INVESTIGATING THE POTENTIAL OF MODERN GEO-INFO TECHNOLOGIES IN PLANNING URBAN COMMUNITY SETTLEMENTS :

The Case of Nairobi Peri-Urban Settlements

BY

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Declaration

This PhD thesis is my original work and has not been presented for a degree in any other University.

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Dedication

This thesis is partly dedicated to my parents - Joel Imwati, a believer in the power of *wisdom and knowledge*, and Joyce Imwati, a believer in *self-determination and hard work*, the two doctrines that have helped to shape and continue to guide my life; and partly to my beloved family - wife Hellen K. Thiaine, and children; Dennis Kairithia, Faith Kamathi, Chris Mwenda and Betty Kanario, for their steadfast encouragement and moral support as I struggled with this PhD project.

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It takes determination and perseverance in addition to academic and professional acumen for one to successfully undertake a challenging project such as writing a PhD thesis of this nature. It would also have been impossible to complete the task of writing the thesis without the support and encouragement of my tutors, concerned friends and relatives, some of whose input has helped to shape the thesis. Circumstances allows for the mention of only a few of the many persons who deserve special acknowledgement and appreciation.

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Abstract

For many years, planners and urban development managers in Third World countries have endeavored to respond to the challenges posed by the phenomenal urbanization trends, but with limited success. The main limitations to planning and management efforts are attributable to the inadequacies of the existing national land use policies, institutional and technical frameworks, mapping and planning systems and approaches. Additionally, the apparent exclusion of the affected community citizens and other stakeholders, of the present day era of democratic information-age society, has further played a major role to ineffectiveness in planning and managing urban settlements of most third world cities, such as Nairobi, Kenya.

In view of the prevailing urbanization trends and challenges therefore, the main purpose of this study is to investigate the potential of modern digital geo-information technologies (GITs) as alternatives for effective development planning and management of rapidly growing urban settlements as opposed to conventionally used cadastral-based geo-systems and planning approaches. The geo-information systems include; Remote Sensing technology (RS), Global Positioning Systems (GPS), Geographic Information Systems (GIS) and the Internet. Further, the study particularly explores the potential of GITs integration with community-based participatory planning and management of rapidly growing urban settlements.

Firstly, the research provides an overview of the theoretical concepts that appertains to the study subject matter (Chapter Two). Secondly a brief analytical review of related literature is given, which initially includes an overview of the current urbanization trends and challenges at global, regional and local perspectives (Chapter Three). Thirdly the mapping, development planning and management needs, problems and requirements in Kenya's urban areas in general, and Nairobi City in particular are examined. Using a case study of a typical peri-urban settlement of Mlolongo, a satellite of Nairobi, spatial development problems are closely studied (Chapter Four). Fourthly, in an attempt to seek diverse views regarding the research problem and concerns, a questionnaire interview instrument is used in soliciting alternative opinions from a spectrum of stakeholders and actors (Chapter Five).

Chapter Six demonstrates the potential of modern GITs *vis-a-vis* traditionally used cadastral-based mapping / planning techniques in terms of; cost-effectiveness and efficiency, accuracy acceptability, multi-user applicability, and enhancement of public participation in development planning, management and governance of urban community settlements. Finally, Chapter Seven provides the summary, conclusions and recommendations as drawn from the research results and study findings

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LIST OF ABBREVIATIONS

AD: After the Death of Jesus Christ
BC: Before the Birth of Jesus Christ
CBO: Community Based Organization
DCA: Directorate of Civil Aviation
ESRI: Environmental Systems Research Institute
FAO: Food and Agricultural Organization
GIS: Geographic Information System
GPS: Global Positioning System
GIT: Geo-Information Technology
JICA: Japanese International Cooperation Agency
Kenya Rep.: Republic of Kenya
KICC: Kenyatta International Conference Center
NCCRN-S: National Centre of Competence in Research North – South of Swiss
NSDI: National Spatial Data Infrastructure
PDP: Part Development Plan
PID: Preliminary Index Diagram
RCMRD: Regional Centre for Mapping of Resources for Development
RESTEC: Remote Sensing Technology Centre of Japan
RIM: Registry Index Map
RS: Remote Sensing
SDP: Structural Development Plan
SOK: Survey of Kenya
UNCHS: United Nations Centre for Human Settlement
WHO: World Health Organization

Chapter One

INTRODUCTION

1.1. Introduction and Background to the Study

In the last few decades, the world has witnessed unprecedented demographic and spatial urban growth. Unfortunately, the phenomenal global urbanization trends now present enormous challenges to urban planners, managers and other players, especially in third world countries. Most of the developing countries lack adequate mitigation measures, such as financial, policy and technical capacity in addressing the prevalent urbanization *syndrome* challenges, albeit, in the face of other pressing administrative, political, and socio-economic development demands that compete for the limited financial resource base (UNECE, 1998, 2000; UN-Habitat, 2008).

Urban development planning and management in most developing countries has therefore remained an elusive exercise, a situation that has led to problematic spatial development and a crisis in most of the Third World nations, such as Kenya. Critically lacking today in the development agenda of most developing countries is a reliable national spatial data infrastructure (NSDI) frameworks and the necessary democratic principles, policies, institutional and technical paradigms to guide the rapid spatial-demographic urban growth currently being witnessed in these nations (UNECE, 1998).

Efficient spatial planning and management systems can only be based on comprehensive geo-information resource-base so as to inform and support policy decision making processes. Sound development policies should be action oriented, inclusive and knowledge–based. Practical knowledge can only be based upon reliability, availability, affordability, functionality and currency of the existing national geo-information resource base, which depends upon the efficiency of geo-data acquisition techniques and management systems, presentation, access and dissemination for various multi-disciplinary uses and applications (UNCHS, 1992, 1993 & 1998; Dale & McLaughlin, 2001).

The adverse effects and implications of the current urbanization trends is more felt in the developing and transitional countries of Africa, Asia and Latin America, often characterized by sporadic growth of unplanned informal settlements in most urban areas, such as Nairobi, Kenya. The spread of informal structures further help to illustrate the pertinent weaknesses and inability of the existing conventional planning and mapping systems in coping with the pace of urban development trends. Hence the urgent need for more cost-effective and efficient alternative initiatives and approaches for addressing the challenges posed by the current urbanization trends (UN-Habitat & Kenya Rep., 2008).

Fortunately at the same time, the dramatic urbanization trends have been accompanied by rapid digital geo-info technological evolution and advancement that, if well harnessed, can offer the modern information-age society new alternative interventions to mitigating the challenges posed by the prevalent *urbanization syndrome*. In view of the foregoing, studies in other parts of the world such as South Africa and some Asian countries indicate that, if effectively harnessed, modern GITs alongside participatory planning approaches can offer the much needed alternative addressing the spatial development planning and management crisis now evident in many urban areas of developing countries (Sliuzas, 2001 and Karanja, 2002).

1.2. Statement of the Research Problem

Lack of sound legal, institutional, technical and administrative frameworks has significantly contributed to the current urban development planning and management crises in Third World countries as urban areas continue to grow without proper planning guidelines in the face of an ever escalating population growth. Evidently, conventionally used cadastral-based mapping and planning geo-systems and approaches are seemingly getting limited in copying with the spatial development demands posed by the dramatic urbanization trends in Kenya and other developing countries.

In absence of the necessary official development control guidelines, many urban dwellers continue to build illegal structures in urban areas in total disregard of the government statutes and regulations. A case that practically highlights such urban

developmental concerns in Kenya is Mlolongo Township, a satellite settlement of Nairobi City. The settlement has virtually sprung up in under ten years without any formal mapping, planning and/or development control guidelines, and now fast degenerating into a slum. Mlolongo settlement is a typical example of many other unplanned peri-urban settlements that are rapidly growing into slums around Nairobi City periphery.

The main focus of this study therefore, is to examine urban planning needs and requirements in Kenya, with reference to peri-urban settlements of Nairobi City in particular, and further to investigate the potential use of modern geo-information technologies (GITs) alternative tools as opposed to hitherto used conventional cadastral-based geo-info systems and planning approaches in Kenya.

1.3. Research Questions

The study is guided by the following three broad questions:

1. What are the planning and management requirements for the rapidly growing urban settlements in Kenya and Nairobi City peri-urban in particular?
2. What is the potential of modern GITs-based systems for efficient planning and mapping of rapidly growing urban settlements?
3. What is the potential of modern GITs in enhancing community participation in development planning, management and governance of urban community settlements?

1.4. Research Objectives

The main objective of the study therefore, is to explore the potential use of modern geo-information technology (GITs)-based approaches in planning / mapping and managing urban settlements in Kenya.

The specific objectives are:

1. To determine planning, mapping and management requirements and needs for the rapidly growing peri-urban settlements of Nairobi City

2. To explore the potential of modern GITs for effective spatial geo-data provision, needed for spatial planning, mapping and management of rapidly growing urban settlements.
3. To investigate the potential of modern GITs-based approaches in enhancing community participation in development planning, mapping, management and governance of urban settlements.

1.5. Research Hypothesis

The study seeks to test the hypothesis that;

As compared to conventionally used geo-info systems and planning approaches, modern geo-info systems are more cost-effective and efficient tools for comprehensive planning / mapping and management in rapid spatial development milieus.

1.6. Study Justification and Contribution

In recent years, research on the use of modern GITs and participatory planning approaches have successfully been taking place in many countries such as South Africa, India and Ghana (Barry and Ruther, 2001). However, investigations indicate that not enough research has been carried out locally in embracing digital geo-systems and democratic planning approaches in Kenya. This is despite overwhelming evidence to show the limitations of traditional cadastral–based systems and planning approaches in meeting the current urban development and management challenges in the country .

The main goal of this study is therefore, to explore the potential use of modern GITs and community-based developmental planning approaches in Kenya. If the results are to the affirmative, the study would help to bridge the existing research gap on the study subject matter. It is also expected that the study findings will significantly contribute to the existing knowledge in local domain on the potential benefits of modern digital geo-technologies and inclusive democratic planning approaches, not only in Kenya, but also in other developing countries of the world in general.

1.7. Research Methodology

The main purpose of the study is to examine the potential of modern geo-information technologies (GITs) in spatial planning and mapping, and the extent to which they can enhance community participation in development management and governance of urban community settlements. The research is therefore *deductive* in nature, in that it seeks to integrate and link technological and scientific knowledge (applied sciences) with community-based development programmes in urban settings (Patton, 1990 and Nachmias and Nachmias 1976).

1.7.1. Data Sources and Collection Techniques

The research employed three main investigation techniques for data collection. First, documentary investigation (secondary data collection) was carried out, based on review of available related literature and concepts to the study subject. The review provided the necessary theoretical and conceptual basis on which the study was anchored. Existing graphical and statistical records, and spatial/attribute information further provided supplementary sources of secondary data.

Secondly, instrumental-aided techniques; field measurements, observations, office visits and personal perceptions provided the necessary primary spatial and attribute sources. Instrument-aided measurements mainly involved the use of remote sensing (RS) techniques (satellite imageries), digital camera system (DCS), hand-held global positioning system (GPS) set, and ground survey measurements. Personal perceptions and casual experience were used to supplement the overall field data collection based on the author's background knowledge on the study subject.

Thirdly, a questionnaire instrument was used to solicit views from a spectrum of relevant stakeholders and actors on various urban land-use planning, mapping and management requirements and concerns in Kenya. The investigations were carried out through face-to-face field interviews with local residents and leaders of Mlolongo settlement, while questionnaire mailing was mainly used for other respondents such as government and local authority officials, land experts and professional categories of respondents.

1.7.2. Study Population and Sampling Techniques

Stratified *cluster sampling* techniques were used for field investigations purposes. Cluster sampling techniques involve the selection of an intact group of the study population where all members (entities and factors etc) are included in the sample and each member becomes a unit of observation (Mugenda & Mugenda 1999). The sampling techniques were therefore based on the following criteria:

i) Being large enough to include the various land-use systems and variables that are typical of unplanned settlements of Nairobi peri-urban areas.

ii) Exhibiting the general characteristics, spatial and socio-economic dynamics of land-use patterns of informal peri-urban / urban settlements.

The target study sample units (or units of observation) comprised the various land use-related spatial and attribute dynamics as observed through field surveys and interviews conducted with the local residents and leaders of Mlolongo Township. The spatial unit locations were selected so as to sufficiently include the various study variables and elements of the target study population. The various spatial elements and variables of observation included spatial extent, nature, types, patterns and trends, susceptibilities and other factors and dynamics found in the settlement. Attribute dynamics included land ownership, land-use and tenure, shelter and tenancy, property rights and interests, demographic, cultural, and other socio-economic dynamics found in the study area.

1.7.3. Data Analysis and Results Presentation Techniques

In order to adequately address the afore stated objectives and research problem, both qualitative and quantitative techniques were used for data analysis and results presentation. Both qualitative and quantitative data was variously collected, compiled, analyzed and presented. For example, analytical discussions were used for theoretical data while simple frequency tables, percentages were used for field surveys and interview data analysis and presentation. Statistical tables, mathematical computations and percentages were mainly used for quantitative analysis and presentation of data collected from field observations and measurements.

1.7.4. Study Area Definition

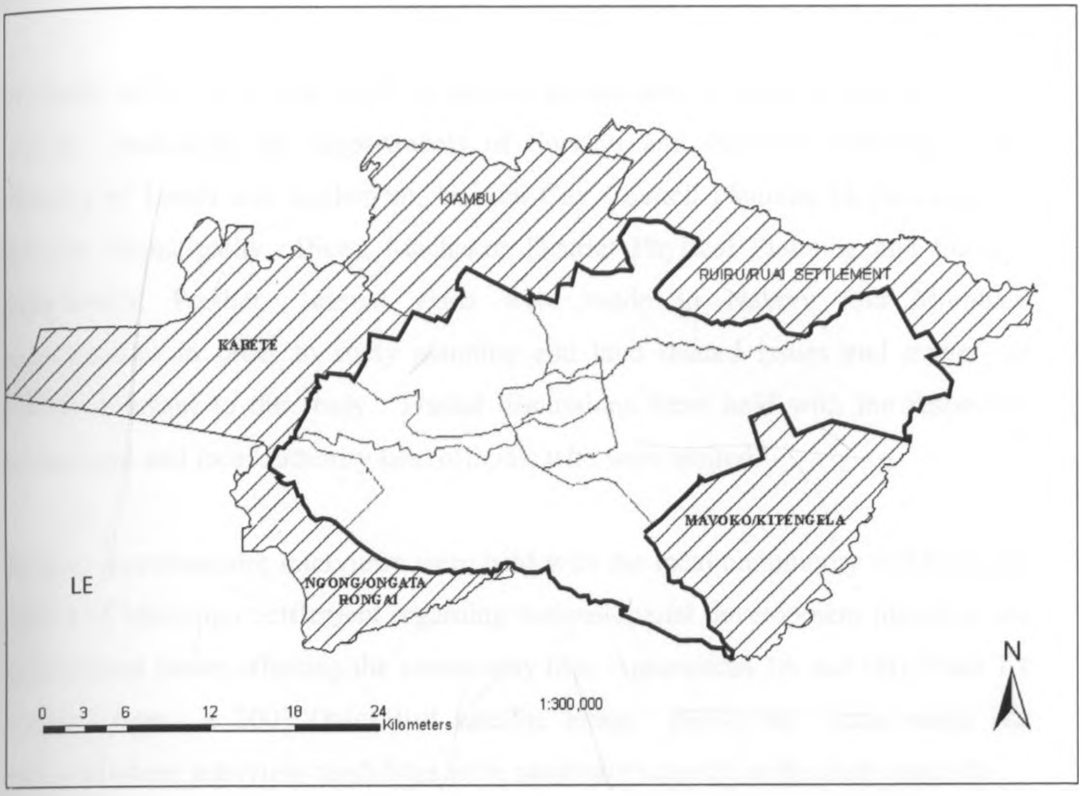
Had it been practically possible, the study would have comprehensively been carried out at national and / or Nairobi's city-wide levels, given the prevailing challenges posed by the dramatic urbanization trends in the country. However, due to logistical, financial and other limitations, the research was limited to Nairobi peri-urban areas. Nevertheless, a brief preview on various urban planning and management needs and requirements was provided at global, regional and local levels (Chapter Four).

To effectively address the research problem, questions and objectives, a sample case study area of Mlolongo Township, a satellite of Nairobi City, was selected for detailed analytical investigations. Further, attempts were made to generalize the discussion at city-wide levels so as to include other urban / peri-urban areas with similar problematic developments. Figures 1.1 and 1.2. are maps of Kenya showing the location of Nairobi and its rapidly growing peri-urban settlements (study area) respectively.

Fig.1.1. Map of Kenya Showing Study Area Setting and Location of Nairobi City

Source; Derived from: *www mapsofworld.com (2010)*

Fig. 1.2. Rapidly Growing Peri-urban Settlements of Nairobi (Study Area)



Legend:

Rapidly growing peri-urban settlements of Nairobi City

City Boundary extend

Source: Prepared from SOK Map Catalogue, (2006)

1.7.5. Field Surveys and Questionnaire Interviews

In order to effectively address the research objectives, field and office visits and excursions were made to relevant study area sites and offices in order to physically observe and examine the prevailing spatial planning, mapping and development needs and requirements. The study area sites visited included; Nairobi peri-urban

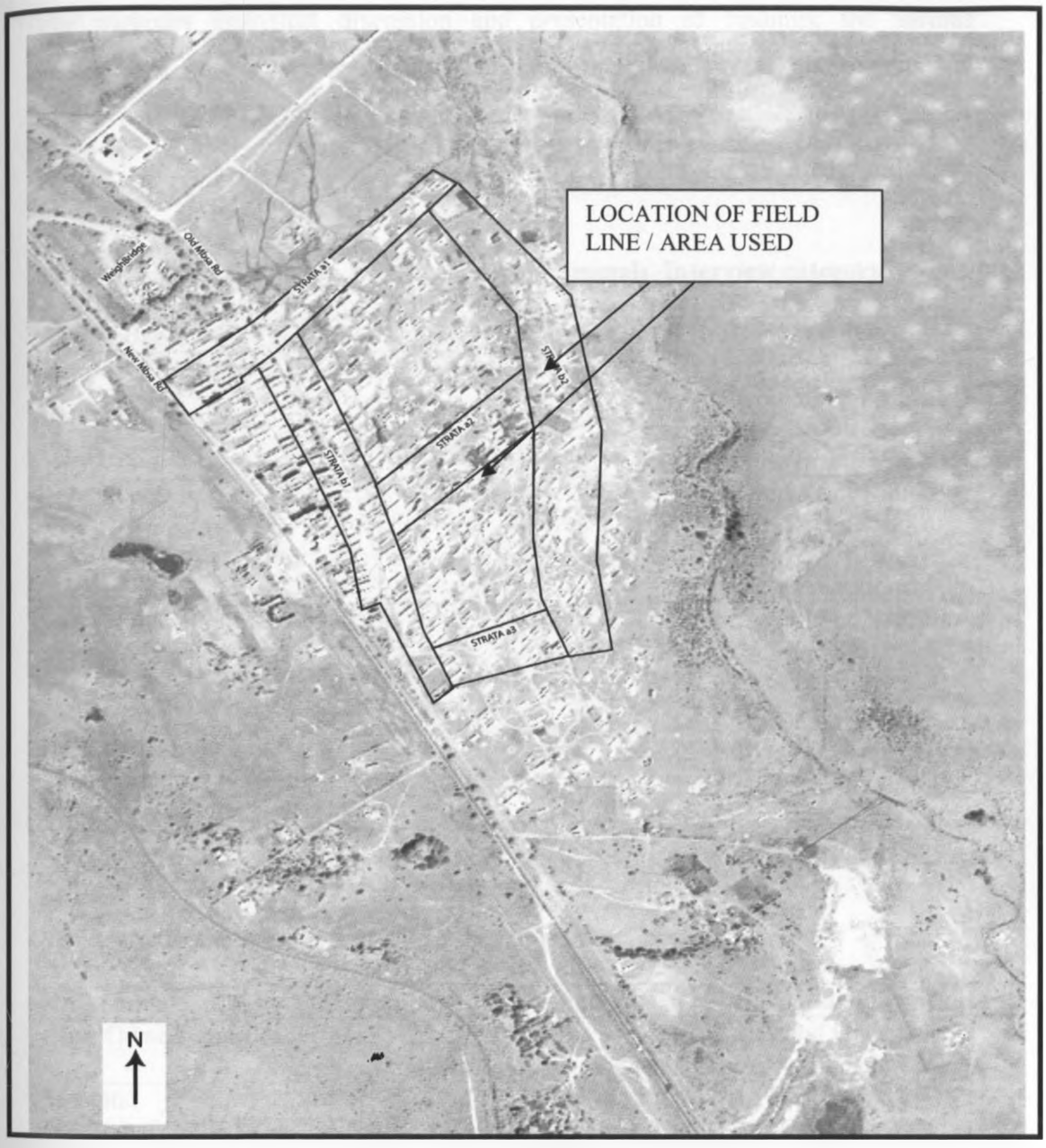
areas settlements of Dagoreti, Ruiru, Githurai, Muiki, Ruai, Mlolongo and Athi River, and Kima Kimie peri-urban settlement of Machakos Township.

Similarly, office visits were made to various government and local municipality land offices, including; the Departments of Surveys and Physical Planning of the Ministry of Lands and Settlement, Nairobi City Council Planning Department, the Mavoko Municipality offices, Machakos District Physical Planning and Surveys departments. Further casual visits were made to Nakuru and Mombasa municipalities in order to study planning and land related issues and matters of concern relevant to the study. Useful discussions were held with the respective government and local authority land officials who were visited.

Further, questionnaire interviews were held with the local community residents and leaders of Mlolongo Settlement regarding various spatial development planning and management issues affecting the community (See Appendices 1A and 1B). Plate 1.1 prepared from a 2003 QuickBird satellite image shows the linear-strata site locations where interview candidates were randomly selected in the study area site.

The main aim of the field surveys and interviews was to study, assess and examine the inherent spatial development planning and mapping requirements, problems, needs and concerns for the various urban municipalities and settlements. By and large, the exercise specifically served in unearthing the depth of public concern regarding the current urban development crisis in in the respective local authorities, and by extension, other urban settlements in the country as a whole.

Plate 1.1. Randomly Selected Interview Sites in the Study Area



Source: Prepared from 2003 QuickBird Image, RCMRD (2006)

Questionnaire Interview Candidates and Respondents

For purposes analytical discussion and presentation of findings, the various respondents were categorized into two main sample sets; (1) Land experts and professionals, (2) Local residents and leaders of Mlolongo Settlements (Tables 1.1 and 1.2).

Table 1.1. Land Officials, Experts and Professionals Interview category

Respondents	Number	Percentage	Respondent Types
Physical Planners	10	33	3 University of Nairobi 4 Government & Local Authority Officers 3 Private Practitioners
Land Surveyors	10	33	3 University of Nairobi, 4 Government & Local Authority Officers 3 Private Practitioners
Land Managers / Economists	6	20	2 University of Nairobi, 2 Government/Local Authority Officers 2 Private Practitioners
Architects & Quantity Surveyors	4	14	2 University of Nairobi 2 Private Practitioners
Total	**30**	**100 %**	

Table 1.2. Local Residents and Leaders Interview Category

Respondents	Number	Percentage	Respondent Types
Land Owners and Leaders	15	25	10 Land Owners 5 Local Leaders
Tenants	45	75	15 Business 30 Residence
Total	**60**	**100 %**	

Sample Set 1: Expert and Professionals Respondents - were selected from varied disciplines, including; private practitioners, professionals in public offices, researchers and academicians. The main aim of the interview was to seek diverse expert opinions and information on challenges faced in urban development planning

and management in Nairobi and other urban areas of the country. A total of 40 candidates were interviewed with 30 of them responding, which constitutes a 75% response rate. This sample set was considered sufficient for analysis purposes, mainly due to the homogeneity of responses from the various candidates.

Sample Set 2: Local Residents and Leaders of Mlolongo - comprised business and residential tenants, land owners and opinion leaders including area chief and his assistant, local councilor and two local committee members of Mlolongo Township. Note that the leaders involved were also land owners in the settlement. A total of 65 candidates were interviewed, 60 of which positively cooperated in the discussion. This gave a response rate of about 92 %. The 5 cases in which the respondents were reluctant to cooperate were found to be suspicious of the exercise mainly due to the sensitivity of land matters in the area. Again due to the similarity of responses on various issues raised in the questionnaire a sample set of 60 respondents, representing 12% of the unit population was considered sufficient for analysis purposes. The settlement comprised about 500 residential and commercial units, mainly high-rise flats at the time of study.

1.7. 6. Research Outline and Process

The introductory part of this chapter briefly elucidates the topic study subject. Therefore, in order to guide the research process and effectively address the afore-stated study objectives and research problem, a multi-staged approach was adopted in the study. Figure 1.3. is an analytical summary and outline of the research process, chapter by chapter.

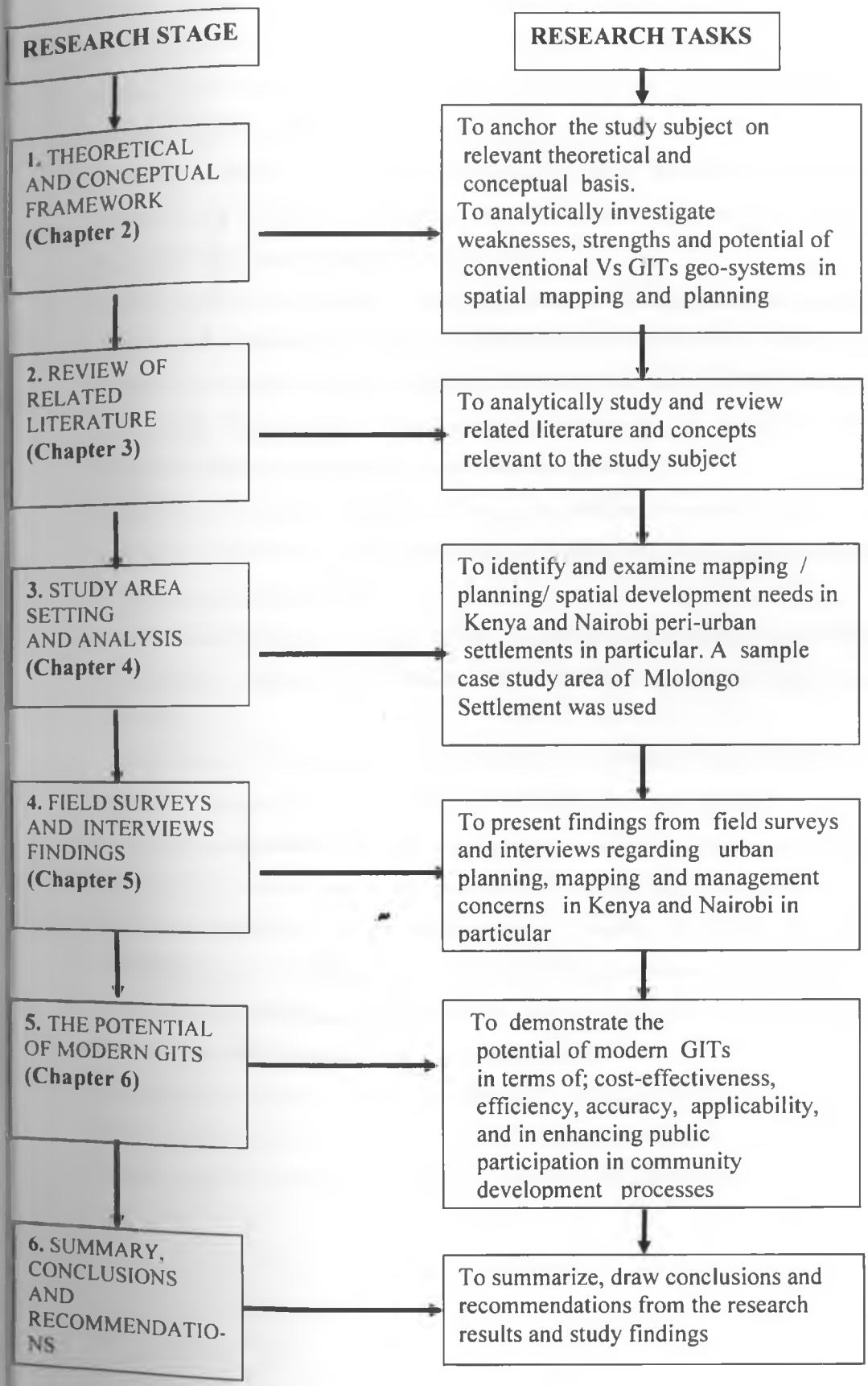
The first stage of the study provides the theoretical and conceptual framework that is aimed at relating and focusing the investigation to the study topic and subject as (Chapter Two). Stage two presents an analytical review of related literature and concepts that are pertinent to the study as provided for in Chapter Three of the thesis.

Stage three of the study provides the study area background, setting and analysis. Urban planning requirements and geo-data needs in Kenya are critically examined with special reference to Nairobi peri-urban settlements. A satellite settlement of

Nairobi, Mlolongo Township, was used as a representative study case sample to closely investigate the various issues of concerns for the sprawling peri-urban areas of the City (Chapter Four). The fourth stage of the study engages practical investigation approach, through field surveys and interviews with a spectrum of stakeholders regarding various issues of study concern as provided for in Chapter Five.

Stage five attempts to practically explore the potential of modern GITs as alternative tools for comprehensive spatial mapping and development planning, especially for the rapidly growing urban community settlements. Based on some pre-determined criterion, comparative empirical investigation and analysis were used to demonstrate the potential of modern GITs versus conventional cadastral-based geo-info systems and approaches (Chapter Six). Finally, Chapter Seven provides the summary, conclusions and recommendations that are drawn from the research results, findings and outcome of the study.

Fig.1.3. Summary of Research Outline and Process



1.8. Definition of Operational Terms and Concepts

Land - the term " land" though associated with many meanings and concepts, is here conceptualized as the physical surface materials on, above and under the earth's surface, the ecosystems, bio-diversities and the complex biosphere that surround humankind (Platt, 1975).

Land use - relates to the human activities or economic functions associated with a specific piece of land. For example, a tract of land on the urban fringe may be put into residential, commercial or industrial use.

Informal land use/settlements - refer to all forms of unauthorized developments on formal and informal land tenure systems. They include slum estates, squatter invasions, hawkers markets, roadside kiosks and other unauthorized residential and commercial developments. These illegal developments are often found on both public and private lands that are vacant and/or unprotected.

Land tenure (or property rights) - refers to recognized interests in land or property vested in an individual, group, community or institution, and can apply separately to land and/or development on it.

Land titling/registration - refers to the process of authoritatively ascertaining and documenting rights to land and/or use as claimed by an individual, group or institution.

Land ownership (or proprietorship) - refers to possession of legal tenurial rights or interests to property by an individual, group, community or institution.

Land use management - refers to the process whereby the resources of land are put into planned good use which is guided by official policies and/or regulations.

Land use planning – in an urban context, planning is the art of foreseeing, anticipating and guiding change, and arbitrating between the economic, socio-cultural, political and physical forces that determine the location, form and effect of land use development (Dale and McLaughlin, 1986).

Peri-urban settlements – refer to settlements found just within and outside official boundaries limits of a given town or city. They are also referred to as suburbs or the interface zones of interaction where urban and rural districts meet.

Sprawl - means to spread in an untidy way in different directions over a large area *(verb).* It also refers to a large area covered with buildings without any formal plan, for example a city's suburban sprawl *(noun), (Oxford* Dictionary, 1995).

Syndrome – refers to a set of *symptoms* which together indicate or lead to a particular disease, or sporadic abnormal behaviour and/or phenomena (Oxford Dictionary, 1995).

Symptom – refers to a change, for example in a body that indicates a particular disease or undesirable phenomena.

Mitigation – means to lessen the effects/impacts, or improve the condition of something.

Geo-Information Technologies (GITs) - refer to the kindred technologies of Remote Sensing (RS), Global Positioning Systems (GPS), Geographic Information Systems (GIS), non-metric Digital Camera Systems (DCS) and the Internet that are currently gaining popularity for geo-spatial data acquisition, processing, analysis, manipulation, information management and dissemination for various multi-disciplinary applications (Lillesand *et al*, 2000).

Data - refers to a collection of characters and/or facts without any semantic connotations or any particular meaning attached to it. For instance digits 2.2 can represent several things, e.g. length, temperature or even a price.

Information - When data sets are organized or processed and have specific semantic connotations attached to them, then they become information.

Knowledge – refers to the insight(s) acquired through the analysis or synthesis of information presented to an individual.

Metadata and Meta-information- refers to data about data and information about information respectively. For example, metadata may be compared to a catalogue or an inventory of particular data sets.

Geo- The prefix *geo-* is used when referring to objects or subjects that are related to the earth; e.g. *geocentric,* which means having the earth as the center; geography - the scientific study of the earth's surface and its features.

Spatial - refers to anything that has physical dimensions or relates to space - e.g. positions, locations and distances of objects on the earth's physical surface or atmospheric space.

Conventional – refers to processes and/or systems and procedures that always follow the traditionally accepted and laid-down ways, methods and techniques of doing things without much change.

Community participation- refers to involvement of the local residents in the initial planning and implementation process of community-based projects through participation in activities such as decision making, funding, material and labour contributions, information provision, governance and management.

Community-based organizations (CBOs) – refers to local community organizations and stakeholders with interest in community development issues and programmes.

Non-governmental organizations (NGOs) – refers to non-governmental organizations and other private organizations with interest in community development issues and programmes.

Stakeholders- refers to individuals and/or organized groups of individuals such as community-based organizations and actors with interest in community development issues and programmes.

Deductive research –refers to the application of scientific knowledge and technical principles in arriving at conclusions and answers that best addresses social problems and/or phenomena through conceptual and empirical analysis deduction process/techniques (Patton, 1990).

Proactive Planning - refers to the *ad-hoc* and / or on-purpose planning actions that are usually necessitated by unanticipated spatial development situations such as the spontaneous growth of informal settlements that now sprout in almost every urban centre in Kenya today, without any formal guidelines and / or control.

Chapter Two

CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1. Introduction

Most urban areas of developing countries such as Nairobi, Kenya, are rapidly growing without any comprehensive spatial development policies, mapping and planning guidelines and / or development control. The inadequacies of the currently used geo-data acquisition systems and planning approaches have been identified as some of the major contributors to the urban development planning and management crisis currently being witnessed in most developing countries, Kenya included.

This Chapter, therefore attempts to briefly and analytically examine the underlying theoretical and conceptual principles, effectiveness and applicability of conventional planning approaches and geo-data systems in spatial planning and mapping against the alternatives offered by participatory planning approaches and modern digital geo-data/ information systems in urban settings.

2.2. Contemporary Planning Concepts and Approaches

Contemporary planning concepts have been variously defined and preferred by various writers (Kaiser et al 1995 and Henderson 1997). Ratcliffe (1974), for example, defines planning as the process of allocating resources, particularly land in such a manner as to obtain maximum efficiency, whilst paying heed to the nature of the built environment and the welfare of the community. Dale and MacLaughlin (1986), further defines planning as the art of anticipating change, and arbitrating between the economic, social, political and physical forces that determine the location, form, and effect of urban development.

Spatial planning encompasses a variety of basic activities such as land use zoning, infrastructure services delivery, development control and environmental management, and other spatial and socio-economic development programs that are aimed at achieving envisioned and desired goals within the natural and built environments of a given land space. However, in view of the various opinions by

different schools of thought, there is no single definition that adequately covers the breadth of activities and practices involved in spatial planning process. Conceptually, however, planning must be anchored on the following principles:

i. *Planning is future-oriented* – Goals and objectives of planning are usually made to affect a future condition in the spatial environment. Sustainability of the spatial-environmental systems should be a main concern of the planning processes.

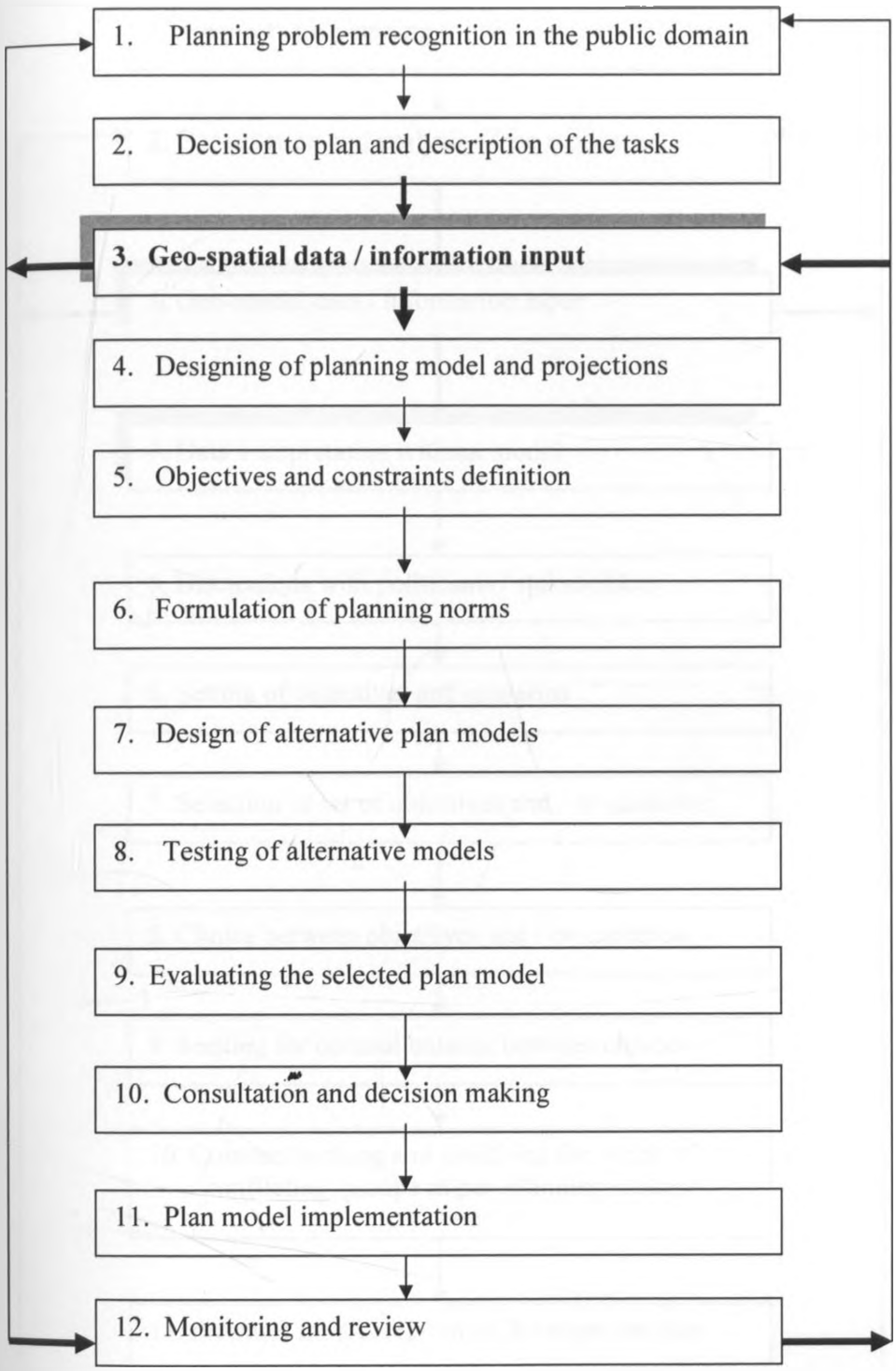
ii. *Planning defines and evaluates alternative solutions to problems* – Good planning practices should be rational and comparative in selecting different alternatives and strategies that best address the problems at hand.

iii. *Planning is political* – Planning decisions usually infringe on rights of individuals or communities – *hence the need to involve the affected stakeholders in the planning debate for acceptance and successful implementation of planning projects.*

iv. *Planning has special moral responsibility* – Planning should be ethical and representative in addressing the needs of the disadvantaged in the society, such as the physically handicapped, minority groups, women, children and future generations.

