EFFECTS OF URBAN GROWTH WITHOUT ATTENDANT INFRASTRUCTURE:

A Case Study of, Zimmermann, an Unsewered High Density Residential Estate in Nairobi

By;

NJUGUNA SIMON (B SC. HONS, Geology, NAIROBI)

This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Arts in Planning
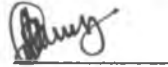
UNIVERSITY OF NAIROBI

December 1998

Declaration
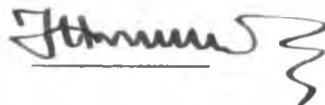
This Thesis is my original work and has not been presented in any university

NJUGUNA SIMON
(Candidate)

This Thesis has been submitted for examination with my approval as a university supervisor

DR. J. MOCHACHE
(supervisor)

Department of Urban and Regional Planning
Faculty of Architecture, Design and Development
University of Nairobi

Acknowledgement

It is through the assistance of many, both individuals and groups, that this research has been successively completed. Top on the list is Dr. J. Mochache, whose selflessness and dedication has molded the work, through high level guidance and constructive criticism. He unreservedly came in at all time to put ideas in their right perspective. To him, do I convey my gratitude.

I am also indebted to the entire staff of the Department of Urban and Regional Planning, among them, Mr. Mairura Omwenga, for their direct and indirect input in this research .

I would also like to extend my gratitude to the University of Nairobi for granting me a scholarship, without which pursuance of this course would have been difficult.

Another vote of thanks goes to my field research assistants, A. Mbote and R. Gichangi, for their selflessness and dedication in collection of primary data . This appreciation is also extended to Florence W. K. And Hellen W. For their secretarial input into this work.

My collegues in the planning program also availed unmatched assistance by creating a conducive working environment. In addition, they freely, willingly and repeatedly came in handy in offering constructive criticism without which this research would not have reached this level of quality.

Lastly, and most certainly not the least, I wish to extend my heartfelt appreciation to my family members for their support, both morally and financially.

To all the people that I have listed, and otherwise, do I express my gratitude.

Abstract

The problem of sanitation is perceived within the context that human waste and waste water disposal is concerned with relocation of waste from the point of generation to a more suitable and non-detrimental site, a factor which is not strictly observed in the Third World countries. The problem of sanitation is more acute in urban areas, more so in the newly developing residential neighbourhoods. Urban population growth, has led to conversion of previously low density areas into high density ones, but sanitation methods suited for low population density areas continue to be used. The effects of this on urban population is worth a study considering that, poor sanitation in the Third World countries, has been responsible for the low life expectancy and serious health problems in these countries.

The work of previous researchers and scholars have documented a list of attempts at improving problems in provision of infrastructure and services in urban areas. The background of poor urban infrastructure, has been attributed to uncontrolled increase in urban population coupled with inability of local and central governments to continue with provision of infrastructure. The outcome of this has been undesirable urban environments. This has continued to be the case despite the existence of an articulate infrastructure and service development policies at global, national and individual urban centers' scales. Sewerage system has been one of the most neglected infrastructure despite the profound polluting effect exhibited by untreated waste water. As such, sanitation especially in the upcoming residential neighbourhoods has been deplorable. Lack of sewerage services and infrastructure has been attributed to expensive installation, running and maintenance costs of sanitation facilities which have been developed in the Developed Countries. Other socio-economic needs, take up all the available resources, leaving behind little or none to sanitation facilities. To counter this tendency, the suggestion of lowering the design standards of the sanitation facilities from the West has all been frequently suggested. The argument has been that effectiveness of sanitation facility, is not necessarily reflected in high installation, running and maintenance costs. Further, both households and community participation has been found to be a viable ingredient in

ensuring provision and maintenance of efficient infrastructure and service, among them sewerage systems.

Zimmermann's, the study area's, physical attributes, together with high residential density relative to the surrounding, describe an anomalous development. Historical development of the estate, reflect a series of irregularities leading to conversion of a formerly grazing field to a high residential estate, albeit without infrastructure. A population of about 56,000 people reside in an area of 400 acres. The estate is characterized by a relatively reliable and constant water supply and house units which have wet cores and water closets within them. These characteristics show high water consumption, hence high waste water production rate. In the absence of a convectional sewer system, cess pits, septic tanks and conservancy tanks, which are meant for low population density areas, are used.

Effectiveness of waste water tanks in Zimmermann was evaluated on the basis of the amount of generated waste water and the capacity of the environment to contain it. The capacity of the environment to contain the generated waste water was based on the capacity of waste water tanks and the frequency of exhausting vis-a-vis subsurface condition, namely the areas with black cotton soils, high water table and flat topography. The high amount of generated waste water was found to be three times the capacity of waste water tanks, meaning that two thirds of raw waste water generated in the Zimmermann is released into the environment without proper control.

The costs associated with outflow of raw waste water from the tanks was evaluated. These costs include high monetary costs in form of exhausting charges to the land lords and environmental costs to the residents. The latter costs include unpleasant odours and muddy streets in the residential neighbourhood. Poor-sanitation-related diseases and actual and anticipated accidents as a result of presence of deep waste water filled tanks which have poor or missing accessories, in a residential neighbourhood were also rampant.

The conclusion drawn from the research is that use of waste water tanks in Zimmermann estate is ineffective. because these facilities facilitate relocation of waste water from the house units into the immediate area. thereby allowing direct contact of human waste and waste water with human beings. This has other indirect implications. such as diseases and unpleasant residential environment. on top of actual and anticipated physical injury risks to the residents. The ultimate solution to poor sanitation situation in Zimmermann is a convectional sewer system. To make this affordable. lowering of its design standards and specifications has been suggested. As part of long term solution. residential units developers should take up the responsibility of providing attendant infrastructure to the neighbourhoods that they create. While the ultimate solutions await to be taken. remedial measures which will improve sanitation situation by reducing the polluting effect of waste water have been suggested. To reduce the possibility of accidents. waste water tanks should be constructed on the side of the residential block and away from the gates and open spaces within the block. Further. separation of waste water from the different quarters of the house units and subsequent separate disposal tanks were suggested. This is in addition to a recommendation that conservancy tanks would be more efficient than septic tanks and cess pits. Still as part of solving the current problems emanating from use of waste water tanks. ventilation of the tanks and construction of some which have a higher surface area-volume ratio are suggested as a way of reducing odours from the waste water tanks.

TABLE OF CONTENTS

CHAPTER 6

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS 131

LIST OF ILLUSTRATIONS

MAPS

PLATES

TABLES

FIGURES

DIAGRAMS

APPENDICES

CHAPTER 1

RESEARCH PREAMBLE

1.1 Introduction

Within the period 1960s and 1990s cities in the third world countries have changed in at least three ways namely; their size, their spatial organization, the quality and distribution of public services and infrastructure and their employment base. The largest of these urban areas have been experiencing steadily deteriorating condition of infrastructure and public services. Deterioration and non-provision of infrastructure within these cities in the 1990s is as a result of national and urban economies having stagnated in absolute terms in addition to increasing urban populations at a rate which has not been matched by increase in resources necessary for roads, sewers, water systems, schools and hospitals provision (UNCHS 1996).

In a bid to counter economic constraints and unaffordable high development costs, more and more urban populations have been moving to the periphery of large cities, where land is cheaper and development costs are relatively low. In these areas shelter is constructed more cheaply using locally available materials and harassment from the police and restrictions of the formal planning regulations are not strictly followed. This expansion of cities into their rural hinterlands not only attenuate major infrastructural elements such as piped water, electricity, sewerage and roads to a point where their efficacy is greatly reduced; but it also adds considerably to the costs of such services. Total lack or partial provision of these, however, infrastructure leads to environmental deterioration and poor habitability of the resulting settlements in addition to sub-optimal productivity of the communities residing in such areas. Lack of, or poor provision of infrastructure is more evident in the newly settled peri-urban residential areas.

As African cities continued to increase in size, during the 1980s and 1990s, declining economic situation led to a precipitous decline in the supply of basic infrastructure and urban services (UNCHS 1996). Kenya being one of the countries in Africa has not been spared by this spate of unharmonious development of urban centers. Virtually all urban centers in the country have experienced urban growth but more serious in Nairobi, Mombasa, Kisumu, Nakuru, Eldoret and Thika. Nairobi being the country's biggest urban center is the worst hit. It has a peri-urban rim in which urban sprawl processes have already produced unsustainable physical development. The rim encloses such areas as Rongai, Ngong and Kikuyu to the West, Kahawa, Kasarani and Githurai to the North, Athi River, to the East among others. Zimmermann is one of the neighborhoods in Githurai occupied by low-middle income earners where the problem of spontaneous development resulting from unserviced residential occupation is evident.

Besides housing structures, water, electricity and a stretch of a one way tarmac road, no other services are provided. This may be attributed to the previous growth models and directions that were taken by Nairobi city. Before 1980, Zimmermann area was an open grazing field. The area was considered to be unsuitable for urban development due to its poor water logged soils. As the population of Nairobi hit the 2 million mark in 1980s, housing continued to be the major taunting problem that the urban worker had to contend with. Many areas which were originally unsuitable for urban development were gradually drawn into the urban development albeit without services.

Zimmermann enjoys an appreciable proximity to the CBD and low land prices, explaining the force behind residential development emergence in the area. Initially, the residential plots were considerably big; up to half an acre (Ndunda 1996). As the demand for housing grew, land prices shot up causing further subdivision, summarily leading to high residential density developments. This high density housing development has resulted to growing

demand for improved sanitation among other services. This demand of services has not been matched by an equivalent supply. Consequently waste disposal is now a serious problem in Zimmermann. Human waste, particularly, has presented the biggest problem. By virtue of the fact that the neighborhood is characterized by multi-level residential blocks and high population densities, waste water disposal is one of the glaring problems. Since the area has not been served with a convectional sewer system, the only option has been the use of cess pools, septic tanks and pit latrines in an area where soakage is minimal. First, black cotton and clay soils which are water logged, make septic tanks and cess pools ineffective. Secondly, the high residential density, of an average of 140 people to the acre, and in some plots upto 200 persons to an eighth of an acre, makes these methods of sanitation a total failure, as evidenced by the continuous outflows of sewage from waste water tanks into open storm-drains along the streets.

This study assessed alternative sanitation systems for Zimmermann and other similar situations. Zimmermann will continue to have increasing population despite the decaying environmental conditions largely because of overall increase in population in the country, falling household incomes and general increase in the cost of living within the city of Nairobi. To provide an understanding on how to deal with problems emerging from increase in population within areas which have not been served with convectional sewer system, the research focused on establishing the methods of sewerage disposal on the ground and their suitability weighed against the amount of sewage produced. Alternative methods of disposal available and which are suitable to handle the amount of sewage were also evaluated. The community's desires and ability, environmental and feasical considerations greatly determined the applicability of recommended waste water disposal methods. Lastly, the study also explored ways through which community participation in sewage management in Zimmermann can be incorporated.

1.2   Problem Statement

In the words of Loehr (1977), the problem of sanitation is perceived within the context that liquid waste disposal is concerned with the relocation of waste from the point of generation to a more suitable and non-detrimental site. In the developing countries, however, more than 90% of sewage is discharged directly into rivers, lakes and coastal waters without treatment of any kind. This can be attributed to man's desire to obtain economic returns at the expense of good quality environment (through pollution). It is this desire that leads to overcrowding; at times beyond the carrying capacity of the environment thereby negatively impacting on the environment. McAllister (1980) attributes the tendency to overcrowd to the direct gains from the house units compared to the gains obtained from good quality maintained environment, at least in the short run.

Fundamental principles in resource use, which otherwise look obvious, seem not to have been considered when development projects are being undertaken. Among such principles is that consumption of any resource is accompanied by production of waste or by-product. The more of a resource is consumed, the greater the amount of waste generated. In this respect, high consumption of water should be accompanied by development of sanitary facilities that are commensurate with the amount of waste water produced. Consequences of improper waste water handling are those that question the reason behind the very existence of the concerned human activities (betterment of man's health in all respects; be it physically, mentally and/or socially). The state of urban areas is deplorable, where man has managed to create unbearable living conditions right in the middle of his most desirable habitat - the urban settlement (Batch 1972). This in itself shows that the man's mind has been polluted; and that urban settlement pollution is only but a symptom of a worse and deep rooted problem.

Zimmermann estate has a special kind of pollution. Domestic waste water freely gets onto the streets and the environment in general due to use of ineffective method of sanitation. Waste water tanks, namely cess pits, septic tanks and conservancy tanks are used in a high density residential area contrary to a requirement that use of such tanks is only effective in areas with a maximum population density of between 30 an 40 persons to the acre (NCC 1998). As a result, one is left wondering whether the roles that a good sanitation system is supposed play have been fulfilled. According to UNCHS (1996), there are three obvious criteria upon which to judge the effectiveness of a sanitary facility of a sanitation method. These are:

- Convenience and hygiene for the user (people need a toilet that, if not in the home, is at least very close and available).

- The extent to which human contact with excreta (and possibly waste water) can be avoided.

- The extent to which the facility is easily maintained.

The UNCHS study includes that, in particular reference to urban settlements, it is only water borne sanitation methods that ensure efficiency in high density residential areas.

- In line with a recommendation that high density residential areas should be served by a water borne sanitation method, over 95 per cent of the house units in Zimmermann estate have flushable toilets and other wet cores such as tap water supplied kitchens and bathrooms/laundry units within them. This means that there are no major problems in regard to getting rid of waste water away from the generating units since the units haven in-built waste water disposal system. However as soon as the waste water leaves the house unit, problems arise because the waste water tanks which are supposed to be disposal systems are overwhelmed. Direct consequences of use of ineffective waste water disposal systems in Zimmermann are a myriad of problems. These are:
- On average, 140 persons are served by 6 to 8 waste water tanks (i.e one per plot) but these

are cases where over 200 people are served by one tank. Resulting in unhindered flow of waste water onto the streets, storm water drains and subsequently into the river.

- The waste water tanks are too deep to allow aerobic decomposition of suspended organic waste resulting into unpleasant odours which characterize the estate. The odour from the waste water tank is further boosted by them stench emanating from partially decomposed waste along the channels through which overflow from waste water drains.

- Poultry within the estate namely ducks, geese and chicken feed from waste water streams and pools. They are later consumed by human beings. This traces an indirect way through which waste water suspended dirt gets to the human beings.

- Some streets are impassable while others are inconveniencing to use either because they are flooded or they are muddy because waste water drains on to them.

- Encompassing the above problems, is the occurrence of diseases. These diseases are caused by indirect ingestion of micro-organisms waste water or through provision of breeding grounds for diseases spreading insects such as mosquitoes.

A reflection on the socio-economic status of residents in Zimmermann estate portray people within the middle income bracket and who are expected to be environment courteous. This casts a shadow of doubt on the appropriateness of maximum population density which can be effectively served by a waste water tanks at the current population density of 30-40 persons per acre. This question can be answered by evaluating the effectiveness of waste water tanks in Zimmermann estate with an intention of probing the possibility of recommending a higher residential density which can be effectively served by waste water tanks.

1.3   **Justification of the Research**

From the number of illnesses and deaths attributed to diarrhoea globally, it seems fair to say that, human faeces remains one of the worlds most hazardous pollutant and related water and sanitation inadequacies still constitute one of the worlds most serious health problems (UNCHS 1996-7). Poor sanitation poses health hazards through several routes including direct exposure to faeces on human habitats, contaminated drinking water, ingestion of fish from polluted waters and ingestion of produce fertilized by waste water (UNCHS 1996). This, notwithstanding, urbanization and urban growth processes without attendant development in water and sanitation facilities, among other infrastructural facilities, has continued unabated in the urban areas of the third world countries. Among the worst hit sectors are the newly developed residential areas which are a product of the urban sprawl process. Such is the process that has seen the development of Zimmermann residential area, among other estates in Nairobi. In this area, high population concentrations are living in areas with inefficient sanitation facilities. The concept of package whole[1] in provisions of complimentary infrastructural facilities has not been observed. Such problems exist where there is a good and reliable water supply system but sanitation facilities allow waste water to form permanent streams and pools along the streets. In such a situation, it would have been better if the water system had not been provided. Better still, is to consider the water and sanitation provision half done and proceed to work on the remaining part of the package whole. The research is aimed at collecting information and to make recommendations on provision of the remaining portion of a package whole namely a sanitation system which efficiently disposes all waste water generated in Zimmermann.

Most of the research work in housing and environmental related undertakings have been

---

[1] The concept of package whole argues that there are some services which do not serve the general human goal of a good health for all unless it is accompanied by other complimentary services. In relation to water and sanitation, the concept argues that a good water system serves to better the health status of people only when it is accompanied by an equally efficient waste water disposal system (Mairura 1988).

focused on the lowest of the income areas. Little is known on the situation in middle income areas; yet it is in these areas where betterment of the situation can easily be carried out by the would be beneficiaries. Failure to identify problems which a resident community can resolve explains the reason why most of the projects manage to go only up to the report writing stage. The middle income earners have both understanding and financial capability to implement projects which better their well being. Denying such areas the much needed environmental betterment studies is holding back development programs that are implementable.

There are areas where the problem is more acute than the area of study. Mathare, Kibera, Kawangware and Korogocho informal settlements areas in Nairobi, are examples Both efficient water supply and sanitary systems are absent in these areas. If the need to provide a solution to the water and sanitation problems was the only criteria for choosing case study area, these informal settlement areas deserve the study. However, evaluation of previous studies show that a good number of studies have been carried in such settlement, but little is known about the middle-income areas. Zimmermann estate can be considered to be occupied by lower-middle income earners as opposed to the listed areas which are occupied by low income earners. Sanitation and water problems are worse with lower income groups. An elaboration of acuteness of the problem, in a higher income area casts some light on the situation in lower income areas and not the vice versa.

1.4   Hypothesis

Considering Zimmermann's high residential density, poor soil conditions, high water table and cost of emptying septic tanks, cess pits and conservancy tanks, the current

methods of sanitation are ineffective.

1.5   Study Assumptions

1.5.1)   Effectiveness of sanitation method can be directly or indirectly measured by evaluating;

-The ease with which waste water comes into contact with user.

-Emission of odours from the waste water handling tanks.

-The amount of untreated waste water that gets into the natural water bodies.

-Health costs the waste water pauses to the residents.

-Dangers paused by the waste water handling chambers.

1.5.2)   The amount of waste water produced from a given residential quarter is a factor of:

-The size of the population of the area in question.

-The number and density of house units which have wet cores and water closets enclosed within them.

-Reliability and constance of the water supply.

1.6   Study Objectives

The study objectives were :-

- To evaluate the extent of the effectiveness of cess pits, septic tanks, conservancy tanks and pit latrines in Zimmermann together with the risks associated with the methods.
- To establish a more effective method of waste water disposal in Zimmermann and other similar conditions.
- To establish how community/household action can be incorporated in sanitation management in an unplanned residential area and where housing development is purely private.

1.7 RESEARCH METHODOLOGY

The study objectives listed above were achieved through collection and and analysis of data. This section enumurates and explains the data collection methods and the analytical technique.

1.7.1 Data Collection Methods

Both primary and secondary data sources were used in the study. As means of documentation, diagrams and photographs were taken from the field.

1.7.1.1 Secondary data

This included a review of published and unpublished literature specifically publications in waste water management and those on demographic factors of the study area.

1.7.1.2 Primary Data Collection Methods

It involved administering of questionnaires, guided interviews, participant observation and informal discussions. This was obtained through conducting a survey through the study area and visits to key informants some of whom were situated outside the area of study.

1.7.1.2.1 Survey Organization

The primary data collection exercise was designed in such a way that data collected in one stage was used in the proceeding stages. The field survey was organized in four

stages namely;

i) Reconnaissance survey

This gave a general view of the study area. In other words, this was a familiarization tour.

ii) General observation survey

The stage involved a relatively thorough and more detailed observation compared to reconnaissance survey. General enquiries from the resident community as well as photographing were included in this stage. Finalization of the sampling design was done with the help of data collected at this stage.

iii) Discussions and interviews

iv) Administering Questionnaire

1.7.1.2.2 Sampling Design

Four principle primary data collection tools were used namely questionnaires, guided interviews, informal discussions and participant observation. The details of each of these is given below

1.7.1.2.2.1 Questionnaire

A set of questionnaires was subjected to the households. Simple random sampling was used to pick the plot from which the respondent household was selected. Out of the approximate 1200 developed plots, 60 were chosen selected by a way of using the plot sub-division plans. A plot was thus picked after every 200 making the sample to be 5 per cent of the plot population. Whenever the selected plot was found to be vacant the one nearest to it was taken.

The second level involved within plot sampling to select the respondent household.

Because of the difference in the levels of development amongst the plots, this level of sampling followed no definite sequence. However, there were efforts to interview households from a mixture of floors within the plots.

Household questionnaire was designed to extract information from the residents which will prove that they are not satisfied with the sanitation situation. Through the use of personal details on the first part of the questionnaire, household sizes thus the approximate population was established. Costs in terms of water bills gave an insight on to the probable amount of waste water generated, while income related questions articulated the socio-economic status of the residents.

1.7.1.2.2.2 Guided Interviews

The choice of subjects of interview involved selection from a limited number of alternatives. It is for this reason that no complicated sampling technique was necessary. Four interviewees were selected. These were two engineers at the sewerage department in Nairobi City Council and three out of six medical practitioners who operate private clinics within the study area. The basis of the choice was the three clinics which had operated longest. The other set of subject were five landlords two of who were also residents of the estate and two rental house informal brokers. The informal rental house brokers were, however, many but the number is sufficient because the brokers communicate amongst themselves meaning that there was no point of interviewing more.

The guided interviews gave an insight into the appropriate sanitation methods suitable for Zimmermann and cast some light on the appreciation of the existent of sanitation problems by the tenants and landlords. This kind of data would not have been obtained from the tenants, that is, by use of household questionnaire.

1.7.1.2.2.3 Observation

There were two levels of data collection based on participant observation. A guided observation served to prove the high water table, poor soil characteristics, condition of the waste water handling tanks, amount of out-flow from these tanks and high plot coverage which does not leave enough space for any other waste water disposal method other than a conventional sewerage system. This data collection method relied on a value free judgement of the researcher. The basis of categorization of the two levels of observation was the details required into:

1.7.1.2.2.3.1 The Whole Study Area

This involved general observation on the status of the streets and the environment within the study area in relation to waste water and the systems used in handling it.

1.7.1.2.2.3.2 Detailed Observation of Sampled Plot

This involved detailed and specific assessment of the status of waste water systems by use of a checklist attached to the household questionnaire. This means that simple random sampling used to select the respondent household was the one used. The waste water system in the selected plot was subjected to thorough inspection.

1.7.1.2.2.4 Informal Discussions

Investigative guidance to people involved in resolution of waste water related problems led the researcher to the chief and the civic leader of the study area. The interest was to get an insight into the kind of problems presented to them and the kind of solutions they

were offering. The two were in a position to give a general overview of the sanitation problem in Zimmermann as opposed to the other who would either given personal experience or technical information.

The informal discussions were intended to show further the inappropriateness of conservancy tanks, septic tanks as well as cess pits in Zimmermann estate.

1.7.2 Analytical Technique

The main research question was the evaluation of the effectiveness of the waste water tanks in containing the generated waste water. Three sub-questions helped in this evaluation. These were:
- Amount of waste water generated in Zimmermann estate
- Capacity of the neighborhood and the environment to contain the generated waste water
- Costs which were associated with operation and maintenance of waste water systems on the ground.

To consolidate the primary data into theme based aggregates of information, data was clustered to answer each of these three sub-questions by a way of dissecting further the aggregate data into finer groups. These were direct data classification into more specific groups. These included:

1.7.2.1 Amount of Generated Waste Water

This was divided into direct and indirect parameters. Indirect indicators were taken to be population characteristics, reliability and consistency of water supply and the nature of house units in regard to inclusion of wet cores and water closets. Direct waste water amount indicators were taken to be individual household water bills and the population

size.

1.7.2.2 Capacity of the Neighborhood and the Environment to Contain the Generated Waste Water

To assess the capacity of the estate to contain the generated waste water, two spheres were focused upon. This included assessment of the capacity of man made structures (waste water tanks) and the naturally provided drainage characteristics. Assessment of the manmade features involved focusing on size and design of waste water tanks while natural drainage elements included assessment of the type of soils and water table level. The two later constituted the sub-surface and topographical characteristics respectively.

1.7.2.3 Costs Associated with Sustaining Waste Water Disposal Systems

Analysis of information on the question was based on two types of costs namely monetary costs in form of exhausting charges and social and environmental costs. The latter included analysis of disease occurrence, environmental pleasantness and occurrence of accidents which were directly attributable to waste water disposal methods in the estate.

1.8 Scope of the Study

This study was confined to the effects of lack of basic infrastructure in a newly developing residential area. It specifically focused on assessment of the effectiveness of waste water disposal methods meant for low population density areas, but which have now been overtaken by events, such that the area has been converted into a high density residential area.

Zimmermann estate was the case study. The estate covers an area of 400 acres with each individual plot measuring about fifteen by twenty two and a half meters. Most of these plots have been developed into residential block some of which are as high as five floors. As many as 45 residential units (which are self contained[2]) are found in one plot. The generated waste water is disposed into a waste water tank serving each plot.

The principle variable which were evaluated included establishment of the amount of waste water generated, the capacity of the environment to contain the generated waste water and the environmental costs of sustaining waste water tanks in a high density residential area. It was against this background that the effectiveness of the current waste water disposal methods in Zimmermann estate was evaluated.

1.9   Study limitations

A number of limitations restricted the scope, coverage and detailing of the research work. First, sewer services consideration should cover whole drainage basins. Zimmermann estate and environs should have been considered. This, however, would have called for more time and resources.

Secondary, technical expertise and input was needed to facilitate accurate and detailed proposal in addition to costs of the implementation of the proposals. However, the study is urban-growth-oriented and could not have been reverted to a purely engineering oriented study. As such, the recommendations in this research are general to an extent that engineering technical studies are a requisite before implementation.

---

[2] Self contained house unit is that which has at least a tap water supplied kitchen, a bathroom/laundry unit and a flushable toilet.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.0   **Introduction**

Problems that are associated with urban growth have been documented for a long time (UNCHS 1996). This shows that most of these problems have been studied and solutions offered. However, the kind and magnitude of these problems have been changing hence the need to search for solutions that are equally dynamic. This search should start with an overview of the past to ensure that recurrent problems are not addressed as if they have just emerged. This shows the need to study the previous works that have tackled sanitation related problems. The intention is to investigate whether there are parts of the research hypothesis that have already been answered by the previous studies.

Secondary data and information obtained from the previous studies was reviewed in the context of the sanitation problems in Zimmermann estate. This formed the basis under which sanitation problems within the estate are related to the general problems that afflict the development of urban areas in the Third World. From this relationship the conceptual framework was formulated.

2.1   **Literature Review**

A review of previous studies in sanitation problems associated with urban growth was based on themes. These themes run through forces that bring about unserviced residential settlements, their impact on the environment, the development of policy that addresses sanitation related problems and the factors which make the environment seem

to be ignored in the process of evolution of solutions to the various socio-economic problems.

Background to Unserviced Urban Settlements

As the 20th Century draws to a close, urbanization has been one of the dominant issue the world continues to deal with. The population in urban areas has continued to rise with some previously less urbanized areas getting an influx of people as the urban areas increase in size.

