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Potential of Digital Geoinfotechs in Planning Urban Community Settlements: The Case Study of Mlolongo Settlement, Nairobi – Kenya

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Abstract: ***This research paper attempts to explore the potential of modern digital Geoinformation technologies (GITs) as alternative tools for spatial mapping, planning and management is compared against the hitherto used cadastral – based approaches in Keny, and Nairobi City settlements in particular. Using a case study of Mlolongo Township, a typical peri-urban settlement of Nairobi, the potential of GITs is empirically investigated in terms of cost-effectiveness, efficiency, accuracy and applicability in rapid spatial development milieu. The research findings demonstrated that modern GITs; namely; Remote Sensing (RS), Geographic Information Systems (GIS), and Global Positioning Systems(GPS) can offer the much needed alternative tools for comprehensive mapping and development planning for the rapidly growing urban settlements in Kenya. The research indicates that, if properly harnessed, use of GITs can go along way in addressing and mitigating the current spatial urban development crisis currently facing the country today.***

Keywords: Land use / Land tenure**;** Informal settlements; Land titling/registration; Land use management**;** Land use planning; Peri-urban settlements **;** Urbanization Syndrome; Mitigation**;** Geo-Information Technologies (GITs)**;RS; GPS; GIS;** Geo-Data/Information**;** Spatial Planning/Mapping; Cadastral; Conventional geo-data systems.

1. Introduction

1.1. Introductory Background

Availability of reliable and comprehensive geo-data/information is critical for any meaningful spatial planning and development management, especially in rapid development milieu . Unfortunately, however the traditionally used geo-data sources and acquisition systems, and the conventionally used planning approaches, are progressively getting limited in addressing the challenges posed by the dramatic urbanization *syndrome* trends currently taking place in most third world countries like Kenya.

Fortunately now, the rapidly advancing digital geo-information technologies (GITS), are currently gaining popularity as alternative sources of comprehensive, up-to -date and reliable sources of geo-spatial data in almost all fields. These modern geo-systems now offer unprecedented opportunities to planners, surveyors, land economists, and other professionals concerned with land based resource development planning and management, never than before. These geo-info systems include: Remote Sensing (RS), Global Positioning Systems (GPS), Geographic Information Systems (GIS), and the Internet based geo-data communication systems.

This paper therefore, attempts to briefly investigate the potential of the above digital systems (GITs), against the hitherto used conventional, mostly cadastral-based geo-data provision systems and planning approaches as alternative tools in addressing the current urban development crisis in Kenya in general, and Nairobi urban settlements in particular. A case study of Mlolongo Settlement, a typical peri-urban settlement of Nairobi, is used to empirically test the potential of GITs in terms of cost-effectiveness, efficiency, accuracy and applicability in rapid spatial development milieu.

2. Conventional vs Gits Based Planning Approaches

A earlier noted above, evidently the hitherto used conventional cadastral-based data acquisition techniques and planning approaches are increasingly becoming limited in addressing the planning spatial and management challenges posed by the current *urbanization syndrome* trends that are found in many developing countries such as Kenya. Hence the need for alternative approaches, now offered by the emerging digital geo-info technologies, for efficient spatial development mapping, planning and management cannot be overemphasized.

2.1. Cadastral-Based Mapping / Planning Model Used in Kenya

Planning and mapping processes in Kenya are strictly governed by both the Planning and Survey Acts of Parliament. The statutes generally involve lengthy and complex official procedures and technical requirements that in most of the cases impend efficient and effective spatial mapping and planning in the country, not only in urban areas, but also in the rural settings as well. For instance, development plans preparation and surveying requirements, e.g. for a given proposed development project are subjected to unnecessary regulatory stages, processes and scrutiny before official registration and approval by the government.

2.2. Alternative Modern GITs-Based Model Proposal

Conceptually, it has been elucidated that modern GITs-based geo-systems can offer viable mapping / planning alternatives to the conventional approaches hitherto used. Figure 2.2. briefly outlines the basic stages that would be involved in a modern GITs-based model. Basically, the process entails the use of remotely sensed data (high resolution geo-referenced satellite imageries), GPS and GIS geo-data sources mapping and development plans preparation and production. Note that

the approach would greatly minimizes the lengthy stages and bureaucratically cumbersome processes as involved the former model, if well adopted.