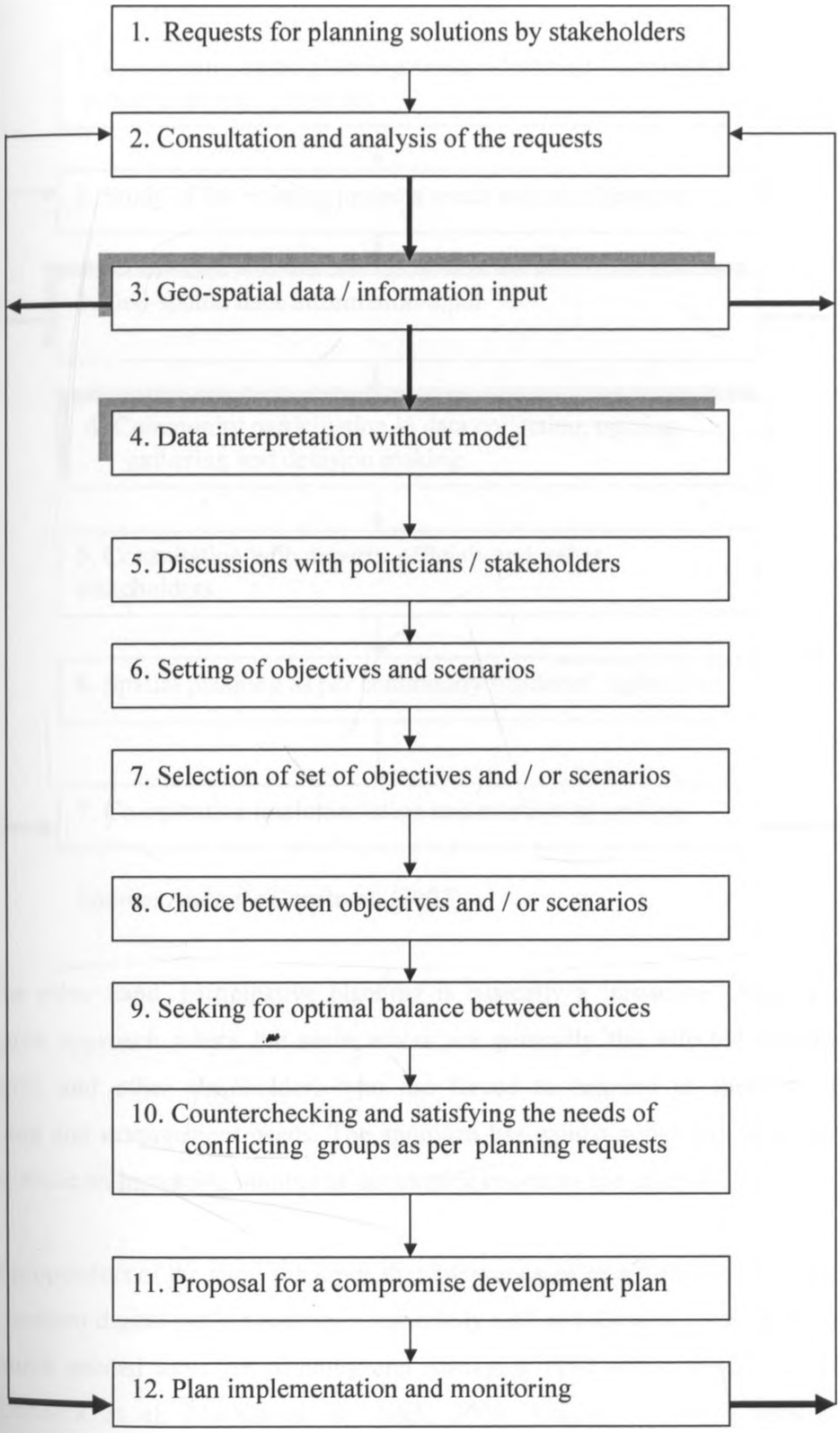
Several approaches to spatial planning and/or plan-making process exist depending on the planning problems being addressed. Figures 2.1, 2.2 and 2.3, briefly outline three contemporary approaches to spatial planning process, namely; systematic, conflict-tackling and participative (co-operative) approaches. Systematic approach assumes a rather conventional approach where there is consensus and the existence of no conflicts between the actors involved in the planning process. Conflict-tackling is used largely as a political approach that is usually aimed at seeking a solution between two different actors in conflict. In this approach, the procedure of plan-making is generally seen as a search for consensus between some conflicting demands that are presented by different politicians and/or other stakeholders (Huxhold, 1991).

Fig. 2.1. Systematic Planning Approach



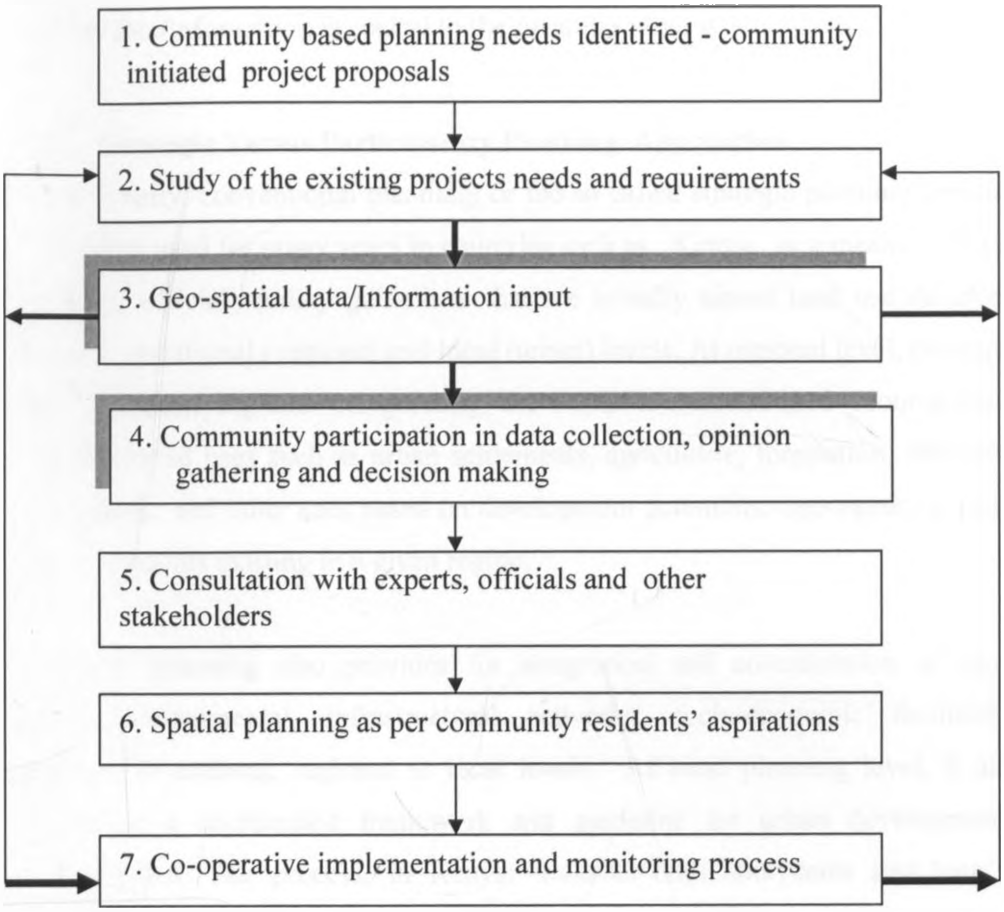
Source; Modified from Sarly, (1972)

Fig.2.2. Conflict Resolution Planning Approach



Source; Modified from Sarly, (1972) & Laurini, (2001)

Fig. 2.3. Participative Planning Approach



Source; Author's Construct, (2007)

On the other hand, participative planning is basically a 'proactive planning' and inclusive approach where the main actors are generally the affected community residents and other stakeholders who are forced to respond to specific spatial planning and management needs. The approach has gained popularity in developed world while an increasing number of developing countries are using it.

Most proponents of the approach argue that integration of community-based planning with modern digital geo-technologies, especially GIS and Remote Sensing, provides the much needed tools for planning and managing third world urban settlements (McCormick et al, MacKinven & Sandt, 2008; Kingston, 2007). Participatory planning is therefore a variant of conflict avoidance and consensus seeking

approaches in that it is solely based on the needs and aspirations of the community. It is to be noted that, in each of the three stated approaches, availability of reliable geo-spatial data/information is central to the planning process.

2.2.1. Strategic Versus Participatory Planning Approaches

Traditionally, conventional planning, or the so called strategic planning approaches, have been used for many years in countries such as Kenya, as a means to formulate strategic official policy guidelines that are broadly aimed land use development control at national / regional and local (urban) levels. At regional level, the approach aims at classifying and categorizing the available national land resource-base into various broad uses such as urban settlements, agriculture, forestation, conservation, recreation, and other uses based on development potentials, opportunities, priorities and constraints existing in a given region.

Strategic planning also provides for integration and co-ordination of physical, spatial-environmental, infrastructural networks, socio-economic facilities and services at national, regional to local levels. At local planning level, it aims at providing a coordinated framework and guideline for urban development and management. The process, in Kenya, involves both short-term and long -term development programs, usually ranging from 5 to 20 years and 20 to 30 years respectively depending on development requirements and needs of a given locality. Local zone plans specifies guidelines for urban land use zoning, development control and regulations that are necessary for efficient and optimum development of a given urban development area. Unfortunately, the complex, lengthy and largely bureaucratic mapping and planning procedures and requirements prescribed by the Survey and Planning Acts have significantly slowed the pace of development planning and management process in the country, especially in the rapidly growing urban areas (Kenya Rep., 1991).

The term 'proactive planning' is used here to refers to the *ad-hoc* and / or on-purpose planning actions that are usually necessitated by unanticipated spatial development situations such as the spontaneous growth of informal settlements that now sprout in almost every urban centre in Kenya today, without any formal

guidelines and / or control. There is a growing usage of 'proactive planning' approaches among planners and stakeholders as it does not require lengthy official procedures that are involved in the strategic (conventional) planning approach. Reaction planning is more inclusive and democratic approach in that it involves constant consultation and/or participation of the community/residents and other stakeholders. The other basic requirement in reaction planning is rapid geo-data source for quick and comprehensive identification, mapping and planning, especially in developed settlements. Use of remote sensing (satellite imagery and aerial photography), GPS and GIS therefore comes handy as viable alternative for mapping and planning such urban settlements.

2.2.2. Best Practice to Planning Modern Urban Communities

Urban planning can be considered as multi-disciplinary process that involves many actors and stakeholders in solving common problems. Normally, there are two main players in the planning game; the official *(de jure*) i.e the government and /or local authority agents on one hand and the un-official *(de facto*), i.e other actors and stakeholders, including local citizens, on the other hand. In most of the cases, however the *de jure* rarely and adequately includes the de facto players in the game (sic), spatial development and management agenda of their communities (Laurini, 2001 and Klein, 1997) .

The exclusion of local residents, has for instance more often than not been detrimental to implementation of development planning projects, especially where the affected residents feel that the intended developments are against the interests and wellbeing of the community at large. In Kenya for example, local residents have severally mobilized themselves to oppose developments in various urban centres, eg in Nairobi, especially where land tenure and use systems are questionable and or in conflicts.

It is also important to note that, today's urban citizenry is more informed and democratically enlightened than of the yester years. Hence, the best practice in planning for modern urban communities should be as much as possible be inclusive,

pragmatic, participative and democratic in nature so as to adequately involve the majority of urban dwellers of the digital-information age.

Stefano et al, (2008), for instance proposes the use and integration of modern GITs with 'proactive community-based' approaches, rather than the routine official approaches, as the "best practice' and interventions to spatial planning and management of today's urban community settlements. Similarly, Home and Barry (1997) recommends the need for a multi-stakeholder approach that involves local community residents and other stakeholders, as a powerful alternative tool towards effective for planning and management of informal settlements in Southern African cCities and in other developing countries.

2.3. Spatial Planning, Geo-Data Needs and Requirements

Spatial planning is a future–oriented activity that should keep pace with the changing geo-data acquisition innovations of the digital era, while focusing on the following goals and aspirations in planning for modern urban communities:

- Better quality of spatial environments (livable, safe, and aesthetically pleasing).
- Effective organization of urban spatial activities (e.g. work, residence, commerce and recreation).
- Environmentally harmonious and socially sustainable "smart growth "of urban and peri-urban communities.
- Efficient infrastructural and communication networking between the various urban and rural functions, administrative, management and services delivery.
- Sustained rejuvenation and revitalization of deteriorating, aging or dilapidated infrastructure and spatial developments.
- Provision of a variety of residential, commercial, industrial housing options, employment opportunities and economic development.
- Democratization and inclusive policy – making process in various planning, management and governance issues among others (Kaiser et al, 1995).

Reliable and up-to-date geo-data is key pre-requisite in any spatial planning process, without which no sustainable urban development can be realized. It is required at every stage of the plan-making process. Reliability and comprehensiveness of a geo-data base further depends on continuous, data collection, updating, dissemination, interpretation, analysis, and presentation to various users and planning agencies. Kaiser et al (1995) refer to the above processes and activities as *"planning intelligence"* that is vital support to any spatial development and management program. Planning intelligence permits conversion of raw data into useful information and knowledge through statistical analysis, modeling and application in support of planning objectives and achievements of envisaged development planning and management goals (Catanese, 1979; Nedovic-Budic et al, 2003).

Planning process requires various multi-contextual and multi-dimensional geo-spatial data sets; land use, land tenure, socio-economic, spatial environmental management, community health, shelter provision, communication, utility infrastructure and services provision. The data should be availed in acceptable formats, accuracy standards and scales, depending on the planning task at hand. For example large scale topo-cadastral maps of 1:1000 - 1: 10,000 are necessary for detail urban planning while medium scale base maps of between 1:10,000 – 1:50,000 are required for most general planning activities.

Spatial environmental and ecological data (e.g. climatic, critical areas, watersheds and drainage basins, habitats etc) may be sourced from ground surveys, remote sensing, global position systems and existing conventional topographic maps to supplement the planning process.

Spatial-attributes data may be derived from existing records and sources; zoning maps, land use and tenure records, subdivision surveys, census tracts, neighborhoods, community knowledge, institutional and districts administrative records. This data may be analyzed, processed and presented either qualitatively or quantitatively. Data on the existing systems of land use/tenure types such as zoning types and the existing land ownership systems are required in deciding the location of various categories of land uses to be included in a development plan. In an already developed planning

area, this data can be collected directly from field observation. Attribute information such as, place names, culture, history, views and suggestions required in the planning process, may be gathered from local residents and other stakeholders. Table 2.1 lists the basic spatial - attribute data/information types that are generally required in planning and managing urban settlements.

Table 2.1. Planning Data Types and Requirements

Data Types	Various Planning Data Requirements and Contents
Land (spatial)	Land use types and systems dynamics – residential, commercial, industrial, recreational, institutional etc ; by density, intensity; ownership, land supply/demand; user conflicts; tenure systems, land registration progress, property valuation and taxation, development potential etc.
Development Plans and policies	Master/structural/strategic plans; zoning and subdivision regulations; building codes; policy development programs; budgeting; conflicts and hazards mitigation etc
Spatial development and housing	Buildings by type; quality and value; development zoning and permits; current status; number of dwelling units; by dwelling type; by quality; supply and demand; types, nature and rate of informal settlements proliferation etc
Environmental and geophysical	Topographic – elevation, slope, terrain; soil types; wetlands, floodplain; air quality; water supply and quality; ecosystems, biodiversities/habitats; natural hazards incidences and location ,etc
Socio-economics and demographic	Totals; by gender; by race; by ethnicity; by education; income levels; employment/ employment; poverty levels; occupation, business types; industrial production etc.
Utilities, facilities /services	Water; electricity; energy; sewage / drainage; solid waste; communication; recreation and entertainment; educational; health and security/safety etc.
Transportation	Road types, traffic flows, adequacy of transport, demands etc.

Source; Modified from Nedovic-Budic *et al,* (2003)

2.4. Geo - Spatial Data Acquisition Systems and Techniques

The source and comprehensiveness of geo-spatial data is of crucial importance to the effectiveness and efficiency of any given planning and management programme Fourie, 2001). In Kenya, for example planners have largely depended on slim geo-data resource base provided by conventional cadastral based mapping and geo-data

acquisition systems. Faced with the rapid urbanization trends therefore, the demand for efficient alternative sources of rapid and comprehensive geo-data acquisition is, needless to say, currently overwhelming. The kindred modern digital geo-technologies, namely; Remote Sensing (RS), Geographic Information Systems (GIS) and Global Positioning Systems (GPS), if well harnessed, can provide the needed alternative.

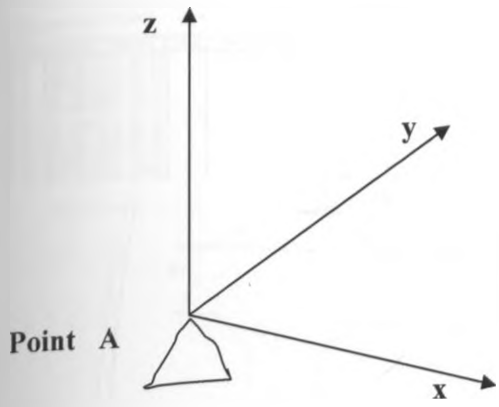
2.4.1. Conventional Cadastral-based Geo-data Acquisition Techniques

Conventional cadastral-based data acquisition techniques have been the basic source of parcel–based spatial data for various land use planning in most countries, Kenya included. However, the traditional techniques are increasingly getting limited in providing planning data as comprehensively and rapidly as demanded by the dynamic urban spatial development trends in most third world countries.

Historically, land surveying is one of the oldest art and science known to man. For instance, The Holy Bible, which was written hundreds of years Before Christ (BC), makes several references to boundary demarcation and land parcel definition (Genesis 2:8, Deuteronomy 27: 17 and Proverbs 22:28). However, it was in the First Century AD, during the philosophical and scientific revolution era when the art of surveying was tremendously developed and perfected by the Greeks. Over the centuries, the technology has seen a lot of improvements in both techniques and styles though the basic concepts and principles still remain much the same (Aduol, 2006; Oliver and Clendenning, 1979).

Conventional surveying and mapping techniques involve tedious, rigorous and costly ground measurements processes. The principle and concept behind the cadastral mapping is to mathematically measure and represent each ground feature or point of interest on a map or plan as accurately as possible, in either two dimensions coordinates (x, y) or in three dimensional orthogonal (x, y, z) system as illustrated in Figure 2.4 (Banister et al, 1998). For instance, the horizontal accuracy standard requirement for specific cadastral boundary surveys is +/- 0.01m (or 1cm), especially in urban areas.

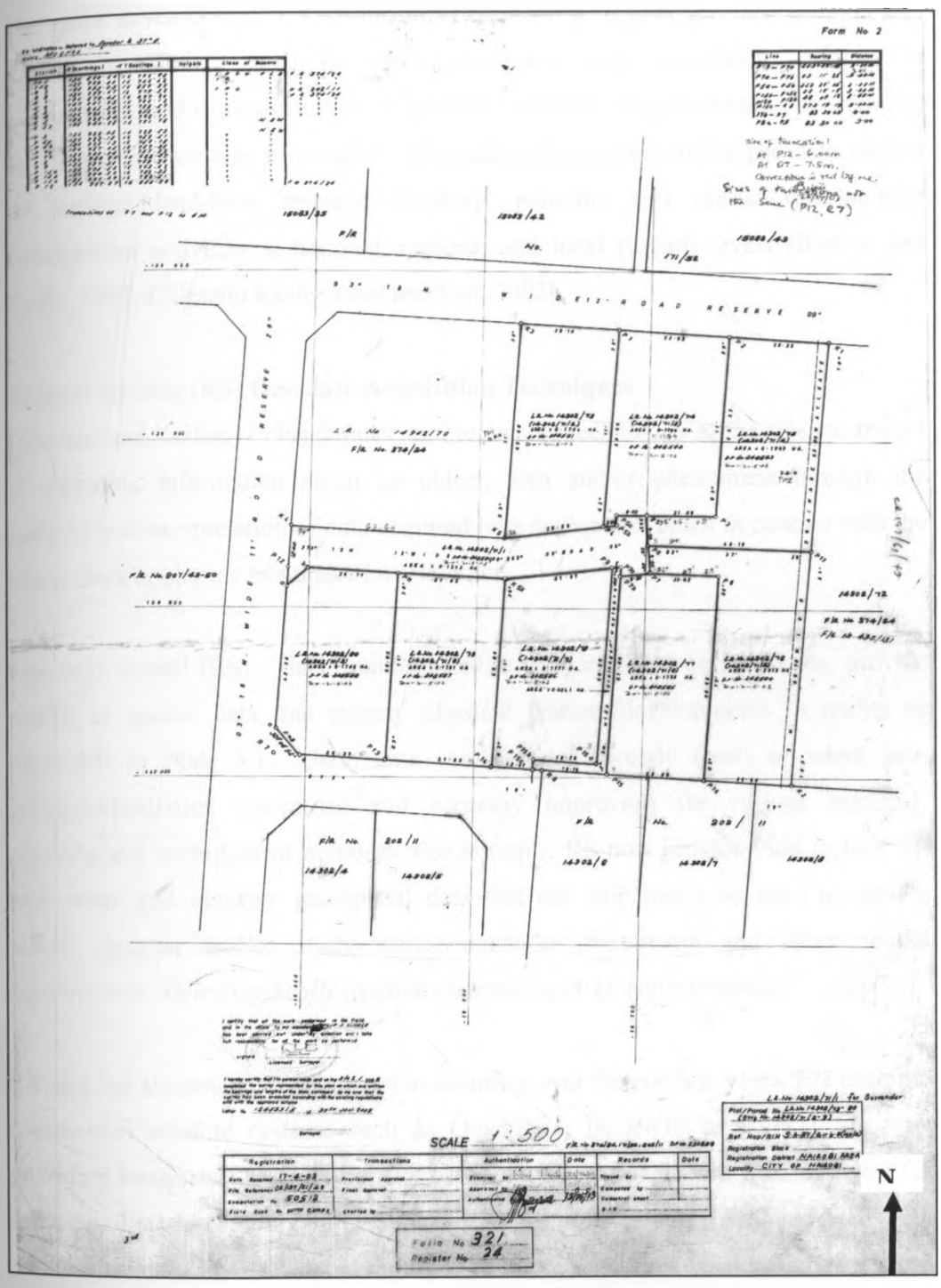
Fig. 2. 4. Orthogonal Plane (x, y, z) Coordinate System



Source: Banister et al, 1998.

It is from such vector measurements (Fig. 2.4), that various cadastral maps and plans are prepared and produced through tediously complex mathematical computations and cartographic processes. Figure 2.5. shows an example of a cadastral map illustrating vector coordinate data prepared from cadastral survey mapping techniques. Note that it requires high level of training in surveying and mapping techniques for one to successfully carry out such high accuracy surveys. In Kenya for instance, it is only university trained graduates (government and licensed surveyors) who are legally and officially mandated to undertake such cadastral title and other topo-surveys. It also takes a long and tedious process by the Survey of Kenya before the survey maps and plans are approved and registered for public use and other planning purposes.

Fig. 2.5. Example of Cadastral Survey Map (Vector Coordinate Data)



Scale: 1: 500

Source; Survey of Kenya (2006).

2.4.2. Modern Geo-data Acquisition Systems and Techniques

The rapid development and advancement of modern digital geo-info technologies (GITs) as efficient tools for rapid geo-spatial data acquisition, information management and dissemination now provides planners unprecedented opportunities for alternative sources of reliable, affordable and comprehensive geo-data needed for various land-base resource mapping, planning and spatial development management activities at national, regional and local (urban) levels (Barrets and Curtis. 1997; Lillesand Keifer,1999 and Esri, 2002).

Remote Sensing (RS) Geo-data Acquisition Techniques

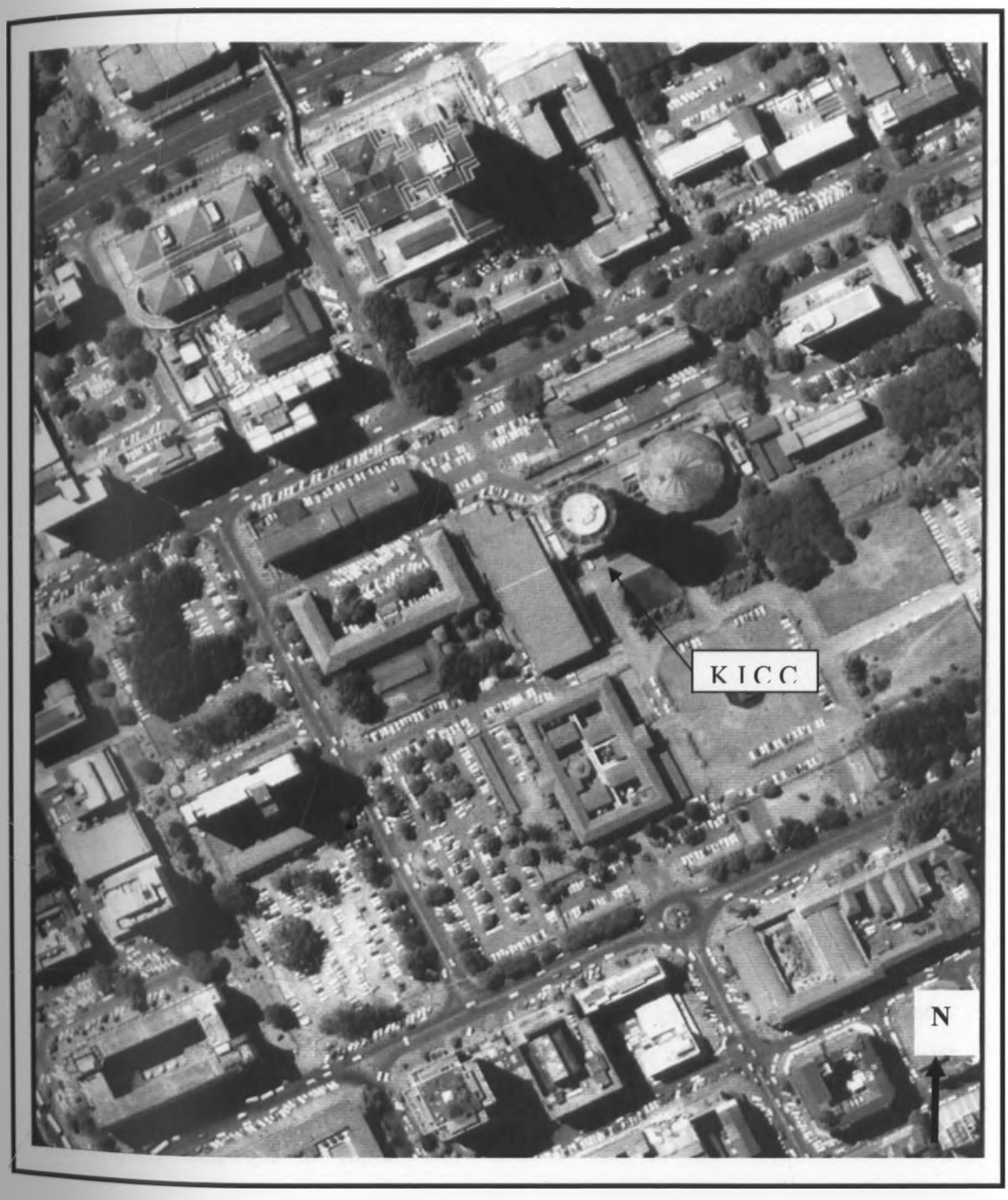
Lillesand and Keifer, (1999) defines remote sensing technology as the science and art of obtaining information about an object, area and/or phenomena through the analysis and interpretation of data acquired by a device that is *not in contact* with the object, area or phenomena under investigation.

Remotely sensed (RS) data, mainly satellite imageries and aerial photos, provide wealth of spatial data that portray physical features/developments *in* reality as illustrated in Plate 3.1. Such data can be used directly (raw) or when geo-referenced/rectified (processed and accuracy improved) for various mapping, planning and management purposes. For example, RS now provide vital source for both *static* and *dynamic* geo-spatial data that can effectively be used to rapidly assess, monitor and/or study static, dynamic phenomena and other spatial developments *stereoscopically* in *three dimensions (3-D) representation.*

RS data has tremendously improved in accuracy over the last few years. For example commercial satellite systems such as QuickBird, IKONOS and SPOT are now providing image data at resolutions of between 0.5-1.0 meters which is sufficient for most detail urban planning and mapping at scales of between 1:1,000 and 1:10, 000. Such data can easily be ordered through the Internet within 1-2 weeks or purchased from local vendors, e.g. Regional Centre for Mapping of Resources for Development (RCMRD) at very affordable costs. It is important to also note that, with now improved image quality, affordability, portability and computer compatibility, modern digital cameras now provide versatile tools for rapid field data collection

(including video interview recording) for various planning activities and as data sources for input in a GIS - data base.

Plate 2.1. QuickBird Satellite Image of Nairobi City Centre



Approx. Scale: 1: 500

Image Source; *www.mapsgeosystems*

Global Positioning Systems (GPS)

Global Positioning Systems (GPS) *has become a solution to one of man's longest and most troublesome problems. It now (instantaneously) provides the answer to hitherto bothersome question, 'Where on earth am I?' For many centuries, this problem was solved using the sun and the stars* (Leica, 1999).

Global Positioning Systems are rapidly gaining popularity as important tools for providing spatial position (coordinates) data rapidly for various mapping and planning activities. The GPS now provides valuable technique for mapping built-up un-surveyed and/or un-planned areas such as informal settlements, which would have been difficult and costly using conventional ground mapping techniques.

For example, simple hand-held GPS sets are currently relatively affordable (at about Ksh. 25,000 or US$ 200) and with improved accuracies of about 2m. Hand-held GPS sets now provide majority of planners and surveyors with handy tools for rapid field position (coordinate) data collection. Their capability for direct digital data input and merging with RS data in a GIS data base, further makes GPS invaluable tool for comprehensive digital mapping, plan drafting and production for various large scale development planning purposes. Fig. 2.6. shows a typical hand-held GPS set which is the size of a common cell-phone.

It is to be however noted here that the higher accuracy Geodetic GPS sets, costing over Ksh. 5milions are relatively complex to use and unaffordable for most people. They are mainly used government institutions, such as Survey of Kenya mainly for geodetic control surveys that require high accuracy standards of about +/- 0.01m and above.

Other GPS-based techniques of acquiring data remotely using devices such as lasers and range finders are rapidly gaining popularity for field data collection from aerial or terrestrial view points. Use of voice technology is also continually being improved as another technique for rapid data collection. For example, suppose somebody walking, biking or driving is equipped with a voice device to capture description of his spatial environment. By directly storing this voice information (verbal

description), or transmitting it to the control office together with hand-held GPS coordinate positions ,eg using a cell-phones, the data can spontaneously be availed for field phenomena assessment, monitoring, and other spatial planning activities, such as traffic flows and progress of engineering works and other dynamic planning activities.

Fig. 2. 6. A Typical Hand-held GPS Set

Source;Leica,(1999)

Geographic Information Systems (GIS)

A modern Geographic Information System (GIS) may be defined as a computer-based system that is designed to gather, manage, analyze, display and disseminate geo-coded and geo-referenced data and information (Korte, 1997).

A modern GIS differs from other computer based drafting systems such as AutoCAD in that GIS offer additional capabilities of performing spatial analysis that other systems lack. It is also differs from traditional land information systems (LISs) in terms of scope and data content as can be seen from Table 2.2. It is to be noted that LISs were initially designed to support parcel-based cadastral operations and other small scale land use management functions before the modern GIS gained in popularity and complexity. A typical desk-top (PC-based) GIS is composed of software, hardware, data and temporal components as illustrated in Figure 2.7. Figure 2.8 further illustrates multi-data sources and contents in a typical modern GIS network.

Table. 2.2. Traditional LIS and Modern GIS Data Contents / Scope

GEOGRAPHIC INFORMATION

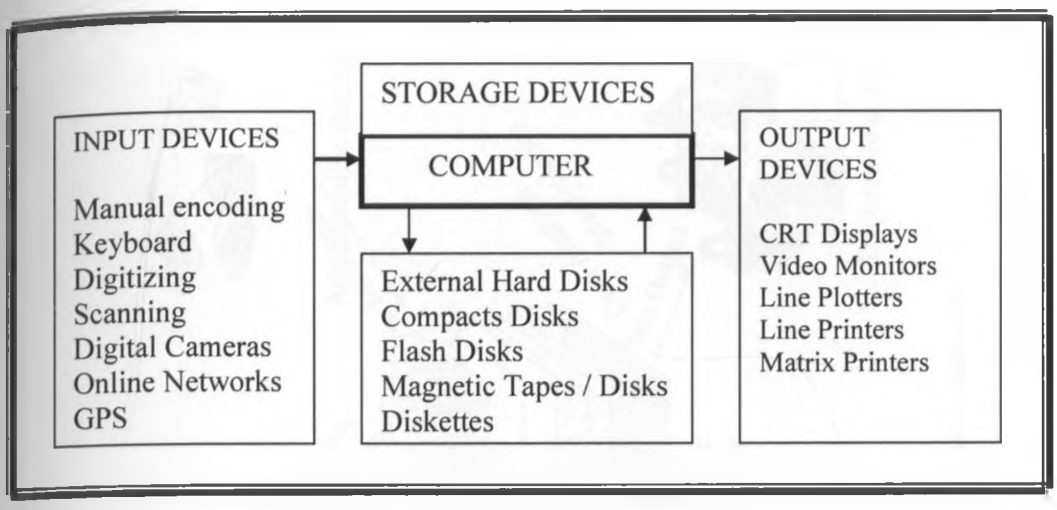
LAND INFORMATION

Environmental Information	**Infrastructure Information**	**Cadastral Information**	**Socio-economic Information**
Soil types Geology Watercourses Vegetation types Climate etc	Utilities Buildings Transportation & communication systems etc	Tenure systems Valuation & taxation Land use zones Boundaries etc	Social amenities Crime rates & Population densities Economic activities etc

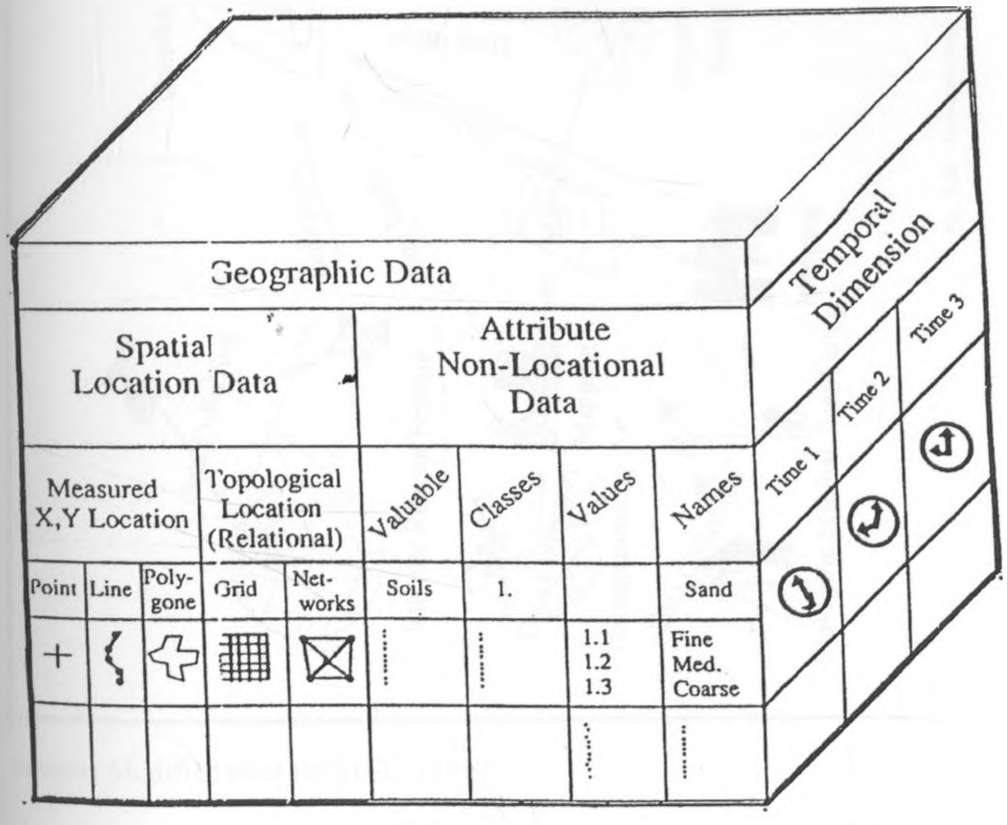
Source; After, Dale & McLaughlin, (1986)

Fig. 2.7. Components of a Simple Desk-Top GIS Module

(a). Hardware and Software Components of a Desk-Top GIS



(b). Spatial / Attributes Data and Temporal Dimensions of Modern GIS



Source; Derived from RESTEC, (1999), Lellisand & Keifer (1999)

Fig. 2.8. Multi-data Source and Contents in a Modern GIS Data-Base

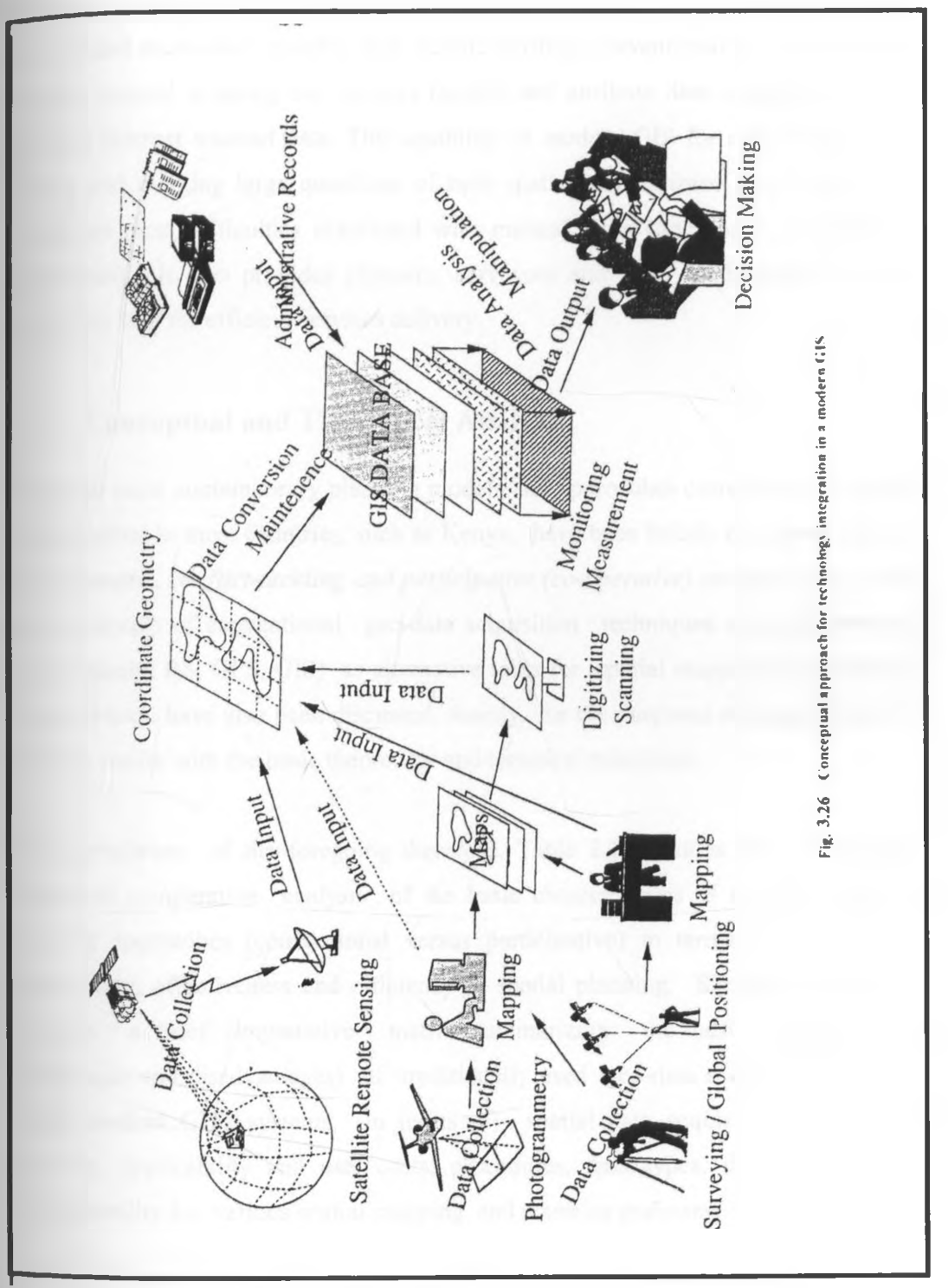


Fig. 3.26 Conceptual approach for technology integration in a modern GIS

Source; Modified after RESTEC, (1999)

The rapid advancement in digital technology, has propelled the development and popularity of modern GIS, especially through integration of various geo-spatial data sources and acquisition systems that include existing conventional and digital data sources, ground mapping and surveys (spatial and attribute data collection), GPS, RS, and Internet sourced data. The capability of modern GIS for automation, data coding and merging large quantities of both spatial and attribute data sets/layers, eliminates most difficulties associated with manual GISs (traditional cartographic techniques). It also provides planners, surveyors and other land managers with invaluable tool for efficient services delivery.

2.5. Conceptual and Theoretical Analysis

The three main contemporary planning models and approaches currently as currently being applied in most countries, such as Kenya, have been briefly elucidated above; the ***systematic, conflict-tackling and participative (co-operative)*** models. Further, the basic concepts of conventional geo-data acquisition techniques *vis-à-vis,* modern GITs (mainly; RS, GPS, GIS) as alternative tools for spatial mapping and planning data provision have also been discussed, mainly for the purposes of acquainting the ordinary reader with the basic theoretical and technical principles.

In recapitulation of the foregoing therefore, Table 2.3 provides brief conceptual theoretical comparative analysis of the basic characteristics of the two classical planning approaches (conventional versus participative) in terms of procedural applicability, effectiveness and efficiency in spatial planning. Similarly Table 2.4. provides a brief comparative matrix summarizing the basic characteristics (advantages and disadvantages) of traditionally used geo-data acquisition systems versus modern GITs systems, in terms of; spatial data acquisition techniques, accuracy, applicability and use, costs, procedures, data types, data formats and interpretability for various spatial mapping and planning purposes.