In 1980, the total population in the developing world (excluding China) was 2211 million which is approximately one half of the worlds population. Of this 2211 million, 28 per cent lived in the urban areas and the general trend was towards urbanization (UNCHS 1981). In one of the latest documents by UNCHS the following statistics have been confirmed. Between 1990 and 2025, the number of people who live and will be living, in urban areas is expected to double to more than 5 billion. The biggest proportion of all this growth, calculated to be about 90 per cent will occur in the developing world (UNCHS 1996). In an attempt to show the aggressiveness of the expansion of the urban centres the following statistics have been filed:

"The average population of the world's one hundred largest cities was over five million inhabitants by 1990 compared to 2.1 million in 1950 and less than 200,000 in 1800. ....Soon after the year 2000, there will be more urban dwellers than rural dwellers world wide" (ibid. p.12).[3]

---

[3] UNCHS 1996), Urbanizing World, oxford University Press New York, USA (p.12).

The problem has, however, not been in the mere expansion in areal extent and the population sizes. The grave lack of urban population supporting facilities and services along with socio-economic and environment deterioration lines have accompanied this expectation. Spontaneous expansion of the urban centres has proceeded without noticeable input from planning circles; instead, economic, political and social forces have taken full control of the situation.

The changes imposed upon a city by urbanization process has almost been the same the world over but only in the direction of change. Problems of urban poverty, mainly due to unemployment, inadequacy of housing and infrastructure have been recorded in all urban centres and throughout history, both in developing and developed countries. What distinguishes the situation in the two types of worlds is the magnitude and intensity of these problems. This difference is a manifestation of the core of the problem which is rapid population growth in the wake of economic hardships. In what UNCHS (1995) describes as a development paradigm: the population of the developed countries has more or less stabilized while the developing countries are still in the blink of demographic and physical changes of a kind and scale never witnessed before.

To a great extent, a legacy of mismanagement of resources, on top of poor resource base, has been blamed for the backward state of the developing countries. Besides rapid urban increase in population in the developing world, the local governments are often cash strapped and do not have the resources to provide even the most basic environmental services for their residents (UNHCS 1996). This would have, otherwise, armed the urban population against a myriad of problems that plague them today.

Kenya is one of the countries in the category of developing world where all the urban centres have experienced and are experiencing, all the problems highlighted above. Nairobi the capital city, houses the greatest number and magnitude of the human

settlement problems. By 1989, Nairobi housed about 36% of the total national population (UNDP 1996). The capital faces a tremendous rate and level of expansion engulfing a previously agricultural peri-urban rim. The centre of the city, however, expands at a rate far below that of residential quarters as vertical developments (intensification) takes control as opposed to lateral expansion exhibited by the residential areas. Housing provision in the recommended densities, locations and level of servicing has been expanding at a rate far below the demand as dictated upon by the rate of urban population increase. The result is a situation where housing neighbourhoods designed to accommodate a certain population have experienced intensification through partitioning, extensions and higher per room occupancy. Infrastructure and services have as a result been overloaded to an extent that some have been rendered unoperational. Despite all these reactions the problem of housing deficiency still prevails. The urban population which has not been accommodated through intensification of the existing residential areas has created new residential neighbourhoods in previously condemned sites and distances from the city centre. This is what is going under the title of squatter settlements, slums, unserviced residential areas and other related terms but all of which describe unplanned settlements. Some of the major characteristics of unplanned low income residential areas are inadequate or complete absence of infrastructure services such as water supply and sanitation (Mairura 1988).

Housing (in totally of the term[1]) has become increasingly difficulty to provide in Kenya. The problem is worst in Nairobi. This is evidenced by the fact that 63-75% of the

---

[1] .... in overall environmental framework where communities in their various culturally accepted basic groups dwell and it has several important attributes such as shelter, privacy, sanitation, recreation, neighbourhood amenities as ...... investment.

housing units are unauthorized due to their poor standards (UNDP 1996). Current government policies and actions, be it local or central, in conjunction with the other housing agents have only managed to scratch the surface of the problem, especially in so far as services are concerned. The result is a situation where the concerned communities have to do the best they can for themselves. Because of the communities' financial inability, those in the low income bracket result to providing the most elementary needs to themselves namely mere roofs over their heads (shelter). This is the force behind mushrooming of slums and several uncontrolled and unplanned settlements on formerly peri-urban agricultural lands and grazing fields. Developments on such lands are cheap because of the distance from the city centre and the missing services, which, further pushes the price of land down. Water supply, refuse collection, convectional sanitary facilities, electric power supply and others are below the required standard and level, when present.

Studies on shortfall in housing standards has shown that there is a threshold cost below which, as Mairura (1988) puts it, housing cannot enter a recognized housing market. He further clarifies that, this does not mean that such a large number of households are homeless or without shelter but rather that the contribution of such structures towards housing stock is not officially recognized because they lank below the defined standard of construction servicing and/or accommodation (Wakely 1976). Investigations have revealed that 80% of Kenya's urban population lack effective demand for any form of convectional housing (Syagga 1987). This high percentage has always displayed an upward trend necessitating a change in altitude towards unplanned settlements. The role of these type of 'illegal' housing cannot be ignored any more.

The local authorities, parastatals and the central government are charged with the responsibility of providing services prior to its development. This is intended to make the subsequent residential developments be within a conventionally acceptable housing

standard. In pursuit of this goal the listed authorities have been allowed to levy service charges on the residents of any one given urban centre. This would then form the financial base of the authorities.

Nairobi City Council is in a financial quagmire. The results are diminishing level of servicing and, its operations nearing a halt. In almost all Nairobi's residential areas, unattended waste in form of garbage heaps, incapacitated sanitary system resulting in overflows onto the streets, run down road systems have become the land mark of the city. The worst hit areas are the residential quarters where such problems have been ignored for years. The government , however, recognizes that housing is not the shelter alone but only one item in a pack of services all of which define a residential environment. The problem thus boils down to shortage of housing which necessitates evolution of housing through self built systems, which ignore many ideals such as sewer systems.

2.1.2   Outcome of Unserviced Urban Residential Settlements

One of the best ways to ensure environmental quality upkeep is by service provision in urban settlements. Service and infrastructure provision is supposed to check concentration of activities on areas which cannot withstand them. Infrastructure services in regard to waste disposal have a direct role to play in environmental upkeep.

Most human activities negatively impact on the environment (Wood 1989). This impact is most pronounced where the intensity of human activities is high such as in the urban centres. The bigger the urban centre the more severe is the negative impact; especially when the services and infrastructure provided are minimal. In a bid to explain the impact. Wood (1989) points out that the use of natural resources gives rise to one form of pollution or another. Total elimination of environment polluting activities would in

turn mean an end to human civilization and diminishing population. Efforts are thus geared towards complete understanding of the possible and probable consequences of activities or their omission on the environment and not total elimination of environment polluting activities.

The term environment may mean different things to different people. Nevertheless, the variations in meaning will certainly include areas of air, water, plants and animals when viewed in relation to natural and man made features and activities to constitute the totality of human surrounding. One of the indirect ways of measuring the magnitude and intensity of human activities can be through measuring the effects of urbanization and urban growth. There are more positive than negative effects of urbanization and urban growth. Negative effects include strain on the existing infrastructure and services. Overcrowding and congestion give rise to other negative effects among them urban horizontal expansion (urban Sprawl) and proliferation of informal and slum settlements. This in turn gives way to environmental degradation and deterioration of physical infrastructure.

According to Stren (1987 problems of urbanization include;

i)   Acute water shortages in the residential ares.
ii)   Uncontrolled dumping of refuse and household waste within residential areas and city centres.
iii)   Pressure on social cultural-facilities
iv)   Escalating prices of food and other consumables
v)   Housing shortage
vi)   Food gap necessitating food importation

Among the serious problems, and which may be considered as a part of housing shortage problem, is lack of sanitary facilities. All major urban centres in Kenya suffer

from lack of standard housing as characterized by dilapidated or missing infrastructure. The problems are directly attributable to high demand. Lack of financial resource for servicing land for residential development further lenders the situation worse. As a component of the poor financial status, most Kenyans in urban areas are only able to secure accommodation in low income areas. As dictated upon by the socio-economic status, it is only a very small proportion of income available for sanitary facilities, this being in reference to the majority of the urban dwellers.

A trail of past failures in service provision creates a backlog on what is to be availed to improve the living conditions of the urban dwellers in low income areas. In some of these places even the most rudimentary services have not been provided. The low income earner has no one to look forward to: since the government and other housing agencies have failed him. As a consequence, he has resulted to improvisation thereby resulting in production of systems that least take care of the environment outside the housing unit. This neglect have evolved problems that have to do with open dumping, overflowing conservancy tanks and pit latrines coupled with lack of drainage systems. These are indicators of the contempt with which environmental issue has been handled, an aspect which can be attributed to ignorance, economic constraints and/or a combination of the two.

Among some of the issues that the community cannot effectively address on its own is sanitation especially where the residential densities leave no other alternative other than water borne sanitation. Previously, the tendency had been to wait for the local authority to run a mains sewer through such an area. All that remained for individual plot developers was to connect to the mains sewer and the problem of waste water disposal was solved. Nairobi City Council has been unable to provide such a sewer system in very many upcoming residential quarters. The result are areas characterized by high

population residential quarters which are served by sanitary facilities meant for low population density neighbourhoods among other inappropriate facilities and services.

The foregoing discussion shows that lack of services in urban areas is a problem that has been addressed for a long period. However, same type of problems seem persistent and almost homogenous over most urban areas in the Third world. These homogeneity and persistence may be an indicator of inadequacy of policy and/or resources needed for the alleviation of the problems in question. In a bid to further diagnose the cause of the poor status of the urban centres in relation to provision of services, a review of policy on infrastructure and service development is warranted. These policies transverse all scale of the human community meaning that they range from global to the individual urban centre in scale.

2.1.3   Infrastructure and Service Development Policy

The past displays a discrepancy between development situation on one hand and the stated guidelines on the other. This is particularly so in the infrastructure and service sector. This situation casts a shadow of doubt on how realistic the policy has been and whether it has always been based on the communities' aspiration in total disregard of what they can afford. These policies, conclusively, run through all the scales involved, be they global or national. The fact that the policy on infrastructure and service development have been treated at a global and national levels indicate that, it is an important element in alleviation of problems in question. The issue to be investigated are the reasons for which such a useful tool has not worked or at least not with the expected efficiency.

Referring to administration of services in Africa, Stren (1985) says that the provision of services is the duty of the local government, the central government and parastatals.

These agencies are also supposed to regulate these services among them water and electricity supply, refuse handling, sewerage network, public transport and housing. These is provided by the policy in a bid to show who is responsible for the provision of these services. Latest views on sustainability of development have modified this statement to include a level of the community's hand in the provision and maintenance of these services. Remarks of Akivaga (1987), that the level of services and infrastructure should be determined by the population density, reflect one of the guiding principles in provision of these services. Care must, however, be taken not to allow the rule of the jungle to operate within the community. The rule states that those who cannot afford services do not deserve them. Mairura (1988) contends that development of some services such as water supply and sanitation as public goods and services to be the duty of public agencies. Further, he adds, there are several things cannot be feasibly provided through the ordinary market mechanism. It is more efficient for the community to consolidate their efforts to achieve these services. This implies the need for government intervention, if not in provision of the same, at least to coordinate the efforts of the community.

From a global scale, the United Nations report of 1976 termed it uneconomical (at least in the long run) to have squatting activities in place with an intention of delivering services later. First, the make shift construction is expensive to the people involved and secondly, installation of services and infrastructure involves either taking longer routes or demolishing some of the structures; any of which means an added cost. These comments were investigated to facilitate appreciating the fact that sanitation service provision is inevitable if the health condition of the inhabitants of low income areas is to be ensured.

In recognition of the high child mortality rate and low life expectancy due to inadequacy of water supply and sanitation, UNCHS (1976) first articulated the objective of

extending basic services to all the people by 1990. This policy guideline was endorsed by the United Nations Water Conference held in Mar del Plata in 1977 where a recommendation to make 1980-90 period the International Drinking Water Supply and Sanitation Decade was arrived at (UN 1977).

In Kenya, historical information has progressive development in policy on infrastructure and service provision. Recent developments reflect a previous bias in service provision against the rural areas. This bias has been diminishing with time although the high population density in the urban areas justify this kind of bias. Nevertheless, contradiction over the population density and level of provision of infrastructure and services seems to arise; by considering the low income-high density vis-a-vis high income-low density urban area. Urban slum areas and squatter settlements have the highest population densities in the country, yet they are least serviced.

In the recent past, development of informal settlements used to be met with a brutal force by the city planning-regulations enforcing agencies. The immediate response to the blight caused by unplanned urban low income settlements was initially to demolish them. Due to the various socio-economic and political pressures as well as appreciation of the role played by informal settlements in provision of shelter, this policy has now shifted to partial acceptance of the settlements (Syagga 1987). Mairura (1988) adds that new strategies have been developed towards solving the problem of inadequate housing. One such strategy is upgrading of the unplanned settlements. This program includes provision of infrastructure such as water and sanitation. Though well intended, the result of this approach in development of informal settlements has greatly contributed to the proliferation of unserviced residential neighbourhoods.

Various clauses in the laws of Kenya reflect the government's position in regard to provision of water and sanitation. The legal requirements in provision of water and

sanitation clearly shows the existence of both intentions and a machinery towards this end. Section 115 of cap 242 (Public Health Act) of the laws of Kenya states that, it is illegal for persons to cause nuisance or any other condition which is injurious to health. Section 118 of the same cap specifies that sanitary facilities may be injurious to health thus must be given special attention. Other listed sanitary facilities are foul ditches, gutter water courses, cisterns, water closets, cess pits soak-way pits, septic tanks, drains and sewers among others. It makes it punishable by law to allow water from any of these spheres to drain into channel which are not meant for that purpose. Section 126 A part B and paragraph (i) gives the local authority a responsibility of regulating sanitary conveniences in relation to drainage, cess pools from buildings. Paragraph (v) of the same section empowers the local authority to regulate private sewers and communication between drains and sewers. The Physical Planning Act Section 36 part V makes it illegal to a have a development plan which is not accompanied by a environmental impact assessment especially in reference to dump sites and sewerage treatment works. The underlying intention is to ensure that the environment is given the consideration that it deserves.

Provision, management and sustenance of services and infrastructure have proved difficult. The government and its agencies have shown that it is no longer feasible to provide free services. The goverment have adopted strategy to ensure better services going under the burner of cost sharing. This should not be construed to mean that Nairobi City Council has relinquished its obligations of ensuring comprehensive services in the area under its jurisdiction. Contrary, there has only been a delegation of part of the responsibility to the beneficiaries. This conclusion holds as long as the national policy of providing clean water and environmentally acceptable sanitation facilities by the year 2000 has not been repealed. It is the modality of achieving it which has been changed. Relaxing of some of the sections of the policy should be balanced

with tightening of some others. This has not been the case explaining why the sanitation situation in the urban areas is in disarray.

Could it be that the problems paused by inefficient disposal of domestic waste water has not been understood ? The answer to this question is scarcely positive considering the efforts which have been made as reflected by the various studies and governments policy guidelines on the same. However. lack of commitment to abide by the laid down disposal methods and procedures reflects some level of ignorance on the nature of domestic waste water among other things. An understanding of the need to efficiently dispose off waste water can be boosted by reviewing what waste water is. This is the focus of the next sub-section.

2.1.4   Operational Definitions

Waste water is that water perceived to be of no use presently and in the future. A great proportion of the water consumed in a household ends up as waster water. Waste water is an aggregate of sewage and sullage. as effluent from a household. and storm water. With the exclusion of storm water. Mara (1982) refers to waste water as domestic sewage. Sullage and sewage are waste waters coming from different quarters of a residential house. Sullage is generated from all domestic water-using activities excluding human body wastes; namely of faecal and urinal origin both of which make sewage. Sullage is also known as grey water and is generated from food preparation. washing of household items and clothes. Domestic waste water. in its totality, is a mixture of sullage and sewage from a residential house.

For a supply connection with a water closet within the house 80% of the water consumed ends up as waste water (Design Manual for Water Supply in Kenya 1986 pp. 86). Smart and Herbert (1992) contend that the volume of domestic sewage produced is

similar to the volume of the water supplied. Estimation places the volume at 220 Liters per capita per day, although these figure is for Europe.

The reaction of man towards waste water is to dispose it and at a site out of reach by senses of feeling, sight and smell. This is because human consciousness detests the presence of waste within his habitat. Waste water needs to be removed from the humans dwelling place through a number of methods. Draining it out, regardless of where it flows to, is one of the most rudimentary methods of disposal on one end while disposing it through a sewerage system marks the other but sophisticated end. Mara (1982 pp. 19) defines a sewerage system as a network of drains, used to collect the liquid and solid waste of a city for subsequent treatment and disposal. Sanitary sewers, therefore collect waste water from the plumbing systems of buildings and convey it to the sewage treatment works.

Nature of Waste Water

Man has rarely managed to achieve an ideal solution to any one problem. Disposal of waste water in a manner that keeps it out of his senses is not an exception to the rule. In a number of instances, waste water finds its way to unintended spheres. Of the most sensitive spheres, where waste water finds its way is into drinking water sources.

According to Smart and Herbertson (1992) pollution of rivers by sanitary systems is the most common form of natural resource pollution. Smart and Herbertson (1992) have classified drainage discharges, which affect water quality into four groups; first are those discharges containing oxygen-demanding substances be they of organic, faecal or inorganic nature. The second group is that which contains substances which physically hinder re-oxygenation of water surface such as oils. Discharges containing toxic compounds form the third group while discharges with high percentage of solids, which

inhibit biological activity by excluding light from penetrating into the water or coating the bed, make the fourth category. This is a characteristic of all waste waters regardless of the place of origin; the only varying characteristics being the percentage composition of each of the four categories of pollutants.

In reference to domestic waste water Smart and Herbertson (1992) contend that, in addition to human faecal waste, domestic sewage contains detergents and other household chemicals and waste from food preparation. This water and its load enters rivers in three forms. It can be in form of effluent from the treatment works. This happens to be the purest form that the waste water gets into the natural hydrological cycle. A worse form is when dilute waste water gets into the system as a result of increased flow. This happens during the wet weather and in places where the sewer system incorporates the storm water drainage system. The worst of the forms is when undiluted sewage gets into rivers, or the environment in general, as a result of old or poorly designed systems (Smart and Herbertson 1992).

The foregoing discussion (in subsection 2.1.4 above) shows that poorly disposed waste water not only makes the residential neighbourhood inhabitable but that it introduces some undesirable elements in the environment thereby negatively impacting on it. The contents of waste water have a pronounced polluting effects if it gets into the environment in its law form. It has already been shown that undiluted waste water from leaking sewers or that which is directly flowing from inappropriate sanitation facilities, has the most pronounced polluting effects. This information seems to appreciated by many urban management authorities. But is this appreciation reflected on the current urban status in relation to provision of efficient waste water disposal systems. This is the subject of the proceeding subsection.

Sanitation Situation

Despite the precise and strong wording of the policy objectives (discussed in subsection 2.1.3 above), the sanitation situation in most Third World urban areas are far from satisfactory[5]. This observation questions the reality of the policy and the commitment of the urban management strategies in Kenya. Policy makers and waste water disposal systems designers in the Third World have aspired to achieve water-borne sanitation standards like those of the developed countries (UNCHS 1976, Agarwal et al 1980, Mairura 1988, UNCHS 1996). This has in most of the cases failed and when successful, it only manages to serve a very small population mainly because of its prohibitively high cost. The backlog in provision of services has, as such, grown big to a point where most governments in the Third World countries are inherently discouraged from taking corrective measures (Mairura 1988)

[5]   The inadequacy of sanitation in Third World urban centres have been documented in many urban management studies, among them:

.... Urbanisation ...., ... University Press, New York USA.

...... W. and .... Minimum Environmental Sanitation Package .... Nairobi ...... Kenya.

....

Kalbermatten John et al 1982, Appropriate Sanitation alternatives, A planning and design Manual. John Hopkin University Press.

One fact seems to be ignored in the production of housing quarters with no sanitation facilities. Shelter developments which are not accompanied by service infrastructure, convectional sanitary system in this case, triggers a chain reaction of self-destructive events all of which amount to environmental degradation. The concept of the package whole, mostly so in water and sanitation facilities, should not be ignored because the consequences are dire. Mairura (1988) put it this way;

"the development of an improved water supply service that is not accompanied by effective sanitation and public health education programmes could itself create a worse problem than that which it was initially intended to solve"[6].

The same can be said of inadequate and poorly designed sanitary facilities. The rampant high infant mortality rate, low life expectancy and gastro-intestinal diseases in the developing countries are largely attributed to poor water supply and sanitation (UNCHS, 1976). It had been verified that more than 80% of the total disease load in the developing countries could be directly related to the absence of clean drinking water and adequate sanitation. Dr. Halfdan Mahler (1976) appeals for change of perspective in planning in regard health in developing countries. He says that the number of water taps per 1000 people would be an infinitely more meaningful health indicator than the number of hospital beds per 1000 people (1977).

The foregoing discussion is a prelude to the point that sanitation facilities provision, their proper designing and management as the hub of the environmental care cannot be overemphasised. The recommendation has been that, sanitation services deserve

. . . . . (1988) Development   f Water and Sanitation Infrastructure   .
. . . me Settlement f . . . . . muku and Kanyango, M A Planning Thesis

priority, if not because of its influence on the quality of the environment that must be protected, because man must be seen to survive (Ibid pp. 143).

World statistics on provision of sanitary facilities are worrying. WHO figures showed that about 71% to 75% of the people in developing countries had been served with excreta disposal facilities between 1970 and 1975. The figures fell to 53% in 1980, though partly due to change in definition on acceptable services. This figures account for all such facilities irrespective of how rudimentary they were. It has been accepted that most of this facilities had not fulfilled at least one of the attributes of a good excreta disposal system, ranging from allowing direct human contact with excreta to letting off an odour. Some of the figures given to show the proportion served seemed grossly exaggerated. Those that seemed plausible were, for example 8 per cent coverage by the system in Zaire and 23 per cent of Burma's urban population. It was later learnt that some governments excluded what they were considering as illegal settlements or considered them to in the rural areas simply because they fell outside the official administration boundaries of the urban areas (Agarwal et al 1980). About 2 million of those that had excreta disposal systems were using simple pit latrines. Of those with better facilities, only 550 million had house connected to a public sewer while 220 million were using septic tanks. The worrying point is that the number of people lacking adequate sanitation in the south had increased to 588 million in urban centres and 2.28 billion in rural areas in 1994 up from 452 million and 2.15 billion respectively in 1990. A worsening situation is reflected by projection of these figures to the year 2000. 3.31 billion, which will be half the worlds population, will not have access to adequate sanitation facilities. This will include 846 million urban dwellers and 2.5 billion rural dwellers (UNCHS, 1996).

The above statistics prove how expensive it has been and has become, to provide convectional waste water disposal systems. Based on household incomes, sewerage

systems and treatment plants were far more expensive than a colour television set (Agarwal et al 1980). Considering this fact, policy makers and designer of waste water disposal systems should take it that; this brand of sanitary system is both unnecessary and undesirable. How unnecessary and undesirable these systems are have been displayed by what happened both in Ghana in 1963 and in India. A sewerage master plan that was completed in 1973 and covered 5 kilometres square of Ghana's capital, Accra. First, the small area of coverage by the system was due to financial constraint. What's more ? By 1977, only 171 connections had been made. This would in turn mean that the cost on each connected house unit if it is only the connected household which were to pay for the system would have been $20,000 per connected household. Quite clearly, only a meagre number of urban residents could afford such a bill especially when it is earmarked for sanitation only. The government could not have forced people to connect, even when it had strained hard to put the mains sewer in place. Technical difficulties have since then cropped up, due to the insufficient flow through the sewers solids settle in the pipes and trucks must flush the system regularly otherwise it would get blocked. Some parts of India's urban areas are facing similar difficulties the situation being that it has been easier to provide the main sewer than to persuade people to connect to it (Agarwal et al 1980).

The sanitation situation in Kenya, like the rest of the Third World countries, is not satisfactory. Few urban residents had access to sewerage systems. Kenya, among other African countries is unusual in aiming to supply sewerage services, to urban population on a wide scale. Many factors make the operation of sewer systems in Kenya ineffective. Among such is the high correlation between availability of water inside the housing units and private flush toilets. Kenya had 21.8 per cent of urban dwelling which had private flush toilets in 1986, while the rest used communal toilets or pit latrines. Most of the pit latrines are in low income areas where there is lack of water. In addition cleansing services, such as exhauster and garbage services were either carried out by the

local authorities or private companies contracted by them. Public authorities in Kenya have provided inadequate cleansing services (Lee-Smith and Syagga 1988).

A close follow up of the problem of sanitation gives a trend where the problem grows worse with size and density of the settlement. Expensive as the system is, water-borne sanitation facilities seem to be the only effective methods in high residential areas (UNCHS 1996). Most of the inhabitants of such areas have not been served by a sewer forcing them to use waste water tanks and pit latrines, their inefficiency notwithstanding. As such excrement and waste water, with it's full load of pollutants, effortlessly ends up in canals, gullies storm water drains, ditches and finally to rivers.

A reflection on the totality of the foregoing discussion proofs that most, if not all, human being prefer to reside in well maintained environment; one that ensures disease-free status and aesthetic pleasantness. Contrary to these preference, most end up living in environment which is characterised by the very elements they detest, for instance pollution. This is an indicator of the existence of forces that peg the community in situation they would have otherwise preferred to stay away from. This therefore shows that there exists human population distributive rules which cannot be just twisted. Socio-economic factors may bind a community to environmentary degrading activities as the only way to ensure their survival. For an assessment of how man finds himself in an environmentally degraded neighbourhood, a review of how socio-economic factors rival efforts to maintain or stay in a pleasant residential environment is necessary.

2.1.6 Socio-economic Versus Environmental Factors

Taking care of the environment is one of the elementary factors that are taken into consideration if sustainability of human activities is to be achieved. Good human health is largely determined by the extent to which negative environmental impact has have

been minimised. Environmental maintenance on the other hand requires an investment of the already scarce resources. Simple rules governing investment of scarce resources dictate that priority be given to the projects with the maximum and most immediate benefits but only as far as the person taking the investment can see. This rule brings out a scenario where socio-economic and environmental benefits have to be weighed and investment made accordingly. The criteria used to decide whether to invest in environmental improvement or economic projects is the focus of this sub-section.

Of all human activities, environmental pollution is the most perversive (Edington 1977). The problem has, however, assumed new dimensions in terms of magnitude and intensity especially so during and after Industrial Revolution (19th Century onwards). Environmental pollution has been attributed to man's desire to make progressively higher socio-economic returns at the expense of the environment (Batch 1972 pp. 1). This is evidenced by overcrowding in urban settlements among other human activities. The densities in such areas are due to mans tendency to cover as much space as possible within the least possible cost. Negative impacts on the environment arising from such activities are worse in places where infrastructure and services have not been provided. The reason behind the missing services is that there, are higher and more direct gains from housing units compared to those derived from maintenance of the quality of the environment (McAllister, 1980 p. 12). Much as these statements are correct, it is also apparent that some situations dictate that environmental issues be kept aside first and attention be given to more pressing needs such as securing food and shelter. This means that those living in the unplanned settlements have only scumbled to forces that they could not have resisted. This situation is as a result of a conflict between faculties governing the human values, conduct and behaviour. Much as any human being places a high value on a good environment, economic pressures necessitate that less be invested in environmental cleaning. For instance a household requires both indoor space and the general outdoor space for movement, sanitary facilities and open space for ventilation

and social and recreation activities. Although mans value system development tends to follow impulses of compatibility and harmony, conflicts among these values are invertible when parameters such as limited time, energy and resources are incorporated as some of the decision making determinants (ibid). Viewed in the light of residential environments, choices other than the best (one which have all the supporting services and infrastructure) are taken in line with what the bundle of the available resources enable one to achieve.

