam in the Inland area. Kinoti therefore did not find evidence that schistosomiasis was being transmitted in the lake at that time, presumably because the ecological conditions had not sufficiently settled down. Once the latter would take place and for instance higher plants would colonize the lake, conditions would become favorable for colonization also by the major vectors of schistosomiasis. As the infection is already present in the area the lake would then become a focus of transmission.

Population survey

Only a limited number of cases could be diagnosed. This was due to underdiagnosing helminth infections, which was further enhanced by the low prevalences of helminth infections prevailing in this area. low prevalence of the disease. Details are provided in table 47.

In 1974 32 cases of S. mansoni infections were found in the lakeside group against 9 Inland. Of these Inland cases 6 originated from households located relatively close to the lake and using the lake for domestic water supply. Unfortunately the migrant status of these persons was not analysed. In 1977 the same pattern persisted but fewer cases could be found. The distribution of the infection therefore is associated with the Lakeside area ($P < 0.05$). The highest prevalence of the infection is in young adults between 15-24 yr. Though male cases are more frequent in the different groups, this association is not of statistical significance.

S. haematobium infections were virtually confined to the Inland area, and here they clustered in households near a small earthen dam used for water supply. In 1974 ten cases were diagnosed mostly in schoolage children. By 1977 the number had increased to twenty and now included a few young adults.

In 1974 all persons infected by S. mansoni had enlarged livers ($P < 0.01$) and in 1977 this concerned 14 out of 24 cases ($0.05 < P < 0.1$). As already noted before, most liver enlargements were minor degrees. The occurrence of S. mansoni showed a weak association with spleen enlargement on both occasions ($0.05 < P < 0.1$), but was not related to anaemia or the reporting of ill-health. With few exceptions all cases of S.haematobium infection had protein in their urine ($P < 0.01$). In 1977 4 out of the 8 infected young adults had very low Hb values below 10.0 g%. No other associations were noted.

TABLE 47: Prevalence* of Schistosomiasis mansoni and haematobium for Inland and Lakeside groups in 1974 and 1977 (No = number stools/urine examined, C = cases diagnosed)

	Inland								Lakeside							
	Males				Females				Males				Females			
	Mansoni		Haemat.		Mansoni		Haemat.		Mansoni		Haemat.		Mansoni		Haemat.	
Age	No	C	No	C	No	C	No	C	No	C	No	C	No	C	No	C
								1974								
0- 4	46	0	48	1	56	0	51	0	36	0	44	0	26	0	27	0
5- 9	61	0	71	3	47	1	52	1	33	3	33	0	43	1	43	1
10-14	27	0	33	2	45	2	48	2	35	6	39	0	23	3	28	0
15-24	18	2	21	0	53	1	55	1	30	8	29	0	41	0	41	1
> 25	40	1	39	0	72	2	76	0	42	1	44	0	66	1	75	0
Total	192	3	212	6	273	6	282	4	176	18	189	0	199	14	214	2
								1977								
0- 4	28	0	35	0	32	0	50	0	37	0	44	0	32	0	36	0
5- 9	30	0	36	4	39	0	68	2	30	1	33	0	32	1	39	0
10-14	28	0	53	3	26	0	43	2	32	2	37	0	28	1	30	0
15-24	21	0	30	5	25	1	42	3	24	7	32	0	25	0	30	0
> 25	17	0	23	1	48	2	76	0	28	4	32	0	61	5	72	0
Total	124	0	177	13	170	3	279	7	151	14	178	0	178	7	207	0

* Diagnosis for S. mansoni by Ritchie's concentration method, and for S. haematobium by examining the sediment of 10 ml midday urine.

2.3 Discussion

No evidence was found during the malacological survey that schistosomiasis was being transmitted in the Kamburu lake. However, transmission could take place in several of the smaller rivers draining upstream from the lake, and it was found that S. haematobium was transmitted in a small dam. Kinoti (1979) concluded that schistosomiasis transmission did not actually take place in the lake. But he was of the opinion that, once ecological conditions in the lake would settle down, and for instance higher plants would colonize the waters, the major snail vectors of schistosomiasis could easily establish themselves. As

sources of the infection are already present in the area, the lake then could easily become a focus of transmission.

Under conditions of low prevalence the worm load of schistosomiasis infections is usually light and fewer worm ova are excreted. The sensitivity of the diagnosis by examining a single urine or stool specimen then becomes reduced, as was evident from the results of duplicate examinations of the same stool specimen reported before. The resulting prevalence figures (having broad confidence intervaLs) underestimate the true situation. Nelson (1958) suggested that a closer estimate of the true prevalence could be obtained by multiplying the minimal figures by three. The observed prevalence figures can be summarized as follows:

	1974		1977	
	Inland	Lakeside	Inland	Lakeside
S. mansoni	1.9%	8.5%	1.0%	6.4%
S. haematobium	2.0%	0.5%	4.4%	0

These figures are not unusual for a semi-arid area like Kamburu. For schoolchildren Ouma et al. (1978) reports from an ecologically similar area, Kitui District, an average prevalence rate for S. mansoni of 6.1% (range 0-20%), and for S. haematobium of 3.3% (range 0-14%). Boys were more often infected than girls. Our observations for the Kamburu population groups are quite similar. The preponderance of infected males is generally assumed to be due to the more outgoing behaviour especially of boys, who for instance bath and swim more often in infected water.

Among the Kamburu population the infections of S. mansoni are concentrated in the lakeside area and appear to be related to lake contact. Though this situation persisted in 1977 the number of cases actually had decreased, suggesting that during the period, most likely, active transmission did not take place (as was stated by Kinoti). As there are no other potential sources in the direct environment of this group the concentration of cases near the lake could possibly be explained if transmission took place in the Tana river prior to establishment of the lake. The age distribution of cases could support such a hypothesis. Persons diagnosed with the infection in 1974 were treated, which could have contributed to the decline in the number of cases.

The cluster of S. haematobium cases found among the Inland group represents a typical feature of the local epidemiology of the infection, namely its focal distribution. Infections, as expected, occurred in schoolchildren and were attended by the usual signs of fresh infection. Infected snails were recovered from the dam. Despite the treatment offered in 1974 the number of cases increased. The dam concerned is the only one of this type in the area. Greenham (1978) demonstrated that minor bloodloss due to urinary schistosomiasis nevertheless could be responsible for a serious anaemia problem, if iron intake is low.

It should be concluded that until 1977 schistosomiasis did not constitute a significant health problem in the Kamburu area. however, all necessary conditions for transmission appear to be present, and the lake may sooner or later become an active focus for transmission of either type of the infection. Either survey of 1974 or 1977 therefore may serve as baseline for any future development in schistosomiasis.

3. OTHER INTESTINAL HELMINTHS

Intestinal helminth infections are widespread in Kenya and each species has

some typical aspects about its distribution (Rees et al., 1974). Hookworm infections are more common at the Kenya Coast and in West Kenya, whereas Ascaris is quite prevalent in Eastern and Central Kenya. In their survey of Kitui District Ouma and Waithaka (1978) also recorded the prevalence of various worm infections in schoolchildren. Prevalence figures were low comparatively.

Also in the Kamburu area intestinal helminths had a low prevalence. As has been remarked the sensitivity of diagnosis from a single stool specimen becomes low in such a situation, and figures are to be considered as minimal. The observations are recorded in table 48, and for comparison the prevalence rates for schoolchildren found by Ouma in Kitui District are given also. It may be concluded that infestations by intestinal helminths did not consitute an important health problem at the time of investigations and appears not to have been affected by the developments taken place.

TABLE 48: Intestinal Helminth infestations of Inland and Lakeside groups in 1974 and 1977 (no of cases diagnosed)

	1974		1977		Prevalence (%)
	Inland Cases (n 465)	Lakeside Cases (n 375)	Inland Cases (n 294)	Lakeside Cases (n 329)	Kitui Distr. (Ouma et al., 1978)
Hookworm	4	5	7	4	1.9-6.6%
Ascaris lumbr.	7	3	7	4	1.7-4.2%
Taenia saginata	0	1	0	1	-
Trichuris trichiura	5	4	6	3	2.4-12.5%
Hymenolepis nana	0	1	4	0	less than 1%

Chapter 12
Concluding appraisal

1. KAMBURU SURVEY: An Exercise in Health Monitoring?

Monitoring health in itself is not much more than the exercise of producing and recording observations related to health. In a more restricted sense it means the close and continued supervision of particular health problems, which demand especial attention and care. The construction of a dam creates such a problem. It is, however, not the sole problem, which is created. Many others, also affecting longterm human welfare are connected with it. Therefore in this case monitoring should be integrated to be relevant.