Table 2.3. Conventional Vs Non-conventional Planning Approaches

APPROACH	CONVENTIONAL	NON-CONVENTIONAL
Procedures , requirements and application in spatial planning	Procedural, rigid, official, state – controlled, centralized, exclusive and bureaucratic top-down approach	Non-procedural, reaction - planning, participatory, inclusive, decentralized, not state dominated, cooperative bottom –up approach
Cost-effectiveness and efficiency in spatial planning	Expensive, tedious, complex, cumbersome, lengthy, *manual / analogue* process	Relatively cheaper, simpler, efficient, enables multi-stakeholder involvement

Table 2.4. Analytical Comparative Matrix

Criteria	Conventional Systems	Modern GITs Systems
Data acquisition techniques and accuracy range	Cadastral surveys and photogrammetric mapping: Accuracy ±0.01m to ±0.1m Scales: 1:1000 and larger	RS, GPS, GIS: Accuracy ± 0.5m to ±5m Scales: 1:1000 and smaller Digital Cameras: Pictorial and video data collection
Applicability and use	Precise parcel based planning and detail topo-mapping	Detailed site, urban and regional planning and mapping
Cost–effectiveness and efficiency for spatial mapping and planning	Expensive and slow in terms of financial, resources outlay and time	Cheaper and faster in terms of financial, resources outlay and time
Planning and mapping procedures and requirements	Procedurally tedious, official and complex Requires high accuracies. Less amenable for public participation	Rapid spatial data sources. Enables automation GIS mapping, plan preparation and production User friendly and amenable for mass participation
Data types, formats and interpretability	Mainly analogue vector, selective data Interpretation difficult for most ordinary people	Digital, raster, thematic, pictorial, stereoscopic (3-D) data. Interpretation easy for most ordinary people.

2.6. Role of GITs in Enhancing Public Participation

As compared to conventional cadastral (vector data), modern GITs sourced digital data (RS, GIS, GPS) is endowed with vast wealth of pictorial data content, that effectively provide virtual reality and vivid spatial representation as portrayed in colour aerial photographs, satellite imageries and GIS map products, usually presented either in 2-D and / or 3-D formats. The vivid features representation can easily enable ordinary citizens to visualize, recognize, interpret and understand their physical environments with minimum introductory explanation. The understanding would further effectively encourage local and / or public participation in the planning, management and governance debate.

It is important to note here that, the local community residents of a given urban settlement (especially informal peri-urban settlements), are the main custodians to vital data/information such as land ownership and use, socio-economic conflicts, cultural rights, spatial development planning problems and needs, etc. that is necessary in the initial stages of planning process. Consequently therefore, when their views, opinions and local knowledge held by the residents are solicited and incorporated in a modern GIS data base module ,and linked with current RS and GPS data of the locality, can provide a powerful tool for efficient planning, development and management of respective community settlements. Hence the need to bring on board the local community residents in the planning, development and management agenda of their settlement.

2.6.1. Conceptual Community-based GIS Development

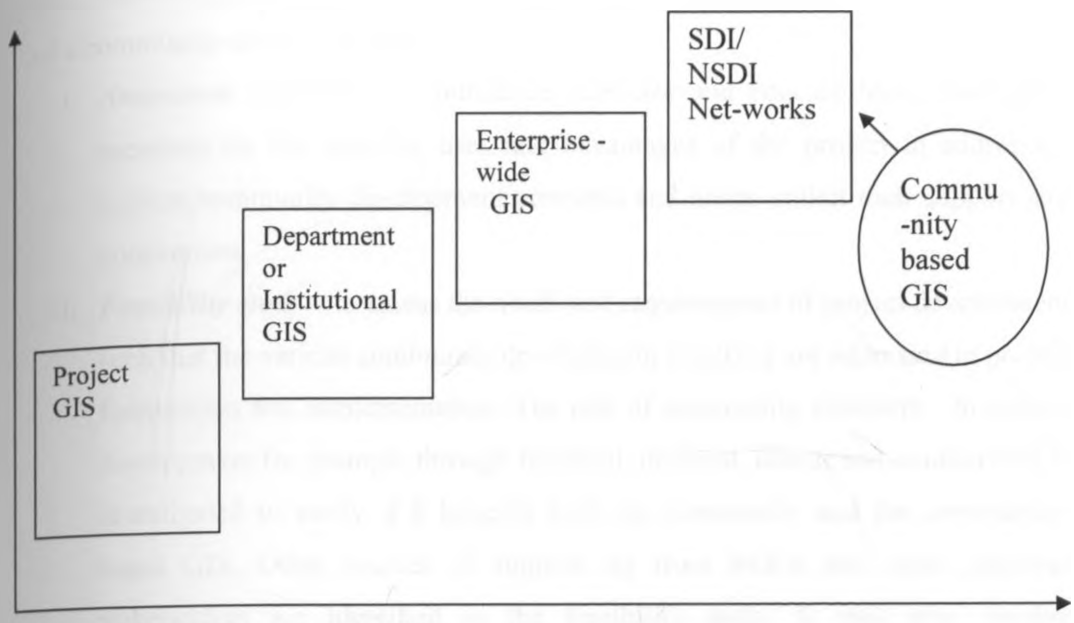
Conceptually, a community-based GIS should be differentiated from other types of GISs such as; project GISs, departmental and enterprise-wide based GISs that are basically meant to serve specific private or public institutional and/or commercial enterprises. The latter category is therefore corporate GISs types that are also usually more complex in design and application and require huge capital outlays.

On the other hand, a community-based GIS is usually initiated and owned by the community members mainly through contributory cost-sharing approach for the benefit of the respective community members (*www.ppgis.net).* Figures 2.9 and 2.10

attempts to illustrate community GIS and other types of GISs in terms of development hierarchy, functions and applications. A community GIS should also be broadly seen as part of public spatial data infrastructure (SDI) for a given local jurisdictional district.

It is important to note here that, currently in most developed countries, public institution SDIs are being networked to create large-scale national spatial data infrastructure (NSDI) frameworks. The growth of NSDIs has been attributed to a drive towards capturing, managing and disseminating large-scale spatial-attributes geo-data/ information packages and their metadata (infrastructure, geo-physical, environmental, socio-economic, thematic etc) so as to cater for various resource development planning and management at regional and / or national levels. A functional spatial data infrastructure (SDI/NSDI) network should be analogously seen as an efficient road or telecommunication network; and just like *roads* and *telecommunication lines* facilitate spatial distribution and delivery of various packages of essential goods and services, SDI networks facilitate the conveyance of virtually unlimited packages of geo-spatial data/information for various spatial development planning and management purposes (Nedovic-Budic *et al*, 2003; Maser, 2000; ESRI, 1999).

Fig. 2.9. GISs Types and Development Hierarchy



Source: Author's Construct (2009)

Fig. 2.10. Community GIS Versus Higher Order GISs

Community – based GIS	**Higher Order GISs**
- Simple modular in design - Low capital and resources outlay - Community owned through cost-sharing - Managed by technicians community employees - To serve identified community needs, eg. land related, socio-economic and revenue generation	- Complex network in design - Large capital and resources outlay - Cooperate enterprises - Professionally managed by Experts - To meet and serve specific project needs, firm, department or institution requirements, eg. spatial planning and management in a government lands ministry

Source: Author's Construct (2009)

2.6.2. Considerations in Developing Community GIS-based Module

The following factors should be considered in the development and implementation of a community-based GIS project:

i. ***Awareness creation*** – to introduce, sensitize and educate local community members on the benefits, uses and advantages of the project in addressing various community development concerns and hence solicit their support and cooperation.

ii. ***Feasibility study*** – to assess the needs and requirements of project development such that the various community development concerns are addressed in project formulation and implementation. The role of community members in project development for example through financial, material, labour and or otherwise is investigated to verify if it benefits both the community and the community-based GIS. Other sources of support, eg from NGOs and other potential stakeholders are identified in the feasibility study. It may also involve formation of community-based organizations spearheaded by local opinion leaders such as chairpersons of women groups and other welfare associations.Thorough cost–benefit analysis should be carried to establish the viability of the project and also whether revenues generated from products and services arising from the development, maintain and sustain the GIS module.

iii. ***Systems accessibility and service delivery*** – Since the facility is community owned, genuine local residents can freely access products and services provided by the system through payment of a specified minimal fee. Outsiders should be levied higher fees. The revenue generated should be used for maintenance; general running of the project and other arising needs such as future expansion. Due to literacy and technical limitations, members of the public can interact with the system through assistance from employed technical.

2.6.3. Conceptual Community GIS Development Strategy

As pointed out above, community GIS is normally a public project, initiated and owned by the respective community residents. Therefore, through multi-stakeholder involvement and support, local communities are able to initiate and develop GIS module networks that can enable them to address various common cross-cutting

spatial development planning and management needs of their settlements. These needs include; infrastructural planning, services provision, development control, environmental management, security surveillance and other spatial and socio-economic development challenges and needs that affect them. Figure 2.11 attempts to strategize a conceptual community-based GIS development module at local levels, and by extrapolation and generalization, at regional (eg. city-wide) levels.

The implementation strategy and model framework development would basically entail the following:

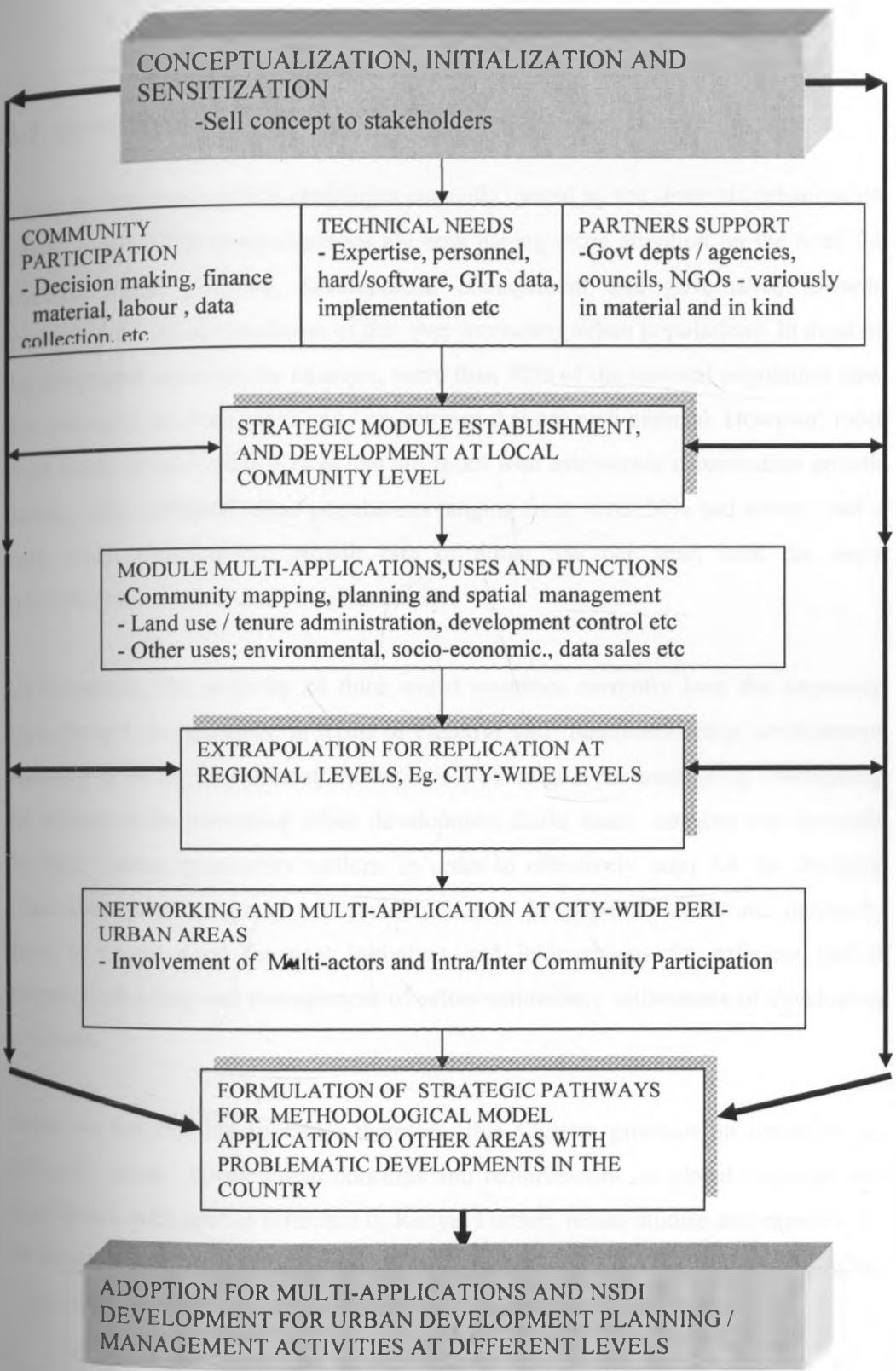
- Use of medium resolution satellite imageries, such as Landsat or SPOT data, and GPS to rapidly locate and map out the various peri-urban developments at local and /or city-wide level (regional) at affordable mapping and planning costs.
- Involving local communities at inter–municipality/jurisdiction settlement levels in identifying development planning and management problems, needs and requirements, especially through intra/inter community networking forums such as community welfare associations (CWAs) and/or CBOs, awareness creation and sensitization campaigns.
- Development of integrated GITs/community based GIS module(s) at community level and networking, e.g. through use of Internet.
- Involvement of stakeholders and partners such as local councils, related government agencies and departments, NGOs, private developers and estate managers for financial and technical support.

Some of the attribute data/information that can be provided by the local residents and easily input into the GIS data-base includes:

- Tenancy and ownership data, e.g. Data that can be collected through interviews to indicate rented and owner-occupied premises, types of tenancy, user types, e.g. commercial or residential, building types etc.
- Proprietorship history and land tenure systems; e.g. council allotment certificates (quasi –legal), disputes, eviction threats; land use conflicts (e.g. Demolition along road reserve now going on as a result of tenure insecurity and user conflicts).
- Other socio-economic attributes data such as; population, income, social services, security and business types.

It is important to note here that, with adequate sensitization and awareness creation, local communities and other stakeholders such as, NGOs, private planners, surveyors, and land managers, government and local authorities can be brought on-board in supporting, developing and implementing such community GIS projects, leading to a multi-stakeholder and participatory *win-win* strategic approach to problem solving for the majority of urban indigent community settlers settlements .

Fig. 2.11. Community-based GIS Development Strategy



Chapter Three

REVIEW OF RELATED LITERATURE

3.1. Introduction

Given the enormous global challenges currently posed by the dramatic urbanization trends, most of the world countries are now paying more attention on the need for effective urban planning, development, management and governance towards improving the living conditions of the ever increasing urban populations. In most of the developed countries for example, more than 70% of the national population now live and work in urban areas and / or settings that are well planned. However, most third world countries like Kenya that are faced with astronomic urbanization growth trends, with estimated urban populations ranging from over 30% and above, and a high urban demographic growth rate of about 5% per year, lack the basic infrastructural services and social amenities.

Unfortunately, the majority of third world countries currently lack the necessary capacity and preparedness, in terms of effective and functional urban development planning policies, institutional and technical paradigms for addressing / mitigating the effects of the prevailing urban development crisis, basic services and demands for their urban community settlers. In order to effectively cater for the charging urban demographic, spatial and socio-economic development needs and demands, there is urgent need for new initiatives and interventions for efficient spatial mapping, planning and management of urban community settlements of developing countries.

Based on the existing literature therefore, this Chapter provides an overview on pertinent urban development concerns and requirements at global, regional and local levels, with special reference to Kenya. Further, recent studies and experiences on potential use of modern digital geo-info technologies (GITs) in planning urban settlements, and their role in enhancing public participation are studied.

3.2. Current Urbanization Trends, Concerns and Challenges: *A Global, Regional and Local Perspective*

The pervasive global urbanization trends now presents enormous challenges to urban planners and development managers of the modern information-age society, especially in the transition and developing countries of the world. For example, in the last five decades or so (after the colonial era), Africa and other third world countries of Asia and Latin America, have witnessed astronomic spatial and demographic urban growth. The phenomenal *urbanization syndrome* now occurring in most of these countries has led to numerous negative and undesirable consequences, including; poor and / or lack of infrastructural services and basic social amenities, eg. shelter, public utilities, access roads, water, electricity, transport and communication, among others. Environmentally hazardous health and life threatening living conditions are a common thing in most urban settlements of third world countries, especially in Africa.

The above consequences are a direct manifestation of the inefficiencies and / or lack of effective spatial development planning, management administrative and governance systems. Faced with other pressing demands and challenges, eg., poverty eradication, provision of social facilities, political, governance and administrative bottlenecks, etc., that compete for the meager budgetary resource-base, most of the developing countries lack the necessary financial muscle and technical capacity to adequately cope with the dramatic urban development trends. For example, unlike in most developed countries of the west where most urban areas have been comprehensively mapped and planned at minimal scales of 1:10,000 and larger ahead of developments, most urban areas of third world countries currently lack any formal mapping , planning and spatial development control.

Efficient mapping and planning systems are a basic pre-requisite to effective and functional spatial, environmental and socio-economic development, management and governance of any given urban settlement, large and medium cities, towns and small market centres world over. Currently, however most third world countries lack comprehensive land use policies, institutional and technical frameworks for addressing and / or mitigating the urbanization crisis, albeit faced with astronomical

demographic growth. In most of the cases, the majority of official policy documents are often found gathering dust in book-shelves, over months and years still waiting for implementation.

According to the UN-Habitat, (2002) a great majority of urban populations in developing countries – particularly in Africa , Asia and Latin America, now live and work in unplanned informal settlements of large and medium cities and towns. In this regard, the Istanbul Declaration of Heads of State and Government more than a decade ago, regretfully acknowledged the undesirable conditions of human life within informal settlements of most developing countries as having reached crisis proportions, hence the need for practical intervention and mitigation measures (UNCHS, 1997). Unfortunately, despite the Declaration, the situation remains much the same to-date in most countries. In Kenya for example, most squatter settlers and urban indigent live in deplorable conditions, often threatened with health and live-threatening situations, and frequently faced with actual physical evictions by both public authorities and / or private land owners on which they squat.

Similarly, Okpala (2001) observes that, there can be hardly any sustainable urban development management, land administration and governance without sound land use planning policies, institutional, technical frameworks, and more so, efficiently functional geo-spatial information resource-base on which such development efforts can be based. Unfortunately however, the existing and traditionally used geo-information systems and planning approaches are proving inadequate in meeting the above demands posed by the urbanization syndrome.

In view of the foregoing, the UN-Habitat (2008) specifically highlighted the growing state of urban human squalor in global terms. It estimates the world's urban dwellers at over 30 per percent who are now living in dirty slums and other informal settlements. The Habitat further says the figure is even higher in Sub-Saharan Africa where over 50 percent of urban dwellers are found in informal settlements. Most of informal settlements are characterized by various problems, including; poor infrastructural services, poor environments and living conditions,

inadequate social amenities, congestion, poverty, social unrest, and land use related conflicts.

3.2.1. Urbanization Challenges in Third World Countries

At regional levels, urban developmental issues and concerns have recently become subjects of many research studies in the third world countries. For example, a Swiss-based Research Network, named; National Centre of Competence in Research North–South (NCCR-North-South), is currently researching on methodological frameworks and strategic pathways for mitigating spatial developmental challenges in developing countries, Kenya included. The NCCR-North-South has employed the term *urbanization syndrome* to refer to the *phenomenal pandemic-like* urban growth now taking place in developing countries (NCCR-North-South, 2003).

According to the above school of thought, the dramatic urbanization trend is currently attributable to most of problematic developmental challenges found in urban settlements of third world countries. These problematic developments are usually characterized by the following *core symptoms:*

- Indiscriminate encroachment and sprawl of urban developments onto hitherto adjacent rural agro-pastoral lands.
- Frequent land use and resources related conflicts, eg. water, grazing rights, etc, which in most cases degenerate into deadly clashes.
- Destruction of natural eco-systems, environmental degradation, pollution and human congestion.
- Conflicting land use and land tenure systems (formal and informal).
- Depletion and/or over-use of existing infrastructure services and other social amenities due to increasing populations in most urban settlements.
- Uncontrolled growth of informal settlements, slums and other unplanned spatial developments among other developmental problems.
- Hazardous living conditions for the majority of the urban indigent especially in risky areas such as wetlands, escarpments and other wastelands.

Although many countries such as Kenya, have initiated official policy programmes that are aimed at addressing the above challenges, including; poverty eradication programme, improvement of urban economies, provision of better shelter and infrastructural services, they have not been successful enough, mainly due to administrative and financial constraints (Mwangi, 2002).

3.2.2. Emergence and Spatial Development of Peri-urban Settlement Zone

The emergence and rapid development of unplanned informal settlements now being witnessed in many countries is one of the major challenges facing many third world countries today. The term *peri-urban* is here being interchangeably used with other common terms such as; rural-urban fringe / interface, suburbs, urban periphery, and more recently extended metropolitan regions (EMRs) *(www.gisdevelopment.net).* However, in our definition, the peri-urban zone refers to the *zone of interaction* found at the edges of a given city, small, medium and large town or urban center jurisdictional limits, and the immediately adjacent rural areas (Berg, 2000; Sandt, 2007).

In most developing countries, peri-urban community settlements are dynamically developing as *zones of conflicts* in that they are commonly characterized by incompatible spatial developments, such as un-harmonious land use and tenure systems, conflicting planning and zoning regulations, development controls, jurisdictional and administrative by-laws, socio-economic developments, cultural and political paradigms. The emergence of this *dynamic zone* with its complex problems of adjustments between rural and urban lifestyles, has led to a myriad of land use planning and management problems in most urban areas of third world countries such as Nairobi, Kenya. It is important to note here that, though of recent peri-urban development concerns have assumed topical research importance in most developing countries, such as South Africa, Asia and Latin America, unfortunately the subject still remains a neglected area of serious urban research locally (Masser, 2000; NSI, 2006).

Composition and Characteristic of Peri-urban Community Settlements

In most countries such as Kenya for instance, peri-urban areas are mainly comprised of informal community settlements, mainly slums and shanties that sporadically proliferate and mushroom mostly on unprotected and vacant private and / or public lands such as, public utility reserves, road reserves, forests, waste lands etc. The majority of squatter invasions are irregular, and in most of the cases, politically and / or administratively motivated. Most of the shanties spring-up over-night, as make-shift structures, mainly made of cartons, polythane papers, cheap iron sheets and other temporary materials affordable to the urban squalor. It is to be noted that normally informal settlements vary in, size, structural development and demographic, social and ethnic composition, and generally lack any definite spatial distribution. The squatter settlements are usually common targets of forced evictions and demolitions by local authorities and/or private land owners due to lack of the necessary legal mandate, land use and tenure rights and security (Anau, et al, 2002; Lasimberg, 2004).

In Kenya for instance, inhabitants of informal settlements comprise of low income and / or unemployed urban poor, where social conflicts, crime, poor living conditions and livelihoods pervade. In order to alleviate the living conditions of peri-urban communities therefore, there is urgent for multi-stakeholder intervention regularization of land tenure, mapping and development planning through effective involvement of the affected community residents. Due to the nature and spatial composition of these settlements modern GITs-based approaches can offer the best viable and cost-effective alternative to planning and managing urban community settlements as opposed to conventionally used approaches (Colchester, 2002; ICL, 2006; *www.landcoaltion .org*).

3.2.3. Urbanization Trends and Challenges in Kenya

Urbanization trends in Kenya has taken leaps and bolds for the last three decades. For example, at independence (1963), the country had about 30 urban centres and a total population of nearly 8.6 million people, of which about 9% were living in urban areas. In 1979, the population had almost doubled to about 17.3 million of

which 2.3 million or about 15% was urbanized in nearly 90 urban centres. The 1989 national census give a total population of approximately 21.8 million against the World Bank Report of 1991 of about 24 million, of which 20% (4.8 million) was urbanized (Kenya Rep., 2002.

The 1999 census results estimated the national population at over 30 million people with an urban population at over 10 million. This gives a population growth trend of between 3% and 4%. With the un-released 2009 official census results, the current population is estimated at anywhere between 35 and 40 million with an urban population approaching 30% of the total. Currently Nairobi's population is estimated at between 3.5 to 4.0 million with other large cities like Kisumu and Mombasa at anywhere between 1.0 to 1.2 million people. Other large and medium towns in the country are experiencing similar exponential spatial and demographic growth
(Kenya Rep. 2002 & 2008)

Currently there are well over 115 urban municipalities and councils and numerous market centres in the country. Unfortunately, most of the old and new urban centres continue to expand and grow without any realistic and / or comprehensive guiding structural, demographic and socio-economic development plans. Further more, the existing policy, institutional and technical paradigms for urban development management have not kept pace with the dramatic urban spatial and demographic growth, neither have they been pro-growth or pro-poor enough towards addressing and / or mitigating the urbanization challenges in the country.

In an attempt to address urban development crisis, the Government has established whole ministries, such as the recently established Ministries of Housing and Nairobi Metropolitan Development that are aimed at mitigating the current urbanization challenges in the country. However, for such initiatives to succeed they must be anchored on sound and functional spatial development planning and urban management frameworks and systems, but unfortunately such frameworks are now lacking. Lack of an inclusive land use planning policies, institutional and technical and statutory weaknesses of Physical Planning, Survey Acts and other land related

laws governing land use management and administration further compounds the current spatial development crises, especially in urban areas of the country.

Though many of government land policies in Kenya have emphasized on the importance of urban land-use planning and management in the last few decades, research indicates that most of the policies have largely been ineffective, mainly due to lack of efficiently functional national spatial data infrastructure (NSDI) frameworks and appropriate development planning and management approaches Due to this inadequacy, activities such as land use planning, development monitoring and control, land tenure administration, land valuation and taxation, environmental management, services and infrastructure provision, administrative and political boundary demarcation and land policy decision making are difficult if not impossible to implement (Mwaura, 2003).

The current urban land use planning approaches in the country are largely sectoral and uncoordinated. The unprecedented growth of small urban centres and the expansion of existing local authorities through uncontrolled subdivision and settlement of peripheral urban lands currently overwhelms planning authorities in terms of capacity and resource availability in meeting the planning and management demands presented by escalating spatial and demographic urban growth in the country. For instance, the majority of new and up-coming peri-urban settlements, urban centres and markets continue to develop without any comprehensive structural physical development plans, mainly due to the inadequacies of the existing mapping and planning systems and approaches. This has not only resulted into various land use and tenure related conflicts, but also proliferation of haphazard and amorphous morphological spatial developments in these centres without any control.

For instance, Njuki (1999), observes that, though the government has endeavored to regularize informal urban developments in the country, it has been faced with daunting administrative constraints mainly due to the inadequacies of the existing traditional systems of data provision and poor planning approaches. He regrets the continued use of conventional cadastral mapping techniques that were designed in the 1950's and are now, not only *antiquated*, but also ineffective for rapid and

comprehensive mapping of complex spatial developments found in informal settlement areas. Though conventional cadastral technique has been hitherto the primary system for defining land and property rights and, hence for supplying planning data in urban areas, its complex technical measurement procedures it is a system that is hardly understood by most people without basic training in surveying and mapping, hence limiting its popularity and applicability for dynamic and comprehensive urban land use planning.

Similarly Yahya (2002), while investigating customary tenancies in the urban and peri-urban areas of Mombasa District in Kenya, also observed that, due to lack of reliable geo-data, most of the informal land tenure / use rights were recorded in the *clan's collective memory.* The contents of these *mental registers* are normally customarily transmitted verbally from generation to generation. This *verbal data* can not be depended upon in terms of spatial and legal accuracy, hence the urgent need for documenting these records through involvement of the local residents, if the rampant land related conflicts in the District are to be effectively mitigated. He also blames this geo-data dearth on the inadequacies of the traditional cadastral systems of data acquisition.

One of the major challenges facing the country today is poverty eradication that is prevalent in most urban and rural areas. In this regard the Government of Kenya, for example drew up a National Poverty Eradication Plan policy for implementation in the period 1999-2015 (Kenya Rep.,2008). Poverty is an ethical, social, political and economic imperative of humankind whose causes should be addressed in the concept of sectarian strategies, such as effective spatial-environmental management, food security, population control and management, adequate health and shelter provision, efficient human and natural resources development planning and management at local, regional and national levels. One of the limiting factors in these sectors is the lack of an effectively efficient geo-spatial information resource-base on which informed development policy decision making processes can be based (UN – Habitat, 2001).

Kenya's socio-economic life-line is largely based on its rich natural land-based resources. However, one of the most pressing issues in country today is the need for effective land use planning, management and administration system. For example, the majority of spatial, environment and socio-economic problems and conflicts in both urban and rural areas of the country today are land (use and tenure) related. In the last three decades, Kenya has experienced dramatic urbanization growth, spatial, demographic and socio-economic growth.

Spatially there has been multiplication, increase and concentration of urban centres coupled with an overwhelming growth and sprawl of large and medium cities and towns that is paralleled by proportionate urban population increase. This has resulted into stiff competition and / or depletion of the available amenities and services, including; secure land tenure and use, shelter, social facilities resulting into undesirable conflicts, especially in urban areas. Unfortunately due its inherent weaknesses, the existing mapping and planning process is currently, by and large, unable to effectively meet and / or address the spatial development demands, especially in the rapidly growing urban settlement areas.

3.3. Spatial Planning and Mapping Process in Kenya

Spatial planning and mapping processes in Kenya are mainly governed by the two Acts of Parliament, namely the Physical Planning Act Cap.286 (Rev. 1996) and the Survey Act, Cap 299 (Rev. 1989). The inherent weaknesses of the two Acts and other related land statutes have, to a large extent, played a big role to spatial planning and management inefficiencies in the country's urban settlements (Olima, 2003). For instance, the rigid procedural requirements prescribed by the two statutes are generally lengthy, complex and bureaucratic in nature, hence significantly contributing to the inefficiencies of planning and mapping process in the country.

The existing planning approach is generally based on the Master Plan Model of planning that was adopted from Britain by-laws and regulations at independence in 1963, more than four decades ago. The master plan approach basically rely on rigid regulations and centralized town planning system that effectively capture the

dynamic urban sprawl from central areas of urban centres into the peripheral areas. This has lead to the emergence of a dual development pattern for most urban centres; a planned central area and generally unplanned peri-urban zone. The unplanned peri-urban zones are in most cases found in the adjacent private freehold land which are haphazardly and / or informally subdivided and developed with or without proper planning guidelines.

The restrictive regulations that are the tenets of the *master plan strategy,* usually involve unrealistically high cadastral survey standards, tedious procedures and requirements, and slow data delivery that militate against efficient planning and mapping, hence further escalating informal development crisis in most urban areas. In effect the bureaucratic planning and mapping approaches as prescribed by the two statutes (briefly analyzed below), largely excludes multi-stakeholder participation in development planning, mapping, spatial management and governance processes (Kenya Rep. 2002).

3.3.1. The Physical Planning Act, Cap. 286 (Rev. 1996)

The preamble to the Act reads; *An Act of Parliament to provide for the preparation and implementation of physical development plans and for connected purposes.* In accordance with Part ***IV-B,*** Section 24 (1) of the Act, it is only the Director of Physical Planning who, "may prepare with reference to any government land, trust land or private land within the area of authority of a city, municipal, town or urban council or with reference to any trading or marketing center, a local development plan".

By interpretation and application, therefore, it means that the Act effectively excludes the affected residents and other stakeholders in the crucial stages of planning decision making and plan implementation.

The Act is also restrictive and seemingly rigid in terms of what spatial data types and processes that are required for land use development plan preparation. For example, Section 25 (a) and (b) spells out the content and requirements of a local

physical development plan, usually referred to as Part Development Plan (PDP) preparation. It specifies;

> (a) the type of survey in respect of the area to which the plan relates, should be carried out in such a manner as may be prescribed by the Survey Act....; and
> (b) such maps and descriptions as may be necessary to indicate the manner in which the land in the area may be used having regard to the Third Schedule (of the Act) in relation to each type of the physical development plan.

The above brief reference to the relevant sections of the Act imply that the Act by its nature, leaves little room for multi-stakeholder involvement in the planning process. It can therefore be largely regarded as essentially bureaucratic and / or top-down planning approach.

3.3.2. The Survey Act, Cap 299 (Rev. 1989)

The Survey Act is the sole authority in setting standards and guidelines on all types of spatial-attribute data / information acquisition necessary for planning in the country. The preamble to the Act states; *An Act of Parliament to make provision in relation to surveys and geographical names and the licensing of land surveyors, and for connected purposes.*

The Act vests all the powers as regards to land survey activities in the country on the Director of Survey and his Appointees. Section 22 for example states that; *Any survey of land for the purposes of any written law for the time being in force relating to the registration of transactions in or of title to land (other than the first registration of the title in accordance with the provisions of Land Consolidation Act or the Land Adjudication Act) shall be done in accordance with the directions of the Director of Surveys.*

The Act clearly dictates on; 'who should carry the survey, how the survey should be carried out, what standards and accuracies, what material and instruments, etc (See Section 45 and The Survey Regulations under Subsidiary Legislation of thee Act).

In the strict sense of the Act, it is only licensed surveyors and / or government survey officers who are legally mandated to carry out any type of land survey....by interpretation collection data required for planning purposes (Sections 2, 3, 10-20). In effect the Act therefore excludes other stakeholders in providing planning data and information by further noting that; data collection, custody and ownership, and all land records belong to the Government. Section 32 (1) and (2) of the Act, for instance states;

> *(1) Every surveyor who executes any surveys in accordance with the provisions of this Act and of any provision made thereunder shall send to the Director all plans, field notes and computations relating thereto, and all such plans, field notes and computations shall be deposited in the Survey Office and shall become the property of the Government;*
>
> *(2) No plan deposited in the Survey Office in accordance with subsection (1) shall be altered or amended in any way without the permission of the Director.....* and; *No land shall be deemed to have been surveyed or resurveyed until the plan thereof has been authenticated by the signature of the Director or of a Government Surveyor authorized in writing by the Director.... by the affixing of the seal of the Survey of Kenya.*

Section 36 (a) and (b) continues to warn that; *No person, other than a surveyor, shall;*
(a) survey any holding or land for the purpose of preparing any plan which is attached to, or is referred to in, any document ..., or deal with or affect any right, ... under any written law for the time being in force relating to the registration of the land or title to land; or
(b) perform any survey which affects or may affect the delimitation of the boundaries, or the location of survey mark, of any holding or land registered or to be registered under any written law for the time being in force relating to the registration of the land or title to land.

The above rigid and restrictive statutory requirements therefore effectively excludes stakeholders participation in geo- data acquisition and / o collection , and hence in spatial planning and management processes. The fact that the Act , by its nature and interpretation effectively prohibits other types data collection techniques, including

modern GITs techniques in urban areas, other than the slow and costly cadastral methods as stipulated in the law, means that planning data inadequacy for urban areas is here to stay if no urgent policy and legal changes to the *status-quo* are made.

Section 42, further discourages collection and use of cheaper alternative data sources by other actors, by stipulating that; *Any person who intends to carry out any aerial photography (by extension satellite imaging) for use in mapping or similar purposes shall before carrying out the same, give to the Director in writing not less than one month's notice of his intention to do so.*

From the above brief description and analysis of the two Acts, it is evident that their inherent weaknesses, both statutory and technical, significantly contribute to the slow pace and inefficiency in spatial mapping, planning, land use development management and administration, especially in urban areas of the country. It is also to be noted that, other land related statutes such as the Registered Titles Act (RTA) and the Government Land Act (GLA) are equally to blame on the current situation on land crisis in the country.

In recapitulation therefore, the foregoing strongly postulates that the need for comprehensive policy, statutory, technical and institutional re-arrangement, review and / or complete overhaul of the existing land use planning, mapping, development management and administration paradigms is seriously wanting. It is also important to note here that, the seemingly exclusive and the bureaucratic conventionally attitude that....'*the professional (planner, surveyor, manger, developer, etc)... know-it-all and do-it-all doctrine'* ... virtually denies other stakeholders, especially the affected local community residents the vital opportunity to fully participate in development planning, management and governance of their respective settlements, hence the urgent need for an institutionalized multi-stakeholder approach.

3.4. Evolving Role of Geo-Info Technology in Spatial Planning

Different schools of thought have taken different stances on conventional and communicative (non-conventional) scientific rationalities regarding underpinnings of planning theory and the evolving role of geo-info technology in planning for today's modern democratic society. Conventional rationality is based on procedural and positivist ideals, which put geo-data and information gathering and scientific analysis at the core, without involving the majority of actors in the process. It largely assumes a direct and technical relationship between geo-data / information and the quality of decisions made based on this information.

On the other hand, the more progressive-cum-modern realists have argued that scientific rationalities should provide insight into the evolving role of geo-information and public participation in spatial development planning and management process. Communicative (corporate) rationality focuses on an inclusive process, public participation, dialogue, consensus building and conflicts mitigation approach (Innes, 1996; Keat & Urry, 1982; Feyerabend, 1978).

While the two theoretical stances are often viewed as competing, the role of geo-information is however crucial to both: it is not restricted to the opposing view-points. Participants in spatial planning and management processes now heavily rely on multi-sourced, multi-context and multi-dimensional geo-spatial data/information now being availed by modern GITs. This data/information mainly includes spatial-graphics, attributes, and statistical, quantitative and qualitative measures and have the cognitive meanings attached to spatial environments. Realists such as, Guhathakurta (1999), observes that the evolving role of digital geo-info technologies in spatial planning now transcends the "communicate versus calculate (functional)" dichotomy to even higher levels of community development planning, management and governance.

Computerized digital geo-systems have progressively been used to support planning functions for over 20 years now. The 1990s, for example saw a rapid increase in the use of modern GITs by planners in the developed countries, and of recent in the third

world countries. Studies conducted in the USA and Australia, for example, point to local urban planners and managers as the most progressive users of digital geo-information. Recently, they have been joined by researchers, commercial and non-profit sectors such as NGOs and community based organizations (Sieber, 2000).

The current global trends of today, s modern information-age society is that of "*moving from manual systems to digital records computerization, modernization and automation, to e-market geographics and democratic citizen-online inclusive approaches*" (ESRI, 1999). Most developed countries have taken cognizance of this reality and are aggressively harnessing the use of digital geo-information systems through citizen-online involvement in most community-based resources development planning and management activities, and with profound benefits. Developing countries are therefore left with no alternative, but to follow suite if the challenges posed by the current ***urbanization syndrome*** in these countries are to be effectively mitigated.

Sadly to note is that, though critical for sustainable national economic development, effective spatial planning practices in most of the developing countries have remained an elusive reality, a situation that has led to problematic spatial development crisis in these nations (Maser, 2000). Critically lacking in the development agenda of these nations is a reliable national spatial data infrastructure (NSDI) paradigm and the necessary supporting democratic principles, land policies and institutional frameworks for spatial development planning and management. Over two decades ago, Dale and McLaughlin (1986) for example, expressed the above concern better by stating that;

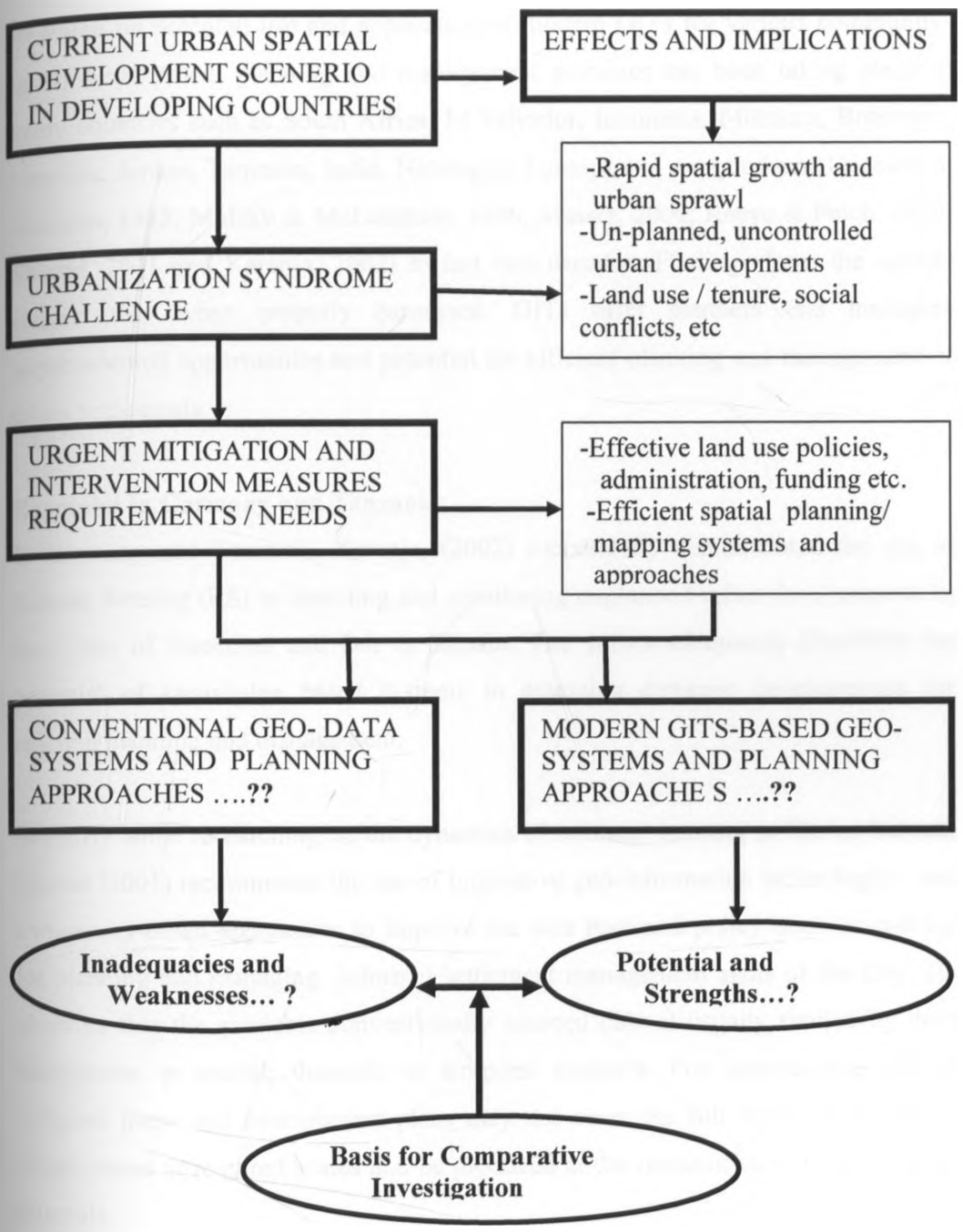
> *'....the need for thoughtful and careful stewardship of the land, together with more intensive use and management of its resources, has emerged as a matter of major global concern. Increasingly, it has been recognized that policy makers, planners, land administrators and individual citizens all have a need for basic geo-data and information about land resource...., and the need for spatial data on a day by day basis'.*

The above statements are as relevant, if not more critical today, as they were in 1986 when Dale and McLaughlin wrote them. Given the current astronomic global urbanization trends therefore, the need for urgent and sound policy-based *actions* by the relevant government authorities and other stakeholders in addressing and / or mitigating the challenge can not be overemphasized.