It is true that the house structure and the outdoor space with appropriate infrastructure and services make a harmonious combination. On the other hand, the resources are limited to such an extent that, low income earners cannot afford this optimal standard. The result is a residential neighbourhood which matches what the residents can afford. Rationality dictate that house structures be accorded greater importance while the rest can await a better economic situation, whenever that will be. Abraham Maslow had a more comprehensive coverage on the modality through which such a decision is be arrived at. He contends that, human beings', like the other animals', actions are geared towards survival. These actions are as a result of a list of needs each of which has a different value. He evolved a list of needs in an ascending order of importance hence the descriptive title of Moslow's Hierarchy of needs. He recognizes five basic needs that are a requirement to all people and cultures. The proposition has physiological needs at the bottom, then safety, belonging, esteem and self actualization at the bottom. The proposition further clarifies that the lower category of needs must be fulfilled before the successive higher need. This implies that, it is only after physiological needs have been attended to, that safety will be looked into. Physiological needs include matters to do with body functioning requirements such as food, water warmth etc.

To explain how some of the needs in the higher levels of Moslow's hierarchy of needs are never addressed, Mairura (1988) says that, ends have value in so far as there are

means to achieve them. Values governing behaviour, he adds, are not focused on ideals but on ends-in-view. Unserviced residential areas for low income earners, therefore, are only a reflection of deficiency of resources. Shelter constitutes a physiological need. Sanitation seems to be in the safety category, in that it is supposed to check against illnesses. This is the case even after considering the most elementary of sanitary facilities. Water-borne sanitation facilities will even rank higher because they are meant to provide convenience hence can be lumped into the "esteem" providing need. In this case a water borne sanitation system is the ideal whereas a pit latrine is an end-in-view.

It should not be, however, forgotten that what is viewed to belong to what category of needs in Moslow's Hierarchy of needs is situation dependent. A water-borne sanitation situation is only ideal in low density areas. Considering a residential area with population density provision of the same almost is the basic minimum. As soon as the waste is away from the production site, the problem can assume a different dimension. This happens when high density residential areas are not served by a sewer system. In such a situation, what remains o be done is to provide a system that carries the waste from the doorsteps of the residential blocks.

When looked at from waste management point of view, individuals only mind their most immediate surrounding. They are least bothered about the inconvenience they may be causing to other members of the neighbourhood. This is what Mairura (1988) looked at in terms of a conflict between personal and social values. Hardly do the individuals concerned consider that it is just a matter of time that the effect of poor waste disposal affect the whole neighbourhood including themselves. In order to contain problems emanating from individuals selfishness McAllister (1980) recommends the creation of central agency in the development of waste disposal systems; more so by regarding them as public goods.

•This situation has made most services, which are fondly associated with urbanism, to become progressively unaffordable. UNESCO report on affordability of important socio-economic infrastructure brought into the limelight the enlarging gap between the needs of infrastructure and the capacity of the urban residents to pay for them. Sanitation facilities expenses can be categorised into installation/construction, running maintenance and repair costs. These three categories of cost should be evaluated in view of the proportion of resource that a given community can allocate to sanitation. Cases where colossal amounts of resource have been used in construction of a sewage system only for the intended users not to connect have been reported in Ghana and India (UNCHS 1996). In Nairobi, lack of regular maintenance of the sewer system is a great contributor to the permanency of sewage streams in most estates.

One of the easy ways of addressing a problem facing a community has been to search for other areas where that kind of a problem has been addressed. Sanitation related problems have not been spared by the easy found solutions; but only to the disillusion of all the parties involved. Mbugua (1980) and Kalbermatten et al (1982) had taken note of this tendency and criticized the indiscriminate adoption of water-borne sanitation method as the only acceptable method of sanitation. Agarwal et al (1980) attributed this rate of adoption fascination about the western standards of living in total disregard to economic prosperity. The same methods cannot be expected to be effectively operated by countries characterised by low income people who constitute the majority of the Third World countries. Agarwal (1980) also blamed the multi-lateral and bilateral aid institutions which prepare feasibility studies and master plans and further make it worse by insisting on western engineering consultants who may often know nothing else other that water-borne sanitation technology. This is, however, only a part of a deep rooted problem on the part of the bigger populace and their representatives. An example which verifies this fact is the 1974 Nairobi City Master Plan for Sewerage and Drainage which was pegged on an assumption that the population would be willing and be in a position

to pay for water and sanitation services proposed therein (City Council of Nairobi 1974 pp.5). The truth is that this assumption is conflicting with the reality. Residential land developers are in almost all the instances not willing to pay for sanitation facilities while the tenants will normally not be in a position to.

The scenario displayed by this kind of conflicts is a reflection of high but misplaced expectations. The fact that the primary objective of providing a sanitation system is to improve health condition is normally disregarded. This objective can be attained fully by sanitation technologies which are much less costly than a sewage system (Mairura 1988). Water borne sanitation is only meant for user convenience even when its requirements in terms of resources to be invested and running costs are in multiples of other sanitary facilities (ibid). Further, consumer convenience cannot be the primary goal in many Third World countries, at least for the moment. Elizondo (1980) shares the same sentiments and draws a parallel between intentions behind technological advancement the west and the south. In the south (Third World countries) technology should be aimed at survival while that in the developed world is aimed at increased consumption and convenience. As long as the sanitation system fulfils the qualities listed below, it will have served its purpose regardless of the cost. First, it should not contaminate the surrounding, ground water, springs and wells in the area. It should also be designed in such a way Statistics indicate that 59 per cent of the urban population (excluding China) had not been served by sanitation facilities in 1983 (UNCHS 1996). Environmental related problems are noted to worsen with time meaning that the percentage is even higher today. This is confirmed by the outcome of the evaluation of the UN declared Decade for Water and Sanitation (1980 - 1990). The percentage of people having access to adequate excreta disposal has actually decreased since the decade began (Subrahmayan and Wjetanonic, 1986). Safe drinking water and sanitation provision for all by the year 2000 for developing countries require capital investment which cannot be met even if all the domestic product was directed towards

that end only (UNCHS 1976). This shows the need to have national efforts directed to elimination of the problem.

Consideration of the factors which have produced residential environments which are not desirable have cited socio-economic constraints as the stabling block. Evidently, there are more pressing needs which are favoured by the process of allocation of scarce resources. Parallel to this, the problem of provision of efficient waste water disposal systems keeps on being postponed indefinitely. On the other hand, the negative effects of insanitary residential neighbourhoods continue to bite. The only solution to this problem, thus, is to provide cheap but efficient waste water disposal systems. The systems should be cheap enough for any one particular neighbourhood.

2.1.7   Effectiveness and Affordability of Sanitation Technologies

Sanitary facilities which cannot be afforded by the intended users are not only a wastage of funds but are also the greatest contributors to the poor sanitary condition of most urban centres in the Third World countries. Mairura (1988) observed that actual implementation of most important infrastructure service is held back by the prohibitively high cost, on top of the big blocks in which the resources must be availedthat there is no need to handle fresh faeces and that these faeces should no be accessible to the flies, animals or other people. Lastly is the requirement that the facility should be releasing out minimal bad smell (Ndegwa 1991).

The ultimate goal of providing waste water disposal system is to safeguard community health through the promotion of a safe environment (Keeble 1959 pp. 235). Systems that would minimise the cost but fail to safe guard the purity of the environment may be termed useless. It would thus be illogical to recommend on-site sanitation technologies in places where it is only water-borne sanitation system that can effectively deliver. Soil

conditions and housing density may preclude reliance on-site waste disposal technologies. In such circumstances investment on off-site disposal technologies become a necessity. This may at times be the only way to ensure that all the functions which define a good sanitary system have been fulfilled. This should be considered together with the fact that some on-site systems may prove very expensive especially when operated in high density residential areas on top of not meeting the qualities of a good sanitary system.

A study carried out by Kalbermatten and Gunnerson (1979) showed that, it is more expensive to operate septic tank system than a sewerage system in high density areas as evidenced by the table below.

	Total investment ($)	Monthly maintenance ($)	Total monthly cost ($)	Percentage income of low income household
Pour flush toilet	71	0.50	2.00	2
Pit latrine	123	-	2.60	3
Vacuum truck cartage	107	1.60	3.80	4
Bucket latrine	192	2.30	6.30	7
Composting latrine	398	0.40	8.70	10
Aqua privy	1100	0.50	14.20	16
Mains sewer	1479	10.80	23.40	26
Septic tanks	1645	11.80	25.80	29

Table: Costs of different types of sanitation methods

Source: Appropriate Sanitation Alternatives by Kalbermatten Julius and Gunnerson, World Bank, 1979.

The solution to the problem of poor sanitation in the Third World countries is to be found in adoption of low cost sanitation methods. This has been possible in rural areas where population concentration is relatively low. Due to lack of alternatives, the urban population in the low income areas use sanitation methods meant for low population density despite the fact that such areas have the highest concentration of persons within the region in. The available, high population sanitation methods are too expensive for low income earners. The following sub-section reviews the extent to which the poor sanitation problem in high population density urban areas have been catered for by lowering the design standard of water-borne sanitation technologies thus making it available to urban communities that would otherwise, have not afforded them.

2.1.8   High Population Density Low cost Technology

There are areas where the population density, soil conditions or both do not allow any other sanitation technology other than water-borne if effectiveness is to be ensure. This method allow off-site disposal of waste through a pipe network. The system can either be a sewerage system or septic tanks. Construction and maintenance of septic tanks which would effectively high density residential areas is one of the most expensive available sanitation system. It can also be termed a wasteful undertaking considering that septic tanks have high land requirements. It, therefore leaves no other long term solution to waste water management problem other than a convectional sewerage system.   According to Kalbermatten and Gunnerson (1979), this is one of the most expensive sanitation systems. The plausible consideration is whether the standard of design must be maintained or that it should be altered to accommodate affordability. This becomes an important

consideration when the community and the agencies concerned can not afford such a high standard of a sewerage system (read unaffordably high cost of sanitation).

2.1.8.0 The Developed Countries Sanitation Design Standards; the Unaffordable Option for Third World Countries

High standard and sophisticated waste disposal systems are not a requirement for a high level of general health. To support this remark was the outcome of a 1980 study in Kyoto, Japan, which showed no health differences between sections of the city served by a high standard of sewers and septic tanks, and sections served by a well organised manual collection of night soil (Argawal et al, 1980). This offers some hope to the Third World countries since it just places weight on the management of the sanitary system regardless of how rudimental it may appear. For high density urban populations, the standard of the sewer system can be relaxed as long as maintenance is regularised. This seems to be the only way out of sanitation problem because the resources needed for investment of a copy-right sanitation standard from the worst are not available in Third World countries. No one country in Africa could provide the urban population with these services, at the standard from the industrialised countries, even if all the nations net saving were to be diverted to this cause only (Winblad 1972 pp. 3). The only option is to device ways of altering the specified standards to suit affordability of the community concerned. This should, however, be done only through a scale that does not lender the method useless. This is normally what goes under the burner of appropriate technology.

The use of the term appropriate technology has elicited some controversy. Edmonds (1981) termed appropriate technology not an alternative answer to a problem, but purely as technology that the developing world can afford to use at their level of development, resource endowment and presumably their commitment to attain a new social order that

benefits all members of the society. The future of the systems produced through the use of appropriate technology seems to bother some quarters of the society. The questions raised revolve about what would happen when these systems are outdone by dictates of the expected state of improved economy. Does this not mean a fresh installation of a totally new system ? Edmond (1981) attributes this kind of worry to the perception of the inhabitants of the countries in question. Appropriate technology, according to him, has already been taken as some kind of alternative, in most cases labour intensive and rudimentary way of curing the blatant inequalities in developing countries and which will then be discarded when these countries become capable of mastering the technology used in industrialised countries. This is what the developing countries are aiming at.

Worries about what would happen to obsolete technology may manifest a commitment towards forward planning, but not when it is taken this far. First, a sewage system has an expected life span regardless of the standard of construction. All infrastructure, indeed. subscribe to this principle. Secondly, the worry is attributable to eroded history. The developed countries have attained their present level of development through innovation and subsequent discarding of obsolete technology. The third point revolves about postponement of problem solving as a solution to the same. Should problems be left to take toll on the community just because they create some new problems in the future if they are solved ? Planning as a cyclic process involves solving problems that have been created by solutions to previously perceived problems. This implies that adapting the convectional sewerage system to suit the existing socio-economic conditions should be given a go ahead as long as the emergent system is worth the committed resources. The bottom line of these conclusion is an observation made by Argwal et al (1980) that, "no one design is better than another from a health stand point".

Relaxation of the Design Standard as a Solution the Problems in the Third World

Relaxation of the standards of construction has been tried in Brazil and Pakistan with very good performance. This has offered promising low cost sanitation technology for use in low income areas. The modification was is going under the title of Shallow Sewer System. It was developed by the Rio Grande do Norte State Water company of Brazil specifically for low income high density squatter settlement area. As its title describes, it consists of a sewer laid at shallow depths with small inspection chambers replacing manholes. The system has been operated with outstanding success in many low income areas in Brazil. In some instances it has been found to be more cost effective than on-site systems residential density exceeds 150 persons per hectare (UNCHS 1996).

Realisation of the fact that the developing countries cannot afford the conservative design standards developed in the industrialised countries stimulated the water company to undertake alteration of the approved sewerage system. The government had reached a state of despair in ever providing a sewer system to the low income. It is this alteration that brought some life in provision of sewer services. The high cost of the convectional sewerage system always made the government to keep on postponing the investment indefinitely. The shallow sewer system came in at the light time: with its major advantage being that it could be installed at a fraction of the cost of convectional sewerage system.

About 15,000 people. 10,000 of which are reported to have been below Brazil's poverty line were living on 50 acres of land. Frustrated by the appalling sanitary conditions and with the absence of any other economically and technically feasible sanitation technology condition, they opted for a sewer design that they could afford. The specifications of the design were based on relaxing the standard of the convectional

sewerage system. The minimum pipe diameter was reduced to 4 inches and the minimum slope relaxed to 1:67. Common house connections were laid at the backyards with the households accepting responsibility for their maintenance. This system covered 97% of the population and had no hitches reported in performance for five years. The community had taken full responsibility over the system as manifested by the fact that they paid for the entire capital and maintenance costs. The idea has provided successful and affordable system to an extent that, dozens of communities around the pilot project area for example in Natal and elsewhere in Brazil have adopted it.

To get the system working, a lot of other adjustments other than technical standards relaxation had to be undertaken. Among such was ensuring that the community was included at each and every stage of the project. Tariff schedules for repayment were also redesigned to enhance full community participation, even by those who, would have had problems in repaying. One more important change was undertaken in changing the status quo which was the main barrier to the progress of the society in improving sanitary conditions. The previously restrictive legislation and standards were removed.

The shallow sewer system has also been adopted in Pakistan where one more technical change on the flush system was made. Due to water scarcity in Chisty Nagar (near Karachi) the system has been redesigned to use 27 litres of water per capita per day. This shows a major difference between the shallow sewer system and the convectional sewer system. The cistern flush toilets attached to the latter uses excessive amount of water (in the order of 50-100 litres per capita per day (UNCHS 1996). This is a good indicator of the fact that the shallow sewer system is economical in terms of both installation and running costs although it may have higher maintenance costs because of the likelihood of blockages. Pakistan's sewer costs amounted to less than US $45 per household to install the whole system. These costs include fixing of squatter plate,

toilet grease and sand trap, house connection, lateral sewers, collector mains and primary treatment facility.

Another important lesson from this section is that success in sanitation problem solving calls for input from the beneficiary community. Failure in effective provision of sanitary facilities in the Third World urban centres is attributable to lack of community participation. The community waits for the government and other agencies to provide the services. This only serves to create a longer route through which resources have to go through. Provision and maintenance of sanitary facilities by the local governments only be describing an unnecessary long procedure. The procedure delays at best and chances of misappropriation of the collected funds are increased. Direct community participation by-passes all such loopholes.

Community Involvement in Waste Water Management

For long, it has been assumed that the communities are not aware of their infrastructural needs, mostly so with the low income earners. Decisions about provision of the same, therefore, made from above depending on what the technical personnel deemed right for the community. However, it has now been recognised that this top down approach has been the major reason behind many initiatives and that the communities know their needs meaning that there is a need for them to be consulted and involved in the decision making process. Community participation is gradually becoming a component of all infrastructure planning and decision making (UNCHS, 1996)

It has been proofed that the community is normally willing to pay for services (UNCHS 1996), especially if these services are efficient. Contrary to the previous views, low income communities living in informal and unplanned settlements have been paying more than those in planned area; sometimes up to between ten to a hundred times

especially for water supply. Other positive elements from community participation provides a sense of belonging and ownership as well as better care for the investment. It also reduces cost (ibid).

In the past, community participation has been practised in most sectors in the developing nations. Infrastructure provision and maintenance has enjoyed this kind of input, examples being water and sanitation provision and upgrading of access roads in the rural areas. The situation is different in the urban areas. The tendency have been to await service provision by the local and central governments. Many problems facing these local governments have rendered provision of such services impossible. As a result governments inability to meet existing demands, communities, households and NGOs are also becoming more involved in mobilising funds to build their water and sanitation schemes or to operate and maintain existing ones. The urban situation has as such grown from bad to worse prompting the community to wake up for their own survival.

One of the best example of community involvement in provision of infrastructure was observed in Karachi. As documented in UNCHS (1996) the involved collaboration of NGOs and community. Low income households within a street worked collectively, generally collecting small contribution from each household and then sub-contracting out the work. The resultant estimated cost was a seventh of what the local authority was asking for. Once the installation was over, the community assumed the responsibility of maintaining and repairing the system. This system has been efficient than those run by the local government (UNCHS 1996).

In an attempt to rise up against deteriorating urban environment, a good part of solid waste management has already gone private in Nairobi city. The situation in the middle and high income areas have as a result improved tremendously. Sanitation and waste

water handling has not made any headway along this line of management. Problems associated with poor sanitation especially in the newly developed residential areas, especially where sewer services have not been provided, is growing to be out of hand.

Policies on sanitation seem unachievable, a norma mostly blamed on the community. Policies are the reflections of community's aspirations. These aspirations have been accused of being too high to be achieved (Mairura 1988). Provision of services by any other body other than the community itself creates a sense of irresponsibility in line with Mairura's (1988) observation that:

"Individuals are least bothered by the waste they produce; there is little felling of personal responsibility for the waste produced by an individual for he she beliefs that somebody else will find a painless and effortless solution to the problem" [7].

This clearly shows that there is a difference between community's awareness of the existence of a problem and the willingness, ability or both to solve it.

One of the major problems facing waste disposal systems is the amount and the rate of production. UNCHS (1997) attributes a good proportion of waste management problems to unsustainable and wasteful production and consumption patterns. In view of these, it recommends intensification of efforts aimed at reducing production and discharge of waste. Efforts towards these end can only be effective if they are directed towards the resident population. Bearing the costs by the community not only in water consumption but also in disposal of waste water would go along way towards managing the amount of waste water produced.

Mairura E.O. 1988 Development : Water and Sanitation Infrastructure in Unplanned .....
...... Nairobi, U.A planning ...... p12. ....

The recommendation that the community take up sanitation related problems from the local authorities means that it would have to sacrifice some resource and time towards this end. Despite this disadvantage there are several associated advantages. Every investment calls for a sacrifice in one way or in order to divert some resources to sanitation infrastructure development. In recognition of this fact, Ndegwa et al (1985) compared cost sharing concept to a surgical amputation, where one part is sacrificed to save the whole. In this case, the duty assigned to the professionals is to ensure that the community understands the whole operation. Brazil's and Pakistan's shallow sewer systems (UNCHS 1996) as well as Karachi's community intiated sanitation infrastructure projects. These three cases show where, how and when the community should is ripe in resolution of problems that have defeated the agencies that have been entrusted with them.

The whole of the foregoing discussion shows that a series of failures are responsible for the poor status of urban areas infrastructure as observed in the Third World countries. A chain of omissions ha resulted to urban environments which have litre of the required infrastructure and service: on of the best example being waste water disposal systems. This series of omissions have been summarised in the conceptual framework that follows.

2.2   CONCEPTUAL FRAMEWORK

2.2.1   General View of the Development Trend of Urban Area in the Third World Countries in the Context of Infrastructure and Service Provision

In the process of urban growth and urbanisation, smaller sub-process lead to others, but the core of all them is urban population growth. In appreciation of these fact, man has adapted various measures to lessen the negative effect of urban growth in a bid to ensure

that the urban areas remain habitable. Among other things, provision of infrastructure is one of the most innovative population growth counter-measure that man has adopted to support high population density in the urban areas that would have, otherwise, not been possible.

Infrastructure provision, extension and expansion (where it is already in existence) and the right pace checks against most negative effects of urbanisation and urban growth. Each successive stage in the growth of urban area should be accompanied by a suitable increase in the level of infrastructure provision. Real life experience, however, has shown that such services are partially provided, mostly so in the Third World countries. The emergent scenario is a backlog of infrastructure provision at every successive stage in urban growth. This cumulates in degradation of urban environments (see figure 2A).
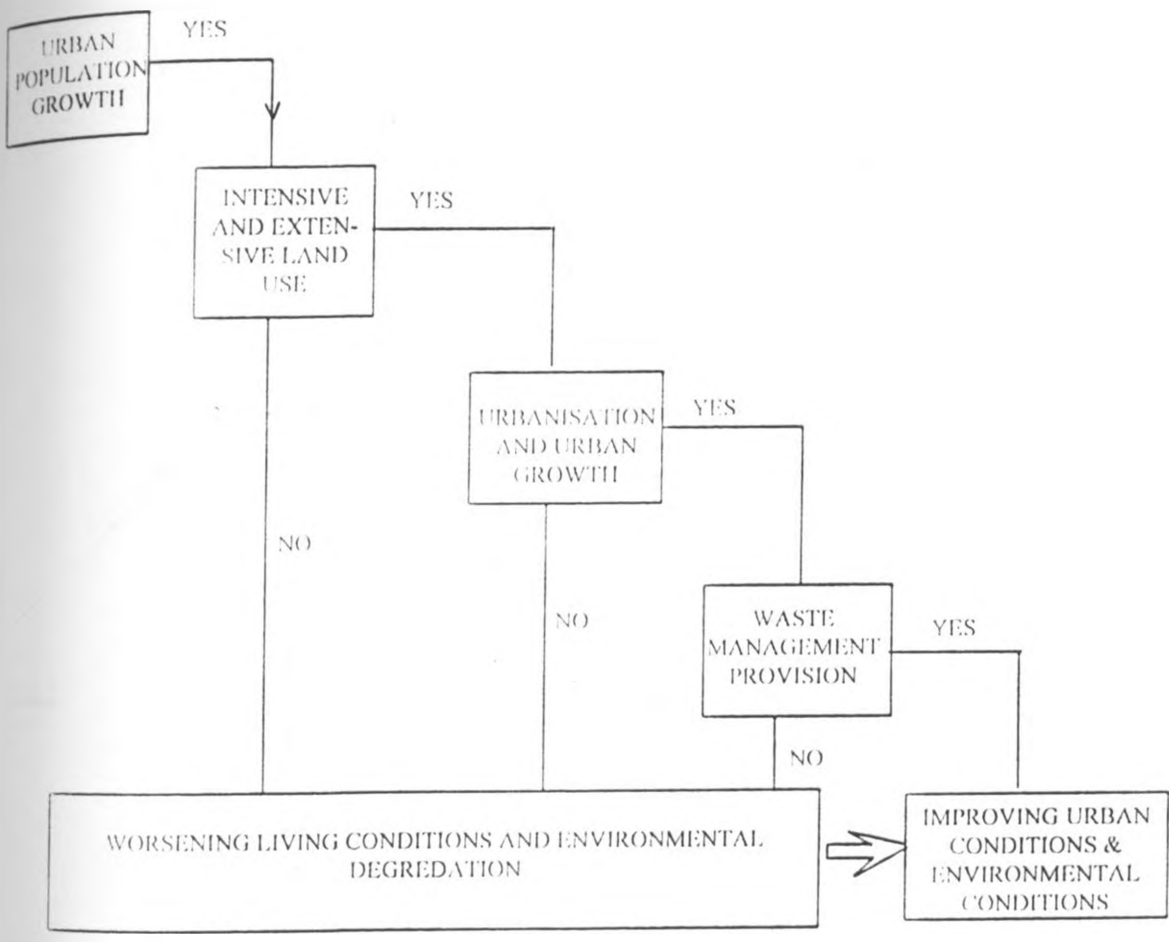
Source: Own Empirical Derivation

Explanation to figure 2A

Urban population growth leads to intensification of land use in the built up areas. The remainder of the population is accommodated in the area around the older urban region, leading to a horizontal expansion of the built up urban area in the process of urban growth.

Waste management systems, among other forms of infrastructure, should accompany the horizontal expansion of the urban region's built up area. Whenever this is not the case, the result is a poorer urban environment. This is the process which have already been taking place in Nairobi. To address these problem, each and every 'NO' in figure 2A needs to be converted into a 'YES'.

Direct translation of a poor living conditions for example those characterised by a degraded environment, to one that is desirable calls for colossal amount of resources. In addition, poor structures which had been provided previously would present substantial problems in the process of urban renewal and redevelopment.

2.2.2 Waste Water Management Systems Vis-a-Vis Increasing Residential Densities

Of the three major types of waste from urban areas namely garbage, human and industrial waste, human waste management poses the greatest challenge in the Third World countries. This is because solid waste can be managed by the already established institutions, while industrial waste management can be made to be the responsibility of the concerned industries. Human waste management in urban settlements poses a great challenge in high density residential areas where off-site (water borne sanitation) system are the only effective methods. This is particulary so when institutional bodies such as the municipal councils have been defeated by the problem. The problem is compounded

by the fact that owners of residential plots operate individually in reference to waste water management in situations where sewer services have not been provided. These used to be in the low density residential areas.

With time, previously low population density areas have been intensively occupied converting them into high density residential areas. The conversion has, however, not been accompanied by provision of convectional sewer systems. As such waste water tanks and pit latrines (which are meant to serve low density population areas) continue to be used resulting into permanent streams of waste water from the overwhelmed waste water tanks. These waste water gets into the natural water bodies and the environment in general without being treated (see figure 2B).