This concept motivated us to undertake health research in the construction and postconstruction phase of Kamburu Dam. Health research formed part of a larger ecological project. It necessarily concentrated more on community health than on rural development, which was part of other projects. Unfortunately research on health was, in the case of Kamburu Dam, not very well integrated with rural development activities.

Starting from such a broad concept we were confronted with the necessity to engage the following questions, and objectives:

- To ascertain how health monitoring is feasible using methods and procedures which are available to and within the competence of government health services in the countries concerned.
- To demonstrate some of the consequences for the health of the population concerned by the building of the Kamburu Dam.
- To document the association between health and socio-economic, environmental and individual characteristics; and to explore the structure of causes of ill-health in order to find ways of preventing disease and promoting health of the population in future.
- To consider if monitoring could influence health policies.

It is appropiate to briefly consider how far we succeeded in implementing these objectives.

2. IN HOW FAR COULD HEALTH MONITORING BE WORTHWHILE? BY AFRICAN GOVERNMENT HEALTH SERVICES?

It is evident that the task of health monitoring should be undertaken by government health services, or their counterparts in River Basin Development. A close coordination with the policies of these governing bodies, a guarantee for continuity of the investigations over a number of years, adequate protection of the interests and the privacy of the populations concerned, are arguments to support this statement.

As outlined by Lwanga (1980) monitoring requires an integrated system of observations, and facilities for their storage and interpretation. Data should be of sufficient precision to be serviceable. The emphasis here is on sufficient and not on scientific standards. The practical value of notoriously imprecise data from hospital returns for health planning has been documented by Diesfeld (1973).

To be useful in practice the value of data depends on the validity of tests and questions utilized for diagnosis and documentation, and on the reproducibility of results obtained. Even professional investigators are not always aware of the level of reliability of data they are generating. Such aspects are also often disregarded in articles and reports, forcing the reader to accept results at face value. We have to a limited extent built this type of evaluation into the survey procedures, and the results have been documented in Chapter 6.3. There were quite a few inadequacies. On the other hand it could be shown also that adequate reproducibility was obtained for most items which had been subject to standardization and training. A notable exception concerned the failure to assess smallpox scars, the diagnosis of which may seem easy, reliably.

Concerning health status, the dependent variable, we are of the opinion to have made valid observations, and documented health status in a valuable way. Observations were of a basic nature, and could have been improved, though at rapidly increasing price and at a disproportionate cost. We failed to document ill-health from the point of disability, type and costs of preferred treatment, and other socio-economically important items of information. Some more of this type of information should have been included.

We relied on traditional approaches for the selection of the socio-environmental indicator variables, and were not guided by specific objectives. The selection of indicator variables should be based on the intention to identify 'high risk groups', and also to learn about the contribution of man-made health factors to the local pattern of disease. These variables should describe the relevant design features of the various components of development. The functional classification of infective diseases in relation to water supplies by Bradley (White et al., 1972) is most instructive for this purpose. If also for other aspects of development indicator variables could be selected relating the design features to aspects of morbidity, this could contribute greatly to setting realistic priorities, and allocating resources optimally.

The selection of indicator variables is critical for health monitoring in Integrated River Basin Development, in contrast to more traditional types of health research, because they have to provide the link to other sectors of development. Except for water supply, there has so far been very little effort to study in more detail the relationships with health of design features of development. While the investment of major resources for the provision of permanent housing in some of the large man-made lake resettlement projects may be viewed as progressive, from a health point of view this may have been wasteful. It appears that there is a need to define better the health features of development, and apply the understanding gained to improving the process.

Our own experience proves that health monitoring is feasible by government health services, provided sufficient attention is given to those elements which make it meaningful. These comprise: well defined questions and objectives, the selection of valid and contributing health- and indicator-variables, the gathering of representative and reproducible results, and sufficient effort for the analysis and interpretation. The potential usefulness of the approach utilized in Kamburu was appreciated by the Ministry of Health of Kenya. When plans for the construction of a fourth and large dam were approaching implementation, a baseline health survey was conducted in the area (see: Upper Reservoir Report, Tana River; Ministry of Health, Kenya; April, 1976).

Guidelines for conducting the epidemiological research concerned are scattered, and few are sufficiently comprehensive to eliminate the need for consulting with experienced investigators. Often recourse to locally available consultant advisors is not possible. For the purpose of health monitoring, but also for other types of operational research, there is a need for a comprehensive manual, which provides answers to the most critical questions which may arise. Such a "cookbook" type of manual could serve for reference, but also for training of co-investigators and fieldworkers. Such manuals were prepared for malaria eradication by the World Health Organisation, but these have too limited a scope.

The following are some more practical aspects of health monitoring which to a large extent determine whether efforts for this purpose will be successful:

(1) The need for data to be reproducible should be appreciated by all team members, including non-professional ones. They should be familiar with sources of observer and subject variation, and how these can be minimized. On the basis of understanding the need for supervision and duplication is more easily accepted.

(2) The project leader should have control over all activities related to the investigation. This is particularly important if the survey team comprises members belonging to different departments and authorities. The project leader should be actively involved in data collection, and not direct field operations from a far away office. Project leadership requires the discipline to regularly supervise field operations in a systematic way.

(3) Survey procedures need to be standardized, and apparatus calibrated. These desiderata also apply to verbal items for communication and observation. A system for the evaluation of data quality should be incorporated into the survey procedures. Making blind duplicate observations is a practical and efficient method. Similar procedures can be developed for laboratory work (Goddard, 1980). Feedback from the quality control system can also be used during data collection, to maintain or improve the standard of observation.

(4) The representativeness of the data ultimately depends on public cooperation. For securing a good response it is needed that community leaders and the population understand the purposes and usefulness of the survey. Work schedules should observe local customs, market days, agricultural activities and so on. Firm appointments should be made and kept. In return for cooperation simple services should be provided such as treatment of minor ailments, referral for more serious complaints, transport to and from the field stations for the old, infirm, mothers with small children. Research stations should be located conveniently. Often schools provide a good basis for operations.

(5) Ample and reliable transport facilities are essential, especially in more remote areas. Frequent breakdowns in transport will discourage and demotivate staff, disrupt survey procedures, preclude keeping appointments made and thereby increase the non-response. Potential abuse of motorcars can be controlled by keeping track of petrol consumption and mileage.

(6) While many people seriously object to taking venous blood samples, the collection of capillary blood by fingerprick is usually tolerated. With the appropriate techniques capillary blood can be used for serological studies, in addition to the usual haematological and malaria tests. The scope and quality of health observations could be considerably expanded if the capil-

lary plasma specimens were employed for selected serological tests. The usefulness of a multipurpose serological survey for health planning in Kenya was shown by Geser et al. (1970).

(7) Facilities for automatic data processing are advancing rapidly in African countries, though the human factor needed for their operation may be hard to obtain. For the monitoring of larger population groups and a more extensive set of variables automatic processing can be more efficient. Apart from the potential reliability and speed, computer processing does offer the great advantages of the application of advanced statistical methods for analysis of variance and co-variance. More extensive and sophisticated health monitoring requires the use of computers.

(8) If possible a statistician should be consulted on matters of design, sample size and survey methods, and a computer specialist on matters of data processing and retrieving. Such advices have optimal efficiency if obtained at the beginning of the preparation of survey protocols. Under more ideal circumstances a statistician and computer specialist should be part of the team.

(9) For the maintenance of team-motivation, it is worthwhile to provide for acceptable boarding and lodging facilities during periods of fieldwork. The inconvenience and cost of being away from home for prolonged periods should be compensated by adequate field-allowances.

3. COULD HEALTH IMPACTS BE IDENTIFIED?

The identification of health impacts rests on double criteria. Firstly a change needs to be documented, and secondly a causal relationship has to be demonstrated between the change and one or more variables from the complex associated with man-made lakes.

A fundamental constraint for satisfying these criteria is embodied in the research design for such studies. An Expert Panel to the International Bank for Reconstruction and Development (IBRD, 1976) concluded regarding the health effects of the provision with safe water:

> " The problem with collecting field observations on the health effects of water supply is that on a cross-sectional basis "other" things are never equal, and on a through time basis "other" things can usually not be held constant or accurately controlled. Consequently it is extremely difficult to identify and measure exactly the health impacts of improved water supply, and there is a limit to the precision attainable. "

Dam projects harbour a complex of man-made health factors besides the one on water supply, reason why this conclusion is even more pertinent to studying health impacts of man-made lakes.