Okpala (2001) again notes that, economically, socially ecologically/ environmentally, sustainable development planning of towns and cities is difficult and potentially ineffective in the absence of reasonably adequate geo-spatial data and information regarding the available land on which urban developments are sited - a need that can only be satisfied by the availability of comprehensive, reliable and affordable geo-spatial data sources and appropriate planning approaches as opposed to hitherto used traditional geo-data acquisition techniques and planning approaches.

Further, Payne (2000), also observes that, due to the inadequacies of the existing conventional geo-data acquisition techniques, it has been difficult for governments to formulate appropriate policies for planning and managing informal settlements and spatial developments in rapidly urbanizing countries by noting that conventional geo-info systems unnecessarily impose costs which militate against widespread applications given the scarce resources and capabilities of third world countries, hence the urgent need for exploring new alternative innovations. Fig. 3.1. for example summarizes the current urban development scenario and the need for alternative interventions in addressing the urbanization crisis in developing countries.

Fig. 3.1. Current Urban Development Scenario in Developing Countries



Source: Author's Construct (2009)

3.4.1. Recent Studies on Potential Use and Application of Modern GITs

Research on potential use and application of modern GITs for various community-based development planning and management activities has been taking place in many countries such as South Africa, El Salvador, Indonesia, Morocco, Botswana, Namibia, Jordan, Tanzania, India, Nicaragua, Jamaica and many others (Ericsson & Eriksson, 1998; Mulaku & McLaughlin, 1986; Masser, 2000; Reeve & Petch, 1999; Sliuzas, 2001 and Karanja, 2002) in last two decades. Findings from the studies suggest that when properly harnessed, GITs offer planners and managers unprecedented opportunities and potential for efficient planning and management of urban settlements.

Examples in Germany and Tanzania

In Germany and Tanzania, Karanja, (2002) successfully demonstrated the use of Remote Sensing (RS) in detecting and monitoring unplanned urban developments in the Cities of Hannover and Dar es Salaam. The author adequately illustrated the potential of knowledge based systems in assessing dynamic developments for reaction planning and management.

Similarly while researching on the dynamics of informal housing in Dar es Salaam, Sliuzas (2001) recommends the use of innovative geo-information technologies and community-based approaches to improve the data base and policy decision-making for planning and managing informal settlement management areas of the City. He observes that the available conventionally sourced data is usually limited by their deficiencies in spatial, thematic or temporal contexts. For instance the official cadastral maps and development plans may not cover the full extent of the urban development at required scales and be produced at the required short term planning intervals.

A project by World Health Organization (WHO) carried out in the informal settlements of Dar-es-Salaam in the year 2000 to identify priority areas for the construction of health clinics, also illustrated the practical applicability of RS and

GIS technologies for rapid mapping and planning of dynamic socio-economic developments in informal settlement areas (Kyariga, 2001).

Example in Colombia

In Colombia another study by Turkstra (1998) demonstrated the potential of aerial photography for rapid monitoring of urban growth and land use changes in the City of Villavicencio between 1939 and 1994. Using simple un-rectified near-vertical multi-date aerial photographs it was possible to rapidly depict the emergence and proliferation of squatter settlements within the urban and peri-urban areas of the City, and therefore provide the much needed geo-data for forward planning and management.

Examples in Britain, South Africa and Kenya

For a long time, Britain has relied on general boundary surveys that are based on photogrammetric techniques using hedges and physical features for demarcation, delineation and mapping of property boundaries. In South Africa, GITs-based point position (PP) techniques are being experimented for mapping and planning informal settlement areas of South African cities, while in Kenya aerial-photo-enlargements (or PIDs techniques) have been successfully used since 1966 for quick mapping and land registration in many rural areas of the country (Imwati, 1989; Mulaku, 1995; Barry and Ruther, 2001).

General boundary mapping techniques and concepts are based on the premises that, where position accuracy is not the primary concern, especially when the sole purpose of the survey is to identify approximate location of land parcels and not their precise dimensions, lower accuracy mapping techniques, e.g. using high resolution satellite imageries and/or aerial photographs are sufficiently cost-effective alternatives to the expensive conventional cadastral survey and mapping techniques.

However some proponents of high precision cadastral and geodetic survey and mapping techniques strongly hold the alternative view that, traditional techniques are here to stay given that the techniques have survived the test of time and proven high technical accuracy standards, reliable in minimizing and/or mitigating disputes in

urban and other specific boundary survey areas (Aduol, 2006, Halakhe, 1989 and Mwenda, 1986). Most attribute majority of the land and boundary litigations in PID mapped areas in Kenya to the inherent inaccuracies of the general boundary survey techniques. But, it should be far and foremost noted that one of the main argument of this study is the need to harness the potential advantages offered by modern GITs, albeit their relatively lower accuracy levels, as viable spatial mapping / planning techniques alternatives in urban settings, in a complimentary manner and not as a replacement to the relatively costly conventional cadastral-based techniques.

3.4.2. Integration of Modern GITs with Community Participation

An overview of recent works by various authors strongly indicate that, effective use and integration of modern GITs with community participation now offer the much needed intervention to mitigating the challenges posed by the current urbanization trends in developing countries (McCormick et al,; MacKinven & Sandt, 2008; Kingston, 2007). Many examples on use of GITs and public involvement in community planning and management are currently found in various internet publications such as Public Participation Geographic Information System (PPGIS) and GIS development *(www.ppgis.net and http: //www.gisdevelopment.net.) www.landcoalaition.org, www.cenesta.org, www.ermisafrica.org, www.iapad.org*, and other current website publications and journals.

Most of the writers have shown that with adequate sensitization local community/ residents are able to understand and visually interpret satellite images and GIS maps of their settlements and hence offer opinions and views regarding spatial development planning and governance of their communities. Kingston (2007), for example demonstrates the potential use of satellite imageries to develop internet maps for use by the public through interactive 'public participation GIS' to access spatial geo-information on-line that can help in improved services delivery to local communities, and hence enhance participatory planning and management of relevant settlements.

For example, through use of GIS data base and internet communication, the public can be interactively engaged in various routine community management and governance activities. Unlike the complex conventional cadastral-based planning approaches that rarely involve ordinary community residents, modern GITs-based planning process is comparatively simpler, user friendly and hence amenable for mass participation. The approach generally entails scaling down of inherent complex technicalities and processes involved in the latter by simplifying data collection, visualization, mapping, plan making and decision making.

Community-based participatory planning is a multi-stakeholder approach that involves people of different backgrounds (especially local residents) in the planning process. Involvement of local residents in the planning process allows for the needs of the residents to be considered in the overall planning, development management and governance process of a given community (Armer, 1998). Participatory planning is seen as a pragmatic reaction that considers the prevailing local situation, available resources and what works for, and is affordable to the community/residents.

Community involvement further enables local residents to pool resources together in solving common problems or threats to their settlements, such as contributing towards community development projects, or resisting construction of dangerous industrial developments in their settlement. The pooling together gives them the synergy and the capacity, both financial and moral resolve to address various issues which would have been otherwise impossible for individual community members.
The modern society is endowed with the intelligence to comprehend and positively respond to various issues that affect it. Hence with minimal sensitization, community residents are now able to effectively participate in various development planning, management and governance matters affecting individual members though the following communication channels:

- *Debate* – local residents can effectively participate in the initial development planning debate regarding a given development project by giving their views based on their interests and local experiences.
- *Information and data gathering* – most basic information and attribute data about a given community settlement, especially regarding land issues such as

tenurial and cultural rights, is in the custody of the local residents. They can only freely and willing provide this data/information if they are made part and parcel of the process.

- *Facilitation and support* – with adequate sensitization, community members can willingly contribute in various ways, including financial and material donations, labour and land space provision in support of the project implementation especially when made to feel as part-owners of the project.
- *Decision-making process* – residents can readily and effectively participate in decision making processes regarding community-based project implementation, land related dispute resolution, environmental, social and governance issues that affect them

The concept of public involvement in spatial planning and management is not new. Various people have proposed different levels and degrees of public participation in planning and management processes (Craig, et at, 2002 and Kingston 2002). Figure 3.1, for example, is a ladder indicating levels of public participation in community planning and management process. The bottom level of the ladder for instance indicates low public involvement in the process.

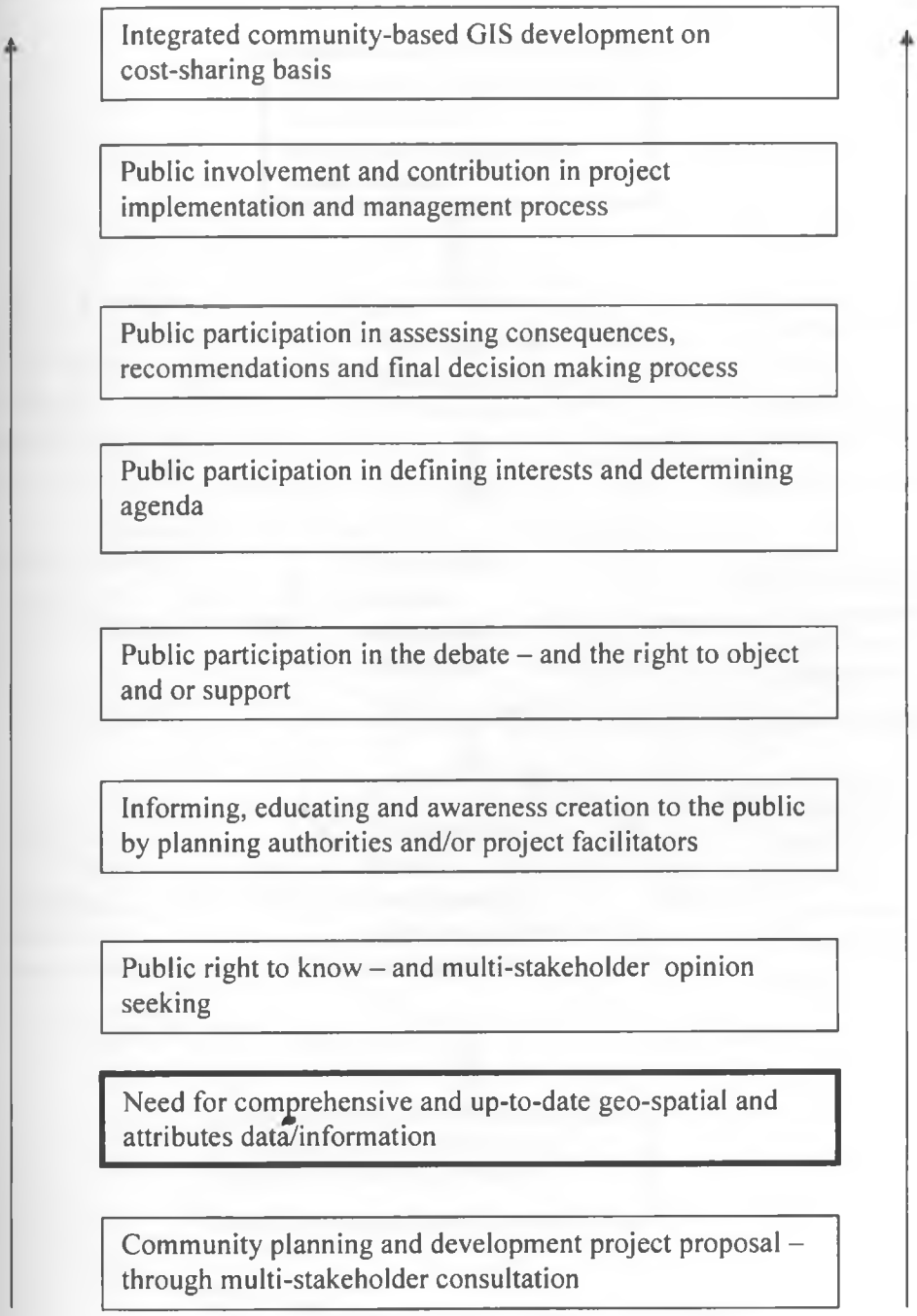
The fore-going account points to the efficiency of the existing geo-data/information systems and planning approaches in effective development planning, management and governance of urban community settlements. Fig.3.2. conceptually summarizes community-based participatory planning and management model, underlining the need for efficient and effective geo-info systems and planning approaches as support-base.

In order for the public to actively participate in decision making regarding their community development matters, they should be fully aware of spatial aspects of their community environments that they live in. This can only be effectively realized if the public members are able to visualize and understand the spatial nature and reality of their settlement. Apparently, conventionally used urban plans, maps and written statements may look easier to be understood by planners and other

professionals, but a lot of ordinary people are unable to interpret and or understand them (Nobre,1999).

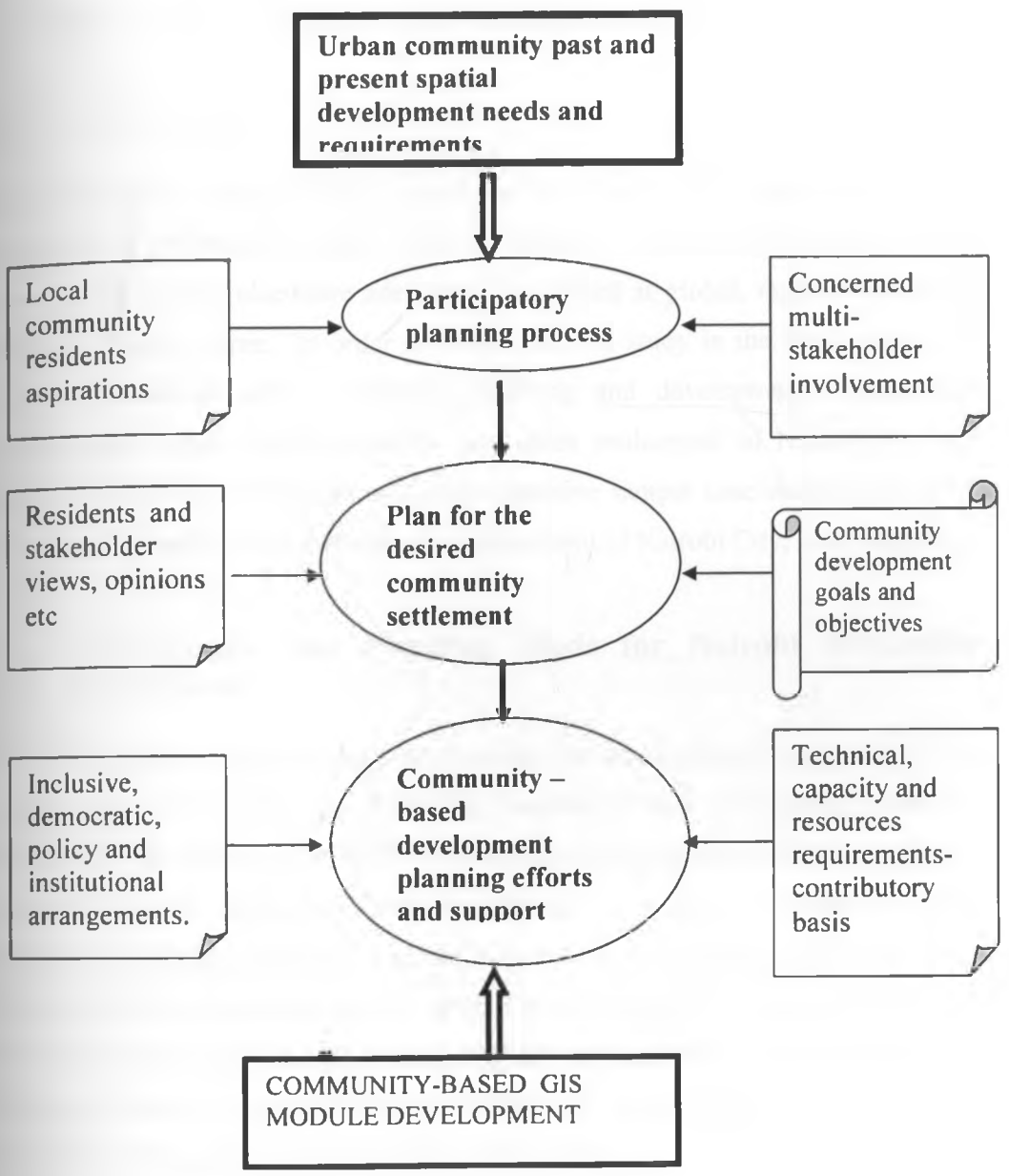
To enable the public to positively contribute to the planning debate, including their opinions and spatial/attribute information, and hence offer constructive remarks regarding proposed development plans, there is need for more interactively communication mechanism and geo-data/information presentation media. Studies and experiences indicate that pictorial data and virtual graphics (photos, satellite imageries and animated virtual graphics) are easily comprehended, understood and interpreted by the majority of lay-people (Laurini, 2001). Satellite imageries and aerial photographs (remote sensing data), GPS, GIS and the Internet now provide the mechanism and media for enhancing public participation in planning urban communities. Figure 3.3 further illustrates the basic approach, process and requirements in developing an integrated community-based planning and management GIS model.

Fig. 3.2. Public Participation Ladder



Source: Modified after Kingston (2007)

Fig.3.3. Participatory Community GIS Module Development Approach



Source: Author's Construct, (2008)

Chapter Four

THE STUDY AREA BACKGROUND AND SETTING

4.1. Introduction

The challenges currently being posed by the phenomenal urbanization trends (urbanization syndrome), spatial mapping, planning and management needs and concerns, have been elsewhere adequately elucidated at global, regional and local levels in Chapter Three. In order to further set the study in the local scene, this Chapter examines urban mapping, planning and development management requirements, needs and problems for peri-urban settlements of Nairobi. For the purposes of detailed investigations, a representative sample case study area site of Mlolongo Township, a satellite peri-urban settlement of Nairobi City, was selected.

4.2. Development and Planning Needs for Nairobi Peri-urban Settlements

Before Kenya's Independence in 1963, Nairobi City occupied only about 90 km^2 in spatial extent. After 1963, the 'Old City' boundaries were extended to cover the present City area of about 700 km^2. The new boundary limits enclosed the then agro-pastoral adjacent settlements now comprising of Langata, Waithaka, Riruta Parklands, Roysambu, Dandora, Ruaraka, Kahawa, Njiru, Embakasi (including Jomo Kenyatta Airport) and Mugumoini (Nairobi Game Park) as they are today. However the boundary changes were demarcated without any supporting and comprehensive long term strategic development plan to guide the spatial growth of the extended metropolis (Mbogua et al, 1973 and Kingoriah 1980).

Since the 1963 boundary changes, the gazetted City limits have remained much the same despite the city's astronomical demographic and spatial growth over the last few decades. The 1979, 1989 and 1999 National Census for example, estimated the population of Nairobi City at about 0.828, 1.325 and 2.137 millions respectively (Kenya Rep., 2005). Currently the population is estimated at over 3.5 million people This reflects a growth rate of about 4 % per year. At this rate the functional City

region is estimated to host a population of about 6 million by the year 2030 (Kenya Rep., 2008).

The demographic growth of the City's peri-urban settlement areas has been accompanied by the City's economic influence and spatial expansion from its former jurisdiction limits of about 700 km^2 to now encompass about 15 local councils and municipalities of the neighbouring Districts of Kiambu, Thika, Machakos and Ol-Kajiado with an estimated functional metropolitan region area of about 32,000 km^2. The spatial growth has led to rapid mushrooming of the new residential-cum-commercial satellite centers and informal settlements that now skirt the old city jurisdiction and the neighbouring urban councils without any comprehensive and coordinating physical development plan, a situation that now present City Hall and the neighbouring local authorities with numerous planning and management challenges.

4.2.1. Spatial Development Concerns for Nairobi Metropolitan

Faced with the enormous challenges as currently posed by the astronomic spatial growth and sprawl of Nairobi metro region, the Government of Kenya, through the newly formed Ministry of Nairobi Metropolitan Development, recently formulated policy measures and interventions towards addressing the spatial, infrastructural and socio-economic development crisis now facing the rapidly expanding metropolis. The strategic development initiatives are comprehensively aimed at incorporating the adjacent local municipalities and councils in the proposed Nairobi Metropolitan Region (NMR) strategy framework (Kenya Rep., 2008), including; Kiambu, Limuru, Machakos, Mavoko, Thika, Ruiru, Kajiado, Karuri, Kikuyu and Tala/Kangundo local authorities.

The NMR is initially intended to cover about 32,000 square kilometres of the immediate jurisdictional zone, but later extended to encompass the existing rural districts of Kiambu, Kajiado, Machakos, Thika, and parts of other adjacent districts comprising a spatial aerial extent of about 70,000 km^2 as shown in Figure 4.1. The main objectives of the NMR initiatives was to coordinate and harmonize the dynamic spatial growth/sprawl, infrastructural and socio-economic development through

comprehensively effective land-use planning, management and governance. The strategic framework is further aimed at optimising the region's resources utility, transportation, services delivery and effectively addressing the different and diverse needs of its fast growing population, especially the majority of low income and poor urban populace living in substandard informal settlements that comprise over 70% of the region's total population.

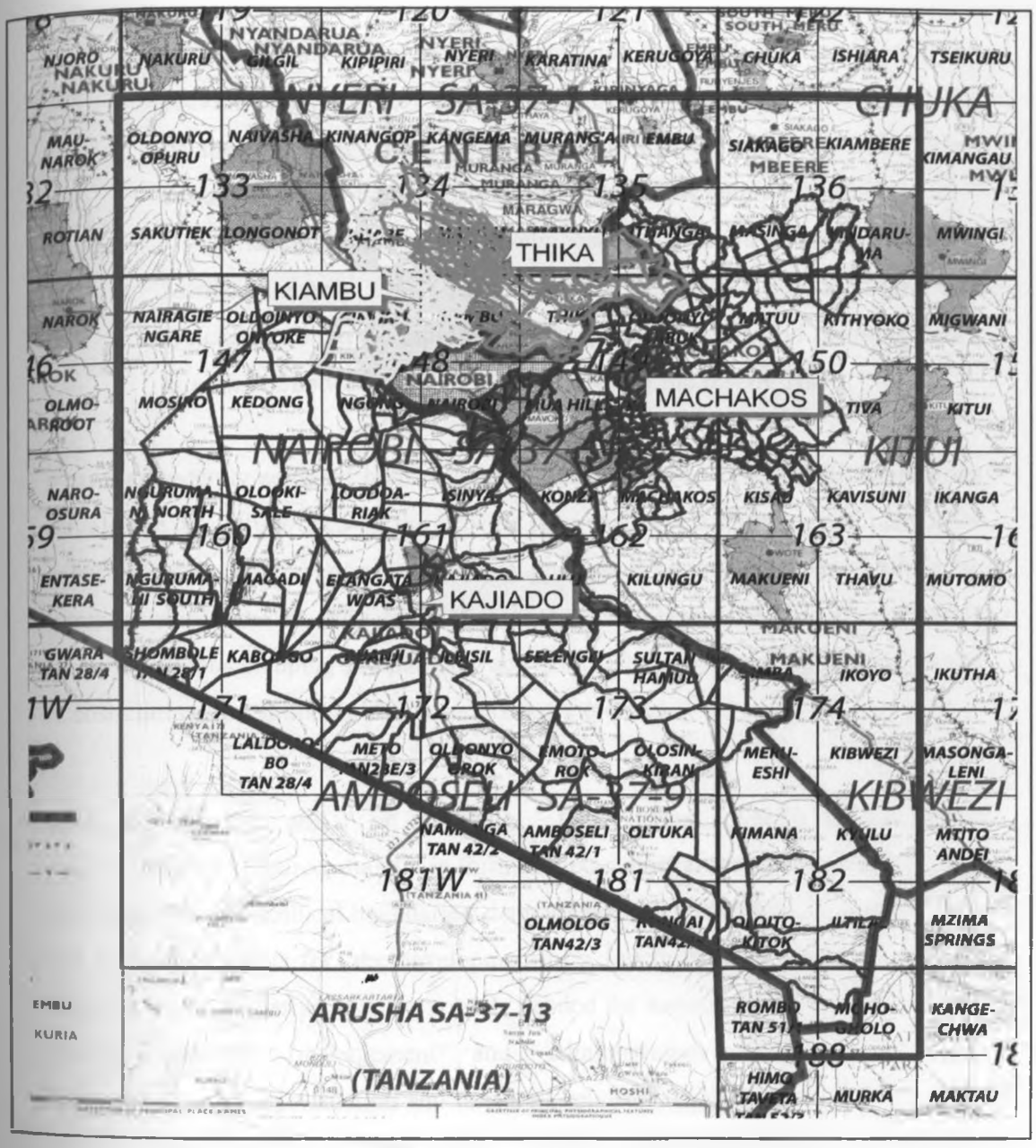
Further more, through the initiative, the Government intends to drastically reverse the current sporadic proliferation and mushrooming of informal settlements and other unplanned structural developments through efficient spatial planning and management of the newly created NMR. The on-going slum upgrading project at Kibera, which one of the largest and oldest slum in Africa, is meant to serve as a pilot case for the redevelopment and improvement of other informal settlements, found within and in the peri-urban areas of the City (Kenya Rep., 2008)

4.2.2. Need for a Comprehensive Geo- Spatial Framework for the NMR

For the new Ministry of Nairobi Metropolitan Development (MNMD) to effectively meet its stated ambitious mandate as per the proposed Vision 2030 Initiative, there is urgent need for establishment of a comprehensively functional spatial data infrastructure (SDI) framework on which the various intended development programmes can be based, in absence of which, the various policy decision implementation, and realization of the initiative will be in futility to say the least.

Given the large spatial extent and developmental complexity of the NMR, conventionally used geo-systems and planning approaches cannot efficiently meet the year-marked spatial development demands of the NMR. If well embraced, modern geo-info technologies (GITs) can offer viable and cost-effective alternatives for developing and establishing such large scale geo-spatial data / information resource base (SDI) at metro-wide) levels, as opposed to traditionally used cadastral-based techniques.

Fig. 4.1. Proposed Nairobi Metropolitan Region Districts



Scale: 1: 50,000 Topo-Map Index

LEGEND

- Proposed NMR Extent
- Thika District
- Machakos District
- Kiambu District
- Nairobi Province
- Kajiado District

Source: SOK (2006)

Depending on mapping / planning scales and financial availability, a two-staged alternative approach in establishing a modern SDI framework for NMR can be envisaged;

i. Use of digital photogrammetric mapping (relatively costly) – mainly to provide high accuracy data (at scales of between 1: 1,000 – 1: 5,000) for detailed mapping, development planning and management small urban centres and other high density development areas within NMR.

ii. Use of satellite imaging (relatively cheaper)–medium and high resolution satellite imagery data such as SPOT (2.5m), IKONOS (1.0m) and QuickBird (0.6m) to rapidly provide spatial mapping and planning data (at scales of between 1: 5,000 – 1: 10,000) for the rest of NMR.

Note that, recently acquired high resolution IKONOS and / or QuickBird imageries can also be digitally *draped* on the existing topo-cadastral data (maps and plans), for quick up-dating and revision for detail mapping and planning purposes, while the lower accuracy LandSat and / or SPOT imageries can likewise be used at metro-wide levels for various mapping and planning activities. The above can significantly serve in cost-cutting the initial field data acquisition expenses.

With improvement, and / or up-dating, the existing wealth of geo-spatial data/information resource, mainly in form of topo-cadastral maps, zone maps / plans, administrative and political boundaries, demographic and other statistical data can be can be used as inputs for the development of a functional SDI framework for the intended NMR initiative, that is currently needed for various land-use planning and zoning activities, management and administration (tenure registration, alienation/annexation, valuation and taxation), environmental management, planning and implementation of engineering works, socio-economic management, transportation and communication, among other metro development and management activities.

4.3. The Case Study of Mlolongo Settlements

Mlolongo Settlement, a satellite township of Nairobi, is a typical example of the many unplanned settlements that are rapidly and informally mushrooming at the peripheral zones of the City and its adjacent rural district jurisdictions. The settlement was therefore selected as a representative sample case study site for the purposes of detailed investigation on various planning, mapping and spatial developing needs and requirements for the City's peri-urban settlement areas. Mlolongo was selected as a suitable candidate based on the following criteria:

1. Its proximity to the City boundary, though administratively the township falls in Machakos District.
2. Its rapid spatial and demographic growth in less than a decade is unique to the study.
3. The settlement has developed without formal mapping, planning and development control guidelines, hence exhibiting a myriad of spatial management problems that are characteristic of other urban and peri-urban informal settlements.
4. Its historical development and location along a major highway (Nairobi-Mombasa Highway), and its vibrant socio-economic activities present good study variables.
5. Recent concerns and attempts by local community residents of Mlolongo to address development planning and management issues in a participatory manner are also in line with the arguments of this study.

Mlolongo Settlement also serves as a typical example illustrating the inability by the Local Authorities and the Government to effectively respond to the current urban development crisis in the country.

4.3.1. Location and Spatial Development of Mlolongo Settlement

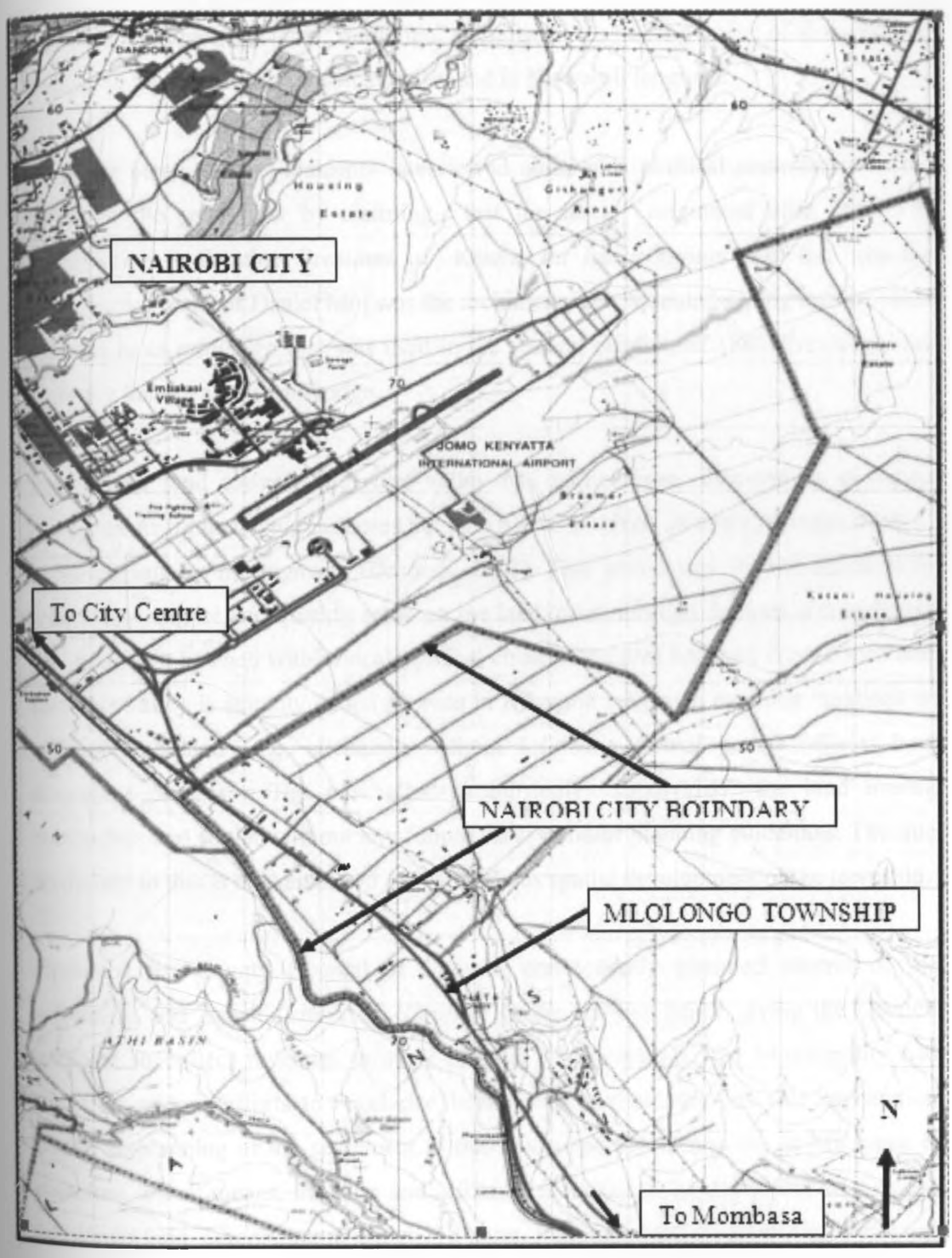
Though administratively located in Mavoko Municipality, Machakos District, Mlolongo Township can be, for the purpose of this study, be considered a typical Nairobi peri-urban settlement. It is situated on the North-Western edge of Machakos District, approximately 20km from Nairobi City Centre along the Nairobi-Mombasa Highway. It falls in Syokimau Sub-location, Katani Location, Athi River Division,

Machakos District boundary, in Eastern Province of Kenya, at the south-eastern *"armpit"* of Nairobi City boundary with Machakos as shown in Figs. 4.2 and 4.3 respectively .

Fig. 4.2. Location of Mlolongo in Machakos District

Source: After Omondi, 2003.

Fig. 4.4. Location of Mlolongo Township with Respect to Nairobi City Boundary



Scale: 1: 50, 000 (Nairobi Topo-map)

Source: Survey of Kenya, 2006

4.3.2. Origin of Mlolongo Settlement

The residents of Mlolongo gave two possible historical origin of the name of the township. Some attached the name *mlolongo* to frequent long queues of slow moving traffic witnessed in the township usually caused by heavy trucks as they slow down at the Weigh Bridge. The term "mlolongo" literally means "a long queue of slow moving things" in the both local Kikamba dialect and in Kiswahili language.

However some of the residents interviewed attached a political connotation to the name of the settlement by claiming that the name originated after 1988 in appreciation to the then President of Kenya, for freely giving them the site for settlement. President Daniel Moi was the architect of the "queuing voting system" then referred to as ***mlolongo*** that was used in the general election of 1988. Previously the area was known as Weigh Bridge.

Part of the land towards the river valley had earlier been allocated to an Asian entrepreneur for quarrying purposes but who had to be given an alternative site away to avoid damage to the highway (Omondi, 2003). This paved way for the residents to irregularly acquire and quickly settle on the land, often through dubious arrangements that that were hatched within local political circles. The area between the old road and the river valley is actually called *Ngwata* in Kikamba language, meaning "grabbed or self-acquired land", i.e, alienation without following formal and/or official land allocation process. The new allottees hurriedly "subdivided" the land among themselves and settled without any formal survey and/or planning guidelines. The true testimony to this is the haphazard and amorphous spatial development of the township.

However, the County Council of Mavoko consequently assumed control of the settlement and issued *Letters of Allotment* to the settlers, hence giving the Council mandate to collect revenues through taxation. Unfortunately, the Municipality had made no serious efforts to regularize land tenure and use through title registration and/or re-planning of the settlement to this day. Land tenure and use in Mlolongo is therefore, by all means, insecure and informal. It is also to be noted that most of the Mlolongo land, comprising of about 112 acres, including part of the township and the road reservation said to have been compulsorily acquired by the Government in 1972

was, at the time of investigation, at the centre of legal tussle between a Mrs. Humphrey and the Government (Thatiah, 2006).

The elderly lady claimed that she was inadequately compensated by the Government, and hence the whole land belonged to her. One therefore wonders; Did the official compulsory acquisition process actually take place as per the law, or was she defrauded?. If so... then the land legally belonged to her since she claimed that the Head Title was still in her custody, though she refused to physically show us the document at the time.

The majority of land owners now agreed that insecurity of tenure is currently one of their major problems. Most live under fear of eviction since they lack legal land ownership documents. The letters of allotments issued by Mavoko Council are not a guarantee to ownership. Those who have attempted to pursue official title registration independently have found it extremely difficult and expensive. So far only two land owners claimed to have acquired title deeds through private surveyors, but at a huge cost. It is not clear how the survey process was carried out since the necessary development plan approvals and cadastral maps could not be traced at the Survey of Kenya offices, though the owners claimed to have official title deeds from the Commissioner of Lands.

4.3.3. Spatial Development and Land Use Patterns of Mlolongo

Mlolongo Township has rapidly grown as a vibrant market centre in the last few years. The township has no administrative functions and is administered from Mavoko Municipality offices, Athi River Township which is located about 5 Km away from the settlement. Its rapid growth has been boosted by its unique location along the busy Nairobi-Mombasa Highway. The availability of cheap land, nearby industrial developments, the heavy trucks Weigh-bridge stop over, accessibility and proximity to Nairobi City has further propelled its demographic and economic growth as one of the City's dormitory satellite townships.

Plates 4.1, 4.2 and 4.3 show the 1978, 1998 and 2003 aerial photos for Mlolongo Township indicating the rapid spatial growth of the settlement, especially between 1998 and 2003, a period of only 5 years. In 1978 for example their was no noticeable infrastructural developments on the site, except for the heavy trucks weighbridge station. In 2003 the settlement had rapidly grown to occupy well over 200 hectares, and currently witnessing astronomic spatial and infrastructural developments (residential, commercial and industrial developments) in the last few years. Figure 4.5. above shows the current spatial extent of Mlolongo Township.

The township is characterized by an incongruent mix of residential, commercial developments, light industries and services. Since the settlement initially lacked the necessary spatial development planning and control guidelines, land use patterns are largely amorphous and haphazard. Compare the physical development pattern of Mlolongo in 2003 (Plate 4.3) with some of planned estates of Nairobi shown in Plate 4.4 where proper planning and security of tenure (title registration) proceeded infrastructural development. This implies that initial planning, the underlying land tenure and use system, to a large extent, dictate the spatial development patterns for a given urban community settlement. Plate 4.5 is a GIS image map showing the general land use and spatial development patterns of Mlolongo Township prepared from a 2003 QuickBird satellite image data as at 2006.