FIGURE 2B Conflicting Waste Water Management Systems Due to Changes in Residential Density Resulting in Environmental Pollution
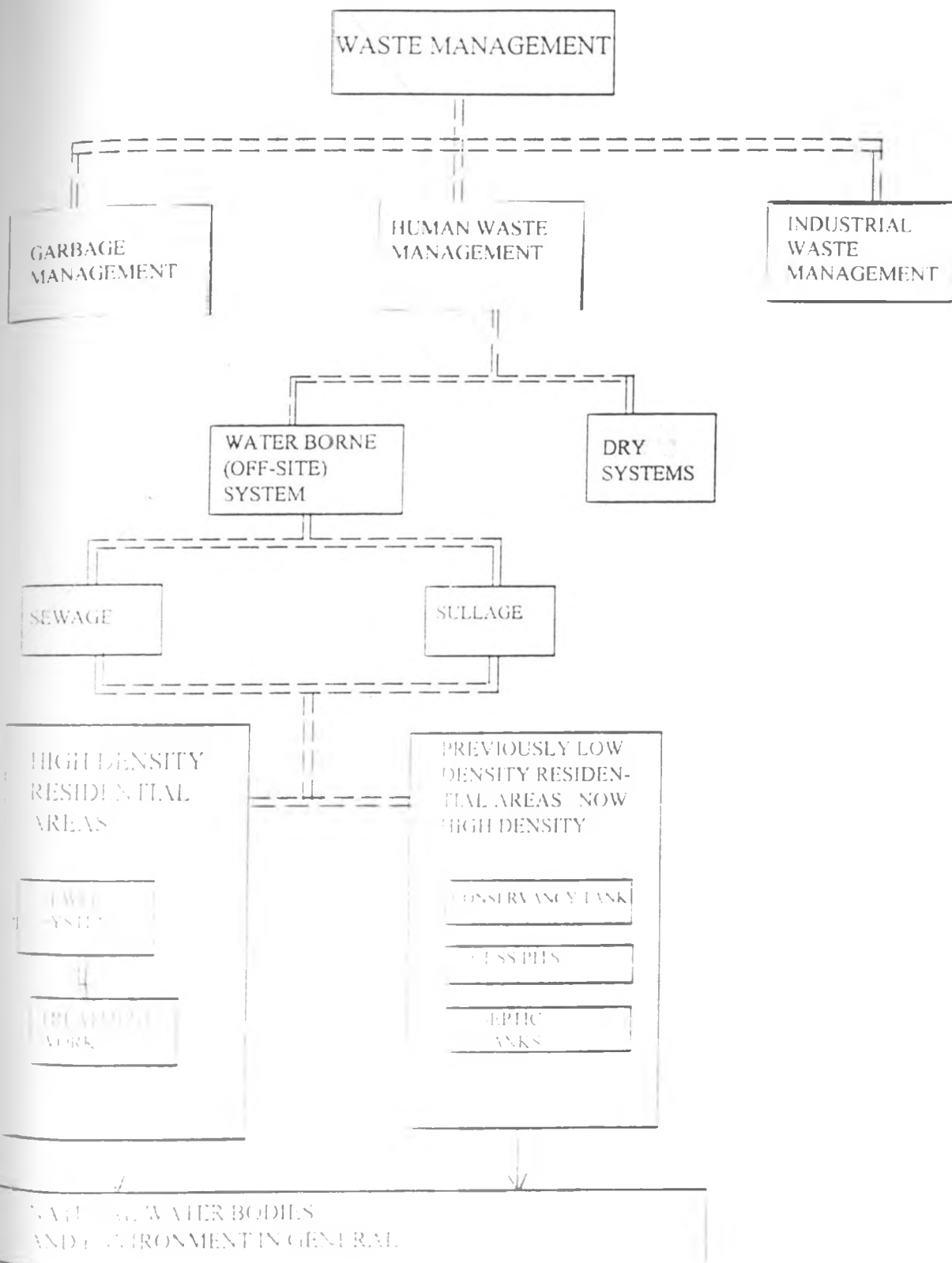
Human waste management is just but one sphere where the level of environmental pollution can be reduced. The sphere, however, contributes a great percentage of environmental pollutants in the third world countries. Environmental pollution in the third world countries is largely from human waste as opposed to the developed countries where industrial waste pollution pauses a great challenge to the environmentalists (UNCHS 1996).

Even when great efforts have been made, waste water eventually ends up in the natural water systems. There are various points through which waste water enters the natural water bodies. The only alternative to ensure minimum pollution to these water bodies is to treat the waste water. Sewage treatment works are meant for this purpose.

Waste water should pass through sewage treatment works before it is released into the environment. A major constraint towards this end is that previously low density residential areas have turned high density but the waste water disposal system are those that were being used when these places were low population density.

A lot of sanitation related problems have been the result. Continued use of low population density waste water management technologies in a now high density residential area result in environmental pollution and general unpleasant conditions of human habitat. Attempts to solve these problems have been highly expensive and thus unattainable. All of these attempts are geared towards a perfect waste water treatment plants failure to which none should be provided at all. Solutions with mild betterment effects have been completely overruled. The trend have been the best or the worst. Zimmermann's solutions have been the worst as no remedial efforts have been made.

SUMMARY

Domestic waste water contains harmful household waste. Human waste is just but one of such constituents but with such a profound polluting effect. When such waste water gets into the environment untreated, the results are polluted rivers and diseases invested living neighbourhoods. Low life expectancy and high incidence of water-borne gastro-intestinal diseases in the Third World countries clearly attest to this fact. This situation has been attributed to the lack of proper sanitation facilities. The problem of poor sanitation is more pronounced in the urban areas, where sanitation facilities meant for low population densities have been subjected to a population that they cannot serve, through the process of densification and intensification of residential development.

Local and central governments have previously have previously supplied the bulk infrastructure in the urban areas. Due to a myriad of management problems and ever growing urban centres in terms, both in terms of size and population densities, these agencies have been unable to provide these services, a scenario that is clearly evident on the ground. As a consequence upcoming residential neighbourhoods have emerge as private and individual developers concentrate on housing structures only. Negative environmental impact from such developments continue unabated.

Overtime development of residential units in unserviced areas have already create a huge backlog of infrastructure and services yet to be provided. This is particulary so with services which the resident communities cannot provide. The most neglected is convectional sewer systems.
In drastic change of events, informal (or unplanned) settlements have been accepted by the governments. Despite the good intention behind a review in the housing policy,

even some of the formal housing units have not been served with the necessary services. This means that the policy on infrastructure and services provision is well ahead of the practicality of the services it is addressing. This means that the efficiency in resources has been the main problem and not the policy.

An evaluation of the competing human needs shows that environmental consideration are only focused upon when socio-economic needs have been addressed. Seemingly, socio-economic needs are the only one which are considered in low income areas due to scarcity of resources. The fact that people are living in residential neighbourhoods with poor sanitation system shows that the range of sanitation technologies available are not affordable to the majority of the urban centres' residents. The major reason behind this is that the sanitation methods are copy rights of those used in the Western World which are then imposed on the Third World countries their poor economic status notwithstanding.

Among other cited failures, lack of participation of the beneficiaries of infrastructure and services in urban areas, have greatly contributed to the upcoming of infrastructure deficient residential neighbourhoods. Several ways through which through which beneficiaries can participate in service provision are many. However, regarding infrastructure that require high technical skills such as a sewer system, the best way to engage effective participation is through financial contribution. Using the collected funds, technical expertise can be sought. In situations where the community has taken the leading role in provision of services and infrastructure, the cost has been shown to be as low as a tenth of what the local authorities would have quoted.

The proceeding chapter evaluates how the elements discussed above contribute to the poor sanitary condition of Zimmermann estate and how they differ from those in other areas of study as documented by the foregoing reviewed literature. Uniqueness of the

contributors to poor sanitation in Zimmerman estate were focused upon with an intention of adding the already listed drawbacks and contributors of such situations. Further a number of questions and which are the basis of the study hypothesis have not been answered. These are:

1) Which are the specific negative effects of using low density sanitation method in a high density residential area with specific reference to Zimmermann estate ?

2) To what extent have waste water tanks failed in Zimmermann and what parameters show their failure ?

3) Other than residential density, what other factors determine the effectiveness of sanitation facility and to what extent ?

4) What kind of community participation is applicable to resolution of domestic waste water disposal problems where most of the residents are tenant with very short security of occupancy ?

5) What intermediary solutions are there which can be put in place as ultimate solutions are being waited for so as to lessen environmental pollution caused by overwhelmed waste water tanks ?

Specific responses to these questions necessitated a case study. The field study area and findings are documented in chapters 3,4 and 5.

CHAPTER 3

ZIMMERMANN: RESIDENTIAL DEVELOPMENT IN THE CITY THE INSANITARY FRINGE

3.1 Introduction

Zimmermann, the study area, is a residential area with peculiar characteristics, all of which emanate from uncontrolled development. With the exception of the study area, other high density residential areas are close to the CBD. In addition to a relatively longer distance from the city center (8 km) the interceding land tract has low density development. The residential area is, thus, anomalous in regard to the abutting developments and distance from the CBD, compared to other residential estates in Nairobi. As a result, service and infrastructure, especially bulk ones such as sewerage system, fall far from this residential area. Zimmermann can be described as a patch of a high density residential (see plate 1) area in the midst of low density developments.

The few of the provided infrastructure are relatively reliable water system, electricity and limited number of telephone connection lines. The rest are completely left but the worst hit are roads and waste water disposal systems. Other than road reserves (way-leaves), no service have been run along these way-leaves. Mud and dust, depending on the weather and distance from the closest leaking cess pit, are the land marks of the estate. The fact that there is no effective waste water disposal system on an area and that the sub-surface is of black cotton soils, all shorts of haphazard measures to make the streets motorable have been taken. Rock boulders in pools and streams of waste water (see plate 2) makes the road surfaces. These streets are then flanked by a variety and levels of developments ranging from undeveloped papyrus infested plots to some which have been developed to bungalows and flats of mixed heights, some times up to fifth floor (see plate 1). More often than not, kiosks of all sorts of forms and colours stand between the motorable part of the road and private plots.

The only community welfare service developments in the area are two shopping centers. a primary school and a single plot for a church. Play fields and open spaces are completely amiss. Consequently, children are found playing in the open and undeveloped private plots besides heaps of garbage. Often, farm animals and poultry such as cows, goats, chicken and ducks besides dogs and cats ravage through garbage heaps and streams and pools of waste water on undeveloped plots on top of a few cases of food crops being grown in pools of waste water (see plate 10).

The above characteristics are clear indicators of the contempt with which planning practice have been taken; at least in so far as Zimmermann estate is concerned. This particular chapter is a description of the area in terms of physical characteristics, history of development and social economic factors with special emphasis on how these factors have blend the insanitary high density residential area.

PLATE 2
A stream of waste water along the street

Physical Attributes of the Study Area

Location

Zimmermann is located in the northern peri-urban fringe in an urbanized formerly agricultural zone. It is approximately eight kilometers from the central business district (CBD) and occupies a wedge like area between Thika road to the east and Kamiti road to the west. It falls in what is regarded as the fin of Nairobi city's area of jurisdiction (see map 1).

Vicinity of the Study Area

To the north of the study area is a bigger and sprawling Githurai estate which extends from Kamiti road in the west to Thika road and beyond in the eastern side. The estate is inhabited by lower income earners (compared to Zimmermann) and has the same or worse sanitation problems. Further north is Kahawa West area. A section of it is served by the main sewer.

To the west of Zimmermann, and separated from it by Kamiti road, is Roysambu area past which is an agricultural area; the main activities being animal and poultry rearing. Pig husbandry is practiced by Farmers Choice company on large scale. Still along the same strip is non-operational Bulley's leather tannery factory. To the north of this factory is a small area which is occupied by Ngomongo informal settlement area past which are coffee estates.

The two roads which are next to one to the estate (Thika and Kamiti roads) provide a fast transport system. This explains the reason for which the study area has a high

population density in spite of the relatively long distance from the city center and the industrial area.

MAP I LOCATION OF ZIMMERMANN WITHIN NAIROBI

to Thika

to Kiambu

to Nakuru

CBD

to Kangundo

JKI airport

industrial area

National park

to Magadi

N

0   2   4   6 miles
scale

to Mombasa

LEGEND

Zimmermann

railway

road

NJUGUNA `98
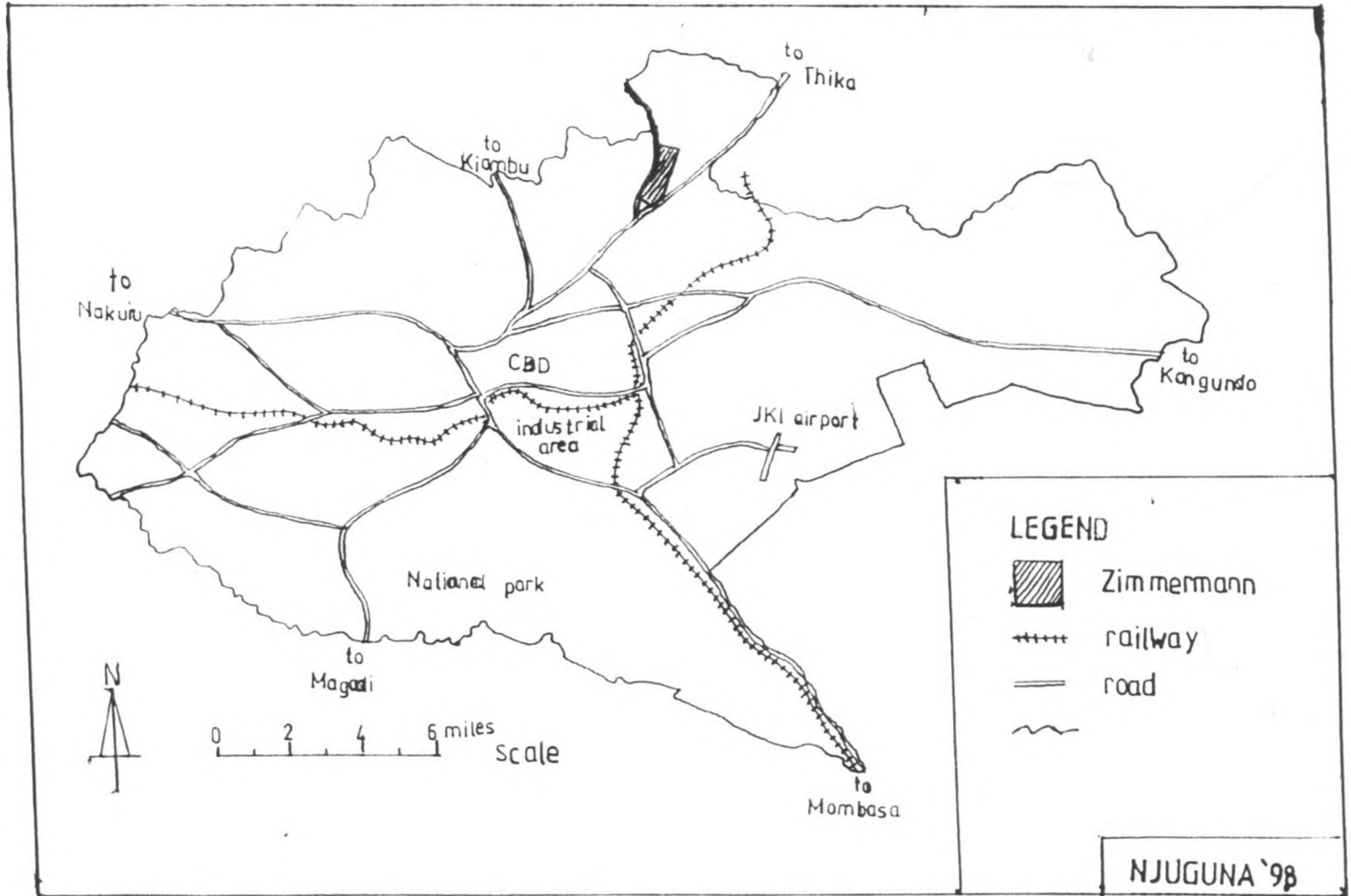
3.1.3 Size of the Study Area

The estate now referred to as Zimmermann is the former land parcel whose registration number was 8345/R. To the west of Kamiti road is a low density developed land and upon which residential blocks development is finding its way. All in all the residential area covers about 400 acres and has been subdivided into plots of an average of 50 by 75 feet or 15 by 22.5 meters about 5/6 of which have already been developed into rental residential units.

3.1.4 Topography

The area stands at an altitude of between 1540 and 1580 meters above sea level. It is flanked by a high ground to the east, south-east, to the west and to the north past Gatharaini river. The area can thus be said to be lying in a basin which opens to the north east (river flow direction). The land slopes to the north and north east forming part of Gatharaini river valley. The upper most part of the estate has a steep gradient slope, flattening off at the middle zone, increasing again towards the north and finally flattening off again over a wide region about Gatharaini river flood plain. Along the river flood plain is a wide zone of marsh land (see map II). Within the estate, also, are numerous patches of marshy areas owing to the high water table characteristic of the area.

3.1.5 Drainage

The area under study covers such a small area; to an extent that it is not sensible to classify the drainage pattern in the basis of rivers drainage system. There is only one permanent river and which forms the boundary of the study area to the north. There are,

however, two springs with their mouths in the estate and which drain the marsh areas (see map II).

MAP II TOPOGRAPHICAL UNITS

MAP II TOPOGRAPHICAL UNITS

R. GATHARAINI

BULLEYS LEATHER FACTORY

SHOPPING CENTRE

CHURCH

ROYSAMBU PRIMARY SCHOOL

N

KANITI ROAD

SHOPPING CENTRE

SHERATON BAR AND RESTAURANT

CHURCH

THIKA ROAD

	Flat
	Marsh
	Seasonal marsh
	Gentle slope
	Steep slope
	Study area boundary
	River

0   100   200   300 m
SCALE

NJUGUNA '98
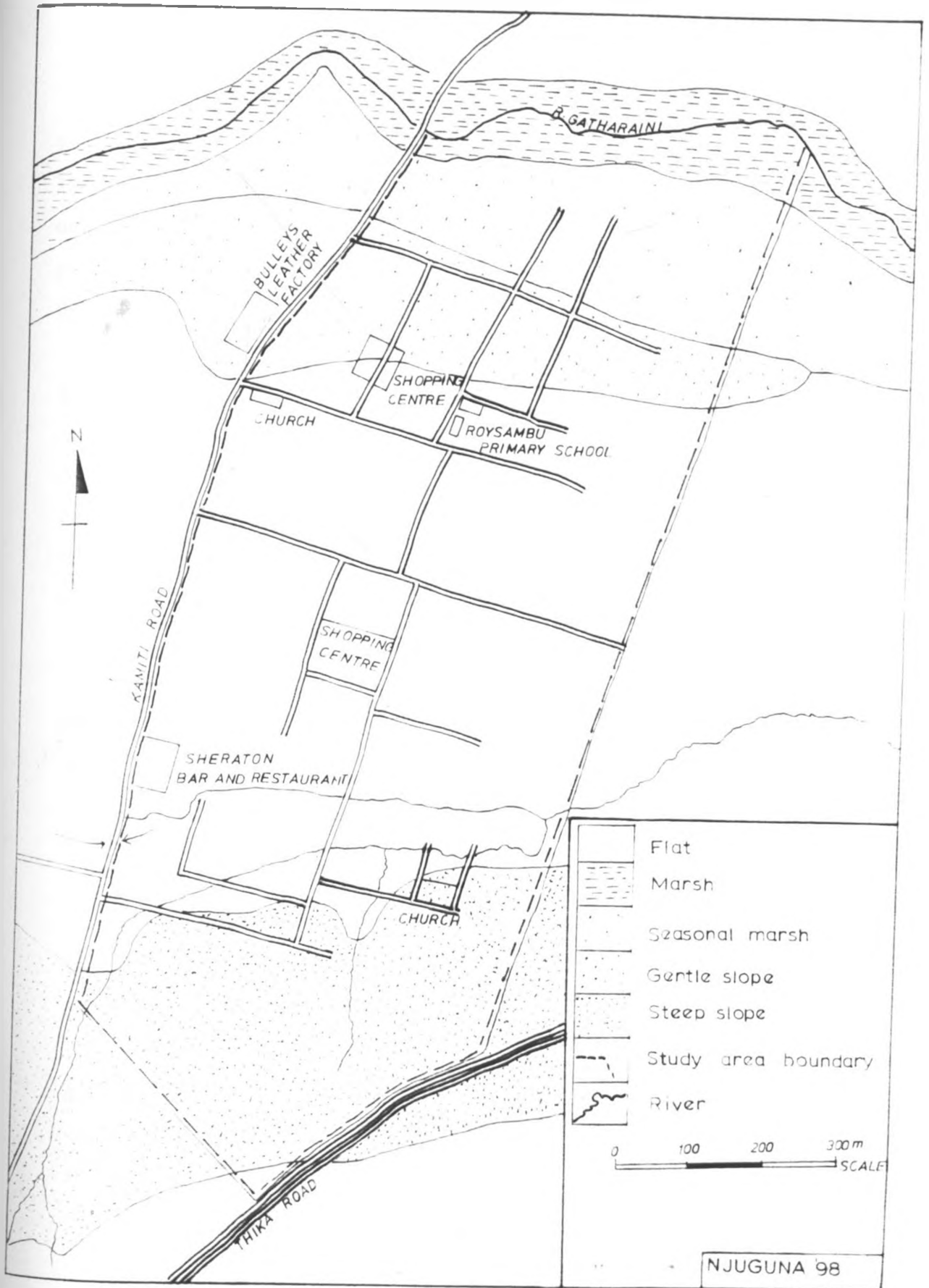
Waste water overflows have contributed a better proportion of the flow in these springs. The central region and the area about the banks of Gatharaini river are poorly drained owing to the high water table, flat topography and black cotton soils. Water reeds and papyrus present in patches manifest the poor state of drainage. The far south land and the land next to the river flood plain has a fair slope, and thus is well drained.

3.1.6 Vegetation

As has already been pointed out, water reeds and papyrus are some of the most common plants. However, the better part of the natural vegetation has been cleared to give way for residential development. Going by the remnant vegetation and the neighbouring wider region the area lies within the Savannah Grassland as characterized by the fast growing elephant grass during the rainy season and drying out as quickly when the dry weather sets in. Trees within the estate are rare and the ones that are there have been planted for ornamental purposes. They are, all the same, rare since plot coverage is always 100 per cent.

3.1.7 Geology and Soils

The area is underlain by volcanic rocks namely trachyte and other nephelinites. Upon weathering, these type of rocks yield the black cotton soils. These soils form the better part of the flat middle zone (see map III). The upper higher ground has shallow red soils and in some patches bare rock. The river flood plain has black cotton soils on the outer edges and alluvial soils about the river bed. Black cotton soils are believed to have continued under-cover alluvial deposits being just shallow depositional material. A small section next to the river flood plain has latteritic (murram) soils. Geological structures such as faults have not been noted if at all present.

MAP III SOILS AND GEOLOGY

R. GATHARAINI

BULLEY LEATHER FACTORY

N

SHOPPING CENTER

CHURCH

ROYSAMBU PRIMARY SCHOOL

DISPENSARY

KAMITI ROAD

SHOPPING CENTER

SHERATON BAR AND RESTAURANT

CHURCH

THIKA ROAD

Aluvial	
Black Cotton	
Murram	
Red Volcanic	
Exposed rock	
River	
Study area boundary	

0   100   200   300m
Scale
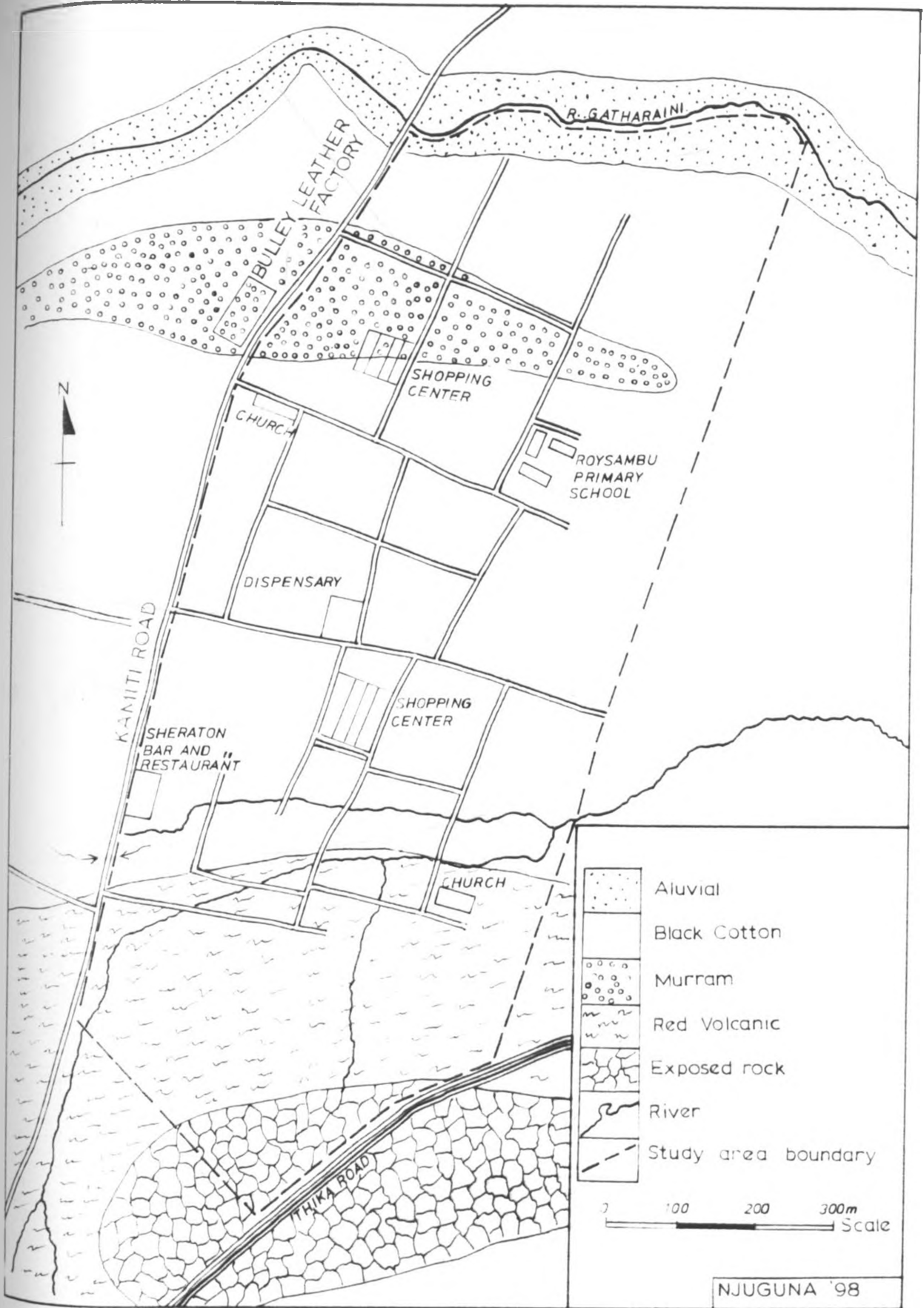
NJUGUNA '98

<u>Climate</u>

The area, like the rest of Nairobi, experiences two wet seasons sand-witched between two dry spells in a year. The long rains come in the months of March, April and May and the short rains around October, November and December averaging out to 700-900 mm per annum. The temperatures range between 18 °c and 29 °c in a year the hottest being the driest months normally around January and February. The coldest months are June and July. The average dairy temperature is 24 c.

The dominant wind direction is east to west with occasional south to north reversal of direction. The most humid months are also the wettest while the driest are the least humid namely January and February.

Historical Perspective

Every Third World country has housing related problems. The severity of the problem increases with the size of the urban center. Kenya, as a country, is not an exception to this generality. Nairobi being the hub of all socio-economic activities have such severe problems. This is not only a current phenomenon but one which sets the historical development of the newly developed peri-urban residential areas. As claimed by Gichohi (1988: pp 65), this is due to land ownership patterns, cheapness of land at the periphery which has accrued from lack of services and the ease with which the planning regulations have been and can be flouted. Hand in hand with this is the profits which land owners get when they urbanize their land.

The entire 400 acres of land covered by Zimmermann estate was initially owned by a German settler and farmer known as Zimmermann explaining the origin of the name of the place previously known as Kabaa and then Roysambu. Zimmermann involved himself in a peculiar kind of farming including snakes husbandry. He raised these creatures for their venom which searched a lot of money and used for the manufacture of snake bites anti-dote.

This land was latter sold out to a land buying company going by the name of Zimmermann limited which also owned the now defunct Bulleys leather tanning factory situated next to the residential estate.