Against this background any research into the consequences of waterdevelopment can at the most employ a semi-experimental approach. In our case we had to be content to compare observations in a study group living near the lake, to ones from a "comparison" group inland.
Besides the location there were a number of differences between the groups. Conclusions deriving from such a design cannot provide proof, nor will they usually be very precise. But as White et al.(1972) stipulated for water supplies:

" It is preferable to use estimates based on informed guesses, and risk error and wrong judgment, rather than implicitly assuming the effect to be total or absent, or have no guidance at all. "

A second characteristic of the research design employed concerns the type of observations. In principle these can be made on a cross-sectional or longitudinal basis, the first having practical and the second scientific advantages. A semi-longitudinal design was employed in Kamburu, which took the form of two cross-sectional surveys with an interval of three years. The longitudinal component was formed by surveying the same population group twice, while health records could be linked individually. This design combined some of the practical advantages of cross-sectional studies with the added reliability of longitudinal observations. If results like those from the Kamburu surveys can be accepted as sufficiently precise, and sufficiently reliable for this particular purpose of health planning, then the semi-experimental and semi-longitudinal approach is more cost-efficient and practical than the longitudinal method.

We were fortunate in having a more thorough longitudinal type of study being conducted during the same period, in a nearby population of Machakos District. This coincidence gave the opportunity to compare the rather crude Kamburu observations to the more reliable and precise ones from the Joint Project Machakos. Observations on demography and nutrition status could be compared between the two studies. The comparison to this convenient yardstick did not result in finding any significant discrepancies. This fact is encouraging, though it could have occurred by chance.

A number of differences were identified between Lakeside and Inland groups, and suggestive trends were also found between 1974 and 1977 observations. These concerned various aspects of health, and of demography. Nutrition and health status showed relatively minor, but on the whole consistent differences. More striking were the changes taking place from 1974 to 1977. A few examples may adstruct this opinion:

(1) In respect of nutrition and haematopoetic status the Lakeside group was initially superior to the Inland people. In the following period some of the advantage in nutrition was lost, while the position for anaemia completely reversed. A coherent complex of changes relating the PCV to spleen enlargment, and spleen enlargment most likely to malaria incidence, appeared to be responsible for the changes in anaemia prevalence among the Lakeside group. Limitations imposed by the fact that only two observations three years apart were available precluded the exclusions of seasonal influences as responsible for the change observed.

(2) Demographically the Lakeside group was characterized by a higher sex ratio, a lower fertility, and there was quite circumstantial evidence supporting higher mortality. Migratory movements also dominated in the Lakeside area.

(3) Socio-economic aspects were assessed with insufficient precision and confined to observations on housing and cattle ownership. From this limited information, however, the picture emerges that the socio-economic situation of the Lakeside group regressed during the period. On the one hand the changes could have been induced by migration. It is not unlikely, however, that on the other hand overstocking of land and cutting down the vegetation especially in the Lakeside area were taking their price through soil erosion.

Apart from the items mentioned, there were some fairly straightforward side observations and conclusions. The literacy level of the population was noticeably being boosted by new cohorts of school leavers. The postdam closure period was not accompanied by observable improvements in the supply of water nor sanitation, the weaning foods had not changed, nor did fish regularly appear in the diet. Of even greater importance was the finding that the prevalence of schistosomiasis had not increased, and that there was no evidence of active transmission going on in the lake.

We therefore answer the question posed at the beginning of this section with a prudent affirmation that indeed health impacts, or their absence, could be identified. Health impacts appeared to affect the Lakeside group in a negative way.

4. THE STRUCTURE AND CAUSES OF ILL HEALTH?

In the context of health monitoring research has a double function. It has to provide quantitative information on aspects of morbidity and health, which is needed for planning the distribution of health facilities, and as an evaluative measure. It, however, also has to provide for better understanding of the "roots" of sickness. The latter we call the structure and causes of ill-health. According to modern concepts on causality of disease multiple causal factors coming from the environment in a broad sense interact with the host, sometimes producing sickness. Previously we argued that operational health research should focus on the contribution by "man-made health factors".

Health monitoring usually will have exploratory objectives, and reasoning on causality will be inductive. Ultimately it aims at identifying socio-environmental factors which are subject to manipulation for prevention. There are limitations to the extent of exploration possible. Firstly because only a limited number of indicator variables can be included in study protocols. A more fundamental constraint is formed by the conditions under which research has to take place and the restrictions imposed on diagnostic and documentary methods.

The identification of structure and causes of morbidity from among the information available is complicated by the multiplicity of factors and their interactions. Methods of multivariate analysis have been available for some time, which enable to some extent disentangling the "web of contributing causes". Basic to this technique is the fitting of statistical mathematical models to the real life situation, as described by the data gathered. Such models are artificial mental structures, which facilitate gaining better understanding about the nature of relationships, and their relative importance. In this sense models never aim at replacing the real situation. Models can be useful also if only a limited amount of information on the etiology is available. In fact this is the situation when interpreting health monitoring data.

We were fortunate in having at our disposal facilities for using the SSPS package for the analysis of data on ill-health. This programme package permits the use of several multivariate analysis techniques by investigators, who do not have a more than basic training in biostatistics. From this package we used a simple linear multiple regression model for the interpretation of the causal structure of specific health aspects, and the results both for analyses on a cross-sectional basis (1974 and 1977 each separately), and on a longitudinal basis (linking individual results of 1974 and 1977) were reported previously. It was shown that by the various models a limited amount of the distribution of

values could be explained. Apart from this, statistical associations could be assessed within the context of the multivariate model. The latter relationships are summarized in the following Tables 49 and 50.

The matrices of Tables 49 and 50 combine the results of separate analyses for each of the dependent variables. They show how indicators may influence several health problems. The matrices provide a framework for the "structure and causes of ill-health" in each survey year, and also for the pattern of change in the period between the surveys. They are, at least theoretically, relevant to the process of health planning, since they provide more explicit evidence on which planning-options for improving health could be founded.

This statement needs to be qualified. The information presented in the tables has value as example, but is less suitable for direct application. The results, however, demonstrate that some indicators identify "risk" groups, such as age, sex and Lakeside living. Others refer to aspects of the socio-environment which influence health, such as property, crowdedness and again Lakeside living. A third category of variables, found in any of the models, concerns variables which obviously did not contribute at all. The cattle index, though being informative, belonged to this category and was eliminated because it did not contribute in any model. It could be concluded that the multivariate models help to distinguish between "contributing" and "unrelated" indicators, within the local ecological framework of health. This is relevant to the health planner because contributing factors could be included in health programmes, or occasionally a programme could be based on them. More often, however, the information gained will serve to design the kind of complementary inputs needed to support a major programme.

In order to make health monitoring more useful for planning, it appears that the following principles should be followed. Health variables should be selected to identify appropiately the major health problems in the community. Indicator variables are most likely to be helpful if they have a bearance upon planning options and engineering designs. The potential to explain health conditions is of secondary importance. The most difficult point however is to find valid parameters for these variables, and to secure reproducible observations.

For several reasons the level of the multivariate analysis performed on the Kambura data remained very basic, and in respect of the concepts at the basis of the models inadequate. As the aim of this report is to demonstrate by the Kamburu data the usefulness of health monitoring, the level of analysis appears sufficient to show the latter. A more fundamental evaluation of the usefulness of multivariate analysis of socio-environmental variables in relation to morbidity was done by Freij and Wal (1977) on data from the Kirkos Study of Addis Abeba. These authors analysed the causal contribution of socio-environmental variables to the incidence of diarrhoea in under-fives. Their findings amongst others substantiate the important contribution of factors related to water supply and sanitation to the occurrence of diarrhoea in the community, and also the determinant function on nutritional status.

At the root of the Kamburu studies was the belief that generating basic information on health is an important tool for improving the fate of the local population. The provision of health information here ultimately has political motives, because what is implicitly known already is made visible in the form of figures. The results have shown that health monitoring of this nature does provide evidence which can be used for evaluation. Also by appropriately analysing the material it was proven to be possible to obtain more explicit understanding on locally important determinants of health.