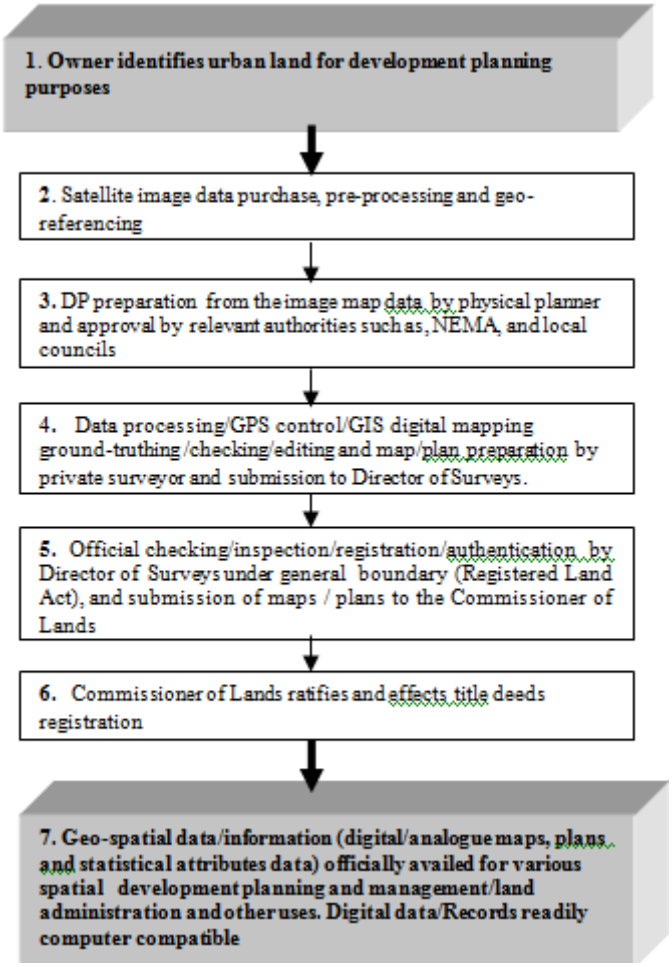

Figure 2.2: Alternative Modern GITs-based Mapping / Planning Model

3. The Case Study of Mlolongo Settlement

3.1. Study Area Definition and Location

For the purposes of detailed and analytical investigations on spatial planning and management needs and requirements for peri-urban settlements of Nairobi City, Mllolongo Township, a satellite settlement of Nairobi, was selected as a sample case study area. 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, and Machakos District in Eastern Province of Kenya. The township is located in the south- eastern "*armpit*" of Nairobi City boundary as shown in Figs. 3.3.

Figure 3.3: Location of Mlolongo Township within Machakos District
Source: After Omondi, 2003

3.2. Spatial Planning and Development Needs and Requirements

In terms of physical location, Mlolongo Township enjoys a strategic physical location as a satellite settlement of a major city, the Nairobi of City. However, despite its advantageous location, the township is rapidly growing (spatially and socio-economically), into an amorphous *slum* without any formal development planning guidelines. Most essential infrastructural services, amenities and facilities for the astronomically increasing population are seriously wanting.

For example, due to lack of formal planning the existing accesses roads are substandard, majority of them being too narrow (less than 3m in width), without formal lay out and / or pattern, leaving no way-leave reserves for other essential infrastructural services such as drainages, sewage lines, water and electricity service lines. The majority of the accesses are un-motorable, filthy, and littered with uncollected garbage. Needless to say the situation would be catastrophically a rescue nightmare in case of fire and / or other health and live threatening calamities.

The poor quality of housing standards in Mlolongo is a direct indicator of lack of proper planning, development control. For instance, the settlement is generally typified by 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 .
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 . 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.

The above scenario is typical of many other peri-urban settlements of Nairobi City, and by extension other urban areas of the country that now calls for urgent spatial development planning and management interventions.

4. Conventional Vs Gits-Based Techniques: A Comparative Empirical Systems Analysis

Evidently, the sorry state of spatial development planning and management situation, as portrayed in Mlolongo settlement, and by extension, other similar rapidly growing areas in Nairobi and the country in general, can be largely attributed to the weaknesses, inadequacies and inefficiencies of the existing conventional mapping and planning techniques and approaches.

As earlier elucidated elsewhere, cadastral-based approaches have been proven to be too expensive, slow and bureaucratically cumbersome in addressing spatial development needs and challenges posed by the astronomic urbanization growth trends in Kenya, as exemplified by the Mlolongo case study.

Therefore in search of alternative intervention measures, the potential of modern digital Geoinfotechs (GITS) are empirically and analytically tested against the conventionally used geo-systems. The investigation is based on a field study carried out by the author in 2009 at Mllolongo Township as a sample case study site. The results and findings of the study are summarized here below.

The following three (3) criteria were used as basis for the investigation and comparative empirical analysis of the two geo-systems in order to practically demonstrate the potential of modern GITs-based techniques as viable tools for efficient spatial mapping and planning in rapid urban development milieu:

- Cost-effectiveness and affordability,
- Accuracy standards and acceptability,
- Potential for rapid mapping and planning,

4.1 Cost-effectiveness and Affordability

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 that are outlined earlier. The analysis was mainly based on data and information such as official fees and records gathered from Ministry of Lands and Mavoko County Council, mapping agencies. Table 4.1. provides estimated monetary and time values of cadastral-based process . For illustration purposes, the simulative analysis was based on a typical unplanned peri-urban satellite settlement such as Mlolongo Township, comprising about 1000 unit plots.