In the early 1970's Zimmermann limited was closed down but not before it hand sold its land to an informal land buying company owned by Africans. The purchased land was owned jointly in the form of shares. One share was going for 13,000 shillings on top of a membership fee of 75 shillings for every share purchased. Share certificates were then issued to each shareholder. It was latter to be confirmed that each share was equivalent to one plot measuring half an acre in size. Subdivision of this, land had not been approved by Nairobi City Council (NCC). Immediately after the share certificates were issued, a good number of shareholders sold their shares. Soon thereafter the land was 'illegally' subdivided amongst the shareholders. The term 'illegal' is used because the subdivisions had not been assessed and approved by NCC in accordance with the Town Planning Act. An unconfirmed sources allege that a former mayor of the city was a stake-holder in the land buying company thus the deal was sealed without the scrutiny of the authority as required. According to the Town Planning Act, the subdivision would not have gone on without, first, providing services and infrastructure. Such services would have included a standard road reserve network, a sewer system, a water system, electrical power supply, refuse disposal system etc. The fact that plot subdivision was not authenticated by NCC gives the reason which underlie the

appearance of the land parcel as one block in the council records. No approved land subdivision map is available for the estate.

Given the individual ownership of land, the stage was now set for further subdivision. Cases of groups of people formed by the poor and the middle income earners to purchase land for housing have often been mentioned. This is because land in Zimmermann was cheap compared to other areas. The main reason behind the cheaper price was the distance from CBD, the missing services and the water logged black cotton soils. The group owned land was then subdivided amongst the owners on completion of the transactions.

The original shareholders also resulted to subdividing their land for sale, making an advantage of the increasing land prices. Subdivisions were informal as a deliberate attempt to evade payment of stamp duty and surrendering part of the land for services. The subdivision exercise had reduced the plot size to as small as an average of 15 by 22.5 meters. The stage had already been set for development of residential houses. The fact that the first houses in Zimmermann were constructed in the early 1980's and that it was not until 1990 that the earth streets in the estate were officially recognized as exemplified by the city councils decision to level them using a tractor exemplifies these facts. As revealed by the data from the field. Zimmermann estate started receiving an influx of people in 1994.

The initial developments were sparse, single level and with densities that were comparatively low. The plots were developed into 2 and 3 bedroom rental houses; each plot with two gates and each of the gate being shared by two housing units. A good number of such house units still remain on the ground. Rental fee was low as 1,500 shillings per month for two and three bedroom houses in the 1980's. As late as in 1994 three bedroom houses were going for as low as 2,500 shillings per month.

The period between 1991-1994 was also marked by worsening economic situation the country over. The trend was that people could afford less and less on housing yet rural-urban migration and household formation was in the increase. Private housing developers had taken note of this trend and were exploiting it through construction of residential units. Soon, two storey residential developments started to appear. However an explosion in this kind of development was most active soon after 1992 when inflation level was high. Rent rate in Zimmermann were on the increase which further stimulated residential development both horizontally and vertically. By 1994 flats as high as 5 floors had started to appear.

Other than the housing structures, no other development was taking place in the area. The only services which are noted to expand with residential units development are water and electricity supply. In the years before 1995 and after 1990 water supply became insufficient owing to the increasing intensity of development. The years 1993 and 1994 marked the apex of this problem culminating in addition of back up water supply from Ndakaini water pipeline. This is the best the infrastructure provision has been done. Electrical power provision has been prompt possibly because of the estates proximity to Roysambu Grid Control Unit. This is not without the frequent blackouts which have also been reported across the whole city.

Socio-economic Background

3.3

3.3.1   Social Characteristics

3.3.1.1   Population Size from previous census data

Establishment of the exact population figures for the area is difficult. The reason behind this difficulty is that Zimmermann as an area has never been included in any census as a unit. The most reliable figures available are those of Roysambu area. Considering that Zimmermann had not been recognized as a unit in the latest census (1989), the entire area must have been considered under Roysambu area. This shows that the estimation of the population figures of the area under interest using this unit may suffer major anomalies. First, Zimmermann is one of the residential areas in Nairobi with the highest population growth and whose rate has not been established. Use of Nairobi's average growth rate of 6 per cent or that of the newly developing areas of 7.6 per cent is an understatement. Secondly, Roysambu area census data must have included more than just Zimmermann's population given that it covered an area of 28 square Kms. The population census of 1979 cannot be used in conjunction with that of 1989 to calculate the inter-censoral growth rate because the 1979 census cover an even wider area (46 square kms) (CBS 1981).

Empirical survey would only have been possible with more time and resource. Since no other more secondary data is available, estimation of the population size was based on the field findings. However, an insight into what was provided by the 1989 census deserves a treatment.

Population of Roysambu Area By Sex (1989)

Male	Female	Total	No. of household-	Area in sq. Kms	Density in Persons/Km
7.900	5.628	13.528	3.977	28	483

Source: Kenya population census (1989) vol 2 (CBS)

Data obtained from the population census of 1989 gives unreliable population size. The field survey provides a better estimate. A total of 1457 plots make Zimmermann estate. From the field survey and, through observation and information obtained from a key informant, one out of every 6 plots have not been developed meaning that there are a total of 1200 developed plots. This means that the sample of 60 households/plots constituted 5 per cent of the plot population of the study area both in terms of total number of plots and resident population. The sampled plots constituted a total of 661 house units. By calculation, Zimmermann estate is made up of 13,320 house units. These house units directly translate into the same number of households (about 13,320). The household sizes of the sample are presented in Table 3.1.

Figure 3.4: Household sizes

Source: Field survey, 1998
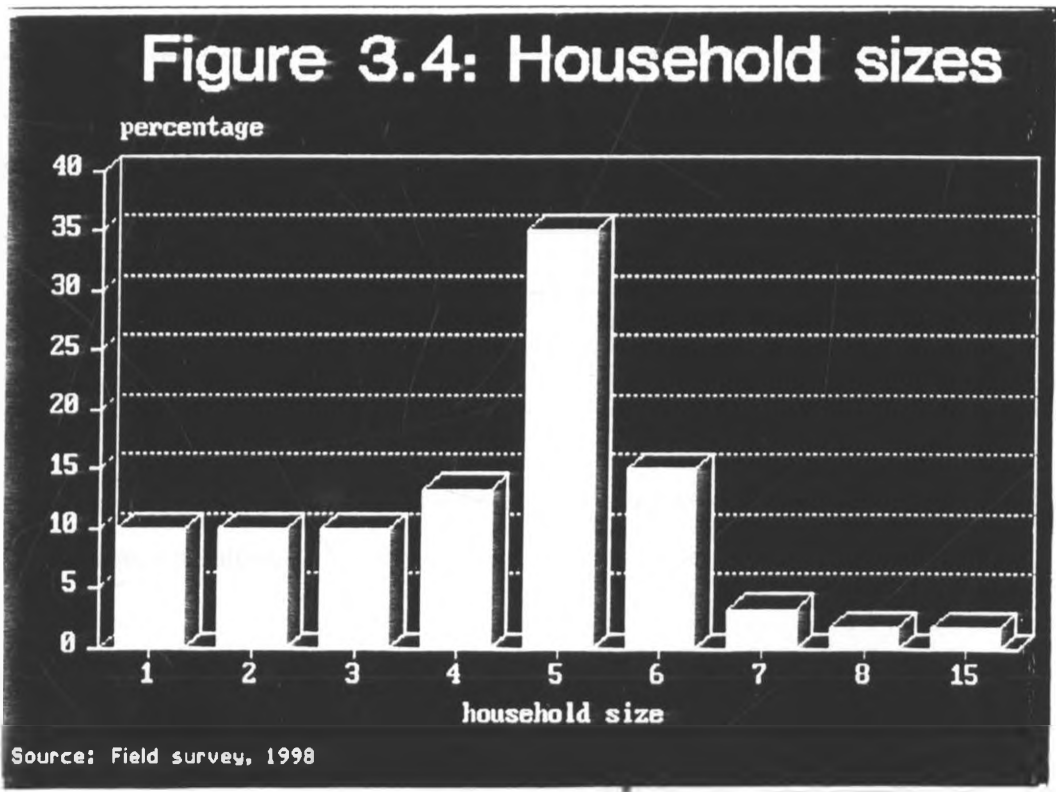
A household which had 15 members was treated as an exception and is thus not reflected in figure 3A above. From the sample, it is apparent that for every 60 households picked a household size of 1 to 8 will recur with the frequency shown in figure 3A. The respective fractions show the following breakdown in terms of household sizes for the whole of Zimmermann estate (see table 3.1, below).

TABLE 3.1   POPULATION OF THE SAMPLED HOUSEHOLDS

Household size	frequency of occurrence	population
1	6	6
2	6	12
3	6	18
4	8	32
5	21	105
6	9	54
7	2	14
8	1	8
TOTAL		249

This means that 59 households had 249 persons. Bay calculation 13,320 households will, therefore, constitute:

$$13320 \frac{1}{59} * 249 = 562151 \text{ persons}$$

SOURCE: Calculated by the author based on the sample characteristics. A population of 56,215 people is spread over the estate. This population is approximately evenly distributed going by the homogeneity of plot sizes, and almost even distribution of storey residential blocks (see plate 1).

Zimmermann estate occupies an area of 400 acres (Ndunda 1995). Estimations from a map of the area confirms this figure considering that the area can be roughly reduced into a rectangular land block measuring 1000 metres in length and a width of 400 metres (see map III). This means that the population of 56,215 people is spread over this area giving an approximate population density of 140 people per acre (population size divided by the acreage).

Nairobi city council (1998) lists residential density of 0-100 persons per acre to be in the low density bracket, 101-250 to be in the medium density and over 250 persons per acre to be in the high density bracket. This means that Zimmerman lies in the medium density residential estate category. This conclusion should, however, be made with reservations because not all plots have not been developed. Even for those with single level developments, a trend where the old development is demolished to pave way for high rise blocks is evident.

3.3.2   Household Incomes

Residents of Zimmermann estate have various income sources namely; employment in City centre within Zimmermann and outside Nairobi. The distribution of these employment areas is as shown in figure 3B below.

Fig 3B: Resid. Employment Areas

within Nairobi
75%

outside Nairobi
8%
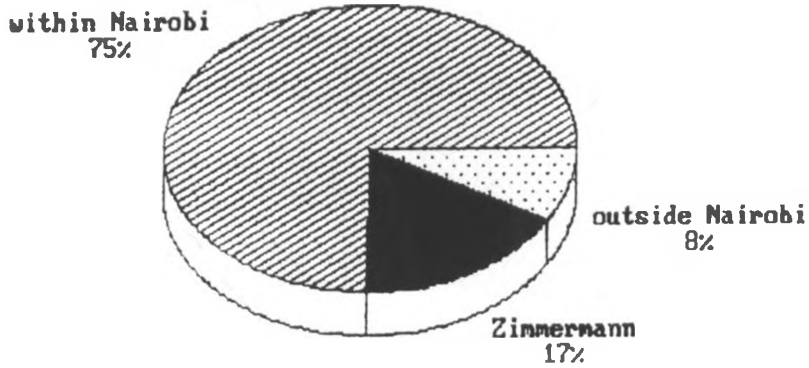
Zimmermann
17%

source: Field Survey, 1998

Figure 3B above shows that over 83 per cent of the persons residing in Zimmermann commute to the places of work. This implies that water usage and hence waste water production is most active in the morning, evening during weekends and on public holidays.

Occupation of the residents is shown in figure 3C below.

Fig 3C: Respondent's occupation

occupation

| clerical |
| engineer |
| house wife |
| banker |
| civil servant |
| accountant |
| teacher |
| informal employment |
| lawyer |
| planner |
| in college |
| lecturer |

0   10   20   30   40   50

percentage

Source: Field Survey
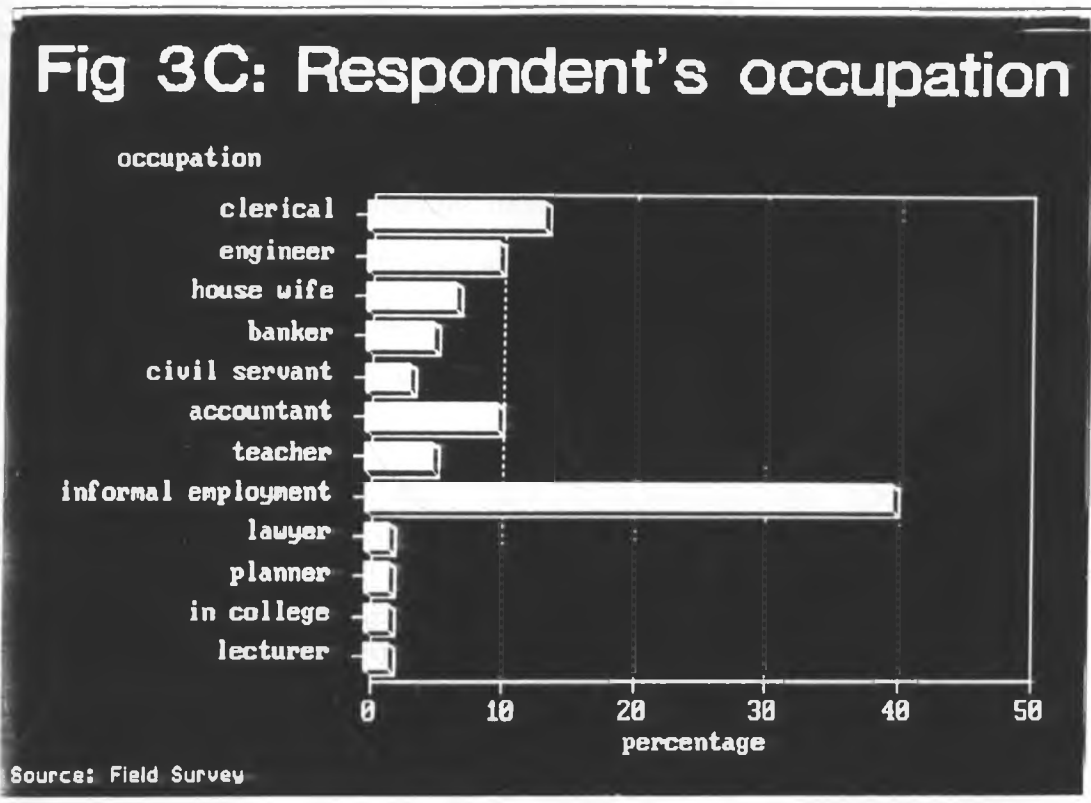
Attempts to obtain the actual income gave unrealistic figures. This observation is evidenced by the fact that only 2 individuals out of the 60 sampled disclosed their incomes. It was, however, doubtful whether the two figures divulged reflected the reality. It is most likely that the two figures of 12.000 and 13.000 shillings per month is only from the formal employment or a single source of income in a case where the person in question has other sources of income. In addition these figures reflect the income of one household member as opposed household income. The divulged figures cannot be thus used to generalise the socio-economic status of the households in the area.

Expenditure combined with the standard of housing structure provides a means to estimating the socio-economic status of the population in the study area. This remains the case even when it is apparent that savings make part of the income and that savings are not reflected in the household expenditure. Consequently, a major draw back in trying to use household expenditures to classify a residential area into low, middle or high income is evident. Consequently, monthly rental fee, water and electricity bill as well as transportation costs were used as indicators of the socio economic category of the people in the study areas. Hospital bills were ignored based on the premise that, the bill is to a great extent involuntary, unlike the other four expenditure units.

Data collected in the field in relation to the rental fees is reflected in figure 3C.

Figure 3.D: Rental fee

Fee in Ksh/month

Source: Field Survey, 1998
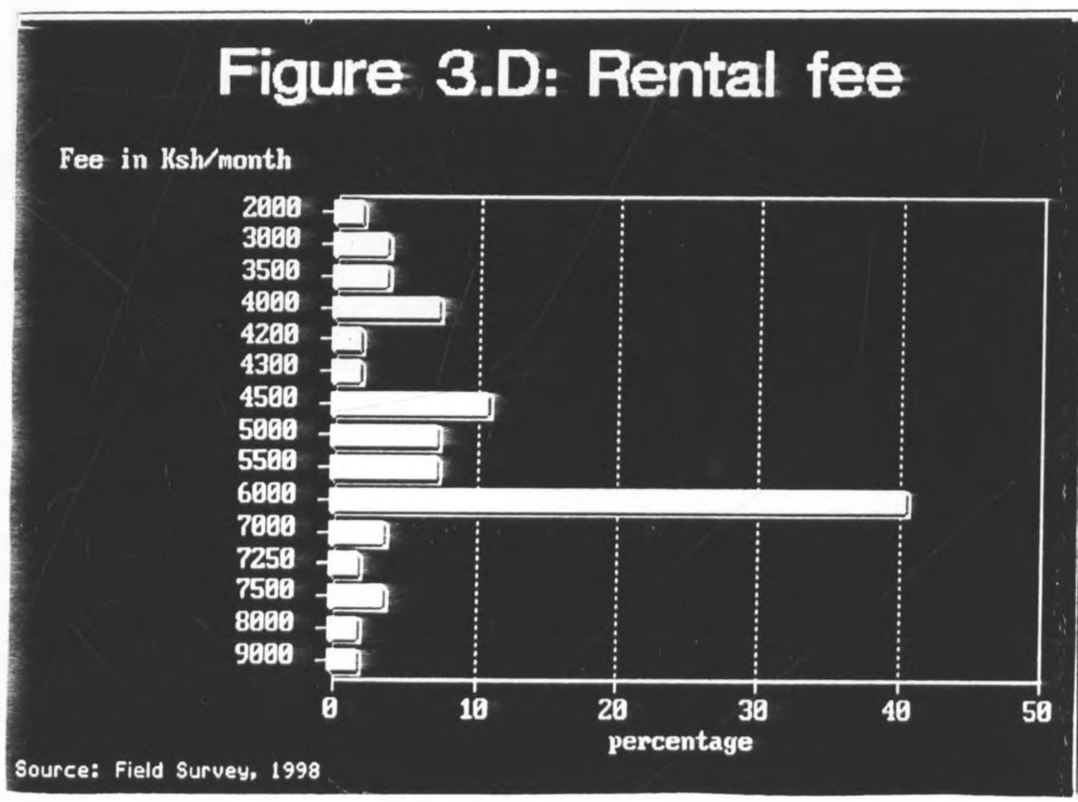
The calculated average rental fee in Zimmermann is about 5450 shillings per month

The second element which helps to reflect on the socio-economic indicator of the estate are expenditures in terms of water and electricity bills as well as transportation costs. These expenditures were summed up and presented in figure 3E below

Fig.3E: Exp. on water, elec & trsp

Fee in Ksh per month

Fee in Ksh	percentage
2000	
2500	
2600	
3000	
3500	
4000	
4500	
5000	
5500	
6000	
6400	
7000	
8000	
9000+	

Source: Field Survey, 1998
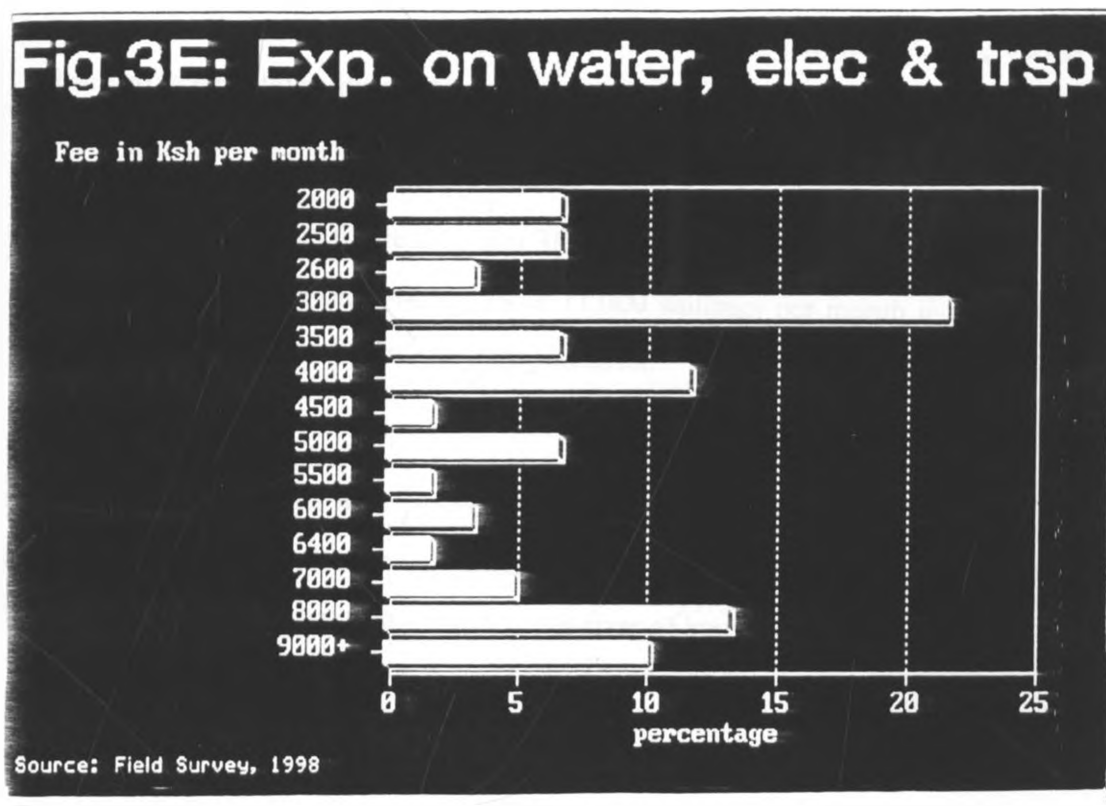
Taking the person spending 36.000 shillings per month as an exception, the average expenditure on the three items is about 4800 shillings per month.

Figure 3E, above, shows that the average expenditure on water, electricity and transport per household for the sample is about 4800 shillings per month. The mode was observed to be 3000 shillings per month.

From the previous two figures (figures 3D and 3E), it is apparent that on average each of the sampled households spends about 11,000 shillings per month in form of house rent, electricity and water bills and transport costs.

In addition to the three bills, above, the living standard can also be judged upon the standard and the size of the house units in which the respondent is residing. Figure 3F, below, shows the composition of the various sizes of house units in Zimmermann.

Figure 3.F: House unit Sizes

two bedroom
58%

one bedroom
13%

single room
15%

three bedroom
14%
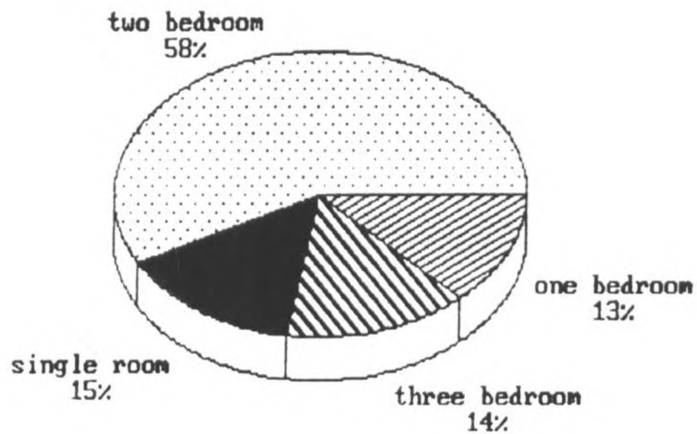
Figure 3F above shows that about 98 per cent of the house units in Zimmermann have at least a kitchen, a bathroom, a living room and a bedroom. In addition, 83 per cent of the sample units have 2 bedrooms on top of a kitchen, a bathroom and a living-room.

In summary households in Zimmerman can afford an average expenditure of 11,000 shillings per month. This figure which does not include food, clothing, school fees, hospital bills and miscellaneous expenses. Further the majority of the persons leave in standard houses. This forms a premise upon which one can conclude that Zimmermann is a middle income residential estate. Water consumption is, therefore, expected to be within the middle income rate. The per capita water consumption has been placed at 135 litres per day (NCC, 1998) a figure which is further supported by Syagga's (1979) contention that low in come earners consume up to 100 litres per day.

There are more females than males in the study area.   Out of the 60 sampled households. 59 of them were found to be composed of 127 females against 106 males. This directly translates to a statistical generality that the ratio of male to female in Zimmermann estate is 1:1.2.

The oldest male was found to lie in 45-50 years age cohort while the oldest female was in the 40-45 years age cohort. More specifically, the household heads' ages range between 20 and 48 years. About 80 per cent of the household heads fall in the age between 20 and 38 years. The mode of the age of the household heads is 30 years where 16.7 percent of the household heads are of this age (See figure 3G, below).
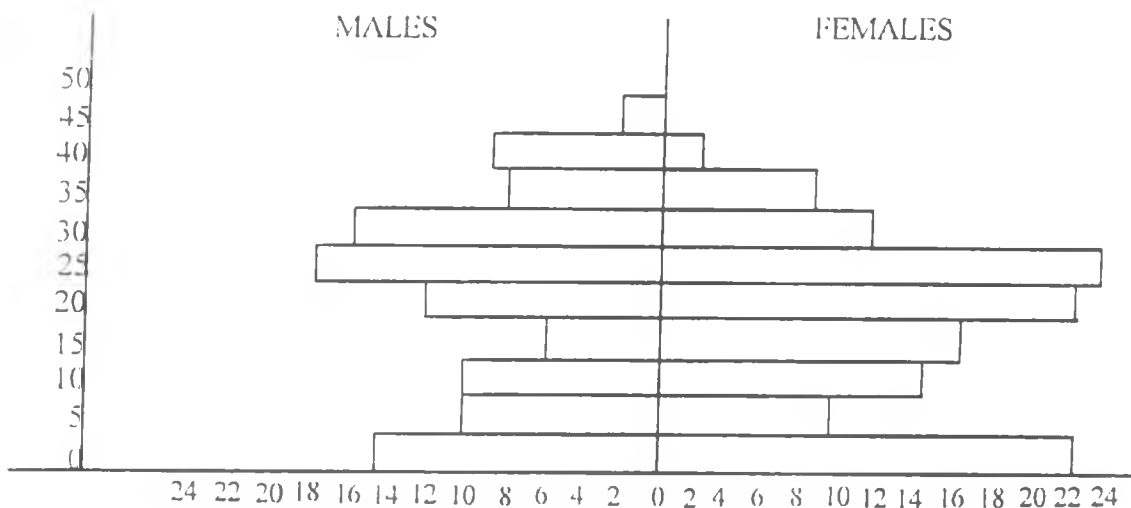
Land Ownership

In appreciation of the number of residents housed in Zimmermann estate, there has been a change of altitude on the part of planning and development control authorities. The previous illegally subdivided plots have been approved and title deeds issued. Land ownership, for those that are landlords is on leasehold. There are two categories of land ownership in Zimmermann. These are the public owned and privately owned. Included in the category of public owned is the land on which Roysambu's Kenya Power and Lighting company grid control is located, roads and road reserves and that where Roysambu Primary school is located. The rest of the land, which comprises more than 95 per cent of the entire area, is privately owned either on a group basis or individually.

Based on field findings, about 83.3 per cent of the plots have already been developed into residential units the majority of which have been rented out. About 97 per cent of residential units are owner occupied. Rented houses have shot in value. The design of these house units are such that they are self-contained and range from one to three bedroom in size. 66.7 percent of houses are two bedroom with a few of them being three bedroom. Rents go for an average of 4500 for one bedroom, 6500 for a two bedroom and 7500 Kenya shillings for a three bedroom. Majority of these houses are flats commonly up to the second, third and fourth floors with a few cases of up to the fifth floor. The rest of the houses block are single level developments. The big size (than expected) of the house units explain the relatively low residential density compared to other residential areas with multi-level developments. This has a direct implication on the amount of generated waste water.

From the initial 13.000 shillings per 1/2 an acre of land prices have shot to between 250.000 and 350.000 Kenya shillings per 15 by 22.5 meters size plot. Plots bigger than this are difficult to find if ever available.

Economic Background

Before the extensive development of housing units on the ground today, the study area was classified as agricultural land. Climatic conditions dictated that the area be economically used in animal husbandry. Nairobi Metropolitan Growth Strategy of 1973 had, however, indicated that the land will be ripe for development by the year 1990. This anticipated development took place earlier than has been foreseen, starting as late 1970's.