TABLE 49: A Review of the Variance Explained (% R2-change) by Various Indicator Variables for the Quetelet Index, PCV and Splenomegaly in Adults, School-, and Pre-schoolchildren in 1974 and 1977

ADULTS

	1974			1977		
Dependent Variable	QI**	PCV	Spleen	QI**	PCV	Spleen
Independent Var.						
Lakeside living	*	2.9	0.8	0.3	6.6	3.9
Sex	4.9	20.3	*	7.7	11.5	*
Age	*	0.9	*	*	0.1	*
Migrant status	*	*	*	*	*	*
Education I	*	*	*	*	(2.9)	*
Education II	0.2	*	2.4	*	1.3	*
Property status	6.2	*	*	3.9	*	*
Crowdedness	*	*	*	*	*	*
Spleen status	1.1	0.9	na	1.9	5.7	na
Malaria par.	*	1.5	*	*	*	*
Quetelet index	na	*	1.2	na	1.5	2.4
Total var.expl.(R2)	13.9	27.4	5.4	14.8	30.1	7.4

SCHOOLCHILDREN

	1974			1977		
Dependent Variable	QI*	PCV	Spleen	QI*	PCV	Spleen
Independent Var.						
Lakeside living	6.4	1.6	5.5	5.1	14.1	1.8
Sex	*	*	1.7	*	*	*
Age	15.4	2.6	*	9.1	2.1	*
Migrant status	*	1.0	*	*	*	*
Property status	*	*	1.7	*	*	*
Crowdedness	*	0.9	*	*	0.9	*
Spleen status	*	9.5	na	*	14.0	na
Malaria par.	*	0.8	9.4	*	*	1.5
Quetelet index	na	1.6	*	na	*	*
Total var.expl.(R2)	23.3	18.6	20.1	15.8	32.6	4.4

* regression coeff. not significant and contribution <1%
() regression coeff. not significant, but contributes >1%
** Quetelet index
na not applicable

PRE-SCHOOLCHILDREN (continue next page)

Table 49 continued:

	PRE-SCHOOLCHILDREN					
	1974			1977		
Dependent Variable	QI*	PCV	Spleen	QI*	PCV	Spleen
Independent Var.						
Lakeside living	4.9	*	1.1	*	8.0	(1.3)
Sex	*	*	*	1.9	*	*
Age	7.2	4.2	*	20.3	6.3	*
Migrant status	*	1.4	*	*	*	*
Property status	*	*	*	*	3.6	3.5
Crowdedness	*	*	*	*	*	*
Spleen status	*	6.8	*	*	12.2	*
Malaria par.	3.8	*	17.9	*	*	3.8
Quetelet index	na	*	*	na	4.9	*
Total var.expl.(R2)	17.5	14.1	21.5	23.4	36.8	9.9

TABLE 50: A Review of the Variance Explained (% R2-change) by Various Indicator Variables for Quetelet-, PCV- and Spleen-Change in Adults, School-, and Pre-schoolchildren from 1974 to 1977

	ADULTS			SCHOOLCH.			PRE-SCHOOLCH.		
Dep. Var.= Change-	QI**	PCV	Spl	QI**	PCV	Spl	QI**	PCV	Spl
Independent Var.									
Lakeside living	1.3	18.6	4.6	*	17.7	2.0	*	0.4	*
Sex	*	0.5	*	*	*	(1.1)	*	*	(2.2)
Age	6.9	(2.7)	*	30.1	*	*	1.7	*	*
Migrant 1974	2.9	*	*	*	*	*	*	*	(1.2)
Education I -1974	*	*	*	na	na	na	na	na	na
Education II-1974	*	*	*	na	na	na	na	na	na
Property 1974	*	*	*	*	*	*	*	(1.7)	4.6
Crowdedness 1974	*	*	(1.5)	3.4	*	*	*	*	*
Malaria 1974	*	*	*	*	*	*	*	*	*
Quetelet 1974	10.5	*	(1.2)	2.4	*	*	57.2	*	*
PCV 1974	*	25.8	*	*	17.5	*	*	45.4	*
Spleen 1974	*	*	*	*	0.1	*	2.0	*	*
Change Property	3.5	*	*	*	0.4	*	*	*	*
Change Crowdedness	2.7	*	*	*	1.6	*	*	*	*
Change Malaria	*	*	(1.0)	*	*	(1.0)	*	1.8	3.7
Spleen increase	*	2.1	na	*	6.6	na	*	6.2	na
Spleen decrease	*	*	na	*	2.2	na	*	*	na
Change Quetelet	na	*	(1.5)	na	*	*	na	(1.0)	*
Total var.expl.(R2)	31.4	53.4	12.6	37.7	48.6	7.6	62.4	59.8	14.0

* regression coeff. not significant and contribution <1%
() regression coeff. not significant, but contributes >1%
** Quetelet index
na not applicable

5. COULD HEALTH MONITORING HAVE POLICY IMPLICATIONS?

The Kamburu Ecological Project was undertaken at the request of, and with financial assistance of the World Bank and the Swedish International Development Agency. Both institutions were involved in financing the Kamburu Dam for the Kenya Government, and requested the project to be carried out as a condition for the loan.

Recommendations were attached to the reports published earlier (Odingo, 1977 and 1979). The proposed actions concerned various Government ministries, and the Tana River Development Authorithy. As the Kamburu Ecological Project was not integrated into the Seven Forks Hydro-electric Scheme it remains uncertain to what extent the project findings will influence development policies in the area. Moreover the project was only initiated when development had been going on for a number of years. This background nevertheless indicates that ecological studies of this nature could have policy implications at different branches and levels of administration, including an international level. Whether at local, national or international level, policy concerns the distribution and allocation of financial resources, manpower or facilities.

The recommendations by the Kamburu Ecological Project suggested two categories of interventions. Firstly, improvements and modifications of the local health establishment and services were proposed (a health centre, programmes for immunization, nutrition, malaria prophylaxis). Their implementation was dependent on the Ministry of Health. Secondly, in respect of the very real potential of active transmission of schistosomiasis in the lake, the most realistic preventive measure appeared barring the people from using the lake for domestic activities and water supply. The implementation of such a measure would have implied the provision of alternative watersources, bathing and watering places, involvement in settlement and agriculture. These subjects fall under the responsibility of various Government Ministries and the Tana River Development Authorithy. Before interventions of this nature are decided on, clearly more motives are required than only health considerations. If this recommendation had been implemented, this would have created, apart from preventing schistosomiasis, other oportunities for improving health. The Kamburu case thus illustrates, that to influence health policies, monitoring needs to be directed at integrated development, and to supply information which makes sense beyond the Ministry of Health.

At the level of government and administration the effect of monitoring on health policies is likely to depend on its ability to contribute to: the setting of priorities, selecting cost-effective interventions, and eventually evaluating these. The Information Planning Model of Chapter 3 was designed with these criteria in mind. Against the background of the findings in "The Kamburu Dam (Kenya) as a Test Case" the following remarks can be made:

(1) The findings demonstrate the type of descriptive health information which can be generated by simple population surveys. The report provides explicit information, of varying precision and accuracy, on vital statistics, nutritional status and immunization, aspects of morbidity, malaria and schistosomiasis. The question is whether this data are sufficient for identifying the main health problems. From bio-medical point of view the answer probably can be a guarded yes. From the community angle, however, it could have been desirable to pay more attention to public awareness and perception of health problems.

(2) A crucial point concerns the sensitivity of the methods employed to detect

changes and differences. The question of sensitivity is important because the usefulness of monitoring to a large extent depends on its ability to identify differences between groups, as evidence of the effect of environmental factors or indicators, but also for the purpose of evaluation. In our case methods proved to be sensitive enough to identify differences between the Inland and Lakeside groups, and in respect of several other indicators. However, it was impossible to decide whether the changes between the first and second surveys were due to seasonal variations in prevalence, or represented a more permanent increase. The need to account for seasonal variations could be taken care of without too many extra efforts. But even then the question whether any changes in incidence are only local, or are part of a larger regional or national pattern, remains.

(3) If monitoring is to make sense to other Ministries besides the Health Ministry it is necessary that items of information, and conclusions on the "structure of ill-health", include matters of concern to these ministries. In Chapter 3 and Table 3 a list of man-made health factors has been given. These cover a broad array of activities and responsibilities, relating to different ministries. If the health effects of any of these factors can be clearly demonstrated, chances are much better that this will have policy implications, than when such relationships are assumed merely on theoretical grounds, or implicitly.

(4) Development policies need to be based on defined goals. Goals for health could be the reduction of mortality or morbidity to a specified level. The attainment of such objectives depends on many factors beyond the control of the programme concerned, and are therefore less satisfactory under development conditions. Goals can also be expressed in terms of basic needs (see Chapter 3, section 4.5). For the health services goals would concern firstly the type, coverage and cost of services provided. Similarly the quality, quantity and cost of other basic needs can be specified and serve as the target for improvement of health conditions. Again the man-made health factors of Table 3 could be mentioned, because they are closely related to basic needs. Feachem (1977) describes a new approach for resource allocation, planning and design of water supply. Abandoning the traditional high grade standard for water supplies, he proposes to use quantity, quality, availability and reliability of water as design components. The decision which design component or combination is appropiate is aided by considering the cost and benefits of the alternatives. Health constitutes one of the values on which cost and benefit are based. It deserves consideration whether this approach could be modified to be applied to other basic needs.