Plate 4.1. A 1978 Aerial Photo of Mlolongo and the Surrounding Area

Source; Survey of Kenya, (2006)

Plate 4.2. A 1998 Aerial Photo for Mlolongo Township

Source; Survey of Kenya, (2006)

Plate 4.3. A 2003 Aerial Photo for Mlolongo Township

Source; Survey of Kenya, (2006)

Plate 4.4. A 2003 Aerial-photo for EastLands Suburbs of Nairobi City

Source; Survey of Kenya, (2006)

Plate 4.5. A 2003 GIS Image Land Use Map for Mlolongo Settlement

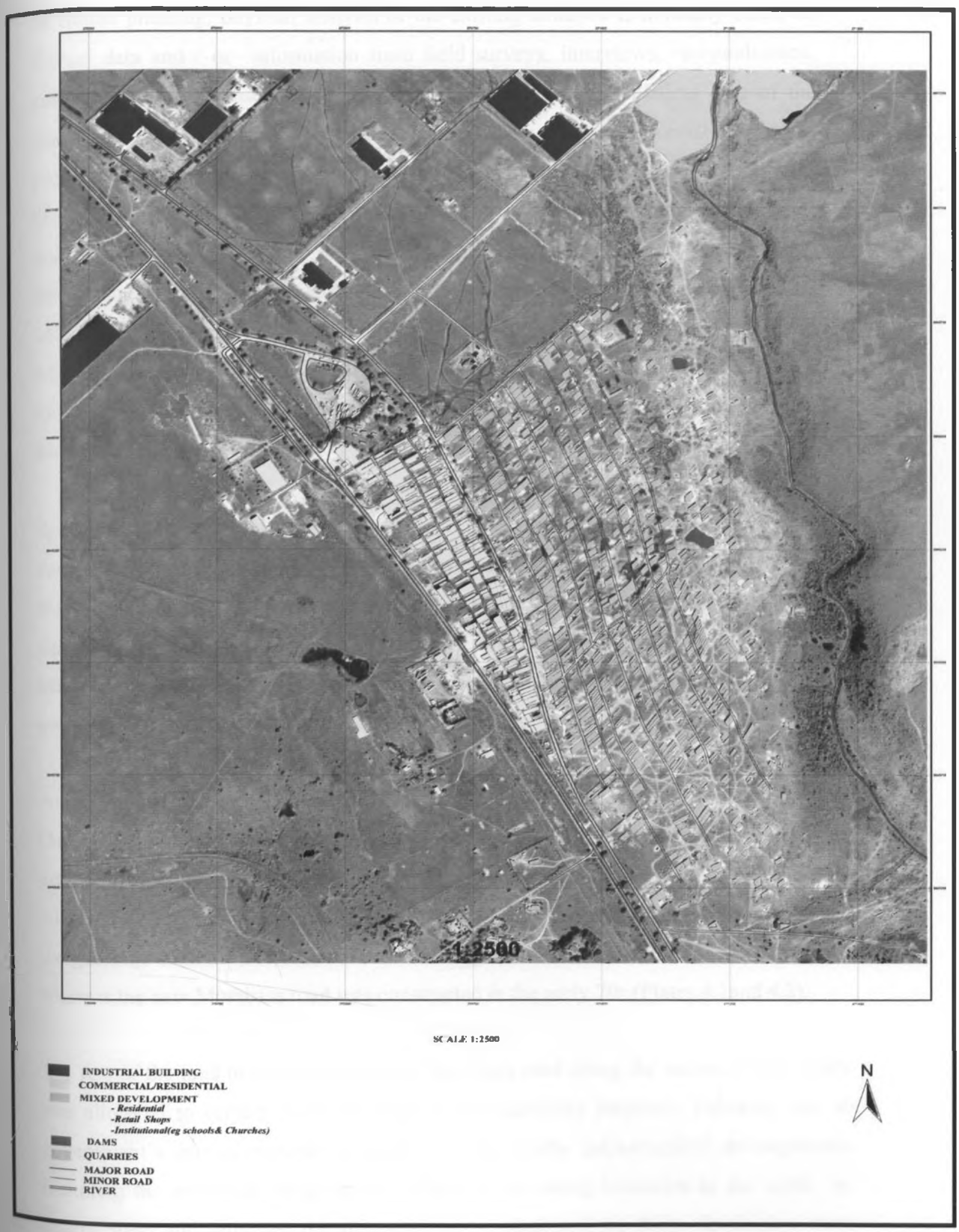


Image Source; RCMRD, (2006)

4.3.4. Physical and Socio-economic Development Dynamics and Attributes

In spatial planning, physical analysis of the existing situation is normally based on factual data and / or information from field surveys, interviews, reconnaissance, casual perceptions, observations and existing graphical and statistical data of the study area (Mugenda & Mugenda 1999). The above geo-data/ information sources provide indicators for rational and realistic assessment of both human and physical elements of growth for both the study area and its surrounding region that exert mutual influence. Therefore for the purposes of spatial analysis of Mlolongo Settlement, its past, present and future development and growth must be identified and understood in relation to its surrounding hinterlands, i.e, Mavoko Municipality in which it falls, and the City of Nairobi for which it now acts as a dormitory town for low and medium earners working in the City, especially in industries along Nairobi-Mombasa Highway.

Spatial-economic Development Dynamics

As can be seen in Plate 4.1, Mlolongo was generally vacant land, except for the heavy trucks weigh-bridge station and its workers quarters. The rest of the land at the time was mainly being used for grazing and beef cattle holding grounds for the Kenya Meat Commission (KMC) factory located at Athi River township a few kilometers away from Mlolongo Settlement area.

As mentioned above, following a presidential directive by the then Kenya President Daniel Moi in 1988, most of the people squatting along the Nairobi-Mombasa Highway near the Directorate of Civil Aviation (DCA) transmission station were relocated to the current Mlolongo township site between the old and new Mombasa Road next to the weighbridge station. Note that the old Mombasa road was constructed in the early 60s whereas the new Mombasa road was constructed in the early 70s (Plates 4.1and 4.2).

The rest of the land to the east of the old Mombasa road along the seasonal river valley was allocated to certain Asian developers for quarrying purposes. However, due to government's fear of possible destruction of the nearby infrastructural developments, including the new road, weighbridge, DCA and upcoming industries to the north by quarry blasts and activities, the allocation was revoked and the Asian developers were

offered an alternative site 15 km away to the west, Katani area. The land left by Asians, was hurriedly and irregularly acquired, developed and settled without any mapping, planning and development control guidelines, in total disregard of the insecurity of tenure associated with irregular land allocation (usually referred to as *grabbed land*, or *Ngwata in local Kikamba dialect*). Politically instigated and informal land and dealings immediately started among the local politicians, local *Wakamba* tribe people and new immigrants, mainly from Nairobi thirsty for cheap land for shelter. Consequently, informal infrastructural development took place thereafter, especially in the mid 90s to date.

The main factors that have influenced the rapid growth of Mlolongo settlement are therefore threefold;

1. Official and political – as initially triggered by uncertainty of land ownership, presidential political directive, and later involvement by the local politicians in irregular land acquisition, allocation and transaction.
2. Administrative- failure by the local authority in effecting formal land allocation, mapping, planning and development control guidelines.
3. Socio-economic – quest for cheap land for shelter and economic business activities by low income local residents and other immigrants from Nairobi.

The ever busy heavy trucks weighbridge stop-over and available employment opportunities from the nearby industries have further fueled the rapid spatial, demographic and socio-economic development of Mlologo Township as a vibrant market centre.

Physical Attributes

In terms of physical location, Mlolongo Township regionally enjoys strategic physical location as a satellite settlement of a major city, the Nairobi of City. Situated at the northern border of Machakos District, along a major highway (Nairobi-Mombasa Road – Class A1 category), next to the internationally famous Nairobi National Park, in the vicinity of Kenya main airport (Jomo Kenyatta International Airport), and adjacent to economically vibrant Athi Rive and Kitengela urban areas, the settlement cannot enjoy a better physical and economic location when compared to other peri-urban settlements of Nairobi. However, despite its

advantageous location, the township is spatially and socio-economically growing into an amorphous slum without any formal planning and the necessary development guidelines. Most essential infrastructural services, amenities and facilities for the astronomically increasing population are seriously wanting.

4.3.5. Infrastructural and Social Amenities Needs and Requirements

Mlolongo's spatial and economic growth has basically revolved around its adjacency to a major transportation system. Though the township is linked with an efficient transportation and communication system, mainly through the Nairobi-Mombasa Highway and its proximity to an international airport, Jommo Kenyatta Airport (JKA), the internal access road network within the settlement is a sorry state of affairs.

Due to lack of planning the existing accesses and / or lanes are grossly substandard, eg, the majority of them being too narrow (less than 3m in width), without formal lay out and / or pattern, and leaving no way-leave reserves for other essential infrastructural services such as drainages, sewage lines, water and electricity service lines, etc. The majority of the accesses / lanes are un-motorable and mostly littered with stagnant, filthy, environmentally and health hazard liquid and uncollected solid wastes. Note that an attempt by the District Physical Planner to prepare a structural development plan for the township in 2004 proved futile mainly due to lack of financial resources and technical capacity as can be seen in the draft provided for in Appendix II(5).

The existing housing and other essential socio amenities and facilities in Mlolongo Township are deplorable and wanting to say the least. As earlier pointed out, the poor quality of housing standards in Mlolongo is a direct indicator of lack of proper planning, development control and consequently, the level of the living standards of the majority of local community residents. For instance, the settlement is generally typified by a spontaneous and incongruent mix of congested and densely populated semi and permanent residential and commercial building units of various types, sizes (horizontal and vertical), and infrastructural composition without any logical spatial pattern (Plates 4.6 and 4.7).

Again due to initial absence of formal planning guidelines, the settlement lacks public spaces for social amenities such as, recreation, children open play grounds, education, health and places of worship, among others. Due to critical demand, most of the above amenities and social services are currently being provided within privately owned premises, in some cases even in proximity of incompatible premises such as bars and brothels that are morally common eye-sore in the township. Currently informal structures are rapidly spreading into risky and hazard-prone areas of the adjacent river valley and its steep escarpments (Plate 4.8). The rapid population increase over the last few years has also overstretched the available basic social amenities, infrastructural services, resulting into increased land use and tenure related conflicts, crime, insecurity and other social conflicts.

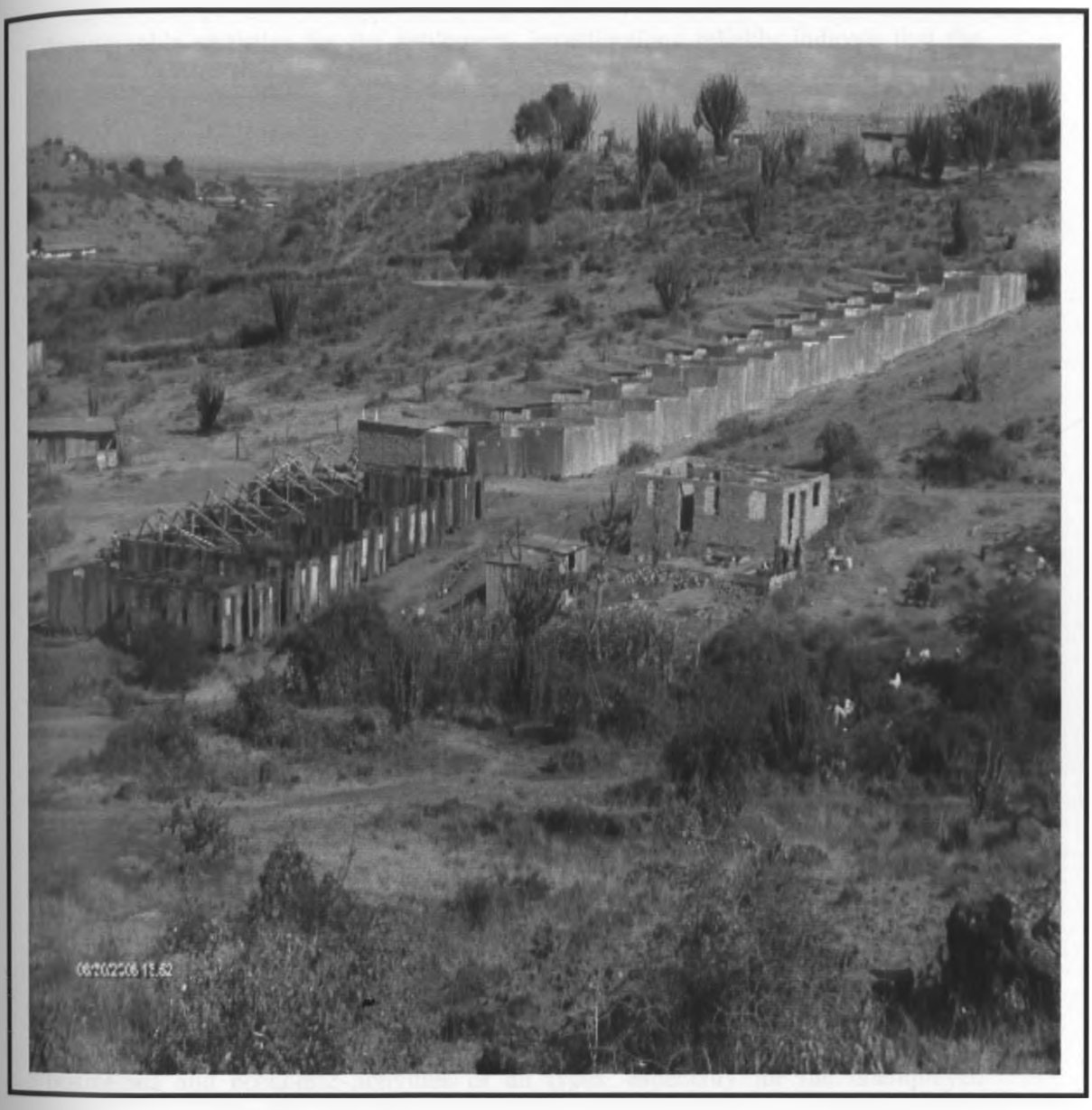
Plate 4. 6. Typical Parallelogram – shaped Building Plots Found in Mlolongo

Source: Author's Pictures, (2006)

Plate 4.7. Typical Un-serviced Infrastructural Development Mix in Mlolongo

Source: Author's Pictures, (2006)

Plate 4.8. Step-roofed Temporary Structures on Steep Escarpments



Source: Author's Pictures, (2006)

4.3.6. Demographic and Socio-economic Development Trends

Though the last national population census data of 1999 does not provide separate demographic statistics for the settlement, investigations reliably indicate that the township has witnessed high demographic growth in the last decade. Casual observations reveal that the bulk of the population comprises young families, mainly of the low income group, who have taken advantage of cheap land, low house rents and employment opportunities in the City, which is only about 15 Km away, and the many industries along the Nairobi-Mombasa Highway. Though the population is largely multi-ethnic, the dominant group is that of the *Akamba* ethnic group who were the initial allottees of the land. However, people from other areas have bought land and settled in the township.

With now over 2000 residential units (most of which are multi-storey buildings) and assuming an average family household size of about 5 people, the population of the settlement may be reasonably approximated at over 10,000 people. By projection, therefore, this population is expected to be more than double in the next 5 years given the high rate of spatial and demographic developments currently taking place within and around the Township. The heavy trucks Weigh Bridge terminal, mainly on transit to countries such as Uganda, Rwanda and Burundi also significantly contribute to the day-and-night commuter population increase to the township.

Mlolongo can be described as a hub of socio-economic activities by day and night. The mix of infrastructural development comprising of residential, commercial and industrial premises provide a conducive climate for affordable shelter, small businesses and economic activities of all types, especially for the unemployed majority of the residents and outsiders. For instance, the majority of small-scale businesses and economic activities generally found in the township include; various types of simple merchandise shops and kiosks, food businesses, hotels and bars, communication and transport related businesses, light commercial enterprises and services that are haphazardly scattered all over the township.

The majority of the local community residents interviewed during the study largely attribute attributed most of the spatial planning, infrastructural and socio-economic

development problems of the township to their exclusion in the development management and governance process by the government and the local municipally authorities. Interestingly the majority of residents. especially the local opinion leaders are now demanding to be effectively involved in the development agenda, as a forward step towards addressing the spatial development and management crisis now prevailing in the settlement. The residents and other stakeholders argued that their inclusion would provide a golden opportunity for them to realistically contribute to the improvement of the community, for example, through better spatial development planning, environmental management, security provision, and regularization of the thorny land-rights and use conflicts.

4.3.7. Environmental Implications and Concerns

Apart from environmental pollution emanating from housing and other physical infrastructure solid and liquid wastes and refuse, nearness to a busy transportation highway and heavy trucks stop-over subjects Mlolongo community to other forms of environmentally hazardous contamination and pollution, including;

iii. Noise pollution - emanating from loud engines heavy trucks at the ever-congested weighbridge station and other regular vehicular traffic on the busy highway.

iv. Semi-liquid, gaseous and dust contamination- emanating from in-organic petro-chemical engine wastes, fumes and loose dust particles from vehicular movement and other transportation activities.

The above pollutants are not only risky to environmental biodiversity, but also injurious to public health. In the same breathe therefore, there is urgent need for policy measures and interventions towards environmental and pollution control and management for Mlolongo and other similarly affected urban settlements in the country. Generally speaking, where possible the government should always put in place environmental policy measures that are aimed at reducing damage to the existing environmental ecosystem, biodiversity and socio-economic well-being of a given area in the country so as to mitigate and / or minimize such adverse impacts and threats such as now found at Mlolongo Township.

4.4. Consequences of Ignorance to Planning Guidelines

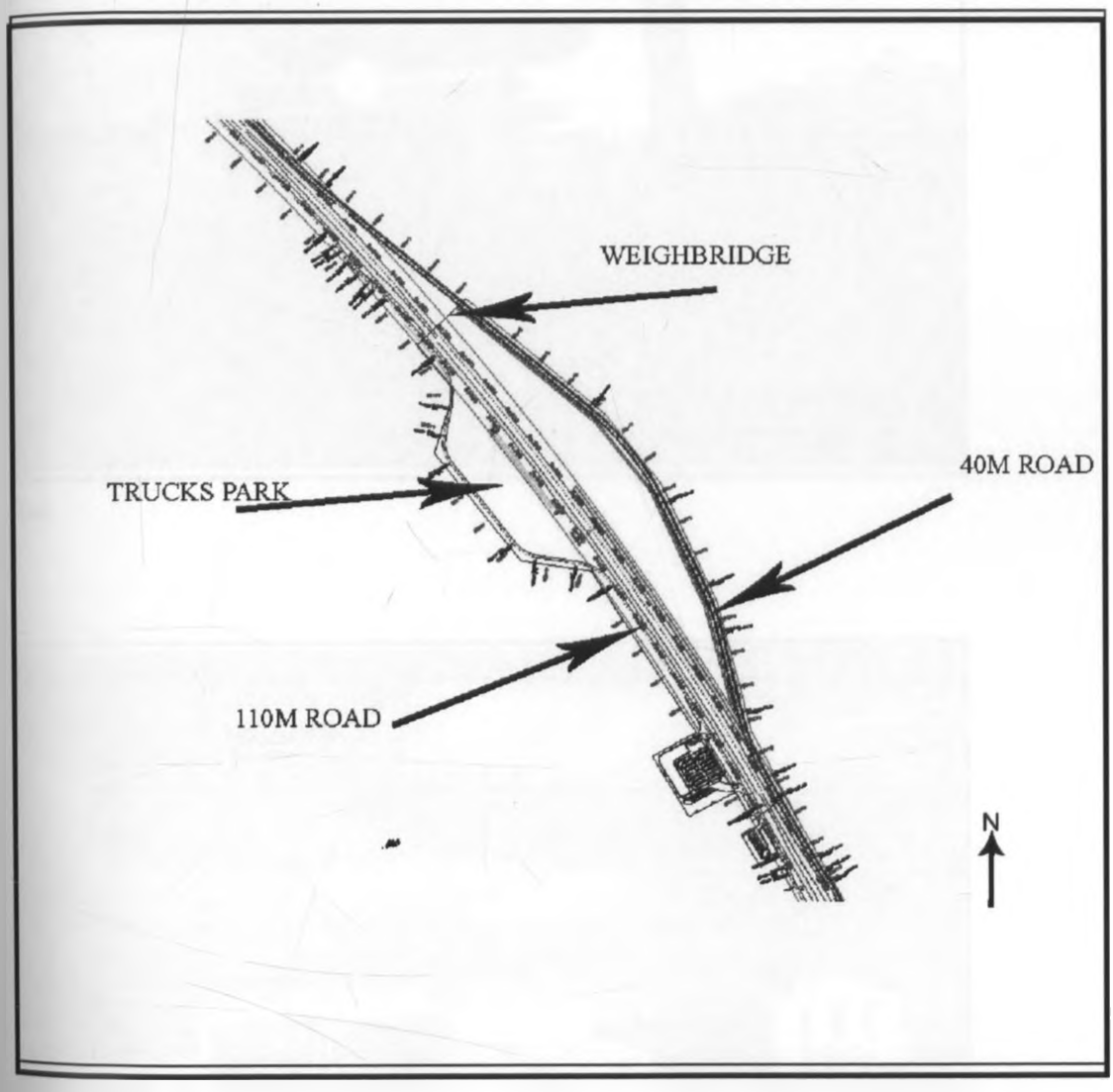
The sporadic growth and development of Mlolongo Township as unplanned / uncontrolled settlement now characteristically exemplifies the prevailing spatial mapping, planning and development management, needs problems and concerns for most peri-urban settlements of Nairobi (both within and outside the City boundary limits), including; Kibera, Mathare, Korogocho, Githurai, Muiki, Ruai and many others. The majority of these settlements (old and new) have sporadically and rapidly mushroomed in the last two decades or so, in total contravention and disregard of the existing statutory official government regulations and requirements, as proscribed in the various Acts of Parliament, including; the Survey Act, Physical Planning Act, Environmental Coordination and Management ACT, and the Local Authority Act, among others.

The bitter consequences of ignorance and /o disregard of the law were for example, realized recently through the demolition of illegal developments that had encroached into the Nairobi-Mombasa Highway road reservation in Mlolongo township (Fig. 4.4). The Ministry of Public Works lived to its earlier notice to the developers and land owners to remove all the structures illegally built on the proposed road reservation or face the bull-dozer. Plates 4.9 and 4.10 show some of the structures that were brought down after their owners failed to heed the ministerial warning. Field inspection indicated that on average, most of the affected structures encroached into the road reserve by between 3 to 5 meters.

The demolition is a clear manifestation of the consequences of public ignorance to the laid–down statutory mapping and planning guidelines and regulations. The local authorities and other stakeholders including professional planners, surveyors, architects, estate managers and developers also carry the blame for sanctioning, approving and implementing such developments in disregard of ethical and official legal requirements. For example, had the local municipality of Mavoko taken some time to carry out simple planning and ground demarcation surveys before approving any development plans, the losses, (which runs in tens of millions shillings), would have been greatly minimized if not avoided all together at Mlolongo. Currently

similar demolitions are now taking place in other parts of the City as the Government embarks on a city-wide roads expansion project, such as the Nairobi-Thika Highway, regrettably at colossal losses to the unfortunate land owners and developers.

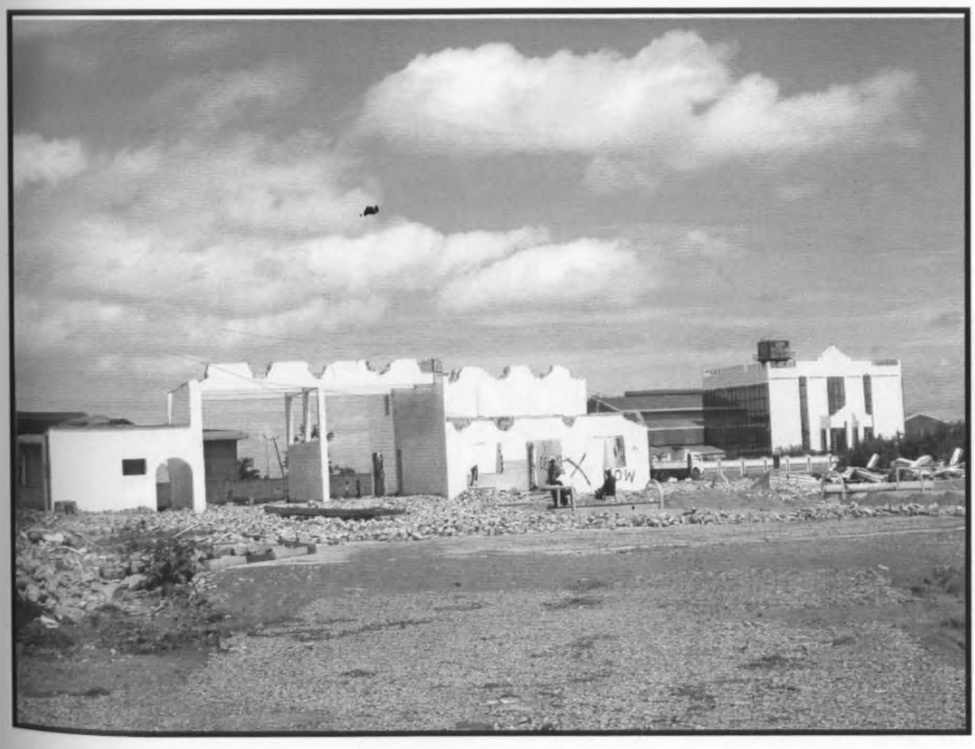
Fig.4.4. Structural Plan for Road Expansion at Mlolongo Township



Source; Ministry of Public Works, (2006)

Plate 4.9. Newly Built Petrol Station Before and After Demolition

(a)

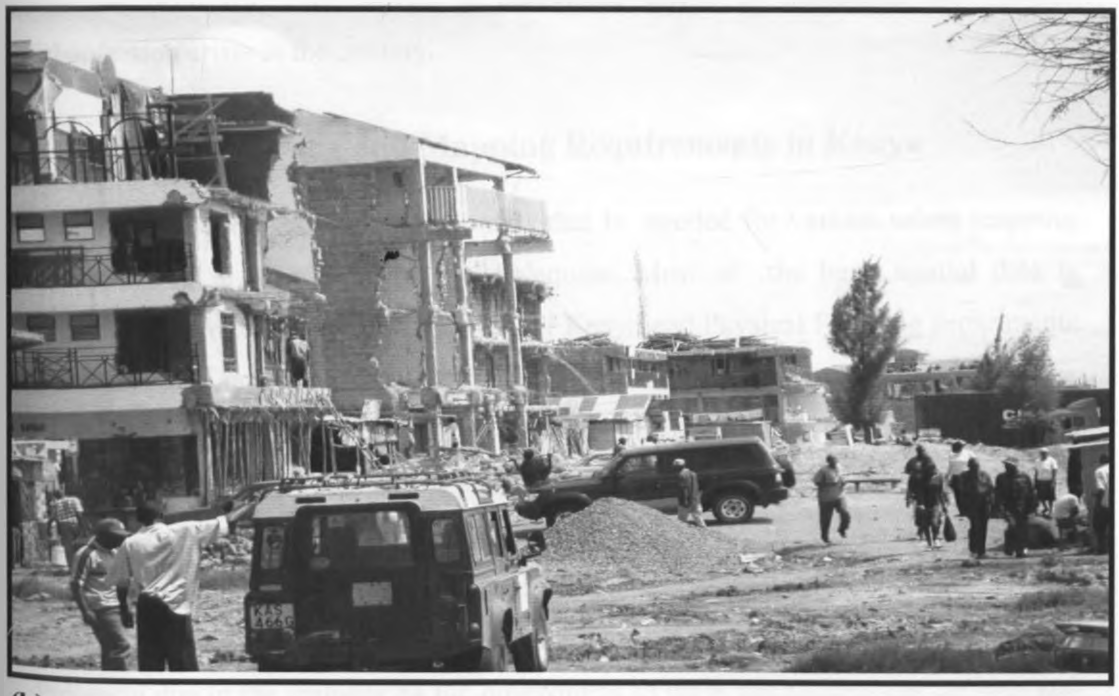


(b)

Source: Author's Pictures, (2006)

Plate 4.10 . Other Demolitions along the Road Reserve

(a)



(b)

Source: Author's Pictures, (2006)

Chapter Five

FINDINGS FROM FIELD SURVEYS AND INTERVIEWS

5.1. Introduction

As outlined in Chapter One, various methods and techniques of investigation were used during the study including; conceptual and theoretical investigations, review of related literature, field surveys and interviews. Both qualitative and quantitative techniques are used for data analysis and presentation of research findings.

This Chapter, therefore examines the current spatial planning and mapping requirements and needs in Kenya, and the rapidly expanding Nairobi metropolitan region in particular. Further, using a questionnaire interview instrument, views from a spectrum of stakeholders regarding the current urban planning, mapping, spatial development and management issues and matters of concern are solicited and analytically presented (See Tables 1.1, 1.2 and Appendix IB). The findings further helps in gauging the level of urban development planning challenges, public concern and the need for interventions in addressing and / or mitigating the current urbanization crisis in the country.

5.2. Urban Planning and Mapping Requirements in Kenya

Currently, the necessary spatial geo-data that is needed for various urban mapping and planning in Kenya is grossly inadequate. Most of the basic spatial data is variously generated by either the Survey of Kenya and Physical Planning departments (government), and private mapping and planning agencies who mainly use traditional cadastral-based (analogue techniques) for data acquisition. Primary spatial data is vital for new mapping / planning activities, amendment and updating of existing data, eg. registry index maps (RIMs), preparation of structural development plans, etc., for both urban and rural development purposes.

Presently due to the inability by the government to carry out subdivision surveys and planning of numerous new grants in various urban centres of the country, the bulk of

survey work has been left to private surveyors and planners. Therefore, the existing geo-data base, mostly in form of survey maps, development plans and other statistical records is, not only inadequate, but also lacks proper organization, custody and management where it exists.

Hence, the uncoordinated nature of the geo-data resource-base in Kenya is currently incapable of inefficiently meeting the enormous mapping and planning demands in the country today. Investigations at the Ministry of Lands, Nairobi Council City and a few district land offices, for instance revealed the following;

- That there is no coordination and / or networking in terms of data collection and sharing by the various collectors, which usually lead to unnecessary duplication of efforts.
- That geo-data/information gathering, processing, storage, management, access and dissemination to users is grossly inefficient.
- That the master RIMs for most urban areas are rarely amended or updated, some even for over 20 years, despite the availability of new cadastral field data.
- That the existing manual cataloguing and storage system, data retrieval data accessibility was a nightmare in various land records offices.
- That data insecurity, due to theft, miss-placement, tear and wear etc, are a common thing in most land record offices.
- That there were no serious attempts in improving the status-quo, eg through of creation of back-up copies, computerization and modernization of the existing geo-data base with the various public land offices.

5.2.1. Status of the Existing Mapping Geo-data Resource-base

The Department of Surveys, Ministry of Lands Survey, is the main provider of various types of spatial data for planning activities in the country. The data supplied by the Survey of Kenya (SOK) mainly include various types of cadastral maps/plans, topographic, geodetic and trigonometric data, aerial photographs, special and thematic maps and other land related statistical data. Tables 5.1, 5.2 and 5.3 indicate some of the basic maps and plans provided by the SOK for various urban,

regional and national planning and management purposes . Sadly most of the data is currently of limited planning use where it exists.

Other spatial data such as land adjudication maps, local development plans and statistical records are found in various provincial and district land department offices. Unfortunately this data resources base is not only inadequate, but mostly out-of-date and unmanaged where it exists, and hence cannot effectively serve any meaningful planning and management purposes.

Investigations at Nairobi City Hall, for instance, revealed that various departments dealing with spatial and socio-economic planning, development and management issues are in dire need for up-date and reliable mapping geo-data/information. Tables 5.4 and 5.5 indicate the level and status of the existing geo-data base in City Hall as at the time of investigation, June 200. Strange enough, the old colonial 1948 structural development plan for the City still hanged on the walls of most offices (See Appendix II).

Table 5.1. Topo-Maps; At Varying Contours Vertical Intervals

Series	Scale	Coverage	Availability	Planning uses
Y731	1:50,000	Coast, South, Central and Western Kenya	Limited old editions	Limited use due to age
SK61	1:50,000	Most urban and other potential areas	Limited old and new editions for different areas	Very useful for urban and regional activities
Y633	1:100,000	Northern and N. Eastern Kenya	Available	Regional planning not much used
Y503	1:250,000	Whole of Kenya	Available	National administrative planning
	1:1,000,000	Whole of Kenya	Available	Limited regional and national planning uses
SK80	1:2,500,000	Kenya, Tanzania and Uganda	Limited	Limited national planning uses

Source: SOK, (2006)

Table 5.2. Township Maps and Plans

Series	Scales	Description and Coverage	Availability	Planning Uses
SK13	1:2,500	Topo-Cadastral for old Nairobi City Centre	Limited – not in production	Very useful for detail urban planning if production resumed
SK59	1:5,000	Annotated Photographic Mosaic for old Nairobi City	Limited – not in production	Very useful for detail urban planning if production resumed
SK88	1:10,000	Topo-cadastral for some parts of Nairobi City	Limited; slowed or halted production	Very useful for detail urban planning if production resumed

Source: SOK (2006)

Table 5.3. Topo-Cadastral Maps and Plans

Series	Scales	Description and coverage	Availability	Planning Uses
SK62	1:1,000 & 1:2,500	Most Nairobi City Registration Blocks	Limited; updates and amends slow, old, poorly maintained	Useful for detail urban planning activities
SK64	1:2.500	Mombasa Registration Blocks	Limited; updates and amends slow, old, poorly maintained	Useful for detail urban planning activities
SK49	1:50.000	Registry Index Maps indicate Registration Blocks in most urban areas	Limited; updates and amends slow, old, poorly maintained	Useful base-maps for urban planning
SK43	1:250,000	Special Sheets sowing cadastral details at national level	Limited	Limited use at regional and national levels

Source: SOK, (2006)

Table. 5.4. Status of the Existing Geo-data Base in City Hall

Map/Plan Name	Source/Type/ Series	Scale	Coverage	Availability/ Status
Nairobi and District	SOK/SK13	1:2,500	City Centre and few old estates	Limited old copies
Nairobi and District	SOK/SK14	1:5000	City Centre and few old estates	Limited old copies
City of Nairobi (Topo-Cadastral)	SOK/SK88	1:10,000	City Centre and few old estates	Limited copies 1976 Edi. Out of Production
Constituencies Nairobi Map	SK 52A	1:50,000	Entire Nairobi	Available-2002 Edi.
Nairobi: Topo-Maps	SOK /10 Shts:148 & 149	1:50,000	Nairobi and Environs	Available at SOK 1996 SPOT Image revised.
Nairobi Zoning Map	NCC / TH	1:33,330	Entire Nairobi	Limited copies-1948; and 1975 amendments
Nairobi Zoning Map	NCC /TH	1:50,000	Entire Nairobi	Limited copies of above 1975 amendments
Structural Plans	NCC/TH	Various	Few Blocks	Limited old copies
Valuation Maps	NCC/TH	Various	Few Blocks	Limited old copies
Registry Index Maps	SOK/SK84	1:1000 1:2,500	Few Blocks	Limited old copies
Nairobi City Centre	SOK/SK66	1:5,000	City Centre	Limited old copies
Nairobi and Environs	SOK/SK20 SOK/SK55	1:25,000 1:100,000	Nairobi and Environs	Limited old copies
City of Nairobi	SOK/SK88 SOK/SK48	1:10,000 1:20,000	City Centre and few Blocks	Limited old copies
Nairobi Cadastral Maps	SOK/SK7	1:10,000	Few Blocks	Limited old copies
Cadastral Survey Maps	Various Sources	1:1,000 others	Various L.R. Blocks	Several copies mainly in Survey Section

SOK/SK=Survey of Kenya / Map Serial No: NCC=Nairobi City Council: TH=Thematic map: L.R. = Land Registry Block: SPOT Im. = SPOT Satellite Image overlay used to revise SOK/10

Source: Nairobi City Council (2006)

Table. 5. 5. Level of Geo-data Needs by Various City Departments

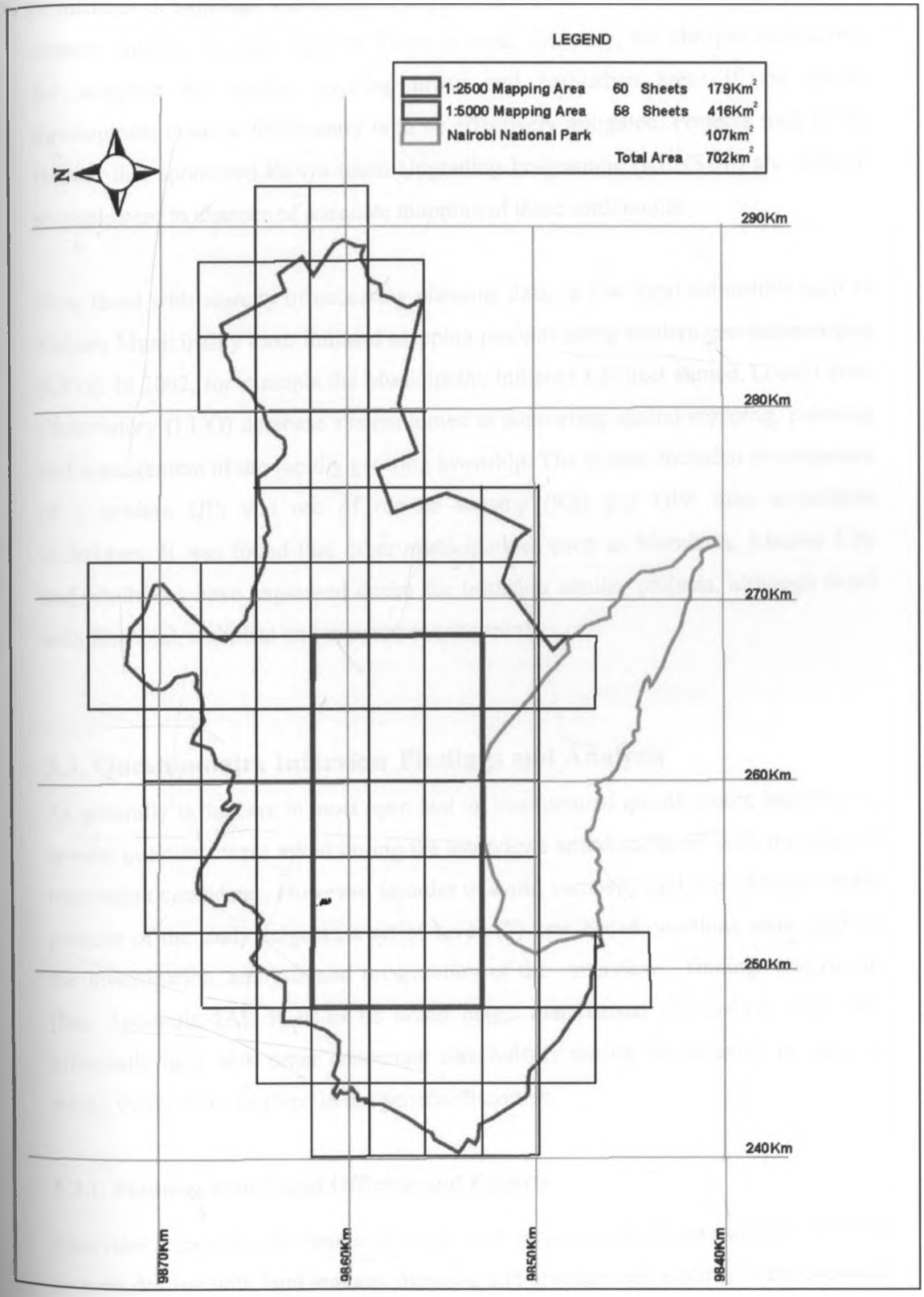
Department / Section	Data type needed	Main use	Demand Level	Availability
City Planning	Comprehensive and uptodate land use maps at various scales	Various spatial development planning activities	Very high	Highly inadequate
Land Valuation	Uptodate cadastral map at City Blocks levels	User classification, valuation for tax assessment	Very high	Highly inadequate
Rates	Uptodate cadastral maps at City Blocks levels	Preparation of taxation records	Very high	Highly inadequate
City Engineer	Comprehensive and uptodate land use topo-cadastral maps/plans at various scales	Preparation of structural plans for various engineering projects	Very high	Highly inadequate
Water & Sewage	Comprehensive and uptodate land use topo-cadastral maps/plans at various scales	Preparation of structural plans for water supply and sewage services	Very high	Highly inadequate
Environment	Comprehensive and uptodate land use topo-cadastral maps	Preparation of zone maps for various environmental management activities	High	Inadequate

Source: Nairobi City council (2006)

5.2.2. Recent Mapping / Planning Initiatives by Various Local Authorities

Given the level of the current planning data inadequacies, financial and technical capacity constraints, the country heavily relies on external donor support for most of its large-scale mapping projects. In 2003 for example, a Japan International Cooperation Agency (JICA) sponsored aerial mapping project for Nairobi City was undertaken and completed in November 2005. The project was aimed at establishing a comprehensive spatial data framework for the City. The mapping provided topographic maps at 1:2500 scales for the City Center and 1:5000 for the rest of the municipality (Fig. 5.1). Unfortunately, most of the adjacent peri-urban areas were not covered in the mapping project. A similar project (by JICA) was underway for the city of Mombasa at the time of the study. Hopefully the rapidly growing peri-urban interlands of the Island will be included in the mapping project.

Fig. 5.1. Aerial-photo Mapping Coverage of Nairobi by JICA Project



Source; JICA Report, (2005)

Photogrammetric mapping projects of such magnitude and scale runs into hundreds of millions of shillings, a cost that is beyond the reach of local municipalities in the country without external support. There is need, therefore, for cheaper alternatives for mapping the rapidly growing urban and peri-urban areas if the spatial development crisis in the country is to be effectively mitigated. Projects such as the Habitat that sponsored Kenya Slum Upgrading Programme (KENSUP) are difficult to implement in absence of adequate mapping of these settlements.

Now faced with scarcity of necessary planning data, a few local authorities such as Nakuru Municipality have initiated mapping projects using modern geo-technologies (GITs). In 2002, for example the Municipality initiated a project named, Local Urban Observatory (LUO) database system aimed at supporting spatial mapping, planning and management of the rapidly growing township. The system included development of a modern GIS and use of remote sensing (RS) and GPS data acquisition techniques. It was found that other municipalities such as Mombasa, Kisumu City and Machakos have expressed desire for initiating similar projects, although faced with financial, technical and manpower constraints.

5.3. Questionnaire Interview Findings and Analysis

As generally is the case in most open and /or unstructured questionnaire instruments, several questions were asked during the interviews and discursions with the relevant respondent candidates. However, in order to avoid verbosity and loss of focus on the purpose of the study subject , a set of seven (7) key broad questions were used for the investigation, analysis and presentation of the interview findings and results (See Appendix IA). It is to be noted here that, casual discussions were also informally held with other concerned stakeholders during the research process, of which views were factored in the general discourse.

5.3.1. Findings from Land Officials and Experts

Interview responses and results findings from various land officials and professional experts dealing with land matters, planning and management matters were solicited,

discussed and analytically presented using simple frequency as provided for in Tables 5.6 to 5.11, based on field investigations and interviews carried out in 2006.