The area, as has already been pointed out, provides housing for over 56,000 people. At least 75 per cent respondents are commuters who go to town centre for work. The rest of the respondents are either housewives, or work within the estate. Offering self employment sites, are a number of supermarkets, several shops, hardware and chemists. Serving the same purpose are the great number of kiosks, glossary sheds and small jua kali enterprise (cottage industries) involved in activities such as carpentry, car repairs, welders and tailoring. Street vendors in merchandise such as second hand clothes, shoes, kitchen-ware are many. Also present are a number of butcheries, bars and a number of private pre-unit schools. There are also a number of private health-care clinics. Construction industry, offers daily jobs for many youths.

Summary

All physical attributes of the area point out to an anomalous characteristics of a high residential area. First, the distance from the city centre is big enough to fit the area being described to be in the peri-urban area. Secondly, the developments in the vicinity of the study area have left a high density residential area in the midst of low intensity

developments. Further, the area covered by the estate (400 acres) is small to an extent that it may have seemed uneconomical to provide bulky service infrastructure such as a sewer system. On the other hand, black cotton soils, high water table and unfavourable topography cannot allow effective operation of waste water tanks.

Historical development manifest a series of mistakes all of which have culminated in the current deplorable status of the estate. Mere cheapness of land brought forth a high density residential estate through commission, at first, followed by a series of omissions. Change of hand of the land reflects a level of irregularity culminating in convertion of a formerly agricultural land into urban land without provision of services which characterize urban land. Planning regulations have been floated at the very nose of Nairobi City Council through an influence of an individual. Sub-division of land have resulted in a population that does not have the required services. In fact lack of services, which means lower price for land, has been the major driving force behind plot subdivision and subsequent occupancy. Economic pressure, manifested by inflation over the years has further resonated the influx of immigrants into the area.

The aftermath of persistent failure in provision of services, hence cheap land has seen the conversion of a formerly grazing land into a residential estate which has housed over 56,000 people. Subsequently, 140 persons are residing in every acre of unserviced land, a population which is distributed in approximately 13,300 house units. Going by the nature of employment, level of education, sizes and standard of house units and the amount of money spent on house rent, transportation, electricity and water bills, Zimmermann estate was concluded to be occupied by middle income earners. The characteristic population structure can be summed up to be that of young families.

The majority, 97 per cent of the household reside in rented houses on pieces of land which have already been recognized to be privately owned; meaning that title deeds have already been issued. Land tenure is on leasehold basis. Already, 83.3 per cent of the plots have already been developed into rental residential units. Of these 83.3 per cent, 56.7 per cent of the plots have been developed in to multi-storey residential units. High level of waste water generation is evidenced by a finding that, 98 per cent of the resultant house units have wet cores and water closets within them and range from one to 3 bedrooms in size.

The resident population relies on income earned by the household heads, their spouse and, in certain occasions, close relatives such sisters and brothers, 83.5 per cent of whom work outside the area of study. In relation to the economic activities, the estate hosts a number of activities other than residential houses. Such include commerce in designated shopping centres, kiosks, roadside sellers, operation of services units such as private clinics and preparatory schools etc.

All the above factors portray a situation where waste generated from the residential area presents a problem. In the absence of a convectional waste water system use of waste water tanks has been unavoidable. Performance of effective waste water disposal systems for low density area, now being used in high density area is expected to be marred by a lot of inefficiency. This phenomenon is the focus of the proceeding chapter (chapter 4).

CHAPTER 4

EFFECTIVENESS OF SANITATION METHODS IN ZIMMERMANN

4.0   **Introduction**

There are various reasons for which a given sanitation technology will be selected from a list of many others. For this particular case, the criteria which used was the ability of the method to relocate the waste water from the point of generation to a more suitable and non-detrimental site. This chapter focuses on the suitability of the use of cess pits, conservancy tanks and septic tanks in Zimmermann in the light of three element upon which effectiveness of sanitation can be measured. By evaluating the amount of waste water produced against the capacity of the environment to contain the generated waste water, the resulting negative or positive balance will show the suitability of the sanitation method. The element of suitability was further refined by analyzing the costs associated with operation of the current waste water disposal systems.

4.1   **Amount of Water Consumed**

An estimate of the amount of waste water generated in Zimmermann was obtained by a way of analyzing the direct and indirect indicators underlying water consumption in a residential estate. Among the indirect indicators are: population size, population characteristics such as socio-economic status and age-sex structure, as well as reliability of water supply, and the proportion of house units with water closets and wet cores within them. Direct indicator of the amount of water consumed has in this case been taken to be payment made in form of water bills.

Indirect Water Consumption Parameters

Population Size

As a general rule, the average water consumption from a given region can be obtained by getting the product of the established per capita water consumption and the population. The population of Zimmermann was found to be 56,215 persons while the social economic status of the population can be summarily be said to be in the middle income bracket. Experimental establishment has placed the per capita water demand of a middle income at 135 liters per day (Nairobi City Council, 1998). Syagga (1979) supports this figure by pointing out that low income areas have an average per capita water consumption of between 36 and 100 liters per day. The two figures work out to a water consumption rate of 7,589,000 liters or 7,589 cubic meters per day for Zimmermann estate.

Population Characteristics

The population structure has an implication on the amount of water consumed. A neighborhood composed of young families is expected to have a higher water consumption than one composed of old couples, even when the number of households are the same. However, the population structure alone, unlike the population size coupled with the socio-economic status, cannot give a specific numeric figure of water consumption. It can only be used to show relative water consumption levels of two or more residential areas with different population structures.

The fact that Zimmermann is generally a residential estate for young families is reflected by the population pyramid (figure 3G) which has a relatively wide center and base. This is further manifested by the fact that 249 members from 59 households had

41 members being children below the age of 5 years. However, presence of more females than males (120 for every 100 respectively) in the study area may be assumed not to have any significant influence on the consumption of water and hence the amount of waste water generated.

It is evident from figure 3G that Zimmermann estate is composed of relatively young families. This means that the per capita water consumption should be expected to be slightly higher than the average. In addition socio-economic status of a population also provide an indicator on the average per capita water consumption. This consideration is, however, also not conclusive unless it is looked at in combination with the size of population in question. Based on few selected expenditures, Zimmermann is clearly a middle income earners settlement area, whose average per capita water consumption is expected to be about 135 liters per day (Nairobi City council, 1998).

4.1.3   Reliability of Water Supply

An assessment of water of water reliability was carried out and established that two criteria can be used. The first was based on the respondents judgement and it may thus include indirect assessment vote relative to other estates in Nairobi. With a water supply rating scale ranging from bad to excellent. 19 per cent respondents rated the water supply as excellent. 33 per cent rated it as good. 33 per cent said it was fair while 15 pe cent said it was poor. The second criteria is more value neutral and looks at the frequency at which the taps go dry in a duration of one week. 19 per cent of the respondents report that they have never witnessed a dry water tap in their houses, while 32 per cent reported that the taps go dry for less than a day in a week. 10 per cent more reported that the taps are dry for a maximum of 3 days while 2 other had problems of

water during the weekends only. 33 per cent respondents reported that dry water taps cannot be said to be a phenomenon with any sequence, that is that disappearance of water was sporadic. The 10 per cent who said that the water supply was unreliable reported that the taps were dry during day light but supply was resumed with reduced water use which happened to be during the night and some hours of the daylight.

Presence of Water closets and Wet Cores Within the house units

Within the study area, water closets and wet cores include, kitchens which are fitted with water taps and at least a sink, laundry unit-cum-bathroom as well as flushable toilets. House units with water closets and wet cores within them is a good indicator of the level of water consumption"

All the house units which were least one bedroom in size, were observed to have had a flushable toilet, a kitchen which is fitted with at least a water pipe and a sink, a living room and a bedroom. This means that they had wet cores and water closets. Of the sampled house units 98 per cent of them were at least one bedroom houses and had all the elements mentioned above, meaning that they had wet cores and water closets within.

Direct Water Consumption Indicator Parameter

The only direct indicator of water consumption in Zimmermann and Nairobi in general, are the water meter readings which are supposed to carried out once every month. In Zimmermann, water bills use is not a reliable method of calculating the amount of water consumed because the residents report that the bills they receive are based on estimations and not the actual meter readings. The resultant bills can therefore only estimate the level of water consumption. In addition, Zimmermann has a specific problem in payment of water bills, in the sense that in a number of cases bills are paid by the landlord and thus are included as part of the house rent as a constant bill. The sample composed of 36.7 per cent of the cases where water bill was included as part of house rent. Under the assumption that payment of constant rate does not significantly affect water consumption relative to one where bill are issued every month, the remaining 63.3 per cent of the respondents data was used to obtain the general water consumption level for the whole sample.

According to the water billing tariff from Nairobi City Council, the higher the amount of water consumed the higher should be the water bill but this proportionality becomes progressively higher. Of the 38 positive respondents 97 per cent of them provided valid figures that can be used in this generalization. Data from the field show that relationship between the size of the household and amount of water consumed is not pro-rata. Although it would be expected that the bigger the household, the higher should be the water consumed, this relationship is only vaguely reflected. This shows that the estimated bills are to a certain extent, not accurate. The extent to which some bills are incorrect can be easily picked from the erratic figure that some households reported. As an example, a household with 15 members consumed about 12 cubic meters of water

the same as two households with one member each, two households with two members each, three households with three members each and four households with four members each.

Using the reported bills and through averaging out a product of, water consumed and the respective household sizes the amount of water consumed per month was calculated (see the table below). Each of the households water consumption was obtained through back calculation using the amount of money that had been paid in form of water bills.

Table 4.1:   Water consumption with respect to household sizes

household size	calculated water consumption in thousands of liters per month
1	10
2	12
3	12.5
4	14
5	20
6	29
7	34
8	35

The average per capita water consumption was then obtained from the figures. This gives 4.625 thousand liters per person per month.

Source: Compiled by the author on the basis of the water bills paid

As shown in the table 4.2 below, theoretical water consumption estimations reflect significant difference with the actual water consumption, especially in relation to

smaller households. Theoretical water consumption per month is obtained through multiplying the capital water demand for a middle income residential estate by the average number of days per month. Both theoretical and observed water consumption are presented in the table below.

Table 4.2: Comparison of calculated water consumption vis-a-vis the findings from the field

household size	theoretical estimation in thousand of liters per month	field data consumption rate in thousands of liters per month
1	4.05	10.0
2	8.10	12.0
3	12.15	12.5
4	16.20	14.0
5	20.25	20.0
6	24.30	29.0
7	28.35	34.0
8	32.40	35.0

This shows that the field research findings closely tally with the estimations documented in the literature. The difference in the two is a result of the fact that Zimmermann's population may be expected to deviate from the average due to its population structure. Secondly, this difference make sense in that, when a household has two members water consumption especially in washing of clothing would not vary much from a household that has one member. In this case, bathroom and toilet water usage is the only water consumption element that varies pro-rata with the number of household members.

Amount of Generated Waste Water

Various factors give an indication of the amount of waste water generated from a residential neighborhood. Of the most important indicators, are household size (hence population size) and household characteristics, all of which are summarily reflected in the water meter readings. Other elements such as presence of water closets and wet core within the house as well as reliability of water supply show the extent to which theoretical estimations can be applied to work out the amount of waste water generated from a given neighborhood. In relation to these elements, Zimmermann estate has been found to be occupied by middle income earners, house units have wet cores and water closets within, is occupied by relatively young families and has a fairly reliable and constant water supply. Previous studies in the generation of waste water have established that 80 per cent of the water consumed ends up as waste water. The following table shows that amount of waste water released from the various household sizes.

Table 4.3: Waste water generation in relation to Household sizes

household size (a)	Water consumption in thousands of liters per month (b)	generated waste water in thousands of liters per month (c)
1	10.0	8.0
2	12.0	9.6
3	12.5	10.0
4	14.0	11.2
5	20.0	16.0
6	29.0	23.2
7	34.0	27.2
8	35.0	28.0

Average per capita amount of waste waster generated can be obtained by getting the product of total amount of waste water generated divided by the number of person generating it, that is;

$$\Sigma(c)\frac{1}{\Sigma}(a) = 133.2\frac{1}{36} = 3.7$$

source: Compiled by the researcher based on the field findings.

Capacity of the Environment to Contain the Generated Waste Water

Various elements show the capacity of the environment to contain the generated waste water generalised from a given neighbourhood. These elements can be divided in to man-made facilities the natural environmental conditions. Man-made facilities include, among other things, waste water tanks. These two features should enhance one another if the waste produced will be efficiently contained. If one of these elements has some attributes which down play its performance, the efficiency of the whole system is reduced. This section evaluates the condition of the waste water tanks and the surface and sub-surface conditions in relation to the amount of waste water generated.

Capacity of the Waste Water tanks

The various types of waste water tanks in Zimmermann are conservancy tanks, cess pits and Septic tanks[10]

---

10 [illegible footnote text]

The use of the three type of waste water tanks is recommended in areas with residential density does not exceed 30-40 persons per hectare (Nairobi City Council 1998). Going by the plot coverage, septic tanks are not adequate for use in Zimmermann estate. However, going by the presence of three chambers there are some on them on the ground. Information obtained from one of the landlords and a resident of the estate enumerated the presence of the three chambers characteristic of a septic tank on a space measuring two by seven metres. This clearly show that the septic tank is ill designed.

4.3.2.1   Required Size of Waste Water Tanks

The population of Zimmermann was found to be 56,215 (refer to section 4.1.1.1) above. Each of these persons produces 80 per cent of the per capital water consumption. Zimmermann's per capital water consumption per month is given in the table below

TABLE 4.4   WATER CONSUMPTION IN ZIMMERMANN IN THOUSAND LITRES

size of the household (a)	frequency of occurrence (b)	water consumption per household (c)	total water consumption (b*c)
1	6	10.0	60
2	6	12.0	72
3	6	12.5	75
4	8	14.0	112
5	21	20.0	420
6	9	29.0	261
7	2	34.0	68
8	1	35.0	35
TOTAL	59		1105

the average per capital per month is given by the formula:

$$\sum(b*c)\frac{1}{\sum}(a*b) \quad \frac{1130}{249} \quad 4.43 \quad [1] \text{ thousand liters}$$

Source.   field survey compilation

Considering that, 80 percent of the water consumed ends up as waste water (Nairobi city Council, 1998) This in turn means that the per capita waste water production in Zimmermann is 3543 liters per month.

[1] world [...] water [...] consumption per day [...] middle income earner [...] nairobi [...] Nairobi City Council [...] This figure [...] [...] per person per day [...] low income earner [...] water consumption rate [...] liters per person [...]

The total number of occupants from 98 per cent of the sampled households is 249 members. This implies that , on average each household unit has 4.22 members. The 60 sampled plot had a total of 661 house units meaning that each plot has an average of 11.2 house units. This further implies that, 59 of the 60 sampled plots have an average of 47.28 occupants (11.2 * 4.22).

The average waste water production in Zimmermann is 3543 liters per month per person. Thus, 47.28 occupants from each plot generate about 167,500 liters of waste water per month (per capita waste water production multiplied by the average number of persons per plot [3543 * 47.28]). Assuming that no waste water drains on to the street, the waste water tanks are supposed to be capable of containing this amount of waste water.

Owing to the small plot sizes, high water table and black cotton soils (see part 4.2.2.1 and 4.2.2.2 below) construction of properly designed septic tanks is not possible and the fact that there will be a lot of ground water seeping in to the waste water tanks does not allow effective operation of cess pits. This implies that, conservancy tanks have been left as the only effective waste water handling tanks in the estate.

Conservancy tanks do not allow soakage of water out of the waste water tank into the soil media. On average, therefore, the conservancy tanks in Zimmermann should at least have a minimum size of 167,500 liters or 167.5 cubic meters in volume if they will not result to over-flows. It should also be borne in mind that this volume of waste water tank would only function with the expected efficiency if the frequency of exhausting these tanks is at least one time per month.

4.3.1.2 Sizes of the Waste Water Tanks as Observed in the Field

Construction trends of the residential blocks in Zimmermann display a phenomenon where waste water tanks are treated as if they are accidentally part of residential development (see plate 4) and not an integral part of it. The positioning of the waste water tanks in respect to the residential block and the servicing road manifest the presence of problems during exhausting (see plate 3).
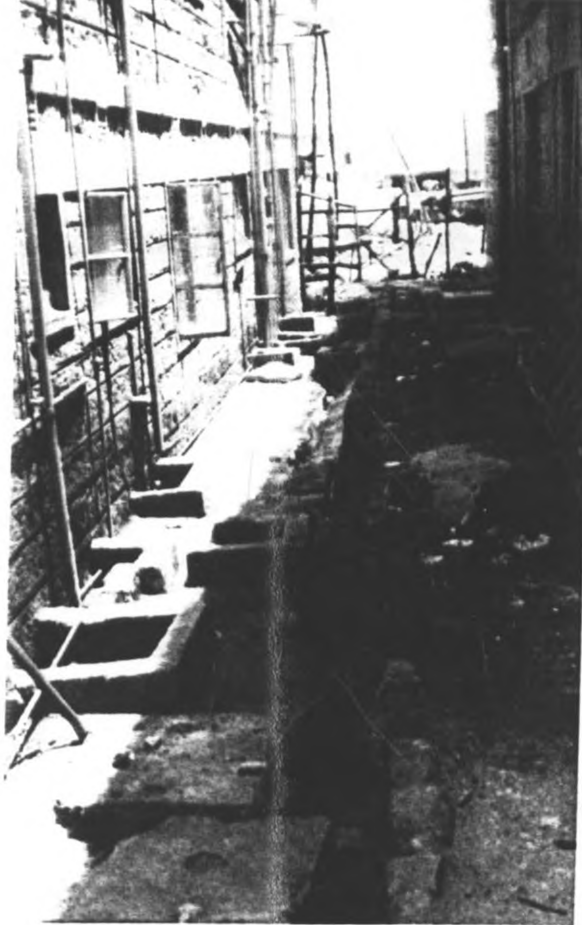
PLATE 3:

Back allays of residential blocks. Here, two waste water tanks for two adjacent blocks are next to one another. Note the elongate waste water tanks and the intense network of fresh and waster water pipes.
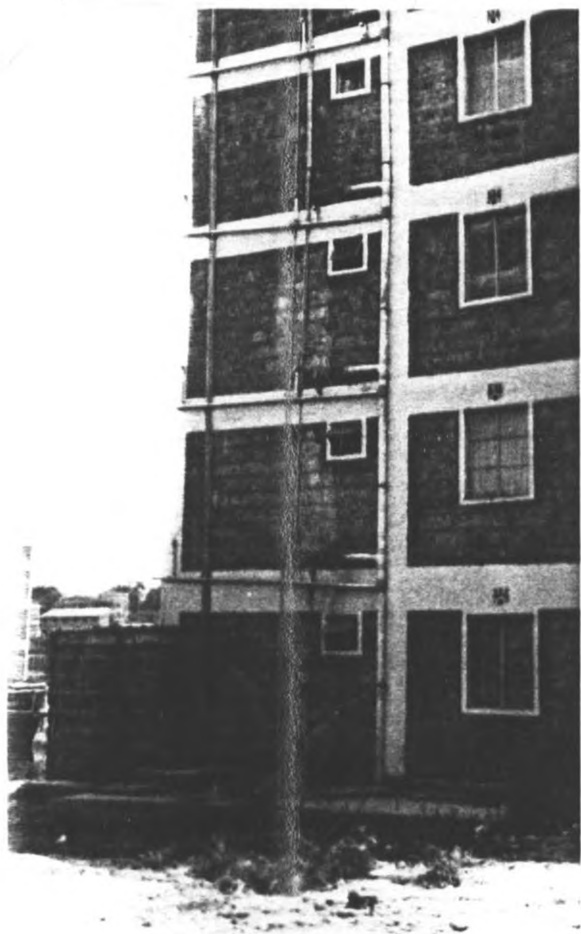
PLATE 4:

Waste water tanks are taken as accidental to the development and not an intergral part of it. Note the small size of the waste water tank despite the many storeys that the block has been constructed.plate 3). In the 60 sampled plots, the following positions of waste water tanks was observed .

Fig 4A: Waste Wat.Tank Location

at the back
52%

not found
2%

centre
13%

on sides
17%

in front
17%
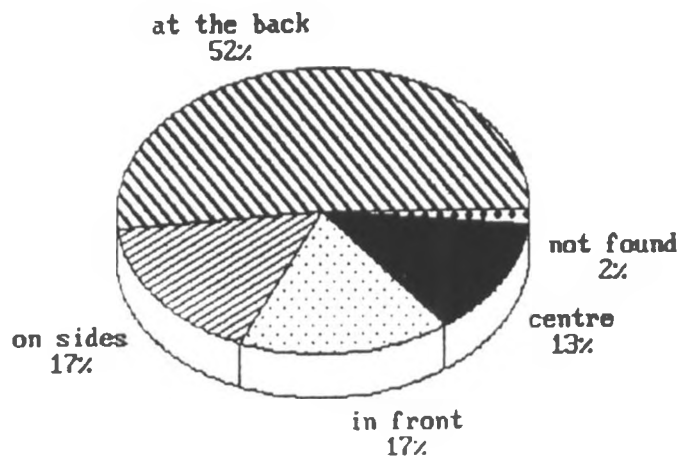
Source: Field survey, 1998

Measurement of the waste water tanks could only be accomplished as far as width and length are concerned for most of the plots. It was only possible to obtain the depths of 8 tanks and which was done through enquiry and not actual measurements. There are, however, no indications that any of the waste water tanks could have been deeper than 10 meters. Of the eight whose depths could be established, the shallowest was two and the deepest 8 meters. The average depth was found to be 4.9 meters the mode being 5 and 6 meters.

The waste water tanks were coming in various extent in terms of areal dimensions (a product of width and length measurements). In some plots there were two such tanks. In the 60 sampled plots, the one observed to have occupied the biggest area covered 40 square meters while the smallest covered an area of 3 square meters. The mode was 6 square meters while the average was 13 square meters.

TABLE 4.5 :AREA COVERED BY WASTE WATER TANKS

area covered by waste water tank in sq m (a)	frequency of occurrence (b)	total area occupied by each of the waste water tanks in sq m (a*b)
3	1	3
4	2	4
5	3	15
6	11	66
8	7	54
9	2	18
10	8	80
12	1	15
14	2	28
15	1	15
16	2	32
18	2	36
20	2	40
21	2	42
24	1	24
25	1	25
30	3	90
36	1	36
40	2	80
not measurable	6	-
TOTAL		703

As previously seen, the average depth of waste water tanks is 4.9 meters. The average volume of the waste water tanks, therefore works out to 63.7 cubic meters.

According to the average amount of waste water produced per plot per month and assuming an exhaustion rate of once in a month, the waste water tank should measure 167.5 cubic meters. This shows that, on average the waste water tanks only measure to a third of the required size.

4.3.2   Subsurface and Surface Conditions of Zimmermann Estate

Subsurface conditions, to a great extent, affect absorption or seepage of waste water from cess pits and septic tanks. Depending on whether the subsurface conditions will contribute or reduce the liquid part of waste from the waste water tanks, one can choose between a cess pit and septic tank on one hand and conservancy tank on the other. The subsurface conditions on the better part of Zimmermann estate leave no other alternative for waste water disposal other than conservancy tanks. The elements of subsurface and surface conditions are poor soils, high water table and unsuitable topography.

4.3.2.1   Poor Soils

As indicated in map III, the better part of Zimmermann is composed of black cotton soils. This type of soil have poor absorptive conditions and is generally described as impervious. As such this type of soil will not allow water to percolate from the cess pits or septic tanks into the soil media. This implies that, at best, there will be no difference on whether a waste water tank is a conservancy tank a cess pit or a septic tank. In case where the water table is high enough, cess pits and septic tanks are worse off since ground water contribution means an added volume of water that will eventually have to be disposed. On normal instances, cess pits and septic tanks are supposed to hold back

the solids while allowing waste water to seep into the soil media, a process that cannot take place in areas with impervious soils such as of black cotton soil. In Zimmermann estate, black cotton soils are found in the upper part area, while alluvial deposits are found within Gatharaini river flood plain.

The upper part of the estate (see map III) is underlain by very shallow red volcanic soils while some parts of the same section have bare rock exposed right to the surface. This means that excavation of waste water tanks is difficult and cannot be deep enough in addition to the fact that, the rock material at the sides and base of the waste water tank will retain both solid and liquid waste. The implication is that, there will be no difference between septic tanks and cess pits on one hand and conservancy tanks on the other with regard to operation.

4.3.2.2   High Water Table

Zimmermann estate is located on a ground with a high water table. In the central part of the estate (see map II), many are the points where the water table is at the ground level resulting into natural springs within the estate. The two main water courses in the area are convergence channels for the water from these springs as well as outflow from waste water tanks. Within the 60 sampled plots the following state of the servicing streets was observed.

TABLE 4.6 :   STATE OF PLOT SERVICING STREET AND ITS COURSE

STATE OF THE STREET	FREQUENCY OF OCCURRENCE	PERCENTAGE
not muddy	23	38.3
muddy with water from the waste water tank	6	10.0
muddy with domestic waste water other than from the toilet	10	16.7
muddy with water from underground seepage	6	10.0
muddy with a mixture of waste water both from the waste water tank and from kitchen and bathrooms	5	8.3
muddy with water from underground seepage and kitchen and bathrooms	3	5.0
muddy with water from the waste water tank, underground seepage and kitchen and bathrooms	7	11.7
TOTAL	60	100

source: field survey findings

Table 4.6, above, shows that 10 per cent of the sampled plots owe their muddy state purely to underground seepage. Another 16.7 per cent of the sampled plots have an element of underground water behind the muddy state of the servicing. In a nutshell, table 4.6 shows that 26 per cent of the sampled plots are located on areas where the water table rhymes with the ground surface. The water table simulates the topographical define but it is subdued such that the sharp and abrupt bulges and depressions on the ground surface are smooth curves on the water table. This means that water table in Zimmermann is only below the ground level where there are anomalously bulging areas over the homogeneous surface. Consequently, in almost the whole of the central zone

(see map II) an excavation below the depth of 3-4 meters will strike the water table. This is clearly evident on the construction sites where water oozing out from the foundation trenches have to be constantly pumped out. Some of the excavation trenches are hardly a meter and a half in depth.

In an area with such a high water table, cess pits and septic tanks get flooded with underground water even before construction is complete. If the construction of such tanks is completed, through a constant pumping out, the result is an extra contribution of water to the waste water tank throughout its life span. As such cess pits and septic tanks in such an area will be less efficient than a conservancy tank.

From the foregoing discussion, it is evident that the central part of Zimmermann, the area in the flood plain and the upper part could only be having conservancy tanks not only because they have been designed but because the rock material on the sides make them operate like conservancy tanks even when they were designed as cess pits or septic tanks. Properly designed and constructed septic tanks cannot be an option in Zimmermann first because of the small size of the plots and secondly because the operation of septic tanks is hampered by the high water table. For them to operate efficiently, septic tanks are supposed to have a maximum depth of 2 meters, reflecting an unreasonably low volume for Zimmermann's residential density. The shallow depth allows for aerobic decomposition and thereby avoiding emission of odours.

PLATE 5: Harphazard methods of covering depressions present on many streets have made some
of the streets immortorable. This has, however, not drained off the waste water pools.

PLATE 6:   Along some streets, waste water in form of pools have made it difficult
to access the house units through the gate.

4.3.2.3   Unsuitable Topography

Topographical morphology dictates the rate of surface flow of water meaning that it is a measure of how well an area is drained. Over 75 per cent of Zimmermann estate is almost flat (see map II). This results in numerous pools of stagnant water (see plates 5 and 6). The source of the water could be underground seepage, domestic waste water, storm water or a combination of any of these. The sloppy area (see map II) is well drained despite the fact that waste water is generated at the same rate as the other parts. This part also enjoys an advantage of the fact there is no direct contribution of water from the underground because the water table is lower in this area. The better part of Zimmermann estate and the neighbouring areas whose topography is not allowing surface drainage on top of being prone to emergence of springs the year all round although the problem is worse during the rainy seasons, is poorly drained.