So far this discussion has been on the possible implications of monitoring on the health policies of government ministries. A different level at which monitoring may influence policy is that of the financing institutions of major development projects. Financing policy is dependent on economic considerations. The assessment of the economic value of health is rather ambiguous. For a few epidemic diseases the impact may be so direct that it can be expressed in terms of productivity. For instance the economic impact of a malaria epidemic in the Gezira Irrigation Scheme (Sudan) in 1974 could be estimated from the reduction in crops harvested. The economic impact of more everyday health problems in the community can only be evaluated by indirect means. The World Bank Health Sector Policy Paper (1980) suggests the following categories of economic costs imposed by ill-health:

- Reduction of the availability of labour
- Impairment of productivity of employed workers, and capital goods
- Wastage of current resources, particularly nutrients (this refers to the loss of nutrients as a consequence of various infections)
- Impeding the development of natural resources, animal wealth and tourism

It would be feasible to incorporate in the health monitoring system items of information which could contribute to making estimates in respect of the first three categories. Explicit information on ill-health, especially if this could be supported by evidence of their economic significance, can serve as an incentive to include health among the parameters by which the economic viability of a project is measured. Consequently it could then be considered to include provisions for health among the items for which financing will be supplied, and integrate health in the planning, financing and implementation of these costly and important development schemes.

6. CONCLUSION

In this report we have considered the type of information needed for promoting human well being and health in waterdevelopment projects. We concentrated on the question whether the collection is possible at all in rural areas of tropical countries. Our findings showed that even with limited means useful data can be gathered. The conditional remarks elaborated in foregoing paragraphs do not constitute unsurmountable barriers. At present the experience gained from multipurpose health monitoring still is meagre.

For health monitoring to be adopted on a wider scale more recognition about its merits and requirements needs to be created. This concerns mostly professionals outside the health profession, who nevertheless take far reaching decisions concerning the development of the domestic environment of future settlements. These usually are social scientists, engineers and administrators. For health monitoring a channel of communication between them and the health profession is needed.

Documents on the medical biological aspects of health in relation to the environment, provided by community health experts, will demand supplementation by more detailed information on human behaviour, on the economic significance of ill-health, and on the engineering and planning options. A transdisciplinary approach, such as indicated, is at the heart of health monitoring. Whereas around the year 1900 more knowledge was required on the biological causes of disease in order to promote disease prevention, by the year 2000 (and even now) the biological knowledge on disease causeation will have become so complex, that emphasis ought to shift to information on how to use most efficiently available means for prevention and health promotion.

At present, except perhaps for water and sanitation, little is known about the relationships between factors in the domestic environment and health in tropical climates. Standards developed in cool-climate and prosperous countries in the past have uncritically been used for the same purpose in climatically and economically totally different tropical countries. As a result the dilemma of how to plan optimally settlements in these areas became obfuscated. A second prerequisite for health monitoring to be successful, besides being transdisciplinary, therefore depends on the understanding of the relationship between Man-made Health Factors (see Table 3) and health. Only by understanding these processes will it be possible to chose suitable parameters for health monitoring. In a future publication we intend to review the available knowledge and experience in a more comprehensive way, beyond the confines of this thesis.

Summary

Dams are among the obvious efforts to improve the economic situation in a given country. They aim at using locally available natural resources. They belong to the most popular means for promoting economic development. A significant number of these programmes have been undertaken in Africa during the past two decades, and it is to be expected that many more will follow. About the history of numerous large and small dams it can be confidently stated that every one was followed by unforeseen effects, including effects on health. In recent years the attention for these effects has rapidly grown and still is expressing itself in relevant documentation. Water and development in Africa are items very different from those in temperate climates. They have to do more with health and well being of the people concerned. That means that much more effort should be spent on planning, monitoring and evaluating the health effects of dams. This pilot study represents an attempt to guide that attention and effort.

In PART I (Chapters 1-3) a frame is presented in which to fit the manifold aspects of health planning, for selecting the components of health monitoring.

In Chapter 1 the wealth of unexploited African waterresources is contrasted to the need of water for water supplies, agriculture, hydro-electric power, industry and transport. It is concluded that in coming decades waterdevelopment will continue at a steady pace. Experiences gained from African projects in the last two decades demonstrate a number of undesirable consequences, some of them due to failures in the planning mechanism, others unforeseen.

Reservoir impoundment is viewed from an ecological angle in Chapter 2. Dam construction is followed by a chain of impacts in terrestrial and aquatic ecosystems. It is intended to broaden the human niche among these ecosystems. The ecological sequelae can be viewed as positive and negative impacts. For planning it is desirable that effects and their impacts can be predicted. Against this background the concept of Integrated River Basin Development is presented. Integrated Development aims at optimal exploitation of opportunities arising, and minimizing the negative impacts.

Chapter 3 addresses the aspects of health and welfare in Integrated Development. The groups affected, the time trend and the nature of health impacts in waterdevelopment is briefly reviewed. The management of Integrated Development has a multidisciplinary character. The management of the health sector interacts with that of other sectors. Adequate information is needed for good management. Surveillance activities and epidemiological studies are the instruments to generate these data for the health sector. In view of the regions where development takes place, the methods to be employed should be of a basic and practical nature. The type of information required for health planning is considered with the aid of an "Information Planning Model". This model distinguishes between several categories of information items. These may regard: the health problems, their aetiology, options for intervention and control, decisions on priority and allocation of resources, evaluating the health programme and the impacts. Man-made health factors should be a major concern to health planners, and could be included in information gathering. The information planning model is intended as a guide in deciding on the contents of health monitoring. A list of man-made health factors is given.

In PART II (Chapters 4-11) an account is given of the health studies and findings of the Kamburu/Gtaru Ecological Survey in Kenya. Chapter 12 presents an epicrise of the Kamburu experience.

The Kamburu/Gtaru Ecological Survey (Chapter 4) was initiated at the instigation of the World Bank and the Swedish International Development Agency. The project was to be located in the Sevenforks Hydro-electric Scheme, which is one of the major waterdevelopment projects of post-independence Kenya. The pluridisciplinary project covered the most serious ecological impacts of reservoir impoundment in this part of the Tana River. Epidemiology was one of the disciplines involved, and the guidelines specified studies on schistosomiasis and nutrition. Designing the health monitoring for the Kamburu Project benefitted from experiences from other rural projects in Kenya. The surveys were intended to supply policy relevant information, but at the start it was not clear what the consequences would be.

The Sevenforks Scheme is located in Central Kenya (Chapter 5), in an area between the Machakos and Embu Districts. For practical reasons the health studies were restricted to the Machakos side, inhabited by the Kamba people. The potential implications for some of the endemic diseases are reviewed. Substantial attention is given to describing the social and domestic environment, and the standard of living. The information partly derived from the project findings. The aspects covered were: administration and population movement, settlement pattern and social services, the household, housing, watersupply, excreta disposal, the role of women, fuel supply, occupation and income. This is the background against which health data should be viewed.

The survey design (Chapter 6) included an Inland and Lakeside sample which served as study- and comparison group. Two series of observations (for 1974 and 1977) are reported, and in the course of time additional series can still be added. After drawing of the household cluster samples all households were visited and interviewed at home. Later householders were requested to attend a health examination session at a central point. Full cooperation was obtained during the household visits. Response for the health examinations was 59-96% in 1974, and 40-90% in 1977. Response was better in the Lakeside area. Children responded better than adults, and women better than men. Data collection included items on the household environment, individual social characteristics, data on nutritional status of children, and health data for all. Several questionnaires were used, but individual data could be linked through the registration number. Data collection was by a team of medical students, laboratory technicians and fieldworkers. The continuity between the survey teams of 1974 and 1977 was limited to one fieldworker, and the author. The accuracy of the information was studied by a system of duplicate observations. Reproducibility of data for which the field team was responsible, on the whole proved to be of acceptable standard. Reproducibility of laboratory tests, carried out by different personnel, was poor.

The main characteristics of population composition (Chapter 7) were the large proportion of children under 15 yrs (50-57%), and the relative deficit of males (sex ratio 80-95). Both are typical for the rural parts of Machakos. Age assessment was not very accurate. Over a period of three years 23 deaths were traced. More deaths occurred in the Lakeside group. The estimated death rates were 4 rep. 10 per thousand. Fertility was studied by the crude birth rate and by the general fertility rates. Fertility appeared somewhat higher among the Inland group (229 resp. 252 per thousand). Migration constituted the most dynamic element affecting population change. Over the three year period emigration exceeded immigration (netto migration minus 48 resp. 61 per thousand). Migratory movements were more frequent in the Lakeside group. Several socio-

demographic characteristics of the population were recorded: education, property holding, cattle holding, duration of residence, crowdedness of households. Generally the Lakeside group appeared more prosperous in 1974 than Inland people. By 1977 this advantage seemed to have been lost.

The assessment of immunization status of children (Chapter 8) was not very satisfactory. Results, however, unmistakably indicated a low coverage of the population (not unexpected for this area), and that the situation in 1977 was worse rather than better.