Table 5.6. Regarding Challenges posed by Current Urbanization

Crisis Level	No. Respondents	(%) Response
Critical	24	80
Not critical	6	20
Total	**30**	**100**

From the above table, 80 % of the respondents admitted that the urbanization syndrome challenge is critical and needed urgent interventions if sustainable urban development is to be realized. Twenty percent of respondents argued that the challenge was less urgent and can easily be managed if the relevant authorities and other concerned stakeholders were committed in addressing the problem. The respondents regretted that, although the government and majority of the local authorities were aware of the dangers posed by the current urbanization trends, there exists no sound policy, institutional frameworks in place and/or technical preparedness to address the challenge.

Most respondents agreed that land management and administration problems such as irregular land alienation, poor land use planning and zoning, development control, valuation and taxation, land related disputes and conflicts were some of the main consequences/challenge of the urbanization. The situation is even worse in peri-urban and small market centres where spatial developments are rapidly taking place without any meaningful attempts to harmonize and/or regularize land tenure and use systems in these areas, hence the rampant land related and socio-economic conflicts currently found in most urban and peri-urban settlements.

In reference to Nairobi, the city has already outgrown its spatial limits and, yet no comprehensive strategic spatial development planning policy framework for the City and its mushrooming satellite towns had been put in place. According to the Director of City Planning, it is technically difficult to plan, control, monitor or assess the rapid

spatial developments in peri-urban areas of the City mainly due to inadequate technical capacity and resources.

Table 5.7. Regarding Planning data needs and Requirements

Data Needs	No. Respondents	(%) Response
Critical	25	83
Not critical	5	17
Total	**30**	**100**

It can be seen that 83% of the respondents agreed that planning data needs are critical. Most respondent agreed that cadastral-based geo-data acquisition techniques were slow and expensive, and hence grossly inadequate in meeting planning data demands. Some surveyors, however have slowly started using GPS for field mapping and computer plotting, though this digital data format is yet to be officially recognized and acceptable by the Director of Surveys.

The existing geo-data such as maps, plans and attributes are not only out-dated, but also limited in terms of; thematic contents, spatial coverage, appropriate mapping scales, compatibility, standards and formats. Another concern by the respondents is that, there exists no mechanism for data networking and sharing, hence planners and development managers are either forced to collect their own data or purchase from others, a situation that leads to duplication of data collection efforts.

In City Hall, data processing procedures such as computations, analysis, recording, map/plans compilation drafting, production and reproduction are done using tedious and time consuming manual techniques. Other problems expressed by various respondents include poor data/information storage and handling, hence making data/information accessibility, retrieval, and dissemination a nightmare. Due to poor storage and handling, data insecurity due to tear and wear, theft and loss is common in most government and council land offices.

Respondents expressed the urgent need to address the various issues raised through the use of cost-effective data acquisition techniques, better geo-information management, updating data and techniques, improved storage, institutional networking and data sharing, and the development of efficient metadata (cataloguing) systems for easy accessibility and dissemination. Respondents further suggested the urgent need for the following measures that would help in meeting the current demands in planning and data management:

- Rapid and comprehensive acquisition of reliable and up to date geo-data;
- Adoption of cost-effective techniques of geo-data acquisition now afforded by modern geo-technologies as opposed to the slow and expensive traditional techniques;
- Improvement in geo-information management through computerization, automation and development of modern GIS modules;
- Inter-departmental networking to facilitate efficient data/information accessibility, retrieval, and dissemination for both internal and external uses;
- Capacity building through recruitment and/or retraining of technical staff on modern digital mapping and planning techniques;
- Increased budgetary allocation in mapping and planning activities among other measures.

Table 5.8. Regarding Land Use Planning and Management Process

Efficiency Level	No. Respondents	(%) Response
Efficient	3	10
Inefficient	27	90
Total	**30**	**100**

Ninety percent (90%) of the respondents said that the current planning and management process in Kenya was very inefficient. Majority of them attributed the inefficiency of the process to the weaknesses of the existing policy, institutional and technical paradigms, that are not only cumbersome and procedurally complex, but also slow and expensive. For example there does not exists a comprehensive planning and management policy guidelines for the City of Nairobi to guide its

current rapid spatial growth. Most structural development plans, zonal development plans and part development plans are prepared in piece-meal and on *ad–hoc* basis, usually on demand, and at times, out of crisis, and hence cannot comprehensively meet the current urban development planning demands. Majority of respondents regretted that there seems to be no serious policy decisions in place for addressing the spatial development crisis posed by the rapid urbanization trends and land use related conflicts in the country.

Land use planning, management and administration functions such as, development zoning and control, subdivision, valuation and taxation, land registration, etc, are grossly inefficient in the absence effective spatial planning and management system. Most respondents identified the following as some of the main weaknesses of the current spatial planning and management system;

i. Lack of comprehensive policy and institutional planning and management frameworks.
ii. Inadequate geo-spatial data/information resource base
iii. Bureaucratic, cumbersome and complex procedures, e.g. lengthy planning approval processes and requirements.
iv. Inadequate and/or incompetent personnel, e.g. lack of trained physical planners, surveyors and draftsmen.
v. Lack of modern tools and equipments, e.g. use of outdated manual tools and equipments.
vi. Administrative and political patronage and interference, e.g. by politicians, external agents and senior officers.
vii. Non-involvement and/or lack of participation by the affected community/ residents.
viii. Land ownership problems, e.g. insecurity of land tenure and use in most urban and peri-urban settlements.

Table 5.9. Regarding Local Use of Modern GITs

Use of modern GITs	No. Respondents	(%) Response
Effectively used GITs (RS, GPS, GIS)	9	30
Not used effectively but aware of GITs potential	15	50
Not aware of GITs potential	6	20
Total	**30**	**100**

The low level (30%) of use of modern GITs by planners, surveyors and other land experts implies that the potential of the geo-systems is yet to be adequately exploited for various spatial planning and management activities in Kenya. Though there are currently several institutions and agencies dealing with modern GITs for data acquisition, products and services provision, 20 % of the respondents were not even aware of their potential use. Only 30 % of those interviewed have actually used RS, GPS, and GPS digital data in their work. Fifty (50%) had partially used or were aware of their potential use and applications. Majority of them were surveyors and planners. In fact most of the surveyors were found to have used the hand – held GPS set for field data collection. Only one respondent (a surveyor) who had developed a fully functional a modern GIS in his firm. The reasons given by most respondents for the low level of use of modern GITs include;

i. Lack of knowledge and training in RS, GPS, GIS and computer technologies,
ii. Lack of enlightenment on their potential use and applications in mapping and planning,
iii. Lack of necessary resources – eg financial and technical capacity,

Though surveyors and physical planners are currently the majority users of modern GITs, most claimed that adequate training was necessary for one to fully exploit the potential of the geo-technologies.

On the importance of harnessing the modern technologies in mapping, land use planning and management in the country, most government official and land experts were affirmative on the following;

i. Review and or amendments of the Survey and Planning Acts to accommodate GITs geo-data sources use and applications.

ii. Revision of the Survey Manual by relaxing the survey standards, procedures and requirements – e.g. the high cadastral mapping accuracy requirements of about +/- 0.01m (1cm) for mapping scales of between 1:1000 -1: 10,000 in urban areas need to be relaxed to about +/- 0.1m - 0.5m in some cases such as peri-urban areas.

iii. Establishment of GISs modules in various public land departments and agencies,

iv. Awareness creation and enlighten to potential users and consumers, such as government and local authority departments, private practitioners, professionals, researchers and academicians on the potential of modern GITs geo-data/information products, uses and applications,

v. Expansion in training and retraining on RS, GPS, GIS and computer related disciplines. Table 5.5 shows the approximate level of personnel training output by various institutions in the country in 2006. More than three times the output (and deployment) of qualified technical personnel is required if the current mapping and planning work backlog pending in various urban and rural areas of the country is to be effectively disposed off (Oduol, 2006).

Table 5.10. Training Levels and Output Capacity by Local Institutions

Institution	Course offered	Training Level	Approx. Yearly output	Deployment
Nairobi University	Survey – YES Planning- YES	Und. Graduate Graduate (M.A)	20 10	70 % - public 30% - Private
KISM	Survey – YES Planning - NO	Diploma	30 - 40	10 % - Public 90 % - Others
Kenya Poly.	Survey- YES Planning- NO	Diploma	30	10 % - Public 90 % - Others
Regional Centre	Survey – YES Planning - NO	Diploma	20	Not available
JKUAT	Survey	Graduate	30	Not available

Table 5.11. Need for Community Involvement

Need Level	No. Respondents	(%) Response
Urgent	27	90
Necessary but not urgent	3	10
Total	**30**	**100**

Ninety percent (90 %) of the respondents stressed the need for more involvement of community/residents in development planning and management process. Most argued it would effectively motivate the residents not only to cooperate and support, but also to make them feel part and parcel of the process. Involvement of the community and other stakeholders would further give them the opportunity to willingly contribute to the process in various ways, including; financial, material and labour, information and decision making. Respondents reiterated that inclusive community–based planning approach would also serve to demystify the seemingly exclusive, bureaucratic and technically complex spatial mapping, planning and management processes.

The few, about 10%, who argued that community involvement is not urgent, claimed that technical aspects such as, surveying/mapping, plans preparation and title registration processes were too technical and hence not amenable for mass participation, and therefore community/residents would have limited role in the processes. However, a common feeling among them was the need for their enlightenment, education and research on the best mechanism for effectively engaging the community/residents and other stakeholders at the grass root level.

5.3.2. Findings from Local Residents and Leaders of Mlolongo

As earlier indicated (Table 2.2), sixty (60) local residents and leaders of Mlolongo Township were interviewed on various development planning and management issues of concerns, problems, needs and requirements. Based on field investigations and interviews carried out in 2006 , their responses and views were analytically presented and discussed as provided for in Tables 5.12 to 5.15.

Table 5.12. Regarding Planning and Management Problems and Needs

Level of Problems and needs	No. Respondents	(%)Response
Acute	56	93
Not acute	4	7
Total	**60**	**100**

Most of the residents, 93%, claimed that infrastructural services such as drainage and sewage system, access roads, lack of open play grounds, education, health facilities and other utilities and amenities are acute problems in the settlement. They attributed most of the problems to lack of proper planning and development control by the local municipality. The population is rapidly increasing, leading to overstretching of the available basic social amenities and infrastructural services. The settlement is for low income community as was found from monthly rents levels at the time that ranged from between Ksh. 2000 to Ksh. 3000, depending on house units sizes and structural types (temporary or permanent).

Other socio-economic problems experienced by the residents include;

i. Undesirable socio-economic developments such as bars and kiosks businesses,
ii. Escalation of insecurity and crime,
iii. Environmental degradation and pollution due to poor solid and liquid waste disposal,
iv. Congestion and poor housing standards,
v. Land related conflicts, especially due to the insecurity of land tenure and use among others.

Most of the above problems are largely attributed to the failure by the local authority in rendering essential services, lack of planning guidance, enforcing development and administrative regulations, despite the municipality collecting taxes from the local residents. On the other hand, the District Planning Officer and Mavoko Municipal Officers interviewed complained about financial constraints, lack of planning base maps and personnel and technical capacity in addressing the problems. The Clerk to Mavoko Municipality however said that plans were under

way for the re-planning of the settlement, land tenure regularization and improvement of services delivery to the community.

Table 5.13. Public Awareness on Technical Planning Processes

Awareness Level	No. Respondents	Response
Generally aware	5	33
Generally not aware	10	67
Total	**15**	**100**

Lack of awareness by the majority of land owners on the technical and official planning and management processes also contribute to poor spatial development of Mlolongo settlement. Views of the fifteen land owners interviewed were sought on the issue. Only about 33% of the respondents were generally aware of the various surveying, planning and land registration processes. When asked why they did not follow or adhere to official when developing their property, some complained that the processes and requirements were technically too involving and costly. Others were just ignorant claiming that other developers had also taken the risks [One wonders why the local authority gives approval to such developments].

Some of the 67% argued that the area was part of rural Machakos District and hence not subject to official local authority development rules and regulations. Others blamed the local authority for not playing its role in educating the people on the same and/or taking charge of the planning and development processes right from the initial stages. They further claimed that the plots were speedily and irregularly allocated (grabbed land or *ngwata* in local Kamba language), hence they had no time to pursue official development processes mainly due to fear of being repossessed of their grab. Most wish they had adhered to the laid down planning requirements, since they can now see the consequences of their ignorance. They said that they were ready to cooperate and support the re-planning and tenure and use regularization initiatives proposed by the Mavoko Municipality.

Table 5.14. Security of Land Tenure and Use

Needs Level	No. Respondents	(%)Response
Acute	58	97
Not acute	2	3
Total	**60**	**00**

A total of 97% of the respondents said that improvement of security through regularization of land ownership and use are critical in the settlement. Most land owners complained that their efforts to have Mavoko County Council regularize land ownership and issue them with legal title deeds has been an endless struggle over the years. They claimed that the letters of allotments issued by the Council were not only insecure guarantee to ownership, but also discourage genuine development and property transactions in the area. Those who have independently attempted to pursue registration of their property had found it extremely difficult mainly due to the bureaucratic procedures and requirements. The two cases who have managed to get their title deeds claim that they spent over Ksh. 300,000 to get their titles through private surveyors, and with a lot of difficulties. This amount is way beyond affordability by the majority of land owners.

The local residents and leaders have now formed a committee known as Mlolongo Development Committee (MDC), that is mandated with the responsibility of fostering a common front where all land owners can collectively contribute money and pay for the tenure regularization and re-planning of the settlement. This is to be done in collaboration with the Machakos District Physical Planning Office and Mavoko Municipal Council. Some have even agreed to demolish parts of their structures that would hinder re-planning process, such as overhanging roof canopies and temporary structures to allow for better access roads, laying of water and sewer lines and other infrastructural utilities.

Table 5.15. Responses on Community Involvement in Planning and Management

Willingness Level	No. Respondents	(%) Response
Willing	60	100
Not willing	0	0
Total	**60**	**100**

All the 60 respondents (100%) agreed that they would like to be actively involved in various development planning and management activities of their community whenever they were called upon. In fact, majority of them attributed most of development problems in Mlolongo to their exclusion in the process by the government and the local authority. They, for instance argued that relevant information required in the planning process, such as land ownership, disputes, land dealings and transactions, place names, location of cultural and burial sites was in their domain. It is to be noted that this data/information is vital, especially at the initial stages of decision making, to the plan-preparation and final plan-implementation stage.

The local leaders further argued that, though not conversant with technical processes, they were able to positively participate in decision making regarding various matters such as land conflicts resolution and/or mitigation, needs and siting of public amenities and facilities. The opinion leaders also claimed that, since they were "the people on the ground" they stood a better chance of convincing the residents on certain important development decisions if they were involved from the word go. They complained that it was unfortunate they were only informed after certain decisions had been made by the concerned authorities, though the residents bore the brunt of the "top-down official" decisions. People therefore tended to withhold support for such development decisions since they felt left-out in the initial process. Respondents indicated the need for public sensitization and education on the importance and implications of proposed projects before implementation, since the projects often involved land while land was an "emotive and sensitive issue".

5.4. Post Research Assessment on the Current Situation

A post research assessment in June and July, 2008, (almost five years since the research was started) indicated that little has been done by relevant planning authorities and stakeholders in addressing the planning and management crisis, especially in the rapidly growing settlements. For example, visits to various government departments and land offices, including Departments of Surveys and Physical Planning of the Ministry of Lands, Nairobi City Hall, Machakos District Survey and Physical Planning Offices and Mavoko Municipality land offices, revealed enormous surveying/mapping, planning, land management and administrative work-backlogs that continue to mount.

In some cases, poor land use planning and management policies, institutional and administrative inefficiencies are to blame for most of the problems. A case in point is Nairobi City Hall, which has failed to effectively make use of the 2005 JICA digital mapping data and GIS data-base despite the colossal amount of money used for the project. Needless to say, the JICA mapping had offered City Hall a golden opportunity to roll-out a new comprehensive structural development plan for the entire City and its environs, but regrettably, the spatial data/information resource is now over 6 years old (since field data collection), and rapidly getting out-of-date to serve any meaningful spatial development planning purposes and needs of the City and its astronomically sprawling environs.

Impromptu discussions held with land officers at the Director of Surveys and Physical Planning Department, Ministry of Lands, for example majority regrettably indicated that the persistent government's laxity in amending the restrictive Survey and Physical Planning Acts, and continued use of procedurally expensive and slow conventional cadastral-based mapping and planning processes, may remain in use for a long time to come unless drastic actions are urgently taken. Majority of the officers, especially those conversant with modern GITs (RS, GIS and GPS), agreed that official (statutory) acceptance, adoption and use of the digital geo-systems is the only viable panacea and intervention in addressing and/or mitigating the spatial development crisis in the country.

Some of the officers lamented that it would be difficult, if not impossible and/or unthinkable, for one to imagine undertaking mapping and/or planning of all urban centres, peri-urban settlements of medium and large towns and cities, and rural markets in the country using conventional ground methods. Therefore, given the rapid urbanization trends, it is unfortunate that informal settlements, and other unplanned and uncontrolled developments will continue mushrooming in most urban and peri-urban areas of the country as the relevant authorities and actors continue to wallow in scarce geo-data, inappropriate planning approaches and ineffective statutes.

However, spot-check visits that were aimed at assessing the current consumer and user levels, revealed that some government departments and local authorities have made significant progress in streamlining and improving their operations through computerization, training of technical personnel in digital mapping and use of modern geo-technologies, especially GIS and satellite data (RS), for various development planning and management activities. Training institutions such as the University of Nairobi, Jomo Kenyatta University of Agriculture and Technology, Kenya Institute of Surveying and Mapping and Kenya Polytechnic University College, were also doing a tremendous job by expanding their training capacity and output in planning, surveying and mapping, modern GITs and other computer-based disciplines. Regrettably the relevant government departments, local authorities and other institutions dealing with land-use planning, mapping and management matters had not fully exploited the existing pool of young technically qualified manpower currently graduating from the above institutions.

Chapter Six

POTENTIAL OF MODERN GITS IN PLANNING / MAPPING URBAN SETTLEMENTS

6.1. Introduction

Based on the conceptual and theoretical propositions and findings from the foregoing investigations (in previous Chapters) it has been shown that, modern digital geo-information technologies (GITs); namely Remote Sensing (RS), Global Positioning Systems (GPS) and Geographic Information Systems (GIS) and the Internet, and community-based participatory planning, can provide viable alternative tools for efficient planning, mapping and spatial development management of the rapidly growing urban settlements, as opposed to hitherto used geo-systems and approaches.

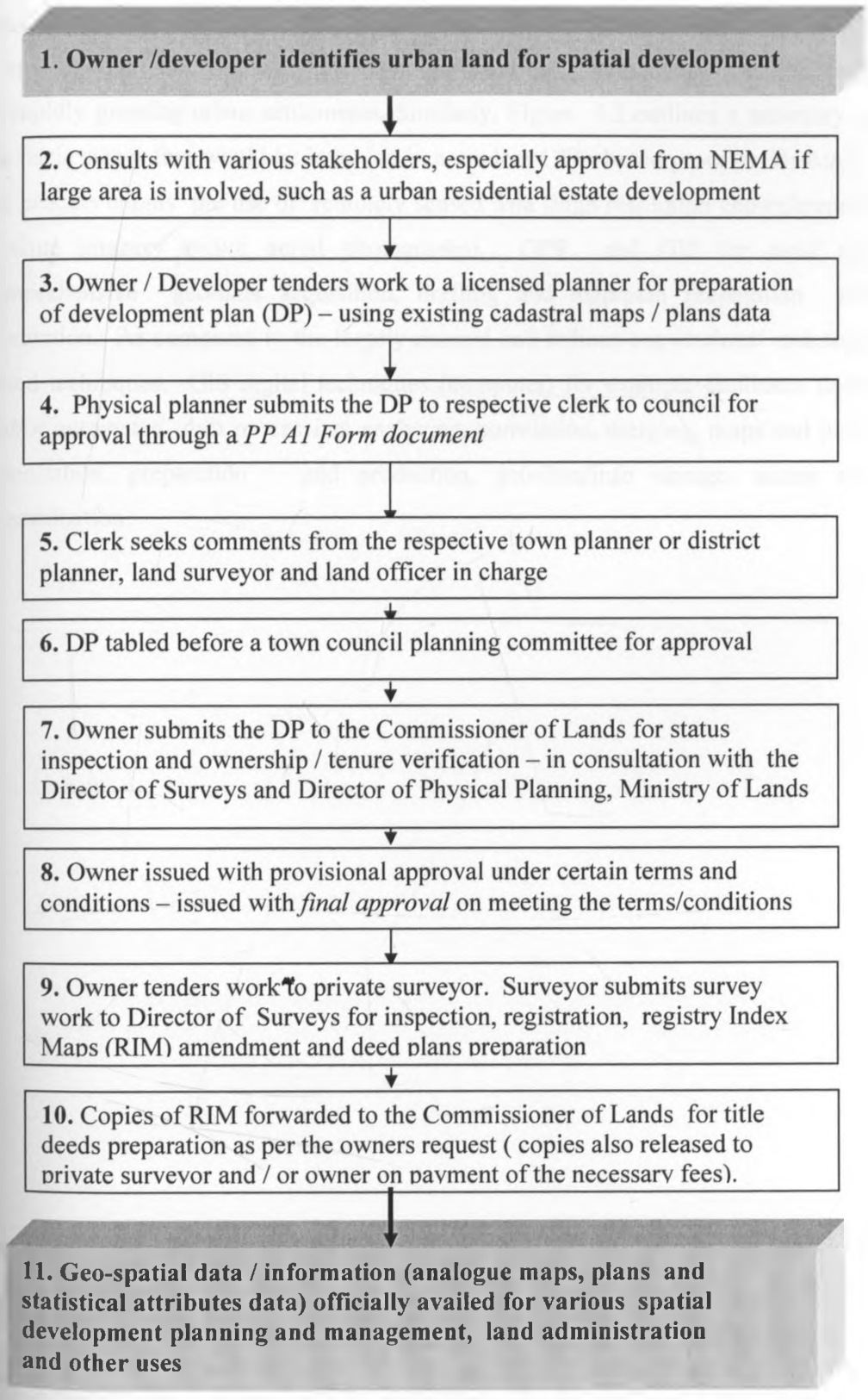
This Chapter therefore seeks to demonstrate the potential of modern GITs *vis-a-vis* conventionally used cadastral-based planning and mapping geo-systems and approaches in Kenya, and by extension, other developing countries of the world with similar urban spatial developmental problems.

6.2. Conventional Cadastral- based Vs Modern GITs Techniques

6.2.1. Conventional Planning / Mapping Process in Kenya

It was indicated (in Chapter Three) that, planning / mapping process in Kenya is mainly governed by two main Acts of Parliament; the Physical Planning Act and the Survey Act, and their weaknesses thereof critically analyzed. Figure 6.1. is a summarized version of the basic stages involved in the conventional cadastral-based mapping /planning process as prescribed by the two Acts' statutory regulations and requirements. However, it should be noted here that, in reality the process is more intricate in practice than what is indicated in the figure.

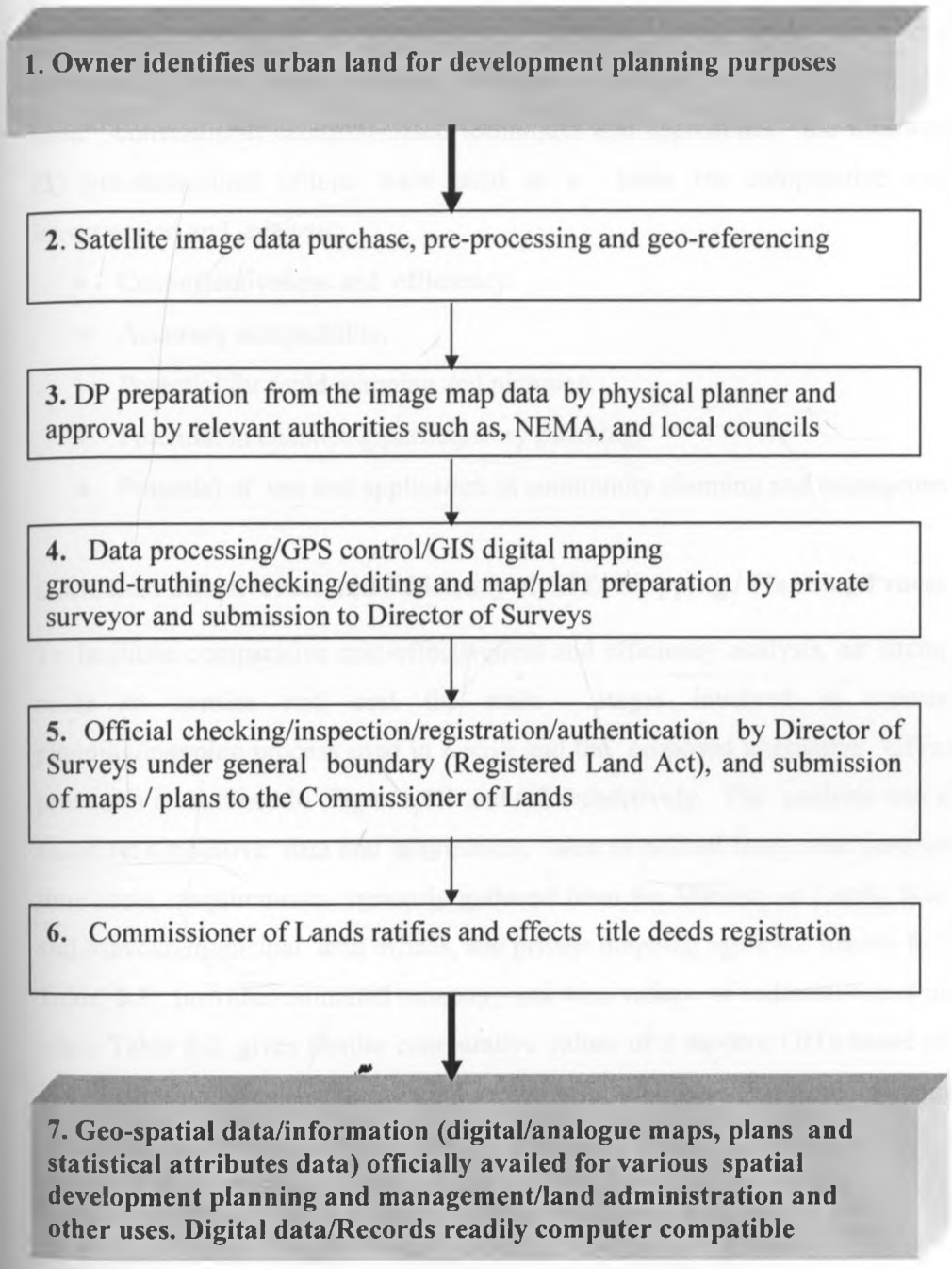
Fig. 6.1. Conventional Cadastral – based Mapping / Planning Process



6.2.2. Proposed Alternative Modern GITs-based Planning / Mapping Process

Again as conceptually found (in Chapter Two), modern GITs-based systems, if well adapted, can provide viable and efficient alternatives to spatial mapping and planning of rapidly growing urban settlements. Similarly, Figure 6.2.outlines a summary of the basic stages that would be involved in a modern GITs-based process. Basically, the process entails the use of remotely sensed data (high resolution geo-referenced satellite imagery and/or aerial photographs), GPS and GIS for rapid and comprehensive geo-data acquisition, drafting and map/plan preparation and production. As compared to the largely manual and tedious conventional cadastral-based techniques, GIS digital techniques (computer) for example facilitates faster and/or automated data processing, analyzing, correlation, merging, maps and plans compilation, preparation and production, geo-data/info storage, access and dissemination.

Fig. 6.2. Alternative Modern GITs-based Mapping / Planning Process



6.3. Comparative Empirical Analysis

In order to practically investigate and practically demonstrate the potential of modern GITs-based techniques for spatial planning and mapping vis-à-vis hitherto used conventional cadastral-based techniques and approaches, the following five (5) pre-determined criteria were used as a basis for comparative empirical investigation and analysis;

- Cost-effectiveness and efficiency,
- Accuracy acceptability,
- Potential for rapid mapping and planning,
- Potential in enhancing participatory planning,
- Potential of use and application in community planning and management.

6.3.1. Cost-effectiveness and Efficiency of GITs Mapping / Planning Process

To facilitate comparative cost-effectiveness and efficiency analysis, an attempt was made to itemize and cost the main stages involved in conventional planning/mapping process used in Kenya and the proposed alternative GITs-based processes as outlined in Figures 6.1 and 6.2 respectively. The analysis was mainly based on simulative data and information, such as official fees, other monitory and time costs, requirements variously gathered from the Ministry of Lands, Machakos and Mavoko municipal land offices, and private mapping agencies, mainly RCMRD. Table 6.1. provides estimated monetary and time values of cadastral-based process, while Table 6.2. gives similar comparative values of a modern GITs-based process. For illustration purposes, the simulative analysis was based on a typical unplanned peri-urban satellite settlement such as Mlolongo Township, comprising of about 1000 unit plots.

Table. 6.1.Cost Estimate of Conventional Planning / Mapping of 1000 Plots

Cost Elements	Rate per Plot (Ksh)	Amount (Ksh)	Time Est.
1.Development Plan (DP) preparation and approval	300	300,000	2 months
2. Field mapping survey	5,000	5,000,000	6 months
3. Cadastral map processing under RTA (Act) by Director of Surveys	1000	1,000,000	12 months
4. Sundry (data, stationery, errands etc)		200,000	
Total Estimate		**6,500,000**	**20 months**

Table 6.2. Cost Estimates of GITs-based Mapping / Planning of 1000 Plots

Cost Elements	Rate per $25km^2$ scene (Ksh)	Amount (Ksh)	Time Estimate
1. QuickBird satellite image data purchase/ ordering, processing, geo-referencing	100,000	100,000	3 weeks
2. Interpretation and DP preparation from image map by planner	100	100,000	2 weeks
3. Data processing/GPS control/ GIS digital mapping ground-truthing/ checking / editing and map revision by surveyor	300	300,000	3 weeks
4.Official checking/inspection/ registration/authentication under general boundary (RLA) by Director of Surveys	100	100,000	4 weeks
5. Sundry (data, Stationary, errands etc)		50,000	
Total		**650,000**	**3 months**

From Tables 6.1 and 6.2. the estimated monetary and time costs are;

1. Modern GITs Process:	Ksh. 650,000	3 Months
2. Conventional Process:	Ksh. 6,500,000	22 Months
Approx. percentage of 1 in 2 :	10 %	14 %

From the above results it can be concluded that modern GITs-based mapping /planning process would be about 10 times cheaper and about 14 times shorter in duration than conventional cadastral-based process. Though simulative data was used for the comparison, the above serves as a good indicator that modern GITs process is potentially more cost-effective and efficient than cadastral-based process

6.3.2. Accuracy Acceptability of GITs Data

Conceptually it was found that, though conventional cadastral-based geo-data acquisition systems (mostly analogue data) are of relatively higher accuracy than modern GITs data the former offers other advantages: rapid and comprehensive data provision, data currency, affordability, computer compatibility, multi-user and ease of applicability that far outweighs their lower accuracy levels. Cadastral-based techniques will continue to play its role where high precision data is required as the two geo-systems continue playing complimentary roles for the foreseeable future, without lessening the importance of the drive towards increased use digital geo-techniques in urban settings.

To practically investigate and demonstrate the accuracy level and acceptability of GITs derived data in mapping and planning, field experimentation was carried out to using actual field measurements and observations. The following simple procedures were used for comparative empirical analysis of satellite image, GIS map and hand-held GPS measurements data against those of cadastral sourced data ;

1. Testing Accuracy of Satellite Image Measurements Data

i.) A total of 6 plots were selected at varying terrain slopes within the study area of Mlolongo Settlement. The purpose for selecting the plots at varying slopes was to practically test the accuracy and acceptability of raw QuickBird satellite image (of 0.6m resolution) measurements at different terrain levels. Note that similar data and mapping techniques are popularly used in several rural areas in Kenya using raw (un-rectified) aerial photo enlargements for field mapping and production of title registration "maps" known as Preliminary Index Diagrams (PIDs) (Mulaku,1995). The six (6) test plots were selected at the following general terrain gradients; 2 plots (1 and 2) on relatively flat ground, 2 plots (3 and 4) on mild sloppy ground and 2 plots (5 and 6) on a steep river side as shown in Plate 6.1.

ii) Using a cadastral tape (chain) ground dimensions of all the parcels were taken as precisely as possible. Parcel distances and areas were computed and reduced using cadastral methods of surveying.

iii). Similar (common) plot dimensions were directly scaled (using engineers rule) from the image map at a scale of 1:2500

iv). The two data sets (linear and plot areas) were computed and reduced to a common mapping scale of 1:2500 for all the six (6) plots.

v). Using analytical computation techniques, the accuracy of image map measurements (linear and area) were empirically compared as shown in Tables 6.3 and 6.4.

It should be noted that since the exercise was meant to asses relative accuracy levels of GITs data, there was found no need for rigorous error analysis, hence relative linear measurement discrepancies between the two data sets were found sufficient enough for comparison purposes.

2. Testing Hand-Held GPS and GIS Image Map Coordinate Data

i). Using an existing cadastral map of a section of Mlolongo Township, five (5) points were selected and coordinates taken (Fig. 6.3).

ii). A hand-held GPS was used in the field to measure the coordinates of the 5 points in the field.

iii). A digital (computer) GIS image map of the area was prepared the coordinates of the 5 points measured using computer cursor.

iv). The accuracy of GPS and GIS map coordinates was analytically computed and empirically compared with cadastral map data. The results are presented in Tables 6.5 and 6.6.

Table 6.3. Chain and Image (scaled) Distance Accuracy Comparison

Plot No. P.No. 1 (Flat Ground)	ChnD (Hor)	ChnD (Slope)	ChnD (Vert)	Approx Slope	ImD (Scale)	Ch-Im (Discr)
Side1	33.0	33.0	0.0	0:0	33.0	0.0
Side2	14.0	14.0	0.0		14.0	0.0
Side3	33.1	33.1	0.0		33.0	0.0
Side4	14.1	14.1	0.0		14.0	+0.1
P.No. 2 (Flat Ground)						
Side 1	69.6	69.6	0.0	0:0	69.5	+0.1
Side 2	49.8	49.8	0.0		50.0	-0.2
Side 3	69.5	69.5	0.0		69.5	0.0
Side 4	49.7	49.7	0.0		49.5	+0.2
P. No.3 (Mild Slope)						
Side 1	39.6	39.5			39.5	+0.1
Side 2	30.8	31.2	0.5	1:62	31.0	-0.2
Side 3	39.3	39.6			39.5	-0.2
Side 4	30.7	32.3	0.5	1:61	30.5	+0.2
P. No.4(Mild Slope)						
Side 1	72.8.	73.6	0.8	1:91	72.5	+0.3
Side 2	79.0	79.2			79.0	0.0
Side 3	72.8	73.5	0.8	1:91	72.5	+0.3
Side 4	79.2	79.1			79.0	+0.2
P. No.5(Steep Slope)						
Side 1	18.0	18.8	1.4	1:13	18.0	0.0
Side 2	12.2	12.3			12.5	-0.3
Side 3	18.1	19.0	1.4	1:13	18.0	+0.1
Side 4	12.2	12.1			12.0	+0.2
P. No.6(Steep Slope)						
Side 1	18.3	19.2	1.6	1:11	18.0	+0.3
Side 2	12.7	12.7			12.5	+0.2
Side 3	18.5	19.3	1.6	1:12	18.5	0.0
Side 4	12.6	12.6			12.5	+0.1

ChnD=Chain Distance; ImD=Image Distance; Hor =Horizontal; Discr = Discrepancy

Table 6.4. Chain and Image Area Accuracy Comparison

Plot No. (Gradient)	Ch.Area (Hor)m^2	Im.Area (Hor) m^2	Ch - Im (Discr)	Discr /accu (1:X)
1 (flat)	446.2	445.5	0.7	1:636
2 (flat)	3445.2	3440.3	4.9	1:702
3 (slopy)	1168.2	1165.3	2.9	1:402
4 (slopy)	5810.5	5787.5	23.0	1:252
5 (steep)	217.4	207.0	10.4	1:20
6 (steep)	240.6	228.1	12.5	1:18

Computations:

Total Chain Dist (Horiz) : 899.6m
Total Image Dist. (Scaled) : 898.0
Total Discrepancy (Error): (Ch. Dist.-Im. Dist) = 1.6m
Cumulative % error : (Total Error / Total Horiz. Chain Dist.) x 100 % = 0.18 %
Therefore estimated accuracy of image = 1.6 / 898 => 1 : 561

From the above analytical computations, it means that for every 561m measured (scaled) on the image one is likely to loose or gain 1m, or about + / - 0.02m (2cm) for every 10m measured. Since the total distance was not continuous, the above result serves as a good linear accuracy estimate, since line segments measurement errors also accumulate. The minimum scalable distance using Engineers scale rule on the image map at 1:2500 scale was found to be about 0.5 meters. This therefore means mapping/planning is possible at tolerable errors of between +/- 0.02 to +/- 0.5m on relatively flat grounds.

Parallelogram formula (*Area = ½ (a +c) x d*) was used to estimate areas of the 6 parallelogram-shaped plots. Again with precautions image area accuracies of over 1:500 can be realized on relatively flat terrains. The above area accuracy estimate is therefore good enough for mapping/planning at common scale of 1:2500.

Table. 6.5. GIS Image Map and Cadastral Map Coordinates Comparison

Point No.	MapCods	Im Cods	Map – Im (Discr)	Discr / accu (1: X)
1 Road1 (E)	270691.23	270690.14	+1.09	1:633
(N)	9846507.72	9846508.03	-0.31	1:1639
2 R20 (E)	270771.81	270771.51	+0.30	1:2572
(N)	9846587.20	9846586.58	+0.62	1:946
3 R1 (E)	270588.84	270589.19	-0.35	1:1683
(N)	9846759.84	9846760.53	-0.69	1:1102
Average (1:X)				**1:1429**

MapCods = Map Coordinates, Im Cods= Image Coordinates

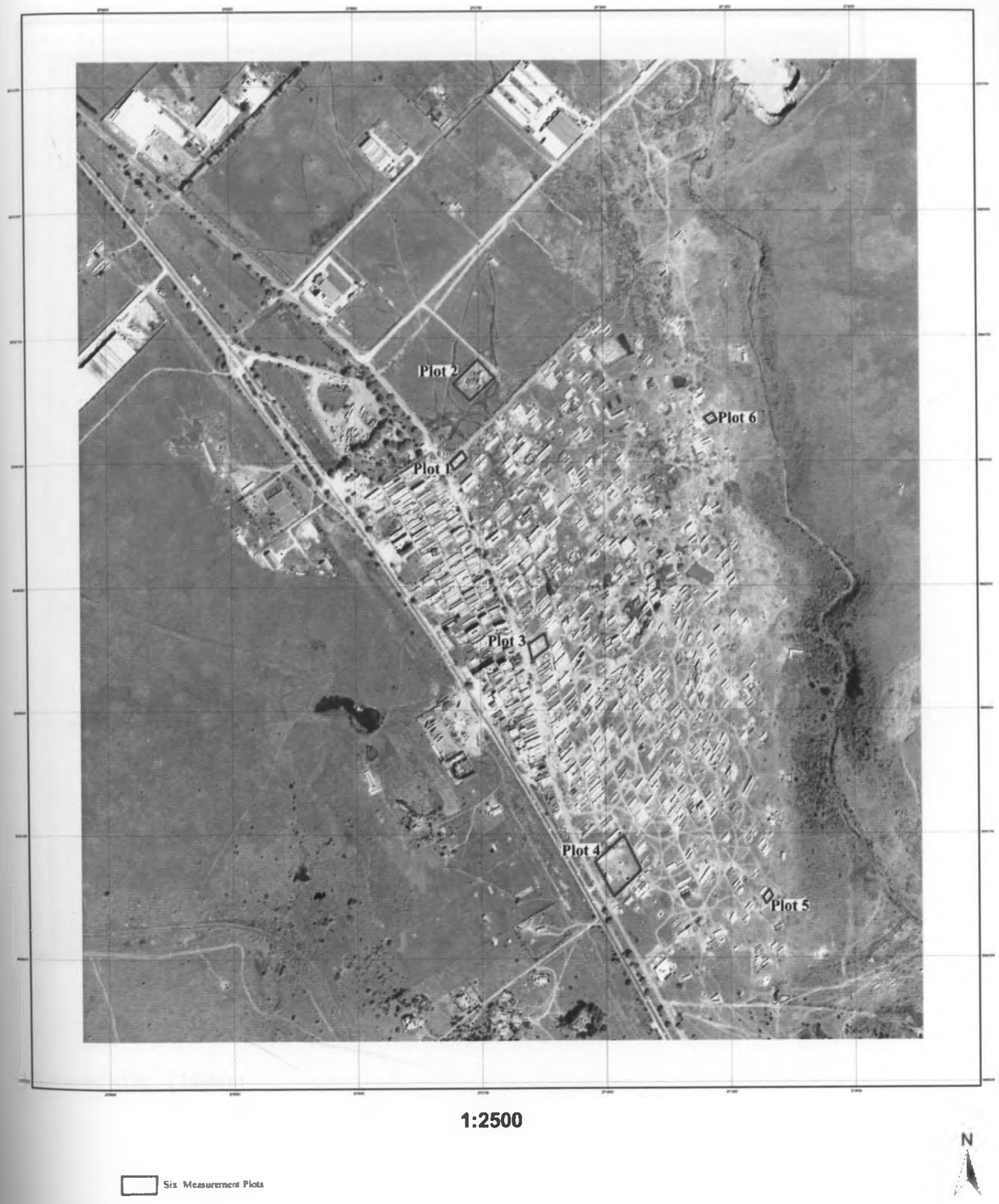
Table 6.6. GPS and Cadastral Map Coordinates Accuracy Comparison

Point No.	Map Cods (meters)	GPS. Cods (meters)	Map- GPS (Discr)	Discr / accur (1: X)
1 Road 1 (E)	270691.23	270695.0	-3.77	1:184
(N)	9846507.72	9846512.0	-4.28	1:120
2 R20 (E)	270771.81	270775.0	-3.19	1:243
(N	9846587.20	9846584.0	+3.20	1:182
3 R1 (E)	270588.84	270592.0	-3.16	1:187
(N)	9846759.84	9846753.0	+6.84	1:110
Average (1:X)				**1:171**

MapCods= Map coordinates, GPS Cods= GPS Coordinates

The above GPS measurement accuracy estimate (about 1:170) is sufficient for point positioning on a 1:50,000 topo-map for general field reconnaissance surveys.