4.4   Summary

The amount of water consumed, is a factor of the population size and characteristic, age-sex structure of the population, reliability of water supply and the number of households with water closets and water cores within them. All of these elements are summarized in the water consumption bills. Through back calculation from the average monthly bills, an average water consumption of 4.47 thousand liters per person per month was obtained for Zimmermann estate. Calculated on the basis of the fact that 80 per cent of domestic water consumption turns to be waste water, the amount of generated waste water worked out to 3.543 thousand liters per person per month (144 liters per day per person). The capacity of the environment to contain the waste water shows that each plot should have a waste water handling systems of not below 167.5

thousand liters; assuming an exhausting rate of once per month. However, the average volume of waste water tanks worked out 63.7 thousand liters. This means that, on average, the waste water handling systems would release 104.2 thousand liters per month from each plot, again assuming a monthly exhaustion rate of once. In cases where septic tanks and cess pits have been used instead of conservancy tanks, their performance have been shown to be worse than when the later is used; given a subsurface which is characterized by black cotton soils and a high water table (on some places it is on the ground surface).

Frequency of emptying waste water tanks shows that, it is only in 2 per cent of the plots that carry out exhausting at the recommended rate, (ie once per month). Even then, the size of the tank is a third the required size meaning that it allows two thirds of the plot's waste water to get into the environment untreated. A further 3 per cent of the waste water tanks are exhausted twice in a year while 12 per cent have it done once every year. In 3 per cent of the plots exhausting is done once every year, while in 5 per cent it is done once every three years. In the rest 75 per cent of the plots, the rate of emptying per month ranges from once every month four years to a situation where it has never been done since the interviewee moved to that house. A consideration that tenants may not be aware about the exhausting service deliverance was ruled out on the basis of the finding that landlords only order for this service after receiving complaints from the tenants.

In the words of Loehr (1977) the problem of sanitation is perceived within the context that waste water disposal is concerned with relocation of waste water from the point of generation to more suitable and non-detrimental site. Further, the efficiency of a sanitation method is judged upon, the extent to which human contact with excreta, including all waste water, can be avoided (Batch 1972). Going by this criteria a conclusion on whether sanitation technology in a given area is effective or not can be made. The foregoing discussion proves that use of septic tanks, cess pits and septic

tanks in Zimmermann estate is ineffective by virtue of the fact that law waste water gets into the environment either directly from the waste water tanks of from pipes that drain from kitchens and bathrooms. Except in the case 2 per cent of the sampled plots an average of between 100 and 160 thousand liters of waste water from each of the developed plots in Zimmermann gets into the environment every month. The contents of this waste water are all forms of domestic waste water ranging from human excreta to detergents, food remains, domestic chemicals eg insecticides etc. This shows that use of waste water tanks in Zimmermann is ineffective. The costs associated with this ineffectiveness of waste water tanks is evaluated in the proceeding chapter (chapter 5).

CHAPTER 5

COST OF USING OF SEPTIC TANKS, CESS PITS AND CONSERVANCY TANKS IN ZIMMERMANN.

5.0   Introduction

A population of 56,215 people on an unserviced land parcel of 400 acres results in a myriad of problems. The most glaring one in Zimmermann estate is that of waste water disposal. An average of 167.5 thousand litres of waste water is generated in a month from each of the developed plots, each of which measures about 15 by 22.5 metres. The only waste water disposal facilities are tanks which can only accommodate a third (63.7 thousand litres) of the generated waste water assuming an exhaustion rate of one time per month. Field survey findings based on the size of the waste water tanks and the amount of waste water produced show inadequacy of the sanitation method. It is only in 2 percent of the sampled plots where emptying is done at the required frequency. As a result, about 150 thousand litres of law domestic waste water is released from each plot into the environment per month. This proves that the use of cess pits septic tanks and conservancy tanks in Zimmermann is ineffective.

Ineffective sanitation methods leads to a number of costs ranging from monetary costs in form exhausting charges to environmental costs within the area concerned. This chapter focuses on both monetary costs of emptying waste water tanks and the negative environmental impact that the overwhelmed waste water tanks pause to Zimmermann residents and environs.

5.1   Cost of emptying Waste water Tanks in Zimmermann

Cost of emptying waste water tanks can be divided into two namely, the actual costs incurred by landlords which is obtained from the number of times that exhausting service has been ordered. The second category is the cost of emptying, taking a hypothetical situation if the services were to be provided whenever the waste water tanks are full thus not allowing any to flow on to the streets.

5.1.1   Actual Incurred Costs on Exhausting Services.

Generally, exhausting services in Zimmermann are rarely asked for although the amount of waste water generated calls for exhausting service every month. It is in 2 per cent of the sampled plots, where the service is offered every month. Even then it should be noted that, on average the size of waste water tanks in Zimmermann (see plate 4) demand exhausting service thrice in a month if no raw waste water is not be allowed to spill into the environment. In 61.7 per cent of the sampled plots, such services are not known to the tenants or have not been order for, for a period ranging from six months to eight years. In another 33 per cent, the service have been ordered once in a time period of four to seven years, while in 5 per cent others it had been offered three times. In 3 per cent of the plots, exhausting had been done once in two years while in 10 per cent it was done once in a year. In 3 per cent of the plots the service was ordered twice in a year. The exhausting charges by both Nairobi City council and illegally operating private exhausters is three thousand shillings for an average lorry load of 10,000 litres (see plate 7). Taking average waste water tank size of 63.7 thousand litres for every plot. The computation of costs of emptying the tanks is shown in the table 5.1. below.

TABLE 5.1:   **COMPUTATION OF THE COST OF EMPTYING WASTE WATER TANKS**

duration after which exhausting is done (yrs) (a)	frequency of occurrence (b)	number of times exhausting has been carried (c)	cost of exhausting in ksh d=[c*(63.7/10)*3000]	average cost per year (ksh) e=d/a	total cost for all such plots per year f=(e*b)
4-7	10	1	19110	3822	38220
3	3	1	19110	6369	19110
2	2	1	19110	9555	19110
1	6	1	19110	19110	114660
1	2	2	38220	3810	76440
1	1	12	229320	229320	229320
-	37	-	-	-	-
total	60				496860

source: field survey, 1998

From the table 5.1 above, about 496860 shillings is spent by 23 plots every year as the cost of emptying waste water tanks. This means that, on average every plot spends about 21600 shillings per year. However, this figure suffers a major draw back in that thirty seven respondents, each from a different plot, reported that they have not heard of the exhausting service in the plot within which they were residing. There are chances that exhausting could have been done in the respondents absence. The positive respondents may also have been reporting exhausting rate which omits the number of times the service was carried out in their absence.

5.1.2   Cost of Emptying Waste Water Tanks as Demanded by the Amount of Waste Water Generated

These costs take an arbitrary situation where no waste water is allowed to drain into the street as a result of overflowing waste water tanks or segregation of waste water into sullage and sewage and where sullage is drained directly on to the street. It would, thus be, the ideal exhausting costs, that would serve the same purpose, and with the same efficiency as a sewer system. Since the field survey revealed that full waste water tanks go for up to eight years without being emptied, the calculations are by no means the actual costs (discussed in section 5.2.1) incurred.

On average, each of the 60 sampled plots generates 167.5 cubic metres of waste water all of which is supposed to be emptied before it overflows on to the streets. Since the average waste water tank size is 63.7 cubic metres, exhausting should be done three times a month (after every 10 days). The average cost of emptying a full waste water tank is given by:

- the number of lorry loads * charge per lorry load, where:
- the number of lorry loads = size of the waste water   tank divided by the lorry load capacity
- number of lorry loads per full waste water tank

$$63.7 \frac{1}{10} = 6.374 \qquad \text{lorries}$$

Since no law waste water is supposed to spill into the environment and there are no provision for charges for half lorry loads, the figure should be to the nearest whole number. This means that, on average, 7 lorry loads will empty one waste water tank. Further, if no waste water is to flow onto the streets emptying should to be done thrice in month meaning that a total of 21 lorry loads are needed to empty one waste water tank per month. This works out to 63,000 shillings per month in form of exhausting charges.

The fact that about 21,600, shillings per plot per month is spent on exhausting service compared to what would have been the cost if exhausting was frequent enough to provide an efficient disposal which matches that of a sewer system (63,000 shillings) provides a basis of estimating the amount of law waste water which drains into the environment. Essentially, only a third of the ideal cost is spent meaning that nine tenths of the waste water generated in Zimmermann drain into the surrounding. This is evident in the field as exemplified by permanent streams and pools of law waste water on the streets and vacant plots (see plates 2, 5, 6, and 8). This have resulted in a number of environmental costs. The environmental costs of sustaining overwhelmed waste water tanks are evaluated in subsection 5.3, below.

5.2   Environmental Costs of Sustaining Ineffective Waste Water Disposal Systems in Zimmermann Estate

Environmental costs include a range of negative effects caused by the waste water that drains into the streets, open and vacant plots and Gatharaini river, to diseases which are directly or indirectly linked to the insanitary situation of estate and accidents that may be attributed to the presence of waste water filled tanks within a residential estate.

5.2.1   Dump/Waste Water Soaked Residential Neighbourhood

Waste water from overflowing waste water tanks or that which drains directly from bathrooms and kitchens flows onto the streets, vacant private plots and in some cases stagnates within the generating plots. As a result pools and streams of law waste water characterise Zimmermann estate. A major hindrance to draining of these pools is presented by the poor black cotton soils and the high water table on

one hand (if natural percolation into the ground is to be relied on) and the flat topography if man-made surface or underground channels are to be used, on the other. The result is a residential estate which is always muddy regardless of the situation of the weather.

Out of stagnant waste water in the streets comes out odours and muddy streets which makes walking and even accessing the house units difficult (see plate 5 and 6). Of the sampled plots, 61.7 per cent had the immediate servicing street muddy. Of these 61.7 per cent, 83.7 per cent of them owed their muddy state to at least waste water directly from the kitchen bathrooms or both. The rest 16.3 per cent owed their muddy state to water seeping from underground. The respondents expressed the fear with which they step on this mud because they know that it is as a result of water draining from waste water tanks and thus contains human waste.

Presence of awful odours either directly from waste water tanks or from stagnant water or a combination of stench from waste water related sources and garbage was reported in 66.7 per cent of the sample. The stench was reported to be emanating from respondent's plot waste water tank or draining gutter, from the neighbouring plots waste water tank or plots afar and which are along the respondents' way either to a friends house, shopping or the street that one uses on his/her way to the main road. Varied combinations of these source of odours were also reported which shows that these are elements which characterise the whole estate and not just a section of it. This may explain the reason for which house rent is relatively low in Zimmermann relative to other residential estates within the city and which have similar house units' size and design standards.

PLATE 7   One of the illegally operating private exhauster in the estate

PLATE 8:   Some multi-storey blocks do not seem to have any waste water draining
           from them. The reason behind this is that waste water is drained through
           undeground pipes on to the street

Diseases

Streams and pools of waste water which characterise Zimmermann estate would be expected to produce an environment with many cases of water related illnesses. These are diseases which are as a result of indigestion of contaminated foods, inhaling contaminated dust as well as diseases which flourish in dump environments. The environ is also relatively rich with disease spreading vectors for instance mosquitoes and houseflies thus high incidence of characteristic diseases.

Three medical practitioners within the estate gave a similar trend of occurrence of diseases which are common in the estate. Two of the clinics had not been operating for long, one having opened in 1996 while the other started operating in 1997. The oldest and whose information can be relied on more, started operating in 1990. In addition to the fact that it has operated for a longer duration than the other two, it enjoys a higher patronage, treating about 30 patients per day, compared to the other two which treat an average of 20 and 10 patients per day respectively. The three clinics are operated by qualified medical doctors, the oldest being run by a doctor who has worked in several Nairobi city council dispensaries and thus was relied on for comparative analysis. The three clinics reported the same ratio of grown-ups to children patients which was 1:3. The diseases treated in a descending order of the rate of occurrence are upper respiratory tract infection (URTI), malaria, diarrhoea and stomach worms related infections in children, typhoid fever and amoebiasis. The three doctors gave a figure of about 90 percent of the URTI to be common colds. They attributed URTI to high humidity (dampness). The oldest of the clinic operators pointed out that URTI have higher occurrence rate during the wet seasons in other areas of the city that he had worked in, but the number of cases he had been attending to in Zimmermann was constant regardless of the status of the weather. He attributed the constant number of incidence of URTI to the high humidity

throughout the year as a result of constantly exposed water surfaces. The three doctors further reported that the rate of occurrence of the other diseases does not show significant difference with other estates in Nairobi. One of the clinic operators reported that he would have expected more cases of malaria than in the other estates in the city, but most malaria patients treat themselves at home and only seek professional medical attention if the disease had resisted self administered treatment. The disease (malaria) is also frequently reported if the patient is a child. Typhoid infection and amoebiasis are indicators of possible waste water leaks into the fresh water pipes, as reported by one of the doctors.

The residents seem aware of the causes of the diseases they report to the doctors as evidence by the claim that they had been boiling drinking water and thus could not understand how they have been ending up with typhoid and amoebiasis. This information is also backed by data obtained through the household questionnaire. Of the sampled households, 31.7 per cent of them reported that at least one member of the household had suffered from a disease that can be directly attributed to poor sanitation, within the past three to six months. Among the diseases listed, in order of the frequency of their occurrence, were malaria (20 percent), typhoid (3.3 percent), common cold (1.7 percent), malaria and typhoid (3.3 per cent), and diarrhoea and common cold (3.3 per cent).

5.3 Accident Risks Paused by Waste Water Tanks

Many waste tanks are constructed on positions where residents walk on them. In 13 per cent eight of the sampled plots, the servicing waste water tank was at the centre of the residential block (see figure 4A), such that children play over them, tenants walk over them to their houses or vehicles are parked on top. In 13 and 33 per cent of others have waste water tanks either on the side and in the front of the residential

block respectively. The rest 52 per cent of the sample had the waste water tanks behind the block. In 2 per cent of the plots, the waste water tank could not be located. Central or front positioning of the waste water tank ensures that they are either walked on, driven on or both.

Secondly, most of the covers to the waste water tanks inspection holes are weak, totally amiss (see plate 9) or are partially broken. In 24 per cent of the inspected waste water tanks, the covers to the inspection holes were concluded to be in a poor status, on the basis of the findings that they were amiss broken or appeared too weak to stand the average weight of a human being. Another 47 per cent were described as fair. In 14 and 15 per cent others the description was good and excellent respectively. It was not possible to locate the waste water tank in two per cent of the plots. Even where the covers are good or excellent, they can be easily lifted off from the inspection hole by hand. Further, the inspection holes do not have protective grill bars (see plate 9) to check against accidental falls if the hole has been opened. To further show the risk factor associated with the use of ill-designed waster water tanks, 27 per cent of the respondents expressed a fear that children can easily fall through the uncovered inspection holes into the waste water tanks or even through opening the inspection holes considering that they have not been fitted with fastening devices. Some were found out to be light enough to be lifted by anybody including children. However, it is only one case of drowning in waste water tanks was actually reported. In situations where residential density allows use of septic tanks, the design standard allows for a maximum depth of one and a half metres, ensuring that, among other things, chances of any one drowning in them is minimal.

PLATE 9

Some waste water tanks have the inspection holes covers missing making them dangerous to the residents, especially children.

PLATE 10 Food crops will at times found growing in pools and streams of waste water in undeveloped plots. This is one of the indirect ways through which pollutants in waste water such as havy metal, used in detergents, gets into the human body

5.4   Summary

The population density of Zimmermann of 140 person per acre results in production of an average of 144.8 cubic metres of waste water per plot per month implying waste water generation rate of 2.145 million litres per acre per month. If the waste tanks water were to be emptied once every month, two thirds of this amount would still get into the environment. The current exhausting rate allows about 140 cubic metres of waste water per month (two million litres per acre per month) to get into the environment. The result has been a number of negative effects and which can be termed costs. First, in an attempt to manage the waste water, an average of 21,600 shillings is spent every month by each plot as opposed to 63,000 shillings which would have ensure that no law waste water gets into the environment. The result of this saving on the monetary costs have resulted in continuous streams and pools of waste water all over the estate. This state exposes the residents to unpleasant residential environment as evidenced by the reported presence of awful odours and muddy streets. The estate also experiences relatively higher incidence of water borne diseases compared to other estates which are served by convectional sewer systems. The higher case of water borne diseases are as a result playing as a good bleeding ground for mosquitoes and flies a well as creating a situation where the environment is humid throughout the year. Law waste water pools and streams may also be leaking to the fresh water pipes resulting in high incidence of diseases such as typhoid. Other diseases which are directly attributable to poor sanitation are URTI, malaria, typhoid, diarrhoea and digestive tract infections. These diseases are directly or indirectly transmitted through contact with waste water or creating grounds for breeding of disease vectors. Additional disadvantage of the waste water tanks use in Zimmermann are risks of falling inside as evidenced by a reported case of person who drowned in a waste water tank. To show the discomfort with which residents live in this environment, 27 per cent of the households expressed a fear that children

may accidentally fall into the waste water tanks. This is clearly evidenced by the depth of waste water tanks. In the eight cases where the depth of waste water tank could be established, it average out to six metres with the one measuring two metres being the shallowest. These depths pause drowning risks to the residents on top of being responsible for the awful odours emanating from them.

The foregoing discussion (chapters 3,4 and 5) have proved that the use of waste water tanks in Zimmermann has resulted in a number of problems, all of which show that the waste water disposal methods in the area are inadequate. This conclusion follow an establishment of the fact that, high rate of waste water generation has not been matched with a sanitation methods which is commensurate to the amount of waste water generated so as to effectively keep raw waste water away from the residents and the environment in general. Waste water emptying charges are high to a point that, most landlords have left them unattended for years. This has resulted in continuous outflows from these tanks to the streets thereby producing an aesthetically unpleasant residential neighbourhood as manifested by a relatively high incidence of water borne diseases and accidents. This shows the need to evolve solutions which will lessen, if not eradicate, the inadequacy of sanitation facilities in Zimmermann estate.

CHAPTER 6
SUMMARY OF FINDINGS, CONCLUSION AND
RECOMMENDATIONS

6.0   Introduction

This chapter draws from the previous five chapters. It puts together the various ideas raised in each chapter to make the study reflect conclusive findings. The first part, which is a summary of findings states, in brief, what has transpired through each section. The second part is a conclusion based on the study hypothesis. The third part provides suggested solutions to the sanitation problems in the study area as well as recommendations for further research.

6.1   Summary of Findings

The study problem was conceptualised with the view that cess pits, septic tanks and conservancy tanks are an ineffective way of managing waste water in high density housing because they cannot stretch beyond a certain level of occupancy. This argument was investigated in Zimmermann estate where that form of sanitation has been used extensively to manage waste water in high density residential area. The findings show that about 67 per cent of waste water in Zimmermann oozes out and flows freely into the streets due to overflows from waste water tanks, and also that attempts to improve the situation has proofed fruitless because of the poor soil conditions which do not absorb any water.

Globally, a study on sanitation problem is justified considering the high number of illnesses and deaths which are attributed to poor sanitation in the Third World Countries. Locally, Zimmermann estate has a unique problem namely use of

sanitation methods suited for low population density areas despite its high residential density. This has resulted into a number of problems, which are poorly quantified. This was the main consideration for justifying the choice of the study area.

A review of the work of the previous studies within the same field shows that a number of solutions have been suggested to the problem of poor sanitation. However, these solutions are, to a great extent, specific to the areas where the respective studies were conducted. In summary, the findings of these studies attribute the problem to inadequacy in housing, a phenomenon which has been brought about by rapid urban population increase. This increase has not been matched with an equivalent level of provision of serviced areas where housing structures can be built. As a result, private housing supply has preceded the development of infrastructure. This problem continues to increase in intensity and extent despite the existence of a policy on services and infrastructure development, at all scales of the concerned spheres and which range from global to that of individual urban centres. This proves that, lack of services cannot be attributed to inadequacy in policy, but rather, to lack of resources to develop the upcoming urban residential areas as stated in the policy. Lack of resources is further viewed as a problem that is attributable to institutional weaknesses within the Developing Nations. The local and central governments have been the main providers of infrastructure such as sewer systems. These agencies can no longer provide these infrastructure because a varied number of reasons but which can be summed up as mismanagement and lack of resources.

Observation across many urban centres has shown that residential neighbourhoods come before provision of infrastructure and services, thereby producing deplorable residential environments. Both global and national statistics reflect minimal

provision and poor standards of infrastructure. where provided. in newly developed low-middle income residential areas. The worst affected are sanitary infrastructure such as the convectional sewer system. The problem is becoming worse with time. urban population growth. and increasing inability by the local and central governments to meet their obligation and as assumption of the role of provision of housing by private individuals continue. Governed by scarcity of resources. a competition between socio-economic needs and maintenance of a desirable environment. has ensued. Based on priority. as provided for in Maslow's Hierarchy of Needs. socio-economic needs have always out-competed the need for a healthy environment. taking almost all the available resources. It is only meagre resources which are reserved for environmental upkeep. It is, therefore, the duty of the policy makers and planners to ensure that the little available resources are used to provide efficient sanitary facilities. This is only possible through evolution of low cost-high population density sanitation technology, as opposed to the previous trend where technologies developed in the Developed Nations have been imported wholesome to communities which cannot afford them. Evolution of sanitation methods that are affordable to the Third World countries can be achieved through relaxation of design standards of the imported technologies. This specifically applies to water borne technologies, in light of the fact that they have been proved to be the only effective sanitation method in high density residential areas. Relaxation of design standards have produced desirable sanitation situations in Brazil and Pakistan (UNCHS 1996). Community participation in provision and management of infrastructure, has also been cited as one of the most effective ways in bringing about desirable urban environments.

The ideas raised by the work of other researchers provide part of general solution to sanitation problems in Zimmermann estate. However, there are specific attributes which are not covered by the findings in other areas but have contributed to the

insanitary status of the estate. Such include the specific contributions of the elements which are highlighted in the literature review to specific sanitation problems in Zimmermann. In order to substantiate the ineffectiveness of waste water tanks in a high residential area, the extent to which these tanks have failed and the parameters which prove these failure, a field survey had to be conducted. Further, besides high residential density, there are other causes of failure of waste water tanks in Zimmermann which needed to be evaluated. In an attempt to get sustainable solutions to waste water disposal problems in Zimmermann, an investigation into the kind of community participation that is applicable in an area with no security of occupancy was also found to be necessary.

From the field findings, the conclusion arrived at is that high population density in an area where house units have wet cores and water closets within them, hence high rate of waste water generation, poor soils, high water table and flat terrain make it difficult to effectively operate non-convectional sewerage systems.

Use of sanitation methods meant for low population densities in high population density areas have resulted in an insanitary residential neighbourhood. The extent to which this problem can be quantified in Zimmermann estate was the major concern of the study. The extent of the problem was evaluated using the amount of waste water generated and how it is dispated. The amount of waste water generated was estimated through multiplying the amount of water consumed with an established waste water generation factor of 80 per cent. This gave per capita waste water generated. On average, waste water holding tanks measured only a third of the required size (assuming an exhausting rate of once per month). Therefore a clear balance of two thirds of the generated waste water was actually not managed by the sanitation systems in Zimmermann.

The emerging issue from this findings is that the functions of an effective sanitation system have not been fulfilled by the sanitation facilities in Zimmermann. This means that relocation of waste water disposal from the point of generation to a more suitable and non-detrimental site had not been accomplished by the systems on the ground. Waste water in the form of pools and streams was all over the estate and in effect created a ground for direct contact to human beings.

All these conditions were either totally ignored or when an attempt had been made to improve the situation, the results were dismal. The other major spatial problems were structurally weak and had poor covering and positioning on the plot. On average, environmental and health problems experienced and anticipated were enormous.

6.2   Conclusion

This study sought to establish whether use of waste water tanks in Zimmermann effectively served the purpose for which such facilities are constructed. This was done through collection of data in regard to the capacity of these facilities to contain the generated waste water. From the key findings, it was established that two thirds of the waste water generated in Zimmermann freely got into the environment. As a consequence, a myriad of problems resulting from presence of waste water and associated facilities have emerged. These problems can be summarised as, a relatively high waste water-linked disease and unpleasant residential environment as evidenced by muddy streets, odours and, actual and anticipated physical injuries from structurally unfit waste water tanks. For this reason, waste water from Zimmermann estate is detrimental to the environment within the estate and elsewhere. The negative effects of waste water within the estate can be summarised to be a relatively higher incidence of water borne diseases as a mark of a level of

environmental pollution. This complex of problems owes its origin to the existing high charges on exhausting services, to a point that landlords have preferred to do without them or reduce the number of times this service has to be provided to their plots. This can be viewed in terms of extending an externality to the environment.

All in all, waste water tanks (cess pits, conservancy tanks and septic tanks) used in Zimmermann are ineffective because the residential density is beyond their holding capacity and the, soil conditions do not allow absorption. It is clear that the high water table contributes water seepage into the waste water management tanks, for which exhausting charges are so high to an extent that they are not done at the frequency that they are needed.

The second, but subsidiary, issue questioned calibration of the 30-40 persons per acre mark as the maximum recommended density for effective use of waste water tanks. This investigation was based on the assumption that the use of waste water tanks in Zimmermann would be found to be effective; at least to a certain extent. However, the research findings showed strong negative environmental impact, a phenomenon attributed to the high residential density (which some plots measured up to 200 persons per an eighth of an acre plot). This means that whether 30-40 persons per acre is sub-optimally low residential density for effective use of waste water tanks or not, is a question which cannot be answered using this research findings. It is, therefore, maintained that, in the absence of a study in a residential area with a population which is lower than the aggregate average for Zimmermann (140 persons per acre), 30-40 persons per acre should be the maximum recommended residential density that can be effectively served by waste water tanks.

The findings to the effect that current sanitation methods in Zimmermann are ineffective, provides a premise under which an exploration into more effective sanitation methods for the area and similar neighbourhoods should be made. These are suggestions meaning that their effectiveness can only be verified through implementation. The suggestions are the principle focus of the proceeding subsection (part 6.3).

6.3 Planning Recommendations

Lack of infrastructure in the development process of the Third World cities is a complex problem which requires input from different approaches. Based on affordability, minimum time frame within which a recommendation can be implemented, the effectiveness of the recommendation on the poor sanitary condition and experience on the concerned recommendation in places where it has been tried, the recommendations were grouped into two namely; short term and long term recommendations

6.3.1 Short Term Recommendations

Based on the premise that, if the best sanitation method (convectional sewer system) may be unaffordable (not available), more effective sanitation methods are better that the ones in use, the following recommendations have been made:

(a) To reduce the polluting effect of the waste water released into the environment, conservancy tanks in place of cess pits and septic tanks should be used. This would counter the contribution of water, through the waste water tanks, by the subsurface.

(b)   Separation of drainage systems from the house units such that waste water from the toilets and kitchen drain in separate tank from the one where waste water from the bathrooms/laundry units drain into. Further, house block design consideration should ensure that storm water does not drain into waste water tanks but rather through the storm water drains (see diagrams 6A and 6B).

To reduce possibility of drowning, all inspection holes of waste water tanks should be covered, using covers which have been fastened or should be heavy enough to be lifted off from the inspection hole. Further, conservancy tanks should be constructed away from the drive/walk-ways and open spaces within the residential block. This can be achieved through the adoption of back-to-back orientation of the blocks (see diagram 6A).