Because ages were not accurate, nutritional status of children was assessed using Weight for Height (W/H) as criteria (Chapter 9). For the first 6 months growth did not deviate much from the Harvard Standard. Between 6-24 months there was an increasing deficit in growth as compared to the Harvard Standard, and this diminished around three years. Even then the average child remained small for the age. While the pattern did not differ much between Inland and Lakeside groups below the ages of three years, at older age Inland children tended to have a lower Weight for Height. Anthropometric values were somewhat lower in 1977, but not significant. According to the anthropometric criteria there did not exist a serious problem of malnutrition, but evidence of under nutrition was not uncommon. Breastfeeding was nearly universal, supplemented in the majority by bottle feeding. The weaning diet was based on maize and milk, occasionally supplemented by other foodstuffs. Though this is basically a sound diet, weaning practices could be improved. Fish consumption was insignificant for adults and children. There was no improvement from 1974 to 1977. Property holding of the household appeared to be associated with W/H. No evidence of the impact of malaria was found.

In Chapter 10 findings about the following features of ill-health are presented: perception of ill-health, the Quetelet index, packed cell volume, spleen enlargement, high blood pressure, protein in the urine and diarrhoea. For identifying the determinants of the main features of ill-health multivariate analysis was used. Distributions were analysed separately for adults, school- and pre-schoolchildren.

Perception of ill-health appeared high. Each adult on the average was not fully well during 2-3 days out of two weeks. Lakeside people suffered more ill-health than Inland, and women more than men.

Judged by the Quetelet index the nutritional status on the Lakeside was, in 1974, better than Inland. By 1977 this advantage had largely disappeared because of decreasing Lakeside values, and increasing Inland ones.

Anaemia was found to be common in the Kamburu population, affecting mostly young children and women. While in 1974 the prevalence was slightly higher Inland, in 1977 prevalence rates had become highest on the Lakeside. Iron deficiency, and a haemolytic factor related to spleen enlargement contributed to the local anemia problem.

Spleen enlargement had a low prevalence in 1974, and had substantially increased by 1977. On each occasion higher prevalences were noted in the Lakeside group. It is suggested that locally spleen enlargement is due to malaria.

The distribution of systolic and diastolic blood pressure of adults was determined in 1974. On the whole the level of blood pressures is low. Hypertension was rare. Between 4-8% of the samples had protein in the urine. Rather arbitrarily this was considered low. Of stool specimens 2-3% had a watery consistency. Watery stools belonged mostly to underfives, giving a point prevalence of 8-10% in this group.

By applying techniques of multivariate analysis a number of individual and socio-environmental indicator variables were identified. In the various models the proportion of total variance explained (R2) varied from 4-37% . Conclusions

based on the models for each of the health variables can be found at the end of resp. Chapter 10-1, 10-2, 10-3, 10-4.

Findings about the parasitic infections by malaria, schistosomiasis and intestinal helminths are presented in Chapter 11.

It is known that malaria transmission in the area was unstable. On the basis of the spleen rate in 2-9 yrs old children malaria was low-mesoendemic in 1974 and high-mesoendemic in 1977. On each occasion malaria concentrated in the Lakeside area. It could not be decided if the increase was a result of seasonal variation, or represented a real change. Anopheles gambiae appeared to be the main mosquito vector. The impact of malaria was shown to be on haematological status and the Quetelet distribution.

Both Schistosoma mansoni and haematobium infections had a low prevalence in the population. Prevalence did not change from 1974-77. Cases of S. mansoni are more frequent on the Lakeside. Though specimens of the main Kenyan snail vector, Biomphalaria pfeifferi, were found in the lake, there was no evidence that the infection was transmitted in the lake. Cases of S. haematobium were concentrated in a small Inland area, near a small pond. A potential snail vector of this infection, Bulinus truncatus, was established in the lake, but was not at the time of the surveys transmitting the disease.

The prevalence of intestinal helminths infestations was found to be low.

Chapter 12 provides a concluding critical appraisal of the Kamburu experience, by discussing four questions:

(1) In how far could health monitoring be worthwhile by African Government health services?
(2) Could health impacts be identified?
(3) The structure and causes of ill-health?
(4) Could health monitoring have policy implications?

In general the potential application and usefulness of health monitoring for planning and implementing development projects is judged positively, but guardedly. Suggestions are made how health monitoring can be made into an effective instrument to collect useful and policy-relevant information for the planner and administrator.

Samenvatting

Vooral in ontwikkelingslanden behoren stuwdammen tot de meest geeigende middelen ter verbetering van de nationale economie. Zij zijn erop gericht het locaal aanwezige potentieel aan water en energie ten volle uit te buiten voor economische vooruitgang. Een aanzienlijk aantal projecten voor stuwdammen zijn in de afgelopen 20 jaar uitgevoerd, en naar verwachting zullen er nog vele volgen. Op basis van de verkregen ervaring kan met aan zekerheid grenzende waarschijnlijkheid gezegd worden dat dergelijke projecten gekenmerkt worden door onverwachte complicaties, o.a. op het gebied van gezondheid. De belangstelling voor deze problemen is in de laatste jaren toegenomen, hetgeen blijkt uit een groeiend aantal publicaties hierover. Het dienstbaar maken van water aan de ontwikkeling van het land heeft in Afrika een geheel andere betekenis dan in landen met een gematigd klimaat. De gevolgen voor gezondheid en welzijn van de betrokken bevolking zijn veelomvattender en ernstiger. Dit zou moeten betekenen dat meer aandacht dient te worden besteed aan de consequenties voor de gezondheid en de planmatige benadering daarvan. Deze studie beoogt hiertoe een bijdrage te leveren.

In DEEL I (Hoofdstuk 1-3) wordt een theoretisch model ontwikkeld dat de vele aspecten van gezondheidsplanning ordent, zodat een stelselmatige benadering voor gezondheidsbewaking mogelijk wordt.

Afrika heeft een grote rijkdom aan rivieren en meren, waarvan het nut voor de economie nog niet ten volle wordt uitgebuit. Dit staat in scherpe tegenstelling tot het grote tekort aan water voor watervoorziening van de bevolking, voor landbouw, de produktie van electriciteit, industrie en transport. Het is daarom te verwachten dat ontginning van dit ontwikkelingspotentieel in de komende jaren gestadig voortgang zal vinden. Tenslotte wordt een kort overzicht gegeven van ongewenste gevolgen in dergelijke ontwikkelingsprojecten. Sommige hadden bij goede planning niet behoeven te gebeuren, het optreden van andere was onverwacht.

De gevolgen van de bouw van waterwerken voor de ecologie van het betrokken gebied worden in het kort uiteengezet in Hoofdstuk 2. De bouw van een dam brengt een kettingreactie op gang in ecosystemen van land en water. Waterwerken vergroten de invloedsfeer van de mens binnen de locale ecologie. De kettingreactie kan voor de ontwikkeling van het gebied ongunstige, maar ook gunstige gevolgen hebben. Om ontwikkeling in goede banen te doen verlopen is het nodig, door goede planning, zowel de positieve als de negatieve effecten te beheersen en uit te buiten. Hiervoor is "Integrated River Basin Development" de aangewezen vorm voor de planning en uitvoering van ontwikkelingswerk.

In Hoofdstuk 3 wordt nader ingegaan op de rol van gezondheid en welzijn binnen het kader van Integrated Development. Eerst wordt nader ingegaan op enige kenmerken van de gezondheidsproblematiek, groepen in de betrokken bevolking, ontwikkeling in de tijd. De management van Integrated Development is per definitie multidisciplinair. Er zijn relaties tussen management in de gezondheidssector en andere sectoren. Goede informatie is noodzakelijk voor effectieve planning en uitvoering.

Voor het verkrijgen van deze informatie is epidemiologisch onderzoek nodig. Aangezien dit onderzoek moet plaats vinden op het Afrikaanse platteland, dienen te gebruikte methoden praktisch en eenvoudig te zijn. De aard van de voor gezondheidsplanning benodigde informatie wordt nagegaan aan de hand van een "informatie model". Er bestaat in dit model een logisch verband tussen de volgende

categorieen van informatie: de aard van de gezondheidsproblematiek, de verantwoordelijke factoren, de aard van eventuele preventieve mogelijkheden, prioriteiten, argumenten voor het verdelen van de beschikbare middelen, evaluatie. Het is speciaal van belang aandacht te besteden aan zg. "man-made health factors". Een aantal van de laatsten worden genoemd.

DEEL II (Hoofdstuk 4-11) bevat een verslag van de bevindingen bij het bevolkingsonderzoek voor gezondheidsplanning in de "Kamburu/Gtaru Ecological Survey. Een kritische nabeschouwing van het Kamburu project is het onderwerp van Hoofdstuk 12.