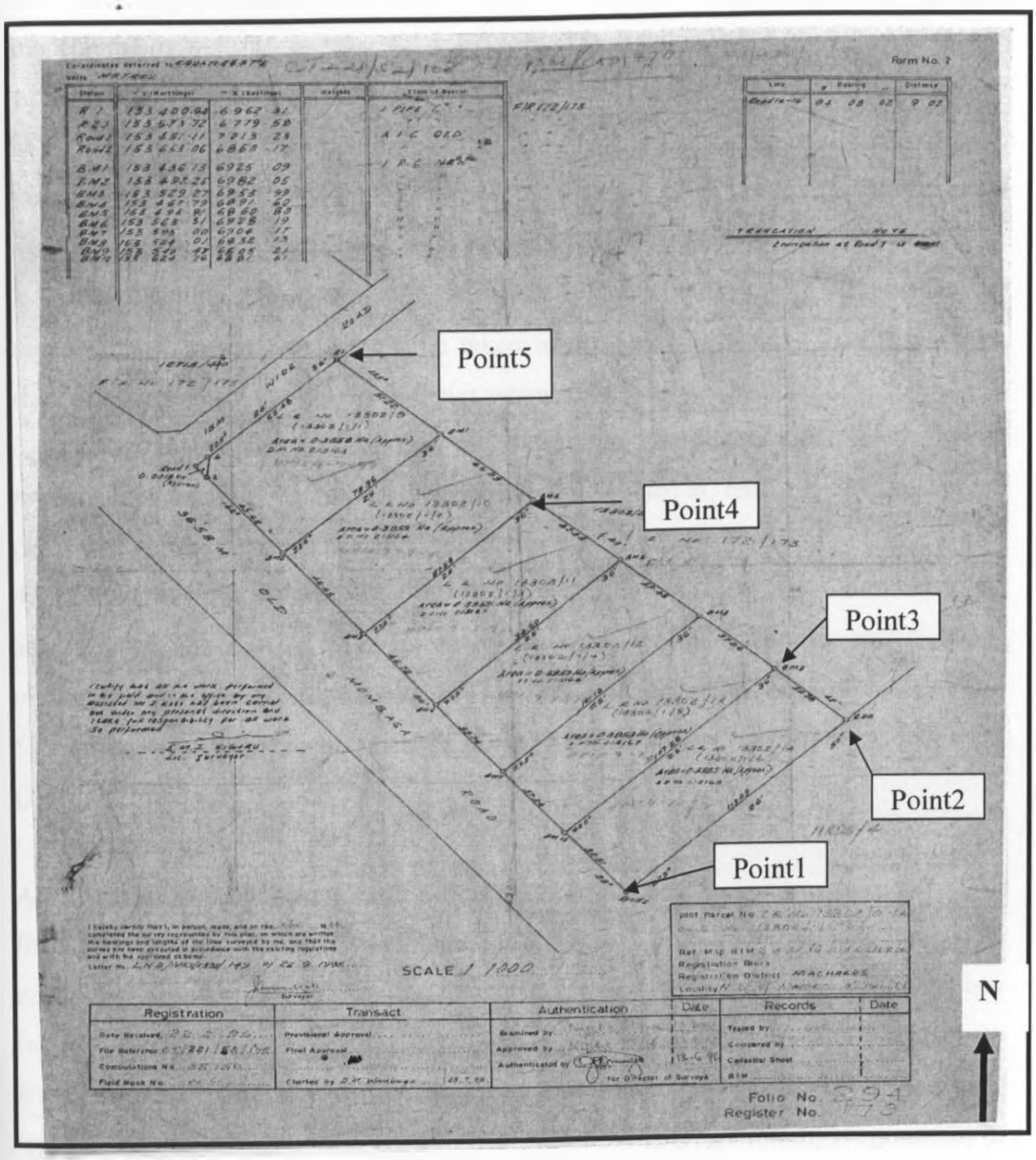
Plate 6.1. Location of the 6 Selected Plots in the Study Area Site



Selected six (6) plots in the study area (marked in red)

Source: Prepared from 2003 QuickBird Satellite Image, RCMRD (2006)

Fig. 6.3. Five Coordinate Points on Cadastral Map of within the Study Site



Scale: 1: 1000

Source: SOK, (2006)

3. Required Field Measurement Precautions

The following precautions should be taken into consideration when taking field measurements;

1. Since the image accuracy (both linear and area) reduces with increasing slope and decreasing plot sizes, supplemental measurements should be taken using a measuring tape (eg. a good quality linen tape) on very steep gradients. The accuracy also depends on the lengths of lines and scale.

2. Since satellite imaging is orthogonal (only horizontal image dimensions are mapped), due precautions should be taken to minimize effects of image shadows, such as over-hangs of roof–top canopies when scaling image distances.

3. In order to improve on accuracy, GPS readings should be taken for at least 3 minutes per reading to allow for stability and with at least 4 satellites being observed. An average of 3 sets of readings per station should be used.

4. Engineer's scale rule measurements may be reasonably approximated to an accuracy of about + /- 0.5m on a 1:2500 map or image, hence scaled image measurements should be rounded to One Decimal Place and in multiples of 0.5m. Similarly precautions should be taken during digitization process when preparing the GIS image map.

Accuracy of PID Mapping Techniques Used In Kenya

In comparison to modern day satellite imaging, aerial photography has been conventionally been used for a long time as a form of remote sensing (RS) technique for spatial mapping and planning by many countries. For instance, aerial-photo enlargements, commonly known as preliminary index diagrams (PIDs) mapping techniques, have been widely used for rural land titling (registration) programmes in Kenya since 1966 under the recommendations of Lawrence Report (of 1966). To date the technique has successfully facilitated registration of millions of parcels in the rural district areas of the country (Mulaku, 1995; Mulaku and McLaughlin, 1996).

Preliminary Index Diagrams (PIDs), though of lower accuracy, are easily prepared from 'un-rectified' aerial – photo enlargements, and used as *quick-fix* mapping / planning alternative source of rapid geo-spatial data as opposed to the expensive and

slow cadastral-based registry index maps (RIMs) prepared from traditional ground survey techniques. The use of PIDs (also referred to as general boundary survey techniques) was purposely aimed at quickening and cheapening the titling and land delivery process in the unregistered rural areas of the country where lower accuracies are tolerable (Kenya Rep, 1966a; Caukwell 1977; Mwenda, 1986; Halakhe,1989 and Imwati, 1989).

The term 'diagram' is therefore purposely used to disqualify PIDs from precise maps cadastral survey generated registry index maps (RIMs). PIDs therefore carry an official *disclaimer* that they are not guarantee to specific boundary location by affixing the word "Approx" (for approximate) to differentiate them from the RIMs (Imwati, 1989). For example, the average mapping area accuracy estimates of PID maps, in relation to parcel sizes on mild terrains, as estimated by the Survey of Kenya (SOK) are given in Table 6.7.

Table 6.7. SOK PID Parcel Mapping Area Accuracy Estimates

Parcel Size (Hectares)	Approx. Accuracy (+/-) (Hectares)	Approx. Average Error(%)
Less 0.4 (1acre)	0.004 -008	1.0
0.4 -1.5 (3.75acres)	0.08-0.1	10.0
1.5 – 12 (30 acres)	0.2-0.4	3.0
over 12	0.4 and better	3.0

Source; SOK (2006)

From Table 6.7, it can therefore be reasonably deduced that the majority of PID parcel areas may be incorrect by between 3% to 10 % of the actual ground measurements. Mulaku, (1995), for instance, arrived at similar accuracies while researching on possibilities for improving PID surveys in Kenya. He found that the minimum expected PID boundary position uncertainty was about +/- 2m and the corresponding area discrepancy was between 5-15 % (average 10%). His analytical investigations were based on a 3.5 hectares average parcel sizes.

6.3.3. Potential of Modern GITs for Rapid Planning and Mapping

To investigate the potential of modern GITs for rapid mapping / planning, a model plan for Mlolongo Township was rapidly prepared using modern GITs techniques. The main aim of the exercise was to demonstrate the effectiveness of GITs in terms of costs, time and comprehensiveness in mapping and planning informal settlements.

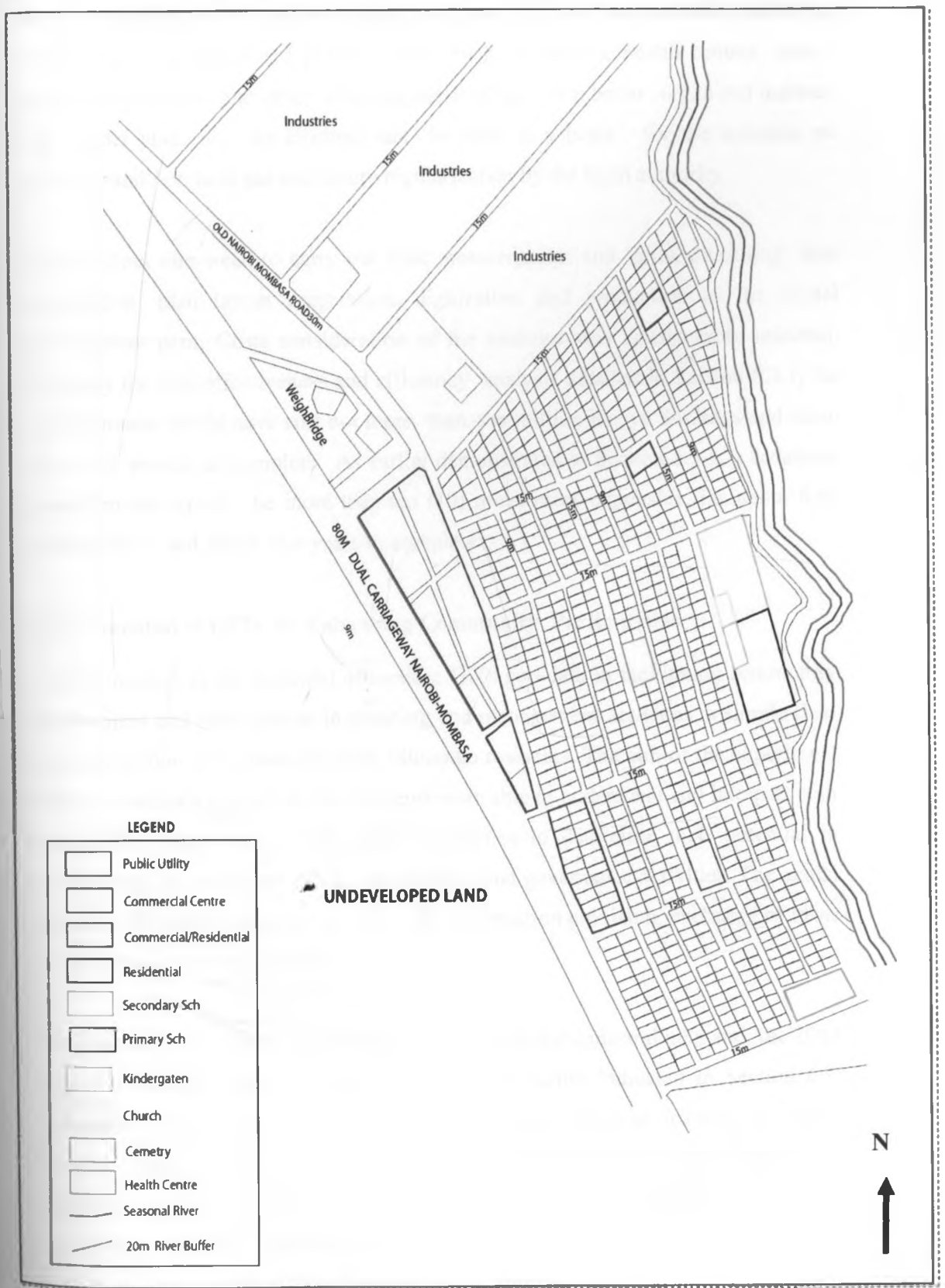
The following simple procedure was used in the experimentation:

1. A geo-referenced QuickBird satellite image (resolution 0.6 meters) of 2003 was used to prepare a GIS land-use map of the study area to identify the various categories of land uses, such as residential commercial and industrial developments (See Plate 4.5). Plate 6.2 shows spatial and attribute (tables) data contents derived from the digital GIS map data base.
2. Using hand-held GPS set and existing topo-cadastral maps of the area, perimeter and blocks boundaries of the planning area were quickly coordinated and mapped on the GIS image map.
3. ArcView GIS software and on-screen digitization techniques were used to rapidly prepare a simplified structural development plan model for Mlolongo Settlement as illustrated in Figure 6.4 indicating possible land use blocks; transport and communication, industrial, commercial, residential and public utilities (schools, health centres, open and recreational spaces), etc.

Plate 6.2. Example of Spatial /attributes Data Contents of GIS Image Map

Source: Author's Construct, (2007)

Fig. 6.4. Model Development Plan Layout for Mlolongo Township



Source: Author's Construct (2006)

Note that the model purposely ignores the existing haphazard development layouts so as to comprehensively include missing land uses such as transportation, industrial, commercial, residential and public utilities such as schools, health centres, open / recreation grounds, and other infrastructure facilities in a better organized manner. The model plan can, for example can be used as a basis for the intended re-planning and / or land use and tenure regularization by the local authority.

It took about one week to carry out field measurements and 'ground-truthing' data compilation, plan layout preparation, digitization and production of the model development plan. Costs consideration of the exercise was considerably minimal. Going by the cost-effectiveness and efficiency analysis detailed in Section 6.3.1, the actual process would have cost not more than one million Kenya Shillings and taken about two months to complete. As earlier demonstrated in Section 6.3.1, a cadastral-based process would be more than ten (10) times more expensive, i.e. about Ksh. 10,000,000/= and about two years to complete.

6.3.4. Potential of GITs in Enhancing Community Participation

In order to explore the potential of modern GITs geo-data in facilitating community involvement and participation in planning and management activities, a simple field experimentation was conducted with Mlolongo residents. The aim of the experiment was to investigate how easily the residents were able to understand and interpret both conventional and modern GITs data, and hence to determine their potential in participating in various planning, management and governance activities. The actual activities included taking part in geo-data/information provision, exchange of ideas and in decision making processes.

The exercise was carried out using an old conventional cadastral map and the 2003 QuickBird satellite image of the settlement. As earlier indicated in Section 6.3, conventional cadastral maps/plans generally portray physical features in vector formats, mainly linear and alpha-numeric descriptions and representation as illustrated on a 1990 cadastral map of the area (Fig. 6.3). On the other hand, remotely sensed data (satellite imagery) portray physical features pictorially (in reality) in raster format representation as illustrated in Plates 6.1 and 6.2..

The following simple procedure was used in the exercise:

1. The cadastral map and the satellite image (enlargements) shown in Figs. 6.3 and Plate 6.2 were simultaneously displayed to a randomly selected group of 10 local residents of Mlolongo. The selected were of different background, but of different literacy levels. All were between primary and secondary school levels, but none had any basic experience in mapping and planning (e.g. map reading)
2. The participants were given simple introduction on the source and use of the two exhibits.
3. Without any further explanation, the residents were asked to try as much as possible to describe any physical features such as roads and buildings portrayed on both exhibits that they could positively identify and recognize.

It was observed that the majority of participants were unable to understand, interpret and/or meaningfully describe features on the cadastral map. Only two participants from the group were able to generally describe linear features such roads and boundary lines. Surprisingly, the majority of participants were able to quickly identify, interpret and describe various features on the image map. Some could even positively identify and pin-point their residences with ease.

The vivid birds-view reality of the haphazard developments as portrayed by the coloured pictorial image further aroused their enthusiasm in the discussion, enabling them to freely provide useful information, opinions, ideas and suggestions on what they wished could be done in order to improve their neighborhood. They provided useful information on land ownership, the need for proper planning, improvement and provision of infrastructural services and essential utilities.

A similar response was recorded when a joint study team from the Department of Urban and Regional Planning of the University of Nairobi, Nairobi City Council and Department of Physical Planning of the Ministry of Lands carried out a policy review with the residents of Nairobi's [so named for the purpose of the study] Zones 3, 4, 5 (Nairobi C.C, 2006). In this case the residents were shown the 2003 aerial colour photo- enlargements of their settlements. The residents were for example able

to easily identify some of the undesirable developments such as unsightly business premises, bars, and restaurants that had become a nuisance in the locality. Consequently, the study team lead by Professor Peter Ngau, was able to gain support of community members in proposing solutions to development problems in the area. Obviously, the study would not have been as successful had the team relied on conventional maps alone.

6.3.5. Prototyping a Community-based GIS Model

The basic component requirements for any GIS development are hardware, software, data, technical and human resources. The size, complexity and design of the GIS largely depend on the availability of funds for acquisition of the above requirements. For a simple Desk-top GIS, the design requires only two PCs, A4 colour printer and scanner and easy-to-use software packages such as ArcView for spatial and attribute data capture, processing, analysis and geo-info reproduction. Tables 6.8 and 6.9 provide the basic requirements and costs estimates for developing a simple community GIS prototype module for a small urban community settlement of about 1,000 residential units such as Mlolongo Township.

The tables illustrate that only about Ksh. 835,000, or say approx. Ksh1,000,000 (about US$ 15, 000-depending on ex-change rate) is required to set up such a module. Assuming that all the 1,000 plot owners of the settlement cooperated/participated in the development on cost sharing basis, it would translate to a contribution of Ksh.1000 per person. This amount is by all means affordable to most of the plot owner, especially if they are adequately assured on accruing benefits from the project. Indeed, many of them could even comfortably afford up to Ksh10,000 (US$ 150) if adequately sensitized. Other stakeholders such as local NGOs can also contribute if adequately involved from the design stage to project implementation and commissioning.

Table 6.8. Basic Requirements for a Simple Community-based GIS Module

Items	Specification	Rate (Ksh)	Amount (Ksh)
Initial Requirements	Public Education, expert facilitation, mobilization costs, etc	100,000	100,000
2. Desktop PCs and Monitors	160GB, 512 RAM, SP: 3.2 $^{+}$; 15 Monitor	50,000	100,000
1.Colour Printer	A4 Size (eg HP3940 DJet)	10, 000	10,000
1. Scanner	A4 Size (eg HP2400)	10,000	10,000
1. Hand-H. GPS	1-2 meter accuracy	30,000	30,000
ArcView GIS	Version 8.2	20,000	20,000
RS Imagery	1 Scene (geo-ref. 25km^2)	4000	100,000
Other data purchase	Existing spatial/attribute	(misc.)	30,000
Data from residents	Land related, socio-economic data /information	(misc)	30,000
Sundry e.g internet	Connection and surffing	(misc.)	20,000
		Total	**450,000**

Table 6.9. Other Resource Requirements.....144

Item	Specifications	Cost Estimate (Ksh.)
Office Rent	Two rooms at Mlolongo	20,000 (2 Months)
Furniture		50,000
Electricity and water bills		20,000
Clerical staff	Secretary and messenger	60,000 (3 months salary)
Draftsman	1 Cartographer	45,000 (3 months salary)
GIS/Computer Expert	1 Technician	60,000 (3 months salary)
Surveyor/Planner	1 Professional	90,000 (3 months salary)
Casual Staff	2 support staff	30,000(3 months salary)
Sundry, eg stationary etc	(misc.)	10,000
	Total	**385,000**

Note: The above rates were based on prevailing local market estimates at the time

Uses and Applications of a GITs Community-based GIS Module

A community-based GIS can be put into a host of uses and applications by community residents and other relevant stakeholders for various development activities of the respective settlements, including :

- Spatial mapping planning and development management and governance.
- Assisting (through consultation with government and local authorities officials) in various land-use administration activities, e.g; land titling and registration, taxation, revenue collection, zoning and development control etc.
- Documentation, modernization and automation of land-related records and services delivery, e.g, property dealings and transactions, dispute resolution, land use auditing, etc.
- Contributing to revenue generation eg. through data sales and other clerical services.
- Crime and security monitoring and management e.g., by the local administration and police in identifying crime spots using GIS maps for patrol purposes.
- Inventory of business and socio-economic activities, eg. commercial and light industries, public amenities etc.
- Planning for new infrastructural services and social utilities e.g. water and sewage systems, schools, health facilities etc
- Assisting in research on various spatial and socio-economic issues of respective urban settlements, eg. environmental management, transport and communication needs, demography trends, economic development activities, etc.
- The government, local authorities and other concerned stakeholders can also use community GIS data-base for various spatial development planning, management and administration activities for the benefit and improvement of lives for the majority of residents in the rapidly growing urban community settlements, such as Mlolongo Township.

6.4. Locally Available GITs-Spatial Data Resources-base

Currently there are many public and private agencies providing modern digital (GITs) data, eg., through digital photogrammetry, satellite imaging, GPS and GIS data products and services at various scales, formats and contents. They include, among others; the Survey of Kenya (SOK) , the Directorate of Survey and Remote Sensing (DSRS) and other smaller private firms such as GeoMaps Kenya Ltd. Unfortunately, in custody of these agencies there exists a valuable wealth of multi-date, multi-epoch and multi-contextual data resource lying idle and underutilized as archive materials. A case in point is the 2003 JICA sponsored Nairobi mapping project that generated aerial photography (colour) mapping data products for the whole City and its environs, but regrettably this valuable data is currently underutilized and now almost "archive' material at SOK and City Hall. The on-going JICA mapping of Mombasa City and its environs is also soon to generate similar wealth of such data.

Various archival and recently acquired aerial colour photography, high and medium resolution satellite imagery data, eg. QuickBird, IKONOS, SPOT, LANDSAT imageries, GPS coordinate data, and GIS data products can be affordably obtained from RCMRD and other local agencies and firms. Reasonably accurate image maps can be freely downloaded through Internet from Google Earth mapping system for most general planning and mapping purposes. If well exploited, therefore, the above geo-data resource-base, provides great potential and opportunity for various land use planning, development management and administration in both urban and rural areas of the country, including; natural resource management, e.g. agriculture, forestry and wildlife, land use assessment, monitoring, change-detection, land use audit, natural and man-made disaster management etc, especially in dynamic spatial development milieus as currently found in most urban settlement areas of the country.

Chapter Seven

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1. Study Summary and Conclusions

The introductory chapter of the thesis, effectively provided a synoptic overview to the study topic and subject, at global, regional perspectives. Consequently a multi-staged approach was outlined and adopted for the research process. Based on the author's background experience on the study subject and review of existing literature, analytical investigation and discussion were used to theoretically and conceptually focus and set the study on the subject matter (Chapters Two and Three). Chapters Four, Five and Six further attempted to anchor the research on the local scene (study area) so as to effectively address the afore-stated research problem, questions and objectives stipulated in Chapter One. Theoretical, conceptual, empirical investigation, qualitative and quantitative analysis techniques were employed in the research process.

7.1.1. Summary

Based on the overall study outcome from the various stages of the study chapters, therefore the following general summary can be drawn from research results and findings;

- As compared to other contemporary planning approaches, participatory planning approaches offer 'best practice' alternative to efficient planning of the now democratic modern-day information-age urban communities.
- Availability and affordability of rapid and comprehensive geo-spatial data / information source is crucial to effective urban development planning, management and governance in rapid spatial development milieus of today's modern society.
- Hitherto used conventional geo-systems and planning approaches are continuously getting limited in addressing the current urban spatial development and management crisis in developing countries such as Kenya.

- If embraced, modern GITs (RS, GPS, GIS and Internet) can offer the much needed cost-effective and efficient tools for rapid and comprehensive spatial mapping , planning and development management of rapidly growing urban community settlements. Furthermore modern GITs were found to be more amenable for mass participation in enhancing community - based development planning, management and governance of urban community settlements.
- Traditionally used planning, mapping, land use development, management and administration systems and approaches are inefficient in addressing and / or mitigating the challenges posed by current urbanization syndrome in Kenya today.
- In absence of sound and effective urban land use development policies, institutional and technical frameworks, the majority of urban and peri-urban settlements such as Mlolongo are rapidly growing into slums, and without any formal planning, mapping and / or development control guidelines.

Through a questionnaire interview instrument, views solicited from a spectrum of respondents on the subject matter further indicated that;

- The challenges posed by the rapid urbanization trends (syndrome) are not only real, but a major threat to spatial and socio-economic development of modern day Kenya (about 80% affirmative response)
- Most of the technical experts and professionals interviewed affirmed that planning data needs and requirements are critical in the country (about 83% affirmative response), and the existing spatial development and management paradigms are defective (about 90% affirmative response)
- Currently, the use of modern GITs as alternative tools for spatial mapping, development planning and management by various local public and private agencies is low (about 30% response), and there is urgent need for awareness creation on potential of GITs, especially with the local technical professionals.
- The existence of huge backlog of planning, mapping and title registration work in most districts and urban municipalities is mainly attributed to lack

of adequate technical and personnel capacity (eg qualified planners, surveyors, and other land experts), that are coupled with official administrative bottlenecks and financial constrains.

- The need for involving the affected community residents in the planning and management process in a participatory manner is of very important necessity (about 90% affirmative response), hence the need for public education and enlightenment for effective participation (about 100% affirmative response)
- The current spatial development planning and management, and other land related socio-economic problems, including; insecurity of land tenure, land use conflicts, crime, congestion and environmental pollution etc., in the rapidly growing urban settlements such as Mlolngo Township are acute (about 93% affirmative response)

As a prove to the stipulated hypothesis, regarding the potential of modern GITs as better alternative geo-info systems and techniques for spatial mapping and planning as compared to conventional cadastral-based techniques, it was empirically and analytically demonstrated that;

- Based on the existing mapping / planning process in Kenya, it was demonstrated that modern GITs-based process was about 10 times cost-effective and efficient (in terms of monitory and time duration) than cadastral-based geo-systems and approaches.
- Using field experimentation it was practically, found that modern GITs can afford sufficient data accuracies for detail urban mapping and planning at common scales of between 1: 1,000 to 1: 20, 000.
- Further it was illustrated that modern GITs can provide better alternatives for; rapid and comprehensive spatial mapping and planning, and enhances public participation in development management and governance of urban community settlements, especially the rapidly growing peri-urban settlements such as Mlolongo Township development plan model.

7.1.2. Conclusions

Again based on the overall study outcome, as summarized above, it can be reasonably be concluded that the postulated research problem, questions and objectives were adequately addressed, and the research hypothesis satisfactorily validated (and proved). Hopefully, the results and findings of the study will serve as a useful reference to both public and private agencies, professionals, experts, researchers, managers, and other stakeholders and actors dealing with land-related matters, at national, regional and local levels.

Further, it is hoped that the overall study outcome will provide a useful researched, technical/methodological frameworks, propositions and strategic pathways to addressing and/or mitigating the challenges posed by the current *urbanization syndrome*, not only in Kenya, but by extension, in other developing countries of the world that are experiencing similar problematic urban spatial and socio-economic developments.

7.2. Recommendations

Arising from the above findings and overall study outcome, the following main recommendations are drawn:

1. Given the rapid urbanization trends in Kenya and other developing countries of the world, there is urgent need for comprehensive review / overhaul and/or amendment of the existing land statutes, policies, institutional and technical paradigms. In Kenya for instance, there is urgent need for overhaul and/or amendment of both the Survey and Physical Planning Acts, and related statutes so as to effectively address the current spatial and socio-economic developmental demands of modern Kenyan society.
2. Secondly, the study calls for speedier official acceptance and embracement of the prevailing modern digital geo-info technological innovations and democratic principles of the modern information age society, eg in adopting the use of modern GITs and participatory

community-based as alternative tools for spatial mapping, development planning and management, especially for the rapidly growing urban community settlements, such as Mlolongo Township.

3. Finally, there is urgent need for improvement of the existing geo-data resource base, eg through records modernization, computerization and automation of services delivery by various public and private agencies. This, for example, can be achieved through effective exploitation of the locally available wealth of modern GITs geo-spatial data resources, technical and human capacity (qualified graduates) and inclusive (public participatory) approaches in development planning, management and governance of urban settlements; as opposed to the largely top-down bureaucratic approaches hitherto used in the country today.

7.2.1. Suggestions for Further Research

In view of the above therefore, it is recommended that future research studies be carried out to:

1. Test, extrapolate and replicate the study findings and propositions in other urban areas with similar spatial problematic developments and challenges in Kenya and other developing countries.
2. Demonstrate actual case studies on successful use of GITs in specific urban neighborhoods to study other spatial, physical, environmental, demographic, and other socio-economic development dynamics in Kenya.
3. Finally, to specifically study and demonstrate the potential applicability of innovations provided by digital geo-info techs (GITs) evolution and democratic principles of modern information-age society in improving the living conditions of the majority of urban poor indigents, especially in Africa, Asia and Latin American countries.

7.2.2. Study Limitations and Achievements

The study has broadly and generally given the picture on the prevailing urbanization trends, and urban development concerns, problems and needs of the modern information-age urban communities at global, regional and local perspectives. However, in an attempt to localize the study, the research investigation specifically limited to a single sample study case area, Mlolongo Settlement, a rapidly growing informal peri-urban settlement of Nairobi City, to diagnostically investigate, examine the pertinent spatial mapping, planning and development requirements for urban settlements in Kenya. By recommendation, a broad scope - city-wide (regional) investigation, would have provided a more encompassing study, but for logistical, financial, time, material and other resources. However, given the available resources, the study has to a large extent, reasonably and successfully strived to achieve the intended goals and objectives.

LIST OF REFERENCES

Aduol, F. O. (2006). *From Rope-Stretchers to E-Mapping*; The Story of the Discipline of Surveying, (Inaugural Lecture Booklet, University of Nairobi, May 2006).

American Society for Photogrammetry and Remote Sensing, (1997). *Manual of Photographic Interpretation*, 2nd Edition. Falls Church, VA.

Anua, N. et al. (2002). Negotiating More tha Boundaries: Conflict, Power and agreement building in the Demarcation of village borders in Malinau.

Armer, J. (1998). *Planning Public Health Care Facilities in Dar es Salaam, Tanzania*: Proceedings of First International Health Geographic Conference, October 16-18, Baltimore.

Bannister, A., S. Raymond and R. Baker (1998). *Surveying;* Seventh Edition. Longman. Singapore.

Barrets, C. and C. Leornard (1997). *Introduction to Environmental Remote Sensing.* Third Edition; Chapman & Hall, New York.

Barry, M. and Ruther, H. (2001). *Data Collection and Management for Informal Settlements Upgrades.* Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi, Kenya, 2-5 October 2001.

Binns, B. O. (1953). *Cadastral Surveys and Records of Rights in Land*; (FAO Land Tenure Study, Rome, (1953).

Camphell, H. and Masser I. (1995). *GIS and Organizations*: How effective are GIS in practice?. Taylor & Francis. London.

Catenese, A. (1979). *Information for Planning*; The practice of local government Planning, International City Management Association. Washington, DC.

Colchester, M. (2002). Mapping as a Step for Securing Community Control: Some Lesions from south East Asia.

Caukwell. R. (1977). Cadastral Survey in Kenya and its Role in the Development of the Country. Master of Science Thesis; Department of Surveying and Photogrammtry, University of Nairobi, Kenya.

Craig, W., et al (2002). *Community Empowerment Public Participation and GIS.* London: Taylor and Francis.

Curran, P. (1990). *Compendium of Cartographic Techniques.* Elsevier Applied Science. London and New York.

Dale, P. (1991). *Geographic Information Systems and their role in urban development*: Cities, 8 (1), pp 10-16.

Dale, P. and McLaughlin J. (1988). *Land Information Management*, An Introduction, with special reference to cadastral problems in Third World Countries; Clarendon Press. London.

Ericssion, A. and Eriksson S. (1998). *Questionnaire regarding cadastral projects in developing countries*; FIG XXI International Congress 7, Cadastre and Management; Brighton, England , July 19-25, 1998.

ESRI, (1999, 2001,2002, 2003). Environmental Systems Research Institute (*ARC NEWS*), Periodicals. 380 New York Street. Redlands California. USA.

FAO, (2006). Participatory Land Delimitation: Experience and Methodolgies, FAO Land tenure Collection, 2006

Fourie, C.(2001). *The Use of New Forms of Spatial Information*, Not the Cadastre to Provide Tenure Security in Informal settlements. Proceedings of International Conference on Spatial Information for Sustainable Development. Nairobi, Kenya, 2-5 October 2001.

Freeman, H, Rossi P. and Wright S. (1979). *Evaluating Social Projects in Developing Countries*; Development Centre for Economic Co-operation and development. Paris.

Genesis 2(8). The Holy Bible, New International Version (1984).

Guharthakurta, S. (1999). Urban modelling and contemporary planning theory: is there a common ground? *Journal of planning education and research. 18(4),281-292*

Halakhe, J.G. (1989). *An Valuation of the Cadastral Boundary Delimitation Process in Kenya*: *M. Eng. Report,* Depart of Surveying Engineering, University of New Brunswick, Canada 1989.

Henderson, J.A. (1997). *Community Planning and Development.* Lecture Notes Spring Semster, 1997; Whittier College, Carlifornia; htt:www.obie,whittier.edu/lecture.html

Home, R. and Barry M. (1997). *Land rights in the new South Africa.* Is new technology the answer?. RICS Education Trust. University of East London.

Huxhold, W.E. (1991). *An Introduction to Urban Geographic Information systems.* Oxford University Press. London.

ILC, (2006). Mapping for Change: Practice, Technologies and Communication: International Land Coalition (ILC), 2006; *www.landcoalition.net*

Imwati, A. T. (2000). *Remote Sensing and GIS Lecture Notes*, Kenya Institute of Surveying and Mapping (KISM), 2000. Nairobi . Kenya.

Imwati, A.T. (1989). An Evaluation of Land Titling in Kenya; M.Eng. Thesis, University of New Brunswick, Canada, May 1989

Innes, J. E. (1996). Planning through consensus building: a new view of comprehensive planning ideal. *Journal of the American planning Association , 62(4), 460-472.*

Japanese International Co-operation Agency – JICA, (2004). JICA Nairobi Mapping Project. Report. Nairobi, 2004.

Johnson, et al. (1992). *Geographical Information Systems (GIS) and Mapping Practices and Standards*. Reston, VA.

Jothmani, P. (1997). *Operational Urban Sprawl Monitoring using Satellite Remote sensing*: Excerpts from the studies of Ahmedabad, Vdodara and Surat, India. (http://*www.gisdevelopment.net).*

Kaiser, Godschalk and Chapin (1995). *Urban Land Use Planning;* University of Illionos Press. Urbana and Chicago.

Karanja, N. (2002). Use of Knowledge Based Systems for the Detection and Monitoring of Unplanned Developments; PhD Thesis. University of Hannover. Germany.

Kenya Rep. (1966a). *Report of the Mission on Land Consolidation and Registration in Kenya* (1965-1966), (By Lawrence and Adams). Government Printer, Nairobi.

Kenya Rep. (1970b). "The Land Adjudication Act"; Laws of Kenya Chapter 284; Revised Edition. Government Printer, Nairobi.

Kenya Rep. (1989 & 1996). The Acts of Parliament; Physical Planning Act Cap.286 (Rev. 1996) and Survey Act, Cap 299 (Rev. 1989).

Kenya Rep,. (1991). Handbook on Land Use Planning, Administration and Development procedures: Ministry of Lands and Housing, 1991.

Kenya Rep. (2002). Report of the Commission of Inquiry into the Land Law System of Kenya on Principles of National Land Policy, Constitutional and Institutional Frameworks for Land Administration (Njonjo C. *et al*, November, 2002)

Kenya Rep. (2003). See 7th , 8th ,& 9th National Development Plans, Sessional Papers and other various Government Policy Documents; Government Printer.

Kenya Rep. (2003). Survey of Kenya Maps Catalogue, March , 2003 Edition.

Kenya Rep. (2005). Statistical Abstract, 2005; Government Printers, Nairobi, 2005.

Kenya Rep. (2005): The Kenya Gazzette, 23 / 09/2005; Government Printer, Nairobi

Kenya Rep.,(2008). Nairobi Metro 2030 Vision: *A World Class African Metropolis:* Ministry of Nairobi Metropolitan Development Report.

Kingoriah, G. K. (1980). *Policy Impacts on Urban Land Use Patterns in Nairobi; Kenya 1899-1979.* Thesis Desertation, Indiana State University, Terre Haute, Indiana. USA.

Kingston, R., (2002). Web Based PPGIS in the UK: In: W. Craig (ed). *Community Empowerment Public Participation and GIS.* London: Taylor and Francis.

Klein M., ' Coordination Science: Challenges and Directions'. *Technology for Collaborative Applications*, Springer Verlag, pp 161-76

Klosterman R.E. (1997). *Guidelines for Computer Aided Planning Models.* URISA Confrence Proceedings, Washington DC; Volume 2.

Korte, P. (1997). *The GIS Book*, 4th Edition. Onword Press. Santa Fe. USA.

Kyariga, T. (2001). *Urban Authority Support Unit, Tanzania*; Proceedings. FIG Conference. Nairobi 2001.

Lasimberg, A. (2004). Community Mapping in Malaysia: *www.ppgis.net*

Laurini, R. (2001). *Information Systems for Urban Planning*. Taylor & Francis. London and New York.

Leica, Co. Ltd. (1999). *GPS Basics*; Introduction to GPS; Version 1.0; English Version. Leica Geosystems Inc. 3155 Medlock Bridge Road. USA.

Lillesand, T. and Kiefer R. (1999). *Remote Sensing and Image Interpretation* 4th Edition. John Wiley & Sons , Inc. New York.

Masser, I. (2000). *Managing our urban future*. ITC Journal. Volume 2 – Issue 3/4 –2000.International Institute for Aerospace Survey and Earth Sciences. ITC News. Enschede, the Netherlands. 2000-2.

Mather, P. (1996). *Geographical Information Handling* – Research and Applications. John Wiley & Sons. New York.

Mbogua, J. P., Nganga A. J. and McNamara R.S., (1973). *Nairobi-Metropolitan Growth Strategy*; Volume 1- Main Report: Nairobi Urban Study Group, 1973. Nairobi City Council, Nairobi.

Mbwagwa, R. K. (2002). *Physical Planning Handbook*; Dept of Physical Planning, Ministry of Lands and Settlement. Nairobi.

McCormick et al,; MacKinven & Sandt and Kingston, J. and Others: *PPGIS Research Papers* (2008): http://www.ppgis.net *and* http://www.gisdevelopment.net.

McLaughlin, J. (2001). *Land Information Management*: From Records Automation to citizens On-Line; Also, Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi, Kenya, 2-5 October 2001.

Moffit, H. F. and Mikhail E. M. (1980). *Photogrammetry*. Third Edition. Harper & Row, Publishers, New York.

Mugenda, O. and Mugenda A. (1999). *Research Methods*; Quantitative and Qualitative Approaches. African Centre for Technology Studies (ACTS), Nairobi.

Mulaku, G. and McLaughlin J. (1996): *Concepts for improving property mapping in Kenya*; *South African Journal of Surveying and Mapping, Vol. 23, Part 4; April 1996, pp. 211-216.*

Mulaku, G.C. (1995). Concepts for PID Improvement; PhD Thesis, University of New Brunswick, Fredericton, Canada.

Mwangi, I. (2001). *Syndrome Pre-Synthesis Project (SSP) Report*: Conference on Regional and Global Perspectives of Syndrome Mitigation Research: Grindewald, Switzerland; September, 2001.

Mwaura, A., (2003). A Framework for Urban Renewal in a Low-income Residential Neighbourhood: A case of Kaloleni, Makongeni and Mbotela, Nairobi, Kenya:- M.A. Thesis, University of Nairobi, Department of Urban and Regional Planning.

Mwenda, J. (2001). Spatial Information in Land Tenure Reform with Special Reference to Kenya; Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi, Kenya, 2-5 October 2001.

Mwenda, J. N. (1986). An assessment of the Cadastral Survey System in Kenya, *M.Eng. Report,* Department of Surveying Engineering, University of New Brunswick, Canada.

Nachmias, D. and Nachmias, C. (1976). *Research Methods in the Social Sciences*. New York, St. Martin's.

Nairobi City Council (2006). *Draft Report on policy review of zones 3,4 and 5 of Nairobi City*. Nairobi City Council. Nairobi.

Nakuru Municipal Council (1996): *Localizing Agenda 21*: Action Planning for Sustainable Urban Development: Proceedings of the Workshop organized by the Nakuru Municipal Council, Habitat and the Belgium Consortium, 6-9 November, 1995.