To reduce the odours emanating from waste water tanks, the tanks should be constructed in such a way that they have a higher surface area-volume ratio. This can be achieved through construction of ventilated, shallower, wider and longer conservancy tanks. This measure would ensure more of aerobic decomposition of organic solids within the waste water as opposed to anaerobic one which is responsible for the reported and observed odours.

In order to ensure a more efficient provision and management of infrastructure, the following suggestions are made:

(a)   Formation of welfare organisation for both landlords and tenants. This will facilitate pooling or resources for provision of services and lobby groups.

(b)   Longer and ascertained security of occupancy of rented houses so as to facilitate participation of tenants in provision of services.

Banning or rearing of farm animals and poultry as well as growing of food crops in high density residential areas, especially where sewer services have not been provided. Regular inspection by public health department would enforce this regulation.

Diagram 6A   Proposed Spatial Utilisation of Plots

9m road
reserve
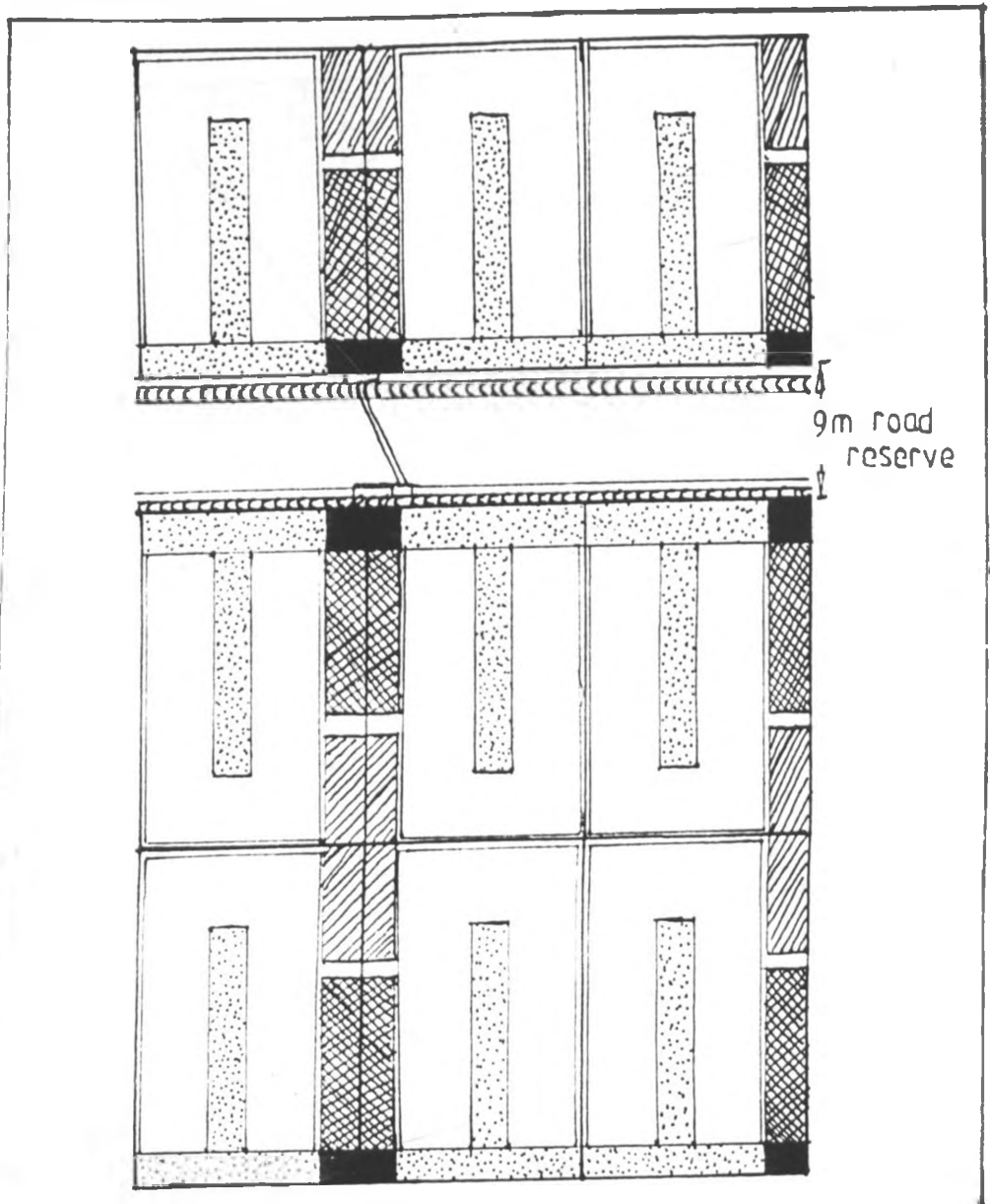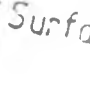
Legend

Residentiat Block	Sewage Conservancy Tank
Open Space	Refuse Chamber
Sullage Conservancy Tank	Storm Water Drainage
0 5 10m scale	Shallow Bore Sewer

NJUGUNA'98

DIAGRAM 6B PROPOSED WASTE WATER SYSTEM
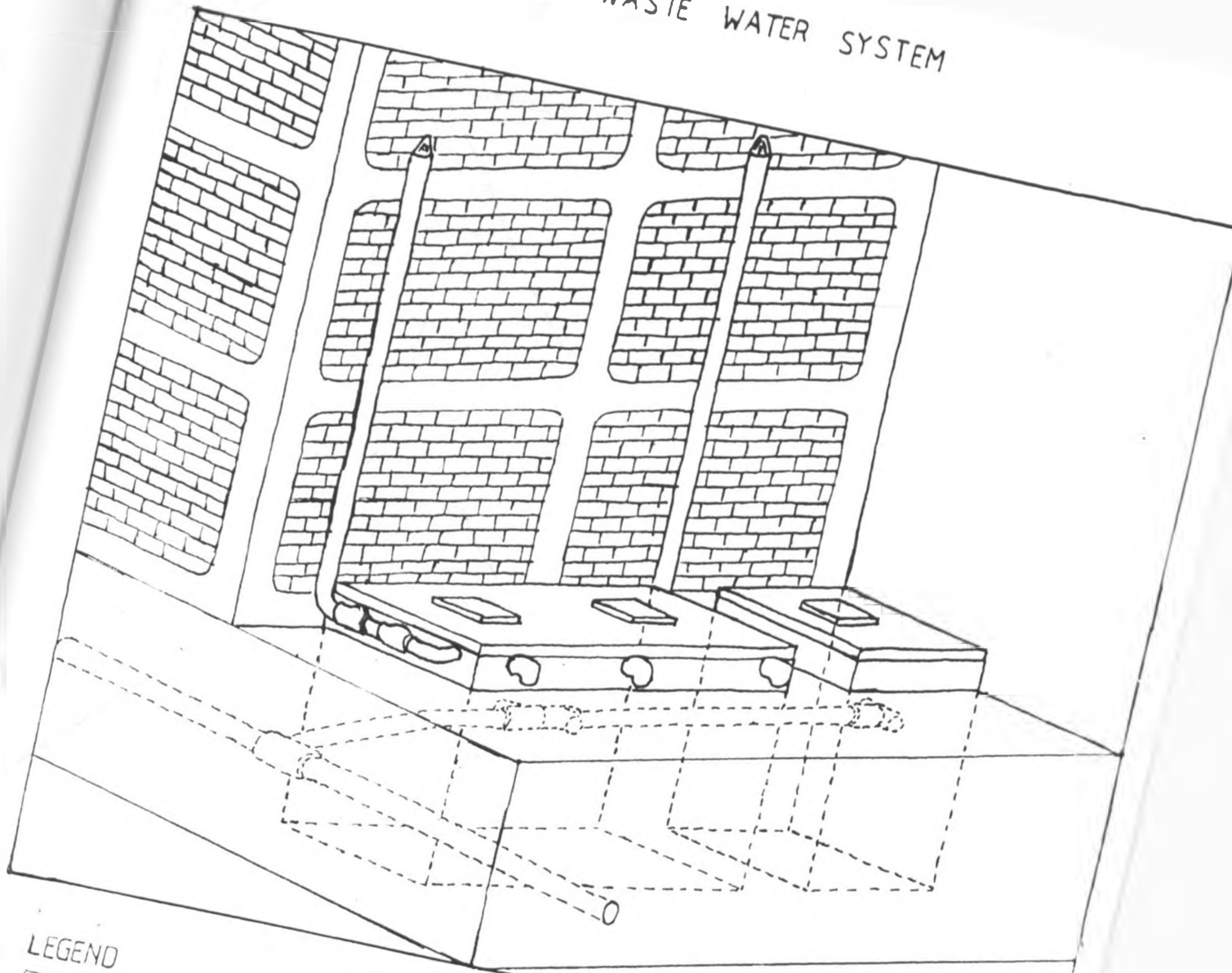
LEGEND

Residential Block

Inspection Hole Cover

Air Outlet

Air Inlet

Underground Parts

Surface Parts

NJUGUNA '98

6.3.2 Long Term Recommendations

- Convectional Sewer System

This would drain Zimmermann estate and other neighbouring residential areas (see map IV). Waste water from Zimmermann estate should be collected by a reticulation system which would be a feeder branch to the bigger trunk sewer.

In order to make the installation of the proposed sewerage relatively cheaper, lowering of design standards is hereby suggested. This should include replacement of man holes with shallow inspection chambers, cheaper conduits, shallow depths of burial and a lower gradient. This is not expected to cause any blockage problems because the waste water tanks, which are currently in use, should serve as sedimentation tanks, thereby only allowing out water which is amenable to transportation through shallow sewer system suggested above (see diagram 6B).

Privatisation of sewer systems provision and management in middle and high income areas. Local and central government should be responsible for the provision and maintenance of the same in low income areas. This recommendation should go along with delegating the responsibility of sewer systems provision in middle and high income areas to the residential unit developers. Payment of such services would ineffective be passed down to the tenants, whose willingness to pay for the said services was established in the field survey.

A policy framework should be put in place to guide high density residential developments such that, the latter does not precede provision of services. This can be achieved through enforcement of control mechanism such as building codes and regulations. Further, the size of waste water tanks should be specified in reference to the floor space of residential units to be constructed, an omission which is partially

to blame for the multi-level residential development in total disregard to disposal of generated waste water in Zimmermann estate.

MAP IV : OTHER UNSEWERED RESIDENTIAL AREAS
AROUND ZIMMERMAN ESTATE

6.4   Further Research Recommendations

The various planning recommendation above require further complimentary research for effective implementation. It is therefore recommended that the listed research work be carried in Zimmermann estate and its environs.

The most promising solution to lack of sewerage systems in areas that deserve them lies in privatisation of provision and management of sewerage systems. The mechanism which would operationalize this process need to be established. The investigations should be along the following lines:

The extent to which partnership between local governments and private initiatives can be in-cooperated without compromising the environment in low income areas.

Organisational structure requirement for a privatized sewerage system.

Secondly, further research needs to be carried out on the method and requirements that would stop tenants living passively, for the reason that they are occupying rented houses, but instead contribute to the development of support infrastructure such as sewer systems. This research should be centred on management within neighbourhoods as opposed to the way it is done currently (a homogeneous service charge which are imposed to every urban dweller).

Thirdly, a major constraint to provision of safe waste water tanks in Zimmermann lies in the diversity of plot utilisation, in terms of built up area, open space, and positioning of accessory units such as waste water tanks. Such a problem would have been easier to deal with, if the uniformity of blocks within cells in the estate was observed. To avert a similar problem in future, a framework that would guide in

bring about uniform development within neighbourhoods or cells within a neighbourhood. in situation where each plot is owned and developed individually, need to be established through research.

REFERENCE

- Agarwal A. et al (1980), **Water, Sanitation, Health for All ?; Prospects for the International Drinking Water Supply and Sanitation Decade, 1980-1990.** An Earthscan Publication.

- Batch. Wilfrend (1972), **Atmospheric Pollution.** New York McGraw - Hill book.

- Batten T. R. (1975), **Community and their Development.** Glasgow. Oxford University Press. London.

- City Council of Nairobi (1974), **Master Plan for Sewerage and Drainage**, Stockholm. SWECO. Volume 1.

- _____ (1998), **Master Plan for Sewer, Sanitation and Water Supply**, Volume 1 (unpublished)

- Dwyer D. J. (1975), **People and Housing in the Third World Cities, Perspectives on the Problems of Spontaneous Settlements.** Longman. London.

- Edmonds G. A. (1981), **Appropriate Road Construction Technology; in Appropriate Technology in Civil Engineering,** Institution of Civil Engineers 13-16 April 1980. Conference Proceeding. Telford. London.

- Elizondo J. (1986), **Reality, Ideality and Morality; Criteria for Technology Adoption in Rural Communities in A. De Giorgio and C. Roveda ; Criteria for Selecting Appropriate Technology Under Different Cultural, Technical and Social Conditions.** Oxford. Pergamon Press. proceeding for IFAC Symposium, Bari Italy 21-23 may 1979.

- Gichohi D. (1988), **Informal Land Markets and Land Policy and its Implimentation in Kenya**

- Government of Kenya (1981), **Kenya Population Census of 1979.** Volume 1 , Central Bureau of Statistics. Ministry of Economic Planning and Development. Government Printer. Nairobi. Kenya.

- _____ (1992), **Kenya Population Census of 1989.** Central Bureau of Statistics. Ministry of Economic Planning and Development. Government Printer. Nairobi. Kenya.

- Kalbermatten John et al (1982), **Appropriate Sanitation Alternatives**, A Planning and Design Manual, Baltimore, John Hopkins University Press.

- Kruijff, G J W (1978), **Aqua Privy Sewerage Systems**, Nairobi, Nairobi

- Loehr Raymod C. (1977 Ed) **Land as a Waste Management Alternative**, Proceedings of the 1976 Cornell Agricultural Waste Management Conference, Ann Arbor, Michigan, Ann Arbor Science.

- Mairura E. O. (1988) **Development of Water and Sanitation Infrastructure in Unplanned Low Income Urban Settlement of Kitui, Kanuku and Kinyango in Nairobi**, Thesis Report. (Unpublished).

- Mara D. (1982), **Appropriate Technology For Water Supply and Sanitation Alternatives for Low income Communities**, World Bank Report.

- McAllister, Donald M. (1980), **Evaluation in Environmental Planning**; Cambridge, Massachusetts; MIT Press.

- Miller C.T. (1979), **Living in the Environment**, Belmont, Wadsworth

- Ndegwa G.K. (1991), **Provision and Use of Public Convenience in the City Centre of Nairobi**.

- Ndegwa P. et al (1985), **Development Options for Africa in the 1980's and Beyond**, University Press, Nairobi.

- Ndunda C. M. (1995), **An Investigation into the Adequacy and Maintenance of Public Services in Zimmermann**, Nairobi.

- Pacione Michael (1981), **Urban Problems and Planning in the Developed World**, Croom Helm, London.

- Republic of Kenya (1984), **Kenya Development Plan of 1984/88**, Government Printer, Nairobi, Kenya.

- _____ (1985), **Kenya Project**, Ministry of Local Government, Farid S.P.A.

- _____ (1986), **Design Manual for Water Supply in Kenya, Ministry of Water Development**, Government Printer, Nairobi, Kenya.

_____ (1986), **Laws of Kenya, the Public Health Act.pp.** 49-65, Government printer, Nairobi, Kenya.

_____ (1996), **Kenya Gazette Supplement; the Physical Planning** Act, Government printer, Nairobi, Kenya.

Smart P. and Herbertson J.G. (1992), **Drainage Design.** Blackie and son ltd. Publishers, USA.

Smith Wallace F., (1975), **Urban Development, The process and the Problems,** Berkeleg, University of California Press, USA.

Subrahmanyan D.V. and Cyjetanovic B. (1986), **A Minimum Environment Sanitation Package for Health,** in the Courier, No. 96 March- April.

Syagga P. (1987), **Housing Policy and Systems in Kenya; Nairobi's Experience.** a paper presented at the international workshop on housing.

UN (1977), **Report of the United Nations Water Conference.** Mar del Plata, 14-25 march 1977, Action Plan para. 15.

UNCHS (1976), **The Role of Housing and Building,** Addis Ababa, United Nations Commission for Africa, E/CN.14/HUS/15 pp.4.

UNCHS (1976), **Report of Habitat,** Vancouver May-june, op Cit, chap. ii Recommendations C.12.

UNCHS (1981), **Review of the Provision of Infrastructure in Slums and Squatter areas and in Rural Settlements.** Nairobi, Kenya.

UNCHS (Habitat) (1996); **Urbanizing World.** Oxford University Press, New York, USA.

UNCHS (Habitat) (1996); **Guide to the Global Environment.** Oxford University Press, New York, USA.

UNCHS (1997), **The Istanbul Declaration and The Habitat Agenda.** Nairobi, Kenya.

UNDP (1996), **Section Review on the Capacity Building for Metropolitan Governance of Nairobi.** Nairobi, Kenya.

UNEP (1998), **World Resources.** Oxford University Press, Newyork, USA

- UNESCO (1966), **Urbanisation in Newly Developing Countries**. Princenton University, New York, USA.

- Wakely P. et al (1976), **Urban Housing Strategies**. Pitman, London.

- Wood C. (1989), **Planning pollution Prevention**. Redwood Burn Limited, London.

- World Health Organisation (1964), **Housing Programmes; the Role of Public health Agencies**. Geneva, Switzerland.

- World Health Organisation (1983), **Maximising benefit to Health**. Geneva Switzerland.

APPENDIX I

Urban Growth Without Attendant Infrastructure; A case study of, Zimmermann, an Unsewered High Density Residential Area

NOTE   The information obtained through this questionnaire will be treated confidentially and will not be used for any other purpose, other than answering the research's questions

Researcher   **SIMON NJUGUNA**

Date/day of interview................... Questionnaire No........
Name of interviewer...........

HOUSEHOLD QUESTIONNAIRE

1. Name of interviewee (optional)...............................
2. Relationship to the head of the household
3. Size of the household ....
4. Plot number ....phase ....
5. Details of the household members (first line is reserved for the interviewee). Options for the relation the to the head of the household.

   -head of household(1)

-Spouse	(2)
-Sibling	(3)
-brother/sister	(4)
-Any other relative	(5)
-House girl/boy	(6)
-others (specify)	(7)

sex (M or F)	age	relationship to head of hsehold	year of settlement in zimma	level of education	occupation	place of work/school	income per month in Ksh

6. House occupancy   rented [ ]/ owner occupied [ ]
7. If rented: how much is the rental fee per month ....
8. Is the house self contained   yes [ ] /no [ ]
9. Size of the house unit (no. of bedrooms In addition to the living room)
....
10. Other bills in KSH per month
    -water ....
    -Electricity ....
    -Refuse ....
    -hospital bills ....
    -Others (specify)   ....
11. How many house units are within this plot ?.................
12. What size and how many are each of the house units ? -- Single room. [ ] -- 1 bedroom
    [ ].-- 2 bedroom [ ] -- 3 bedroom [ ] -- 4 bedroom [ ]

SANITATION QUESTIONS

13 In general. how would you rate the water supply?
    -bad   [ ]
    -fair   [ ]

-good   [ ]
-excellent   [ ]
14 How often do the taps go dry?

during the day [ ], on weekends [ ], has no sequence [ ], never goes dry [ ],one day per week [ ],two days per week[ ], three days per week [ ], more than three days per week [ ]

15. Does the house unit have wet core (bath rooms, kitchen etc) within it......... Yes [ ] /no

16. [ ]

16. Are the other wet core connected to the toilet Yes[ ]/No[ ]

17. If yes, where do you think this waste water drain into

-a cess pit   [ ]
-on to the street   [ ]
-through the cess pit on to the street   [ ]
-others (specify)   [ ] ....
-Not known   [ ]

18. If no, where does each of the waste water drain to

(A)sewage -cess pit   [ ]
           -on the street   [ ]
           -Through the cess pit on to street   [ ]
           -others (specify)   [ ] ......
           -not known   [ ]
(B)sullage -cess pit   [ ]
           -through the cess pit on to street   [ ]
           -on the street   [ ]
           -others (specify)   [ ] ....
           -not known   [ ]

19. For waste water draining on to the streets; what is the reason for this

              -the system has been designed to be like so   [ ]
              -The system has broken down   [ ]
              -When it rains   [ ]

20. Where does roof catchment water flow to?

-directly on to the street   [ ]
-into the cess pit   [ ]

21. Do you sense any odours ...... Yes [ ]/No [ ]

22. If yes, what do you think is the origin of the odour ?

-cess pit   [ ]
-garbage heaps   [ ]
-others (specify)   [ ] ....

24. How often are the waste water tanks emptied?

-Have never heard of it   [ ]
-once since I came here   [ ]
-twice since I came here   [ ]

-More than twice (specify)[ ] ....

25. What problems do you experience with the sanitary system within the house/plot
....
....
....
....

26. Other than the problems covered by the questionnaire above what other sanitation problems do you notice within the estate ?
....
....
....

27. What dangers are paused by these kind of sanitary system (cess pits /septic tanks)?
-illnesses   [ ]
-Aesthetically unpleasant   [ ]
-Risk of falling into the cess pits   [ ]
-others (specify)   [ ]

....
....

28. If the answer to question 26 is illnesses, what kind of diseases have afflicted the member of the family in the recent past and which are directly attributable to poor sanitary system

....
....

29 What improvement should be carried out on the sanitary system?
-provision of a sewer system [ ]   -digging up of open drains   [ ]
-exhauster services [ ]   -Better designed septic tanks[ ]
-others (Specify)   [ ]

....
....

30. Who should undertake these improvement tasks ?
-landlords [ ]   -Nairobi city Commission [ ]
-occupants [ ]   -others specify   [ ]
31. Have you been doing anything to improve the sanitation situation yourself?   yes
                                   [ ] /no [ ]
32. If   the   answer   to   question   31   yes,   what   ....
....
....

33. What are you willing to do to improve the sanitation situation?
-free will contribution in term of cash   [ ]

-payment of related bills   [ ]
-nothing (give reasons)   [ ]

....

....

34. What size of septic tank do you think this is ? ....

....

OBSERVATION GUIDE

35. Number of levels of development in the plot............................
36. On which level is the concerned unit ....
37. State of the servicing street
    -muddy   [ ]
    -dry   [ ]
38. If muddy, where is the water coming from?
    -cess pits   [ ]
    -sullage   [ ]
    -underground seepage   [ ]
39. State of the septic tank
    -overflowing   [ ]
    -Not overflowing   [ ]
40. where it is overflowing, what is the out flow in litres per minute
    ....
41. what is the condition of the accessories of the cess pits
    -poor   [ ]
    -fair   [ ]
    -good excellent   [ ]
42. Approximate size of the cess pit in metres
    -length ....
    -width ....
    -depth ....

SKETCH OF THE SEPTIC TANKS POSITION IN THE PLOT

-Locate any other type of waste collection unit eg pit latrine, garbage pits etc.
-include the estimate dimensions.

APPENDIX II

NOTE   The information obtained through this questionnaire will be treated confidentially and will not be used for any other purpose, other than answering the research's questions

Researcher   **SIMON NJUGUNA**

OPEN ENDED QUESTIONNAIRE TO NAIROBI CITY COMMISSION; WATER AND SEWERAGE DEPARTMENT

1. What are the problems that face the entire sewerage sub-department ?

....

....

2. How have these problems hindered provision of sewerage services in the city ?

....

....

....

3. Are the resultant sanitation problems the same both in old and the newly developing residential estates? Yes [ ] NO [ ]
    If no, what are the differences in the two type of settlements as far as sanitation problems are concerned ?

....

....

....

5. What type/s of infrastructure does the commission consider as a priority in a residential neighbourhood (in order of their importance) ?

....

....

....

6. Is Zimmermann estate a newly developing or an old residential estate ?

....

7. What sanitation problems are facing the estate it ?

Page 156

....
....
....

8. How often do you receive sanitation related complaints from Zimmermann and are these complaints register by the tenants or landlords.
....
....

9. If the complaint is by both landlords and tenants, what does each of them complain about ?
....
....
....

10. What are the residential densities that can be effectively served by septic tanks?
....

11. What is the departments stand on the use of waste water tanks ?
....
....

12. What are the charges and procedures of emptying waste water tanks by the city council ?
....
....

13. How common are private exhausting services?
....

14. What is the state of the city councils exhausting facilities and how has this affected the provision of the services ?
....
....
....

15. How often has exhausting services been commissioned in Zimmermann ?
....
....
....

16. Which sanitation technology options are effective and available for Zimmermann in the light of its high water table, black cotton soils and high residential density ?
....
....
....

17. What are the respective costs for each of the technologies listed in question 16 above ?
....
....
....

18. What explains the fact that the Zimmermann estate does not have a mains sewer?
....
....

19. What criteria does the city Commission use to know whether an estate is ripe for sewer services?

....

....

....

20. Is the city commission providing sanitation services currently?   yes   [ ]   no [ ]

21. If the answer to question 20 is yes, what services is it providing ?

....

....

22. If the answer to question 20 is no, why?

....

....

23. How necessary is it to stick to high sanitation technology standards given that majority of the city dwellers cannot afford them?

....

....

24. Can an individual or a group apply for trunk sewer
    Yes [ ] /No [ ]

25. If the answer to question 24 is yes, what conditions must be fulfilled first ?

....

....

....

26. what assistance would the sewerage department be in a position to offer to such a group?

....

....

....

27 If the answer to question 25 is no, why?

....

....

....

28. What element of beneficiaries' participation in waste water management would the department advocate for?

....

....

....

....

APPENDIX III

GUIDELINE TO OPEN DISCUSSION

A) TO THE CHIEF/CIVIC LEADER

1) Approximately how many plots are in Zimmermann?
2) What is the approximate resident population of Zimmermann?
3) How often do you receive complaints from Zimmermann in relation to sanitation.
4) What kind of complaints are they?
5) What solutions have they complaints been suggesting they been suggesting?
6) Who do they say is supposed to undertake these solutions ?
7) What have the resident and landlords been doing to improve on the situation ?
8) What in your view is the state of waste water handling tanks in Zimmermann ?

B) TO THE LANDLORDS

1) Name (optional).
2) What is the registration number of your plot (plot number)
3) On what part of Zimmerann is it located?
4) How many housing units are on your land parcel?
5) What is the size of the land parcel ?
6) What is the nature of the units ? (size)
7) How many of these have wet cores within (self contained)?
8) What is the approximate water bill per month?
9) What is the size of the conservancy tank and where is located within the plot ?
10) How oven does the conservancy tank get filled up ?
11) How many time is it emptied per year ?
12) How many lorry loads are needed to completely empty it?
13) What are the costs per lorry load ?
14) Where do you exhausting services from (NCC or Private) ?
15) Why not from the other ?
16) How often do you receive complaint from your tenants in relation to sanitation ?
17) According to you, what is the ultimate solution to the sanitation problems in Zimmermann ?
18) What have you been doing towards achievement of solutions you have given to question 17 ?
19) What more will you be willing to do on top of the answer to question 18 ?
20) How has the underground seepage affected the performance of the conservancy tank in your land parcel ?
21) Have the type soil in any way contributed to problems of sanitation.

C) TO THE MEDICAL PERSONNEL

1) Name (optional)
2) When did you start this clinic ?

3) What is the average number of patients do you attend to per month (per day) ?
4) How often do you treat patients from other estates other than Zimmermann ?
5) What diseases do you find to be prevalent in Zimmermann and are they unique to Zimmermann ?
6) Which of these diseases are directly linked to the poor sanitation situation in Zimmermann estate ?
7) Do the patients seem aware of the causes of the diseases you have directly attributed to poor sanitation ?
8) From a medical perspective. what solutions do think will improve people health in relation to sanitation ?