De Kamburu/Gtaru Ecological Survey ontstond op verlangen en met bemiddeling van de World Bank, en de Swedish International Development Agency. Het project werd uitgevoerd in het Sevenforks Hydro-electric Scheme, een van de grote water ontwikkelingsprojecten in Kenya na de onafhankelijkheid. Het multidisciplinaire project richtte zich op de belangrijke ecologische gevolgen van de bouw van dammen in de Tana rivier. Volgens de richtlijnen van het project diende epidemiologisch onderzoek verricht te worden naar het voorkomen van schistosomiasis, en op het gebied van voeding. Bij het opzetten van het medisch onderzoek werd vruchtbaar gebruikt gemaakt van ervaringen op dit gebied elders in Kenya. Het was de bedoeling door middel van surveys beleids-relevante informatie te produceren. Wat dit onvermijdelijk om het lijf had was aanvankelijk minder duidelijk.

Het Sevenforks Scheme ligt in Centraal Kenya (Hoofdstuk 5), in een gebied tussen Machakos en Embu District. Om praktische redenen werd het onderzoek beperkt tot de Machakos kant van het gebied, bewoond door de Kamba's. De mogelijke gevolgen voor het locale ziektenpatroon wordt besproken. De organisatie van de gemeenschap, het leefmilieu en de levensstandaard worden uitgebreid beschreven. Een gedeelte van deze informatie berust op project gegevens. De volgende onderwerpen worden aan de orde gesteld: de bestuurs organisatie en migratie, opzet van de gemeenschap en infrastructuur, de leefgemeenschap, de behuizing, water voorziening, sanitaire voorzieningen, de plaats van de vrouw, brandstof, werkgelegenheid en inkomen. Bevindingen over gezondheid moeten tegen deze achtergrond beoordeeld worden.

In de opzet van het onderzoek (Hoofdstuk 6) werden bevolkingssamples gekozen bij het meer (Lakeside), en van het meer af (Inland), die konden dienen voor vergelijking. Waarnemingen werden gedaan bij onderzoeken in 1974 en 1977, en de mogelijkheid bestaat hier in de toekomst nieuwe waarnemingen aan toe te voegen. Cluster samples werden gebruikt waarbij huishoudens dienden als sample eenheid. Alle gezinnen die in de sample vielen werden thuis bezocht en geinterviewd. Bij een volgende gelegenheid werden de betreffende personen verzocht naar een centraal punt te komen voor onderzoek. Alle gezinnen werkten mee aan het interview thuis. De opkomst bij het onderzoek bedroeg 59-96% in 1974, en 40-90% in 1977. Opkomst was beter in de Lakeside groep. Kinderen hadden een groter opkomst percentage dan volwassenen, en vrouwen meer dan mannen. Bij het interview werden vragen gesteld over de levensomstandigheden, demografische gegevens, en gegevens over voedingstoestand van de kinderen. Het medisch onderzoek betrof zowel kinderen als volwassenen. De op een persoon betrekking hebbende gegevens werden steeds onder hetzelfde registratie nummer genoteerd. Het veldwerk werd uitgevoerd door een team van medische studenten, laboratorium werkers, en assistenten. Slechts een enkele veldwerker, en de auteur, participeerden in 1974 en in 1977. De betrouwbaarheid van de verkregen informatie werd nagegaan door waarnemingen bij de zelfde persoon te herhalen in een geselecteerde groep respondenten. De betrouwbaarheid van waarnemingen van het team was goed. De resultaten van laboratorium onderzoek, dat buiten verantwoordelijkheid van de medewerkers werd verricht, was slecht.

In de bevolkingssamenstelling (Hoofdstuk 7) waren opvallende punten het hoge percentage kinderen (50-57%), en het grotere percentage vrouwen (sex ratio 80-95) Beide zijn typisch voor Machakos District. Het bleek dat leeftijden onnauwkeurig waren. Over de periode van drie jaar werden 23 sterfgevallen geregistreerd, hetgeen neerkomt op een sterftecijfer van 4 resp. 10 per duizend. Er waren meer sterfgevallen in de Lakeside groep. De vruchtbaarheid werd nagegaan met geboorte- en fertiliteitscijfers van vrouwen in de vruchtbare leeftijd. Inland vrouwen hadden een iets hogere fertiliteit (229 resp. 252 per duizend). Bevolkingsgroei werd vooral bepaald door migratie. Gedurende de observatie periode van 3 jaar was emigratie groter dan immigratie (netto migratie 48 resp. 61 per duizend). Meer migraties vonden plaats in de Lakeside groep. Er werd een kort verslag gegeven van de volgende sociaal demografische kenmerken: genoten onderwijs, mate van bezit, stuks vee, de duur van het verblijf ter plaatse, aard van behuizing. Over het algemeen werd voor de Lakeside groep in 1974 een hogere standaard gevonden, maar dit voordeel was in 1977 verdwenen.

De nauwkeurigheid van het vaststellen van de immunisatie status van kinderen (Hoofdstuk 8) was onbevredigend. Toch was het overduidelijk dat de immunisatiegraad laag was (niet onverwacht in dit gebied), en dat de toestand sinds 1974 eerder verslechterde dan verbeterde.

Omdat de leeftijden onnauwkeurig waren, werd voor het vaststellen van de voedingstoestand van kinderen de gewicht voor lengte index (W/H) gebruikt (Hoofdstuk 3). Gedurende de eerste 6 levensmaanden week de groei weinig af van de Harvard Standard. Van 6-24 maanden trad een achterblijven in groei op, die verminderde na de leeftijd van 3 jaar. Maar ook dan bleef het gemiddelde kind klein voor de leeftijd. Hoewel er voor kinderen beneden de 3 geen duidelijk verschil was tussen Inland en Lakeside, hadden oudere Inland kinderen in het algemeen lagere waarden. De anthropometrische waarden waren in 1977 wat lager dan in 1974, maar het verschil was niet significant. Naar anthropometrische maatstaven bestond er geen ernstig probleem van wanvoeding, maar komt ondervoeding regelmatig voor. Borstvoeding werd algemeen toegepast, en bij een groot deel van de kinderen aangevuld met flesvoeding. Kindervoeding was gebaseerd op maismeel en melk, eventueel aangevuld met andere voedingsmiddelen. Vis werd praktisch niet gegeten, en hierin was in 1977 geen verandering gekomen. Familiebezit bleek gerelateerd aan de voedingstoestand. Invloed van malaria op de voedingstoestand kon niet worden aangetoond.

In Hoofdstuk 10 worden enkele meer algemene aspecten van de gezondheids toestand behandeld. Deze zijn: het klachtenpatroon, de Quetelet index, de haematocriet, vergroting van de milt, verhoogde bloeddruk, het voorkomen van eiwit in de urine en diarrhee. Om met het voorkomen van deze afwijkingen verband houdende factoren op te sporen werd gebruik gemaakt van multivariabele analyse technieken. Hierbij werd onderscheid gemaakt tussen het voorkomen bij volwassenen, schoolkinderen en kinderen jonger dan 5 jaar.

Het percentage volwassenen met gezondheidsklachten leek aan de hoge kant. Gemiddeld hadden zij een of meerdere klachten gedurende 2-3 dagen per twee weken. Lakeside mensen rapporteerden meer klachten dan Inland, vrouwen meer dan mannen.

Als maat voor de voedingstoestand van de gehele bevolking geeft de Quetelet index van 1974 hogere waarden aan voor de Lakeside groep. Dit voordeel was in 1977 grotendeels verdwenen door een verlaging van de Lakeside, en toename van de Inland waarden.

Een lichte tot matige anaemie kwam algemeen voor in Kamburu, voornamelijk bij jonge kinderen en vrouwen. De prevalentie van anaemie was hoger in de Inland groep in 1974, maar ook in dit opzicht veranderden de verhoudingen, en werden de hoogste percentages in 1977 in de Lakeside groep gezien. IJzerdeficientie, en

een haemolytische factor verband houdend met miltvergroting beinvloedden het anaemie probleem.

De prevalentie van miltvergroting was in 1974 laag, maar was in 1977 aanzienlijk toegenomen. Zowel in 1974 als in 1977 werd de hoogste prevalentie waargenomen in de Lakeside groep. Redelijkerwijs gesproken is miltvergroting in deze bevolking het gevolg van malaria.

Waarnemingen met betrekking tot de bloeddruk werden alleen in 1974 gedaan. Over het algemeen was het niveau van de bloedruk laag, en kwam hypertensie nauwelijks voor. Van 4-8% van de bevolking had eiwit in de urine, doch dit werd niet als ongunstig beschouwd. Van de ontlastingmonsters die werden ingeleverd hadden 2-3% een waterige substantie. Deze diarrhee kwam voornamelijk voor bij kinderen jonger dan 5 jaar (prevalentie 8-10%).