NCCR – North South (2003). *Research Partnerships for Mitigating Syndromes of Global Change*; Swiss National Centre of Competence in Research North – South; Publication Edition 2002 / 2003. University of Berne. Website: *www.nccr-north-south.unibe.ch*.

Nedovic-Budic Z., Feeney M. F., Rajabifard A. and Wiliamson I.. (2003). *Are SDIs serving the needs of local planning?* Case study of Victoria, Australia and Illinois, USA. Department of Urban and Regional Planning, University of Illinois. Urbana. Website; www.elsevier.com.

Njonjo Commission Report on Land Reform in Kenya, (2003). Commentary. *Daily Nation*, Issue of 7/5/2003. Nairobi.

Njuki, A. (2001). *Cadastral Systems and Their Impact on Land Administration in Kenya.* Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi, Kenya, 2-5 October 2001.

N-SI, (2006). Land and Conflict Transformation: Policy, Practice and possibilities for Land Coalition, North-South Institute, 2006.

Oliver, G. and Clendinning, J. (1979). *Principles of Surveying*: 4th Edition, Volume 1, *Plane Surveying.* VNR Company, New York – Toronto – London – Melbourne

Nobre J.A. (1999). 'Improving Public Participation in Urban Planning Decision Making' . Brochure Report, Public Works Ministry of the Macau Government, May 1999

O' Riordan, T. (1971). *Perspectives on Resource Management*, Pion Ltd., London.

O'Brien, D. (1999). 'Data Access: A Common Window', Proceedings of the SORSA Workshop, Ottawa, August 11-14 1999.

Obudho, R.A. (1997). *Nairobi: National Capital and Regional Hub*, in The Urban Challenge in Africa. Growth and Management of Its Large Cities. Edited by Carol Rakodi. United Nations University Press.

Okpala, C.I. (2001). *Spatial Information*: The Basic Tool for Sustainable Human Settlements Development Planning and Management. Proceedings of FIG Conference. Nairobi, 2001.

Olima, W. (2007). Efficiency and Equity in Managing Land (in Kenya): *Daily Nation* Feature Article; Wednesday April 25, 2007

Oliver, J. and Clendinning J. (1978). *Principles of Surveying*; 4th Edition. Van Nostrand ReinHold Company. New York.

Omondi, F. O. (2003). Influence of Road Transport System on Growth and Development of Human Settlements: A Case of Mlolongo in Machakos District, Kenya :- M.A. Thesis, University of Nairobi, Department of Urban and Regional Planning.

Omwenga, M. (2001). The Missing Link. Spatial Information Required in the Preparation and Implementation of Physical Development Plans in Kenya. Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi , Kenya , 2-5 October 2001.

Otieno J. (2002). A Tale of City without a Plan; *Daily Nation* Article, 11 / 01 / 2002.

Oxford Dictionary (1995). Advanced, New Students Edition, 1995.

Patton, M. (1990). *Qualitative Evaluation and Research Methods*; 2nd Edition, Sage Publications, Newbury Park London new Delhi.

Payne G., Pugh C., Ravetz J. and Meacher M. (2001). *Urban land tenure policy options*. Titles or rights. Habitat International, Vol. 25(3), 2001. *www.styluspub.com/books.*

Payne, G. (1997). *Urban land tenure and property rights in developing countries*. A review. ITDG Publications. London.

Payne, G., Rakodi C., and Abbott J. (2002). *Land, Rights and Innovation; Improving tenure security for the urban poor*. ITDG Publications, London.

Ratcliffe, J. (1974): *An Introduction to Town and Country Planning*. Hutchinson. London.

Reeve, D. & J. Petch. (1999). GIS, Organizations and People; A social technical approach. Taylor & Francis, London.

RESTEC, (199). Remote Sensing Technology Centre of Japan; Lectures on GIS and Remote Sensing, Tokyo, Japan, 1999.

Robinson, H. Morrison L., Muehrcke C., Kimerling J. and Guptill C. (1995):Elements of Cartography. John Willey & Sons, Inc., New York.

Ryttersgaard, J. (2001). Spatial Data Infrastructure- Developing Trends and Challenges; Proceedings, International Conference on Spatial

Information for sustainable Development, Nairobi, Kenya, 2-5 October 2001.

Sabins, F. (1996). Remote Sensing; Principles and Interpretation. #rd Ed. , W. H. Freeman. New York.

Sandt, J. & Mackinen, P. (2007). Mapping Indegenious Territories: The World Conservation Union: *www.ppgis.net*

Sadik, N. (1999). Meeting the urban population challenge. *City Development Strategies 1*: 16-23.

Sarly, R.M. (1972). The Planning Process; University College London. Working Paper.

Seiber, R. (2000): GIS Implementation in the Grassroots. *Journal of Urban and Regional Information Systems Association, 12(1),15-29.*

Sliuzas, R. and Ottens F. (1999). Can geographic information technology improve urban land management practice in Tanzania?; The integration between formal and informal land management in Africa, Dar es Salaam.

Stefano, D. et al. (2008). Participatory Planning as a Tool for Empowerment: Experiences and Lessssions Learnt from the ILC: *www.landcoalition.org*

Survey of Kenya (SOK), (2005): Report on JICA Mapping Project for Nairobi City. Nairobi.

Survey of Kenya (SOK), (2006). Survey of Kenya Map Catalogue, Year 2003 Edition. Nairobi.

Thatiah, P. (2006). Sunday Nation, January 8, 2006; *Special Report.* Nairobi.

Turkstra, K. (1998). Urban Development and Geographic Information: Spatial and temporal patterns of urban development and land values using integrated geo-data; Villavicencio , Columbia. ITC Publication No. 60.

UNESEC, (1998). Convention on Access to Information: Public Participation in decision-making in Environmental Matters: United Nations Economic and Social Council, Geneva, 1998.

UNESEC, (2000). Integrated Planning and management of Land Resources: United Nations Economic and Social Council, April / May 2000.

UN – Habitat (2008). UN-Habitat Report of the Conference on Harmonious Urbanization, October 2008, Kakamega -Kenya

UN – Habitat (2001). Habitat Agenda, Proceedings of the Conference on Human Settlement, Nairobi – 2001. Nairobi.

UNCHS, (1992). "Sustainable Cities" : Programme Outline for Urban Environment. Nairobi, June, 1992.

UNCHS, (1993). "Improvement of Municipal Management": Report, July and October, 1993.

UNCHS, (1996). Urbanizing World, Global Report on Human Settlement. Nairobi.

Wolf, P.R. (1974). Elements of Photogrammetry. McGraw-Hill Kogakusha, Ltd. Tokyo. Japan.

Yahya, S. (2001). Lending a Voice to Oral Registries –LIS as a Tool for Validating Customary Leaseholds. Proceedings, International Conference on Spatial Information for sustainable Development, Nairobi , Kenya , 2-5 October 2001.

Yahya, S.S. (1976). Urban Land Policy in Kenya – PhD Thesis, University of Nairobi.

Yin, R. K., (1984). Case Study Research; Design and Methods; Applied Social Research Methods Series, Volume 5. Sage Publications. Beverly Hills.

APPENDICES

APPENDIX IA: QUESTIONNAIRE INTERVIEW RESPONDENTS

The following are the set of seven (7) broad sample questions that were used to guide the field surveys and interviews.

Set One Category Questions: **To Land Officials, Experts and Professionals**

1. What are your views and opinions on the implications and effects regarding the challenges posed by the rapid urbanization trends (urbanization syndrome) in Kenya and other developing countries?

2. Given that the traditionally used cadastral-based data acquisition systems and planning approaches are proving to be relatively inefficient and seemingly limited for effective spatial mapping and planning, especially for spatial development and management of the rapidly growing urban and peri-urban areas in Nairobi and other of parts of the country;

Questions:

(a) What are your suggestions regarding the existing geo-spatial data needs, mapping and planning requirements ?

(b) What are your suggestions for improvement ?

3. Depending on background knowledge and experience on the use of conventional cadastral survey / mapping techniques and the new digital geo-information technologies (GITS); namely; remote sensing (especially satellite imageries), geographic information systems (GIS), global position systems (GPS) and the Internet;

Questions:

(a) *What are your opinions and views regarding the continued use of the traditional geo-systems and approaches in today's information-age*

modern Kenya?

(b) What are your suggestions on official adoption and use of the advancing digital geo-info technologies (GITs) as alternative tools for spatial data acquisition, mapping, planning and development management in urban settings ?

4. The existing land use mapping, planning, development management, administration and governance paradigms are mainly still based on the British colonial system that was adopted after Kenya's independence in 1963;

Questions:

(a) After almost half a century, do you think it is the time for policy, institutional, statutory and technical paradigms change to the status-quo ?

(b) What are your proposals and / or suggestions on the urgency and needs for the necessary system paradigm's changes and re-arrangements.

(c) In your opinion, does the existing mapping and approaches effectively involve the affected local residents, other relevant stakeholders and actors ?

If NOT, what are your views regarding the need for a more inclusive multi-stakeholder and participatory spatial mapping, planning and development management approach, especially for the rapidly growing urban community settlements ?

Set Two Category Questions: **To Local Residents and Leaders of Mlolongo**

1. The rapid development of Mlolongo township is currently characterized by various spatial, socio-economic and other land – related problematic developments, including; lack of proper spatial planning and development control guidelines, management and governance needs, land use and tenure conflicts, environmental mismanagement, insecurity and crime, needs and requirements among others;

Questions:

(a) How acute are the above problems to you as local residents of Mlolongo?

(b) What are your opinions, suggestions and proposals for addressing and/or mitigating the above , towards improvement and betterment of the living conditions of the local residents?

2. As a typical and unplanned peri-urban settlement of Nairobi, the haphazard spatial growth and development of Mlolongo may be largely attributed to the inherent inadequacies and exclusiveness of the existing spatial land use development system, as proscribed in the various land – related Acts of Parliament;

Questions:

(a). Are you aware of the official government regulations and requirements for infrastructural developments in urban areas, eg. tenure and use rights, need for survey and title (deed) registration development approval, development control, environmental requirements, etc, that are mandatory before any structural developments (e.g building constructions) are officially permitted by the respective local authorities ?

(b). If you did not follow the necessary official procedures (and why) then, are you aware that your property and developments are illegally and officially insecure and at risk?

(c). Given the opportunity, would you like (and how) to be enlightened on the above official processes, and hence to be effectively involved and participate, as part and parcel, in the spatial and socio-economic development management and governance agenda of Mlolongo Township ?

3. In view of the rapid growth and haphazard development of Mlolongo Township as an unplanned informal settlement;

Question:

What are your views and comments on the failure and / or needs by the local authority (and government in general) in addressing the various land related and other socio-economic development issues of concern affecting the community settlement?

APPENDIX IB: LIST OF KEY INTERVIEW CANDIDATES

The following are some of the key questionnaire interview candidates;

1. Government and Local Authority Officers Interviewed

Reuben M. Murugu: Senior Assist Director of Surveys, Ministry of Lands.

David Mashinde: Deputy Director of Physical Planning, Ministry of Lands.

James M. Maina: Deputy Director of Planning, City Council of Nairobi.

John K. Bareh: Assist Director of Planning (Research)- City Council of Nairobi.

Peter M. Mbui: District Physical Planner, Machakos District.

John K. Kariuki: Surveyor, Mavoko Municipality , Machakos District.

John Mugambi: Engineer / Planner (Ag), Mavoko Municipality, Machakos District.

2. Land Experts and Professionals Interviewed

Prof. M. Syaga: Professor, Land Economics and Management, University of Nairobi.

Dr. Tom Konyimbih: Senior Lecturer, Real Estate & Construction Management, University of Nairobi.

Dr. Robert Rukwaro: Senior Lecturer, Real Estate & Construction Management, University of Nairobi.

Dr. Isaack Karanja: Senior Lecturer, Urban and Regional Planning, University of Nairobi.

Dr. Faith Karanja: Lecturer, Geospatial and Space Technology, University of Nairobi.

Mr. David Nyika: Senior Lecturer, Geospatial and Space Technology, University of Nairobi.

Mr. Ibrahim Mwathane: Principal Landscape Surveyors / Former Chairman, Institution of Surveyors of Kenya (ISK).

Mr. Silas .Muriithi: Principal- Two EMS Associates Ltd., Nairobi.

3. Residents and Leaders of Mlolongo Interviewed

Fifty Five(55) Local Residents: Land owners and tenants of Mlolongo Settlement

Five (5) Local Leaders: Local Area Chief, Assistant Chief, Councilor and other two opinion leaders of Mlolongo Settlement.

APPENDIX II: SUPPORTIVE DATA AND MATERIALS

The following are some of the raw supportive data and materials as gathered from various government and private offices variously referred to in the research. Note that no attempt was made to refine and / or amend the same so as to reflect the actual nature and *status quo* of the existing data, hence the poor illegibility.

1. Price List of Maps and Plans Data Available at Survey of Kenya in 2006

SURVEY OF KENYA PRICE LIST

TOPOGRAPHICAL MAPS

		Kshs
1:50, 000	Kenya (Y 731)	400/-
1:50, 000	Kenya (SK 61)	400/-
1:100,000	Kenya (Y633)	400/-
1:250,000	East Africa (Y503)	500/-
1:250,000	East Africa (SK 60)	400/-
1:1,000,000	World Series 1301	400/-
1:2,500,000	East Africa (SK 80)	400/-

SPECIAL MAPS

1:3,000,000	and other Scales National Atlas of Kenya	7500/-
1:4,000,000	East Africa (SK 53)	400/-
1:3,000,000	Kenya Physical & General (SK10)	400/-
1:2,000,000	Mean Annual Rainfall of East Africa 2 Sheets	300/-
1:2,000,000	Rainfall Probability Maps	300/-
1:2,000,000	Monthly Rainfall Map of East Africa 2 Sheets	300/-
1:1,750,000	Tourist Map of Kenya (SK 83)	500/-
1:1,000,000	Kenya Route Map (SK 81)	700/-
1:1,000,000	Kenya Route (SK81B)	500/-
1:1,000,000	(SK 81C, SK 81D & SK 81E)	500/-
1:1,000,000	Population 2 Sheets (per set of two)	500/-
1:1,000,000	Kenya Administrative Boundaries overprint (SK 81A)	500/-
1:250,000	Kenya Coast (SK 79)	400/-
1:250,000	Kenya Vegetation Map (D O S) (LR3006)	400/-
1:250,000	Tsavo West National Park (SK 78)	400/-
1:100,000	Nairobi and Environs (SK58)	400/-
1:100,000	Moru National Park (SK65)	400/-
1:100,000	Mount Kilimanjaro (D O.S 522)	400/-
1:100,000	Nairobi & Machakos Soil Survey (D O S (LU) 3014)	400/-
1:125,000	Mt. Kenya National Park and Environs (D O S 2657)	400/-
1:250,000	Tsavo East National Park (SK82)	400/-
1:100,000	Marsabit National Park (SK 84)	400/-
1:25,000	Nairobi National Park (SK71)	400/-
1:50,000	Samburu & Buffalo Springs Game Reserve (SK85)	400/-
1:50,000	Amboseli National Park (SK87)	400/-
1:25,000	Mount Kenya (SK75)	400/-
1:40,000	Shimba Hills National Reserve (SK93)	400/-

CADASTRAL MAPS *(Dyeline Print)*

	Kshs
1:10,000 Nairobi (SK 7) (3 sheets)	400/-
1:10,000 Eldoret (SK 6)	400/-
1:10,000 Nakuru (SK 16)	400/-
1:10,000 Kitale (SK 17)	400/-
1:10,000 Kisumu (SK 18)	400/-
1:10,000 Mombasa, Malindi (Sk 21)	400/-
1:25,000 Nairobi & Environs (SK 20)	400/-
10,000 Settlement Schemes Areas (SK21 Dyeline Prints)	150/
1:50,000 Settled Areas(SK49)	400/-

PHOTOSTAT PRINTS

Monochrome Fascimile per print	
(A4 size)	10/-
(A3 size)	20/-
Search Fees	200/-
Certified true copy of Deed Plan	2000/-

DYELINE PRINTS (e.g P.I.D, R.I.M)

i) Up to A1	100/
Up to A	150/-
ii) Machine Plots (standard size 80x 120 cm)	1000/-
iii) Miscellaneous Plans per 100sqcm. on medium paper(minimum sh 100/-)	100/
iv) Prints of Survey Plans (cadastral)	
Survey Plan Form 1	50/-
Survey Plan Form 2	100/-
Survey Plan Form 3 & 4	150/-
Plus search fee(for each case above)	200/-

AERIAL PHOTOGRAPHS Shs

Contact Prints	500/-

POSTAGE AND PACKING (By Surface mail)

Delivery within Kenya to other addresses the charges are approximately :-	KShs
Not over 20gms	36/
Not over 500gms	80/
Kenya Atlas (within Kenya)	100/-
Kenya Atlas (international)	400/-

SURVEY OF KENYA PRICE LIST -(COnt.) Kshs.

SPECIAL MAPS

1: 150.000	Aberdare & Lake Nakuru National Reserve (D.O.S 2797)	500/-
1: 1,000,000	Kenya Territorial Sea and Economic Zone (SK 90)	500/-
1:1.000.000	Kenya Bouguer Gravity Anomaly Map (SK 81 G)	500/-
1: 250, 000	Lake Basin Development Authority (SK 104)	400/-
1: 100,000	Maasai Mara Game Reserve (SK 86)	400/-
1: 1,000,000	Kenya Provinces & District Map (SK 81 H)	500/-
1: 40,000	Mount Elgon National Park (SK 94)	400/-
1:1,000,000	Kenya Geodetic Control Network (SK 93)	500/-
1:50,000	Vegetation & present Land use Map	400/-
1:50,000	Landform slopes & Drainage Map	400/-
1:100,000	Suitability map for Rainfed Agriculture	400/-
1:100,000	Suitability Map for irrigated Agriculture	400/-
1:100,000	Evaluation Map of Hazard of soil Erosion	400/-
1:50,000	Surface Geology and Soil Map	400/-
1:100,000	Land form Drainage Map	400/-
1:100,000	Potential Suitability Map for Ranching	400/-
1:100,000	Current suitability Map for Ranching	400/-
1: 100,000	Landform Drainage Map for Ranching	400/-
1:1,500,000	Kenya Birds Shooting blocks SK 83	400/-
1: 1,500,000	Kenya Population Density Map (1979 Census) SK115	400/-
1:1,000,000	Kenya Physical and General SK 57	400/-
1:1,000,000	Parliamentary Constituencies SK 81C	400/-
1:1,000,000	Kenya Map of Wildlife Management SK 81A	400/-
1:1,000,000	2931 Kilimanjaro 1 CAO chart SK 76	400/-
1:1,000,000	2910 Lake Turkana 1 CAO chart SK 76	400/-
1:1,000,000	Kenya hunting Map SK 81B	400/-
1:500,000	Kerio Valley Development Authority Map (North and South sheets) SK 110	400/-
1:50,000	Nairobi Area Parliamentary Constituencies SK 52A	400/-
1:50,000	Mombasa & District Parliamentary Constituencies SK 68A	400/-
1:50,000	Vegetation Map of Aberdares National Park SK 121	400/-
1:25,000	Vegetation Map of Mt. Kenya SK 115	400/-
1:5,000	Glaciers of Mt. Kenya SK 120	400/-
1:30,000	LAKE NAKURU NATIONAL PARK	400/-
1:25,000	Hell s Gate National Park	400/-
1:25,000	Nakuru Municipality Land use Map	400/-

	SURVEY OF KENYA PRICE LIST -(cntd.)	KShs.
1:2,000,000	Integrated A.T.C Radar Coverage & Airspace Organisation	400/-
1:10,000,000	O.A.U - Geographical Distribution of Animal Disease	400/-
1:10,000,000	O.A.U Cattle Distribution Map	400/-
1:10,000,000	O.A.U Goats Distribution Map	400/-
1:10,000,000	O.A.U-Sheep Distribution Map	400/-
1:250,000	Instruments Approach Charts for J.K.I.A Nairobi VOR/DME, RWY06	400/-
1:250,000	Moi International Airport Mombasa VOR/LO MC RWY 21	400/-

TOWNSHIP MAPS AND PLANS

1:20,000	City of Nairrobi (SK 46)	500/-
1:14,000	Mombasa Island and Environs (SK 54)	400/-
1:10,000	City of Nairobi (SK 88)	400/-
1:5,000	Nairobi & District (SK 13 and SK 14)	400/-
1:10,000	Town Maps (SK 92,96,97,98 & 100)	400/-
1:50,000	Nairobi Area (SK 52 & SK 52A)	400/-
1:50,000	Mombasa Area (SK 68 & 68A)	400/-
1:2,500	Town Maps (SK 27,28,29,30,33,36A,40 44,&70)	400/-
1:5,000	Town Maps (SK24,25,31,32,,38,59,66,67,89,99, &103)	400/-
1:10,000	Nairobi (SK 7)	400/-
1:10,000	Eldoret (SK6)	400/-
1:10,000	Nakuru (SK 16)	400/-
1:10,000	Kitale (SK 17)	400/-
1:10,000	Kisumu (SK 18)	400/-
1:25,000	Nairobi & Environs (SK 20)	400/-
1:10,000	Mombasa, Malindi (SK 21)	400/-

Source: SOK Maps Catalogue, (2006)

2. Price List of Satellite Data Available at Regional Centre for Mapping of Resources for Development (RCMRD) as at November 2006

4. Landsat Imagery (Landsat MSS, Landsat TM/ETM+SLC Off & SRTM)

Product Type\Option	USGS ACQUISITIONS*	RCMRD ARCHIVE
Landsat Multi-Spectral Scanner (Landsat MSS) **1972-1992**	$200.00 / Scene	$30.00 / Scene Raw Imagery**
Landsat Thematic Mapper (Landsat TM) **1982-present in some areas**	$425.00 / Scene	$30.00 / Scene Raw Imagery**
Landsat Enhanced Thematic Mapper + (Landsat ETM+) **1999 - May 2003**	$600.00 / Scene	$30.00 / Scene Raw Imagery**
Landsat Enhanced Thematic Mapper Plus Scan Line Corrector Off (Landsat ETM+ SLC Off) **May 2003-present**	$300.00 / Scene	$30.00 / Scene Raw Imagery**
Shuttle Radar Topographic Mission **SRTM – February 2000**		$50.00 / Africa Scene Raw Imagery**

** All USGS acquisitions attract a further 25.00$ shipping and handling fee.*
*** Processing to Composite [FCC/TCC] attracts a further $50.00 fee and $75.00 for Pan-Sharpening.*

5. Large Format Printing and Scanning

Large Format Size	Full Colour Plots on Photo-Gloss	Full Colour Plots on ½ Photo-Gloss	Full Colour Plots on Matte Paper	Large Format Scanning
A0 – 42"	$45.00	$35.00	$30.00	$10.00
A1	$35.00	$25.00	$20.00	
A2	$25.00	$18.00	$15.00	$5.00
A3/A4	$10.00	$10.00		$1.00 / $0.25

Payment: Payment terms are 100% prior to processing of an order i.e. receipt of funds in RCMRD account or clearance of cheque or money transfer.

Delivery: **1.** For Archive Acquisition – 2 to 3 weeks minimum
2. For new acquisition/tasking/programming – 4 to 5 weeks minimum
Note: *Up to 20% cloud cover over 'area of interest' may exist and is acceptable. Further, tasking is carried out depending on prevailing weather conditions; after five attempts, the client can decide to withdraw order with full refund.*

Should you require any clarifications related to specifications in this document, do not hesitate to contact RCMRD: -
Tel: ***+254 20 8560227/1775/0265*** *or Mobile* ***+254 723-786161 / 735-981098***
Email: ***remotesensing@rcmrd.org*** */*
Visit Website: ***www.rcmrd.org*** *&* ***www.rcmrd.org/geonetwork***

Source; RCMRD, (2006)

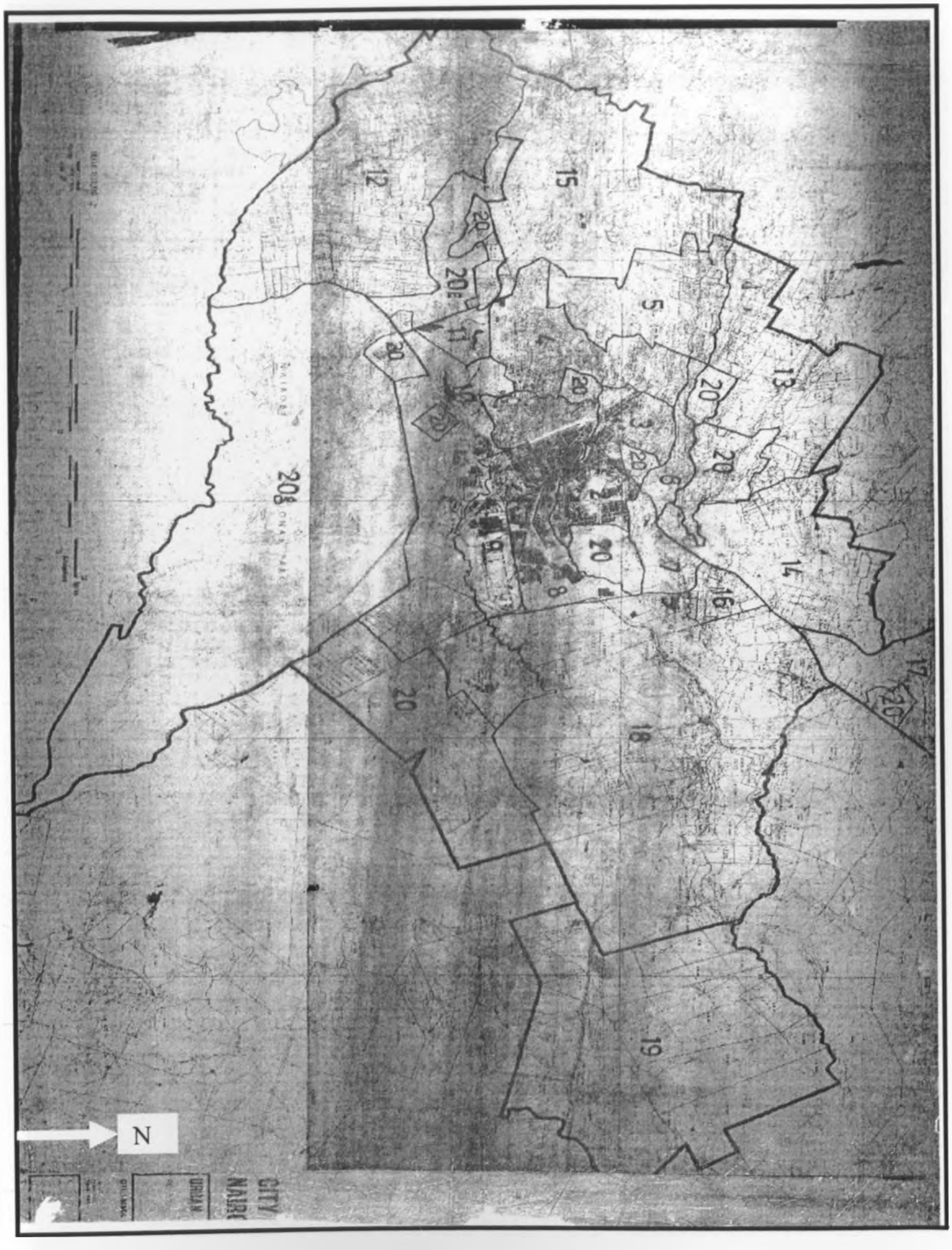
3. The 1979, 1989 and 1999 Population Census Results of Nairobi and other Provinces

KENYA POPULATION CENSUSES, 1979, 1989 and 1999
Population Size by Province and District,1979, 1989, 1999

Province/District	1979 Population Census (000's)	1989 Population Census (000's)	1999 Population Census (000's)			
			Males	Females	Total	Sex Ratio
Nairobi	828	1,325	1,150	987	2,137	117
Kilifi **	431	592	263	292	555	90
Kwale	288	383	241	256	497	94
Lamu	42	57	38	35	73	109
Mombasa	341	462	354	299	653	118
Taita Taveta	148	207	124	124	248	100
Tana River	92	128	92	91	183	101
Malindi ****			139	143	282	97
Coast Province	1,342	1,829	1,251	1,240	2,491	101
Garissa	129	125	205	185	390	111
Mandera	106	124	131	119	250	110
Wajir	139	123	172	149	321	115
N/Eastern Province	374	372	508	453	961	112
Embu	263	370	136	141	277	96
Isiolo	43	70	51	50	101	102
Kitui**	464	653	243	274	517	89
Mwingi***			141	162	303	87
Machakos**	1,023	1,402	446	469	915	95
Makueni***			370	397	767	93
Marsabit**	96	129	61	61	122	100
Moyale***			27	27	54	100
Meru*	830	1,145				
Mbeere***			83	90	173	92
Meru Central***			248	252	500	98
Meru North***			295	313	608	94
Tharaka***			48	53	101	91
Nithi***			100	105	205	95
Eastern Province	2,719	3,769	2,249	2,394	4,643	94
Kiambu**	686	914	366	376	742	97
Thika***			324	323	647	100
Kirinyaga**	291	392	225	230	455	98
Murang'a**	648	858	166	185	351	90
Maragwa***			187	202	389	93
Nyandarua**	233	345	227	239	466	95
Nyeri	486	607	316	339	655	93
Central Province	2,344	3,116	1,811	1,894	3,705	96
Baringo**	204	348	130	135	265	96
Koibatek***			69	69	138	100
Elgeyo Marakwet*	149	216				
Keiyo***			70	72	142	97
Marakwet***			69	72	141	96
Kajiado	149	259	205	200	405	103
Kericho**	633	901	240	232	472	103
Bomet***			186	198	384	94

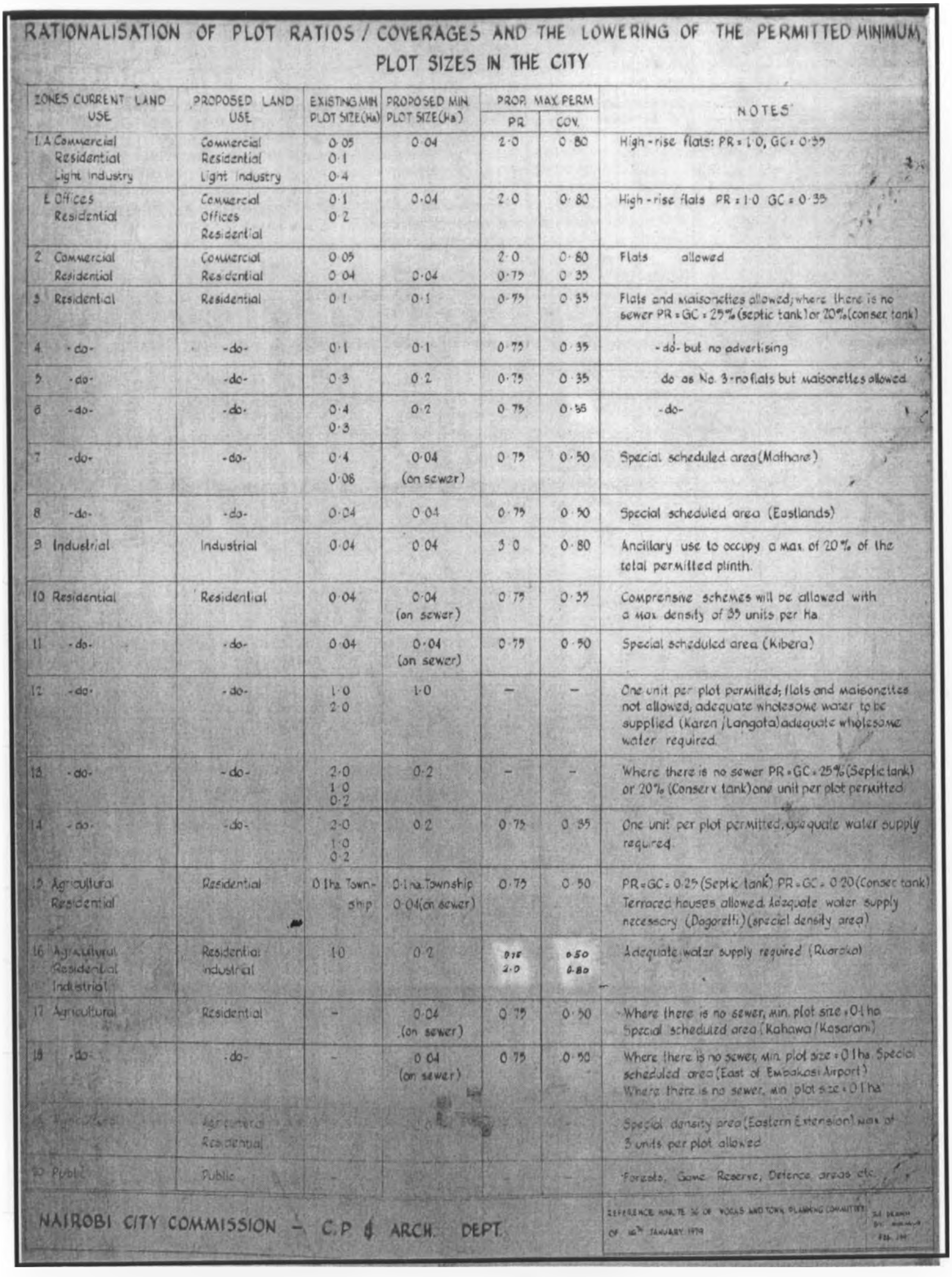
Source; Kenya Rep., (2005)

4. Official Boundary Limits and Land Use Zones for Nairobi City as per the 1948 Colonial Structural Development Plan (also adopted at Independence, 1963)



Source: City Hall, (2006)

5. Land Use Zones for Nairobi City as at 1948 and 1963



RATIONALISATION OF PLOT RATIOS / COVERAGES AND THE LOWERING OF THE PERMITTED MINIMUM PLOT SIZES IN THE CITY

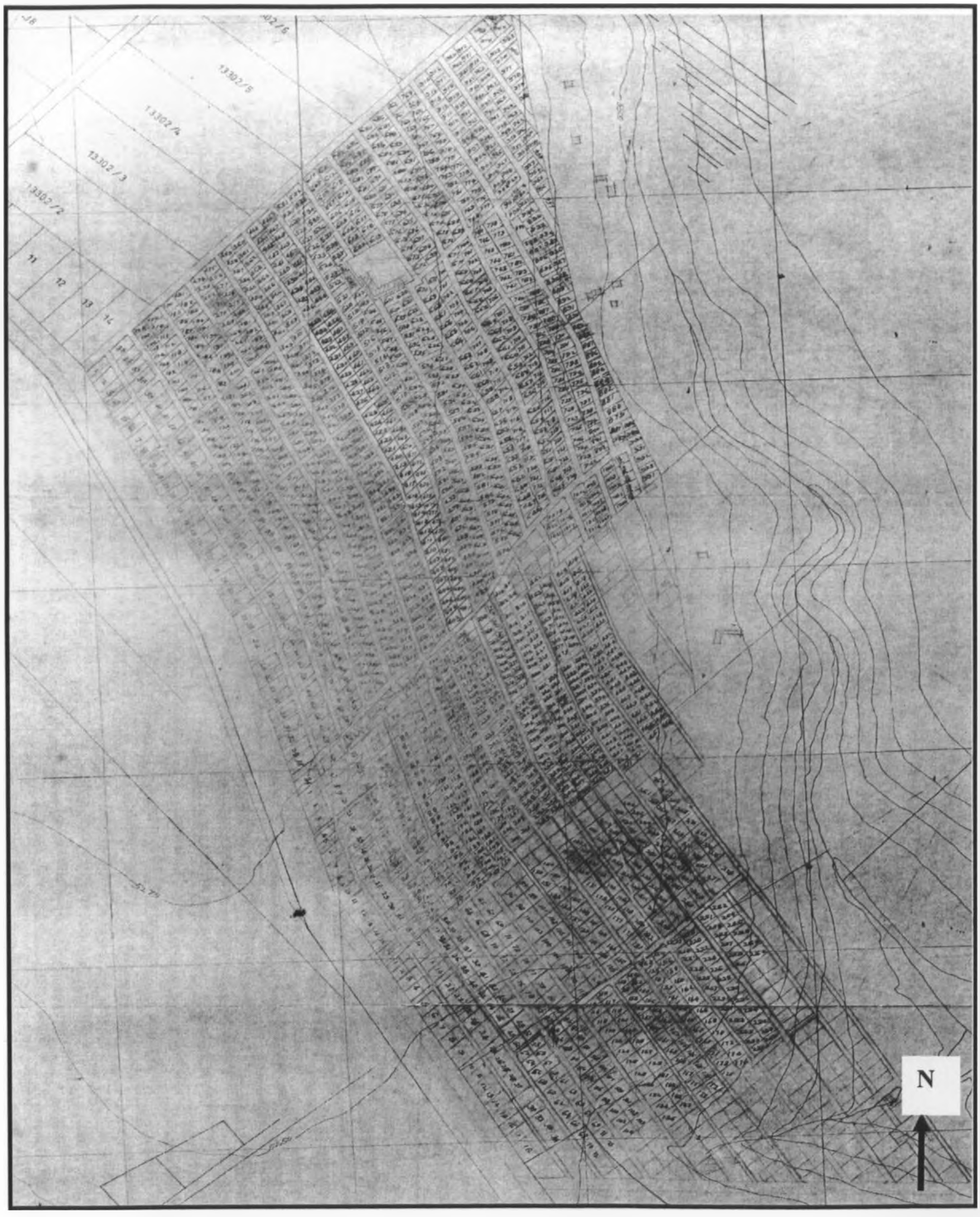
ZONES CURRENT LAND USE	PROPOSED LAND USE	EXISTING MIN PLOT SIZE(Ha)	PROPOSED MIN PLOT SIZE(Ha)	PROP. MAX. PERM. PR	PROP. MAX. PERM. COV.	NOTES
1. A Commercial Residential Light Industry	Commercial Residential Light Industry	0·05 0·1 0·4	0·04	2·0	0·80	High-rise flats: PR = 1·0, GC = 0·35
E Offices Residential	Commercial Offices Residential	0·1 0·2	0·04	2·0	0·80	High-rise flats PR = 1·0 GC = 0·35
2 Commercial Residential	Commercial Residential	0·05 0·04	0·04	2·0 0·75	0·80 0·35	Flats allowed
3 Residential	Residential	0·1	0·1	0·75	0·35	Flats and maisonettes allowed; where there is no sewer PR = GC = 25% (septic tank) or 20% (conser. tank)
4 -do-	-do-	0·1	0·1	0·75	0·35	-do- but no advertising
5 -do-	-do-	0·3	0·2	0·75	0·35	do as No. 3 - no flats but maisonettes allowed
6 -do-	-do-	0·4 0·3	0·2	0·75	0·35	-do-
7 -do-	-do-	0·4 0·08	0·04 (on sewer)	0·75	0·50	Special scheduled area (Mathare)
8 -do-	-do-	0·04	0·04	0·75	0·50	Special scheduled area (Eastlands)
9 Industrial	Industrial	0·04	0·04	3·0	0·80	Ancillary use to occupy a max. of 20% of the total permitted plinth.
10 Residential	Residential	0·04	0·04 (on sewer)	0·75	0·35	Comprensive schemes will be allowed with a max. density of 35 units per Ha.
11 -do-	-do-	0·04	0·04 (on sewer)	0·75	0·50	Special scheduled area (Kibera)
12 -do-	-do-	1·0 2·0	1·0	—	—	One unit per plot permitted; flats and maisonettes not allowed; adequate wholesome water to be supplied (Karen / Langata) adequate wholesome water required.
13 -do-	-do-	2·0 1·0 0·2	0·2	—	—	Where there is no sewer PR = GC = 25% (Septic tank) or 20% (Conserv. tank) one unit per plot permitted
14 -do-	-do-	2·0 1·0 0·2	0·2	0·75	0·35	One unit per plot permitted, adequate water supply required
15 Agricultural Residential	Residential	0·1 ha. Township	0·1 ha. Township 0·04 (on sewer)	0·75	0·50	PR = GC = 0·25 (Septic tank) PR = GC = 0·20 (Conser. tank) Terraced houses allowed. Adequate water supply necessary (Dagoretti) (special density area)
16 Agricultural Residential Industrial	Residential Industrial	1·0	0·2	0·75 2·0	0·50 0·80	Adequate water supply required (Ruaraka)
17 Agricultural	Residential	—	0·04 (on sewer)	0·75	0·50	Where there is no sewer, min. plot size = 0·1 ha. Special scheduled area (Kahawa / Kasarani)
18 -do-	-do-	—	0·04 (on sewer)	0·75	0·50	Where there is no sewer, min. plot size = 0·1 ha. Special scheduled area (East of Embakasi Airport) Where there is no sewer, min. plot size = 0·1 ha.
[illegible]	Agricultural Residential					Special density area (Eastern Extension) max. of 5 units per plot allowed
20 Public	Public	—	—	—	—	Forests, Game Reserve, Defence areas etc.

NAIROBI CITY COMMISSION – C.P & ARCH. DEPT.

REFERENCE MINUTE 36 OF ROADS AND TOWN PLANNING COMMITTEE OF 16TH JANUARY 1979

Source: City Hall, (2006)

6. Draft Development Plan for Mlolongo Township Prepared by the Machakos District Physical Planner (2005)



Source; Machakos District Physical Planning Office, (2006)