Met behulp van de multivariabelen analyse konden verbanden gelegd worden tussen de gezondheidsvariabelen en een aantal indicatoren met betrekking op persoon en milieu.

In de verschillende modellen lag het percentage verklaarde variantie (R2) tussen 4-37%. De uit deze modellen getrokken conclusies werden kort samengevat aan het eind van de deelverslagen resp. Hoofdstuk 10-1, 10-2, 10-3, 10-4.

Het onderzoek naar malaria, schistosomiasis en andere parasitaire darminfecties staat in Hoofdstuk 11. Het is bekend dat de transmissie van malaria in dit gebied niet stabiel is. Volgens het criterium van miltvergroting bij 2-9 jarigen was malaria in 1974 laag-mesoendemisch, en in 1977 hoog-meso-endemisch. Bij beide gelegenheden kwam malaria meer voor in de Lakeside groep. Door mogelijke seizoensinvloeden kon niet worden vastgesteld of er een werkelijke toename in de transmissie was. Anopheles gambiae was de vector. Malaria had invloed op het voorkomen van anemie, en op de Quetelet verdeling.

De prevalentie van infecties door Schistosoma mansoni en S. haematobium was laag, en er traden geen duidelijke veranderingen op. Gevallen van S. mansoni werden voornamelijk in de Lakeside groep gevonden. Hoewel enkele Biomphalaria pfeifferi slakken bij het meer gevonden werden, waren er geen aanwijzingen dat transmissie daar reeds plaatshad. Gevallen van S. haematobium werden in het Inland gebied gevonden. Een slak die potentieel S. haematobium over kan brengen vermenigvuldigde zich wel in het meer, maar er was (nog) geen transmissie.

De prevalentie van darminfecties door wormen was laag.

Een kritische nabeschouwing van de met het Kamburu project opgedane ervaring wordt gegeven in Hoofdstuk 12. De volgende vragen komen aan de orde:

(1) Is "health monitoring" praktisch uitvoerbaar door Afrikaanse gezondheidsdiensten?

(2) Was het mogelijk gezondheidseffecten aan te tonen?

(3) De struktuur van factoren die het voorkomen van ziekte beinvloeden?

(4) Kan "health monitoring" een bijdrage geven tot het te voeren beleid? De bruikbaarheid en het nut van "health monitoring" voor ontwikkelingsprojecten worden gematigd positief beoordeeld. Suggesties worden gedaan hoe deze vorm van gezondheidsbewaking tot een effektief instrument voor planning en beleid gemaakt kan worden.

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Appendix 1: DETAILS ABOUT THE MULTIVARIATE ANALYSES

A The Variables and Codes

1.	Lakeside living	Inland=0, Lakeside=1
2.	Sex	Male=0, Female=1
3.	Age	Decimal midpoints were used for age intervals (yrs.) of Pre-schoolchildren: 0.25, 0.75, 1.25, ..., 2.75, 3.5, 4.5 Schoolchildren: 5.5, 6.5, ...14.5 Adults: 20, 30, ...60
4.	Migrant status	Persons resident >3yrs= 0, Persons resident <3yrs =1
5.	Education I	Adults with 1-4 yrs educ. =1, Others =0
6.	Education II	Adults with >4yrs educ. =1, Others =0
7.	Property status	For information on units see Table 5 in Chapter 5. The range of scores from 1-15 was transformed to the codes 0-5. Codes 1 to 3 increase stepwise by 1 unit, code 4 represents 4-6 units, code 5 represents 7 or more units.
8.	Crowdedness	For each household the no of people was divided by the number of rooms (excl. the kitchen). Values <1 were given code 0, values between 1-1.99 code 1, and so on up till code 8.
9.	Spleen status	Hackett code 0 =0, Hackett code 1-5 =1
10.	Quetelet index	The original value up to one decimal was used, range of values 110-290
11.	Packed Cell Vol.	The calibrated reading up to one decimal was used, range of values 18-55%
12.	Disability	One point was given for a day of restricted activity, and 2 points for a day of total disability. For 2 weeks from 0-28 points could be obtained. Codes were assigned 0 =0, 1-5 =1, 6-10 =2, etc.
13.	Change Variables	These were obtained by subtracting the 1974 value of the variable concerned from the 1977 value
14.	Spleen increase	Any change from spleen =0 to spleen =1 was given the code =1, all others the code =0
15.	Spleen decrease	Any change from spleen =1 to spleen =0 was given the code =1, all other the code =0

B A Specification of the Computer Programme Used

The conceptual model according to which variables were entered in the analyses has been discussed in Chapter 10. Here details will be provided about the computer programme used for the calculations.

The calculations were performed with the aid of the Regression Subprogram of the SPSS - 11 Program Package. In this subprogram variables can be entered stepwise, or all at once. The last facility was used.

The calculations were performed operating the program under the Standard Option. This implied that variables included in the regression statement were entered in the equation, provided the statistical criteria of the Standard Option were met. Variables not meeting these criteria were discarded, and the analysis terminated. The statistical criteria of the Standard Option are:

(1) All variables specified in the regression list up to a number of 80 can potentially be entered in the equation.
(2) Before variables are entered F-ratio's are computed. A variable of which the F-ratio is less than 0.1 will not be included.
(3) Also for each variable the tolerance is computed. The tolerance is the proportion of its variance which is not explained by other variables in the list. Variables with a tolerance of less than 0.1% will not be included.

Conclusion:
This program, and the option used, were considered suitable for exploring the relationships between dependent and independent variables. A few times individual variables were not entered in the equations for not meeting the criteria (2) or (3). Because of the low cut off level variables which added little additional explanation to the models were still included.

C The Discriminant Coefficients

The Regression Subprogram of the SPSS - 11 Program Package does not have a special program for discriminant analysis. Instead the discriminant coefficients were obtained by dividing the regression coefficient by the "constant", while the variance of the discriminant coefficients was obtained by dividing the variance of the regression coefficients by the "constant" squared. The "constant" was calculated with the formula given by Kleinbaum and Kupper (1978).

D Results of the Multivariate Analyses

For each of the analyses the intercept, the regression/discriminant coefficient, and the proportion of the variance explained per variable (% R2-change) and for the equation (% R2) are given in tables. Readers wishing information on other details can obtain a copy of the computer print outs by writing to the author: Noolseweg 2, 1251 GP LAREN (NH), The Netherlands.

Appendix 2: INTERPRETATION OF THE MULTIPLE REGRESSION EQUATION

The key concepts and terms of multiple regression analysis are explained in the introduction to Chapter 10. The interpretation of a multiple regression model is illustrated by this appendix. As an example we have taken the model describing the QUETELET INDEX distribution of ADULTS in 1977 (see Tables 33 and 49). The equation is:

$$Y = 184 + 7.96\,X1 + 13.07\,X2 - 0.06\,X3 + 3.38\,X4 - 0.40\,X5 - 6.42\,X6 + 3.42\,X7 - 0.16\,X8 - 10.67\,X9 - 4.09\,X10$$

where:

Y	the "predicted" value of the Quetelet index
184	the intercept, the value of the Quetelet index if all indicator variables have the value =0
X1	Lakeside living - for Lakeside persons 7.96 is added to the intercept
X2	Sex - for females 13.07 is added to the intercept
X3	Age - for a person in the age interval 25-34 yr, 30x0.06 is subtracted from the intercept
X4	Migrant - for a migrant 3.38 is added to the intercept
X5	Education I - for a person with 1-4 yr education 0.40 is subtracted
X6	Education II- for a person with > 4tr education 6.42 is subtracted
X7	Property - a person with 3 property units adds 3x3.42
x8	Crowdedness - a person with crowdedness 4 looses 4x0.16
X9	Spleen - a person with a enlarged spleen looses 10.67
X10	Malaria - a person with malaria parasites looses 4.09

The equation explains (R2) 14.8% of the total variation in the distribution of Quetelet values for adults in that year. The indicators with significant regression coefficients contribute (R2-change) most: Lakeside living (0.3%), Sex (7.7%), Property (3.9%), Spleen status (1.9%). Though some of the remaining indicators have large regression coefficients, they contribute less than 1% because of the large variability of their values, which is obvious from the standard error. Indicator variables which have high values (age: 0.25-60, Quetelet: 110-290, PCV: 18-55) may increase or decrease the intercept considerably, even if their regression coefficient is small.

The interpretation of the discriminant models is in principle analogous to that of the multiple regression model. The resulting value L ultimately is used to assign the individual to one or the other category of the dependent variable.

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