Table 4.1: 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**

From **Tables 4.1** the estimated monetary and time costs are derived;
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 %

Based on the above results, therefore, it can be seen that, modern GITs-based process would be about 10 times cheaper and about 14 times shorter in duration than conventional cadastral-based process.

4.2. Accuracy Acceptability

As earlier mentioned it is to be noted that cadastral-derived data is however, more accurate than modern GITs (RS, GPS and GIS) derived data, hence more useful for precision urban mapping and planning. Cadastral-based techniques therefore remain necessary where detailed planning/mapping, boundary re-establishment and dispute resolution in urban centres and other formerly cadastral surveyed areas. Consequently, both conventional and modern geo-techniques will continue playing complimentary roles for the foreseeable future for what is termed as modern approaches, without lessening the importance of the drive towards increased use digital geo-techniques.

Theoretical investigations indicate that, data obtained through modern GITs, though of relatively less accurate level, offer the advantages of rapid, uptodate and comprehensive data sources. To practically support theoretical findings, an experiment was carried out to test the accuracy level and acceptability of GITs- derived data for planning purposes.
For the purposes of experimentation , a raw QuickBird satellite image of about 0.6m resolution, was used for field distance measurements between selected 6 points at different terrain levels as shown in Figs. 4.4 below The measurements were then compared with coordinates distances between the same points as derived from a cadastral map of the area

(presumed to be more accurate). The process was carried out both manually and digitally (using computer). GIS techniques were then used to prepare a model plan for the site area (Mlolongo) from the image data at a scale of 1:2500

Save the detailed field experimentation, it was practically proved that GITs derived data and mapping process is practically feasible at acceptable accuracies about +/- 0.5 meter on relatively flat terrains, which good enough for various urban planning purposes at common scales of 1:2500 and below. Note that the new satellite imaging systems are currently providing data at resolutions of between 0.2 and 0.5 meters, hence providing better opportunities for mapping planning activities.

In order to test the accuracy of a hand held-GPS, the GPS coordinates of the 6 points were taken (3 times) and compared with their cadastral coordinates. It was found that when carefully used a simple hand-held GPS e.g, ***Gamin***, can rapidly provide coordinates measurements at accuracies of between +/- 2.0 to 5.0 metres which is good enough for rapid spatial mapping and planning at scales of 1:10,000 and below, common required for both urban and rural planning activities.

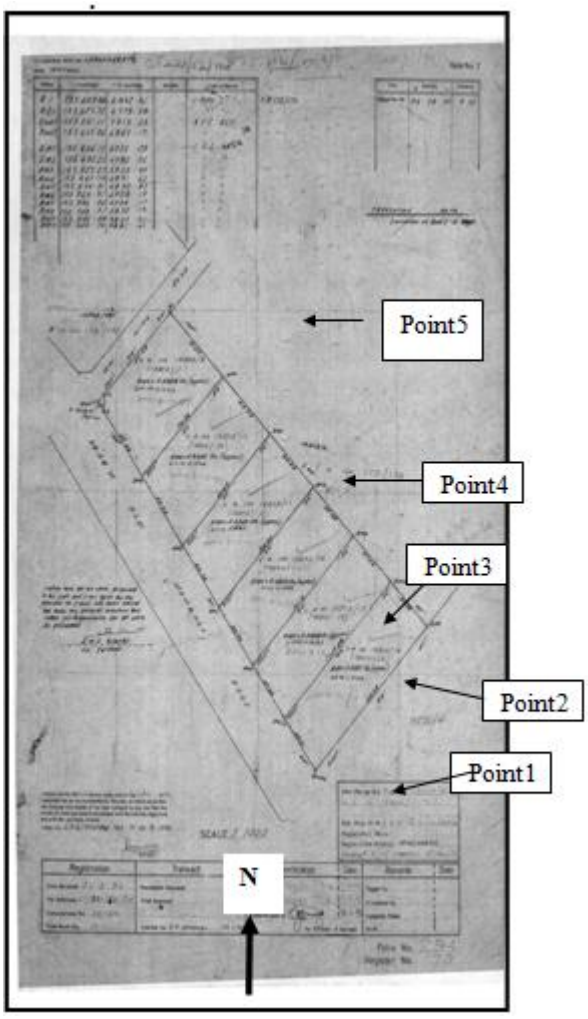

Figure 4.4: Selected Five Coordinate Points on a Cadastral Map of the Study Area
Source; SOK, (2006) Scale: 1: 1000

4.3. Potential for rapid mapping and planning urban developments,

To practically demonstrate the potential of modern GITs for rapid mapping/planning unplanned settlements, a model plan for Mlolongo Township was prepared using GITs techniques. The main aim of the exercise was to investigate their efficiency in mapping and planning unplanned urban settlements such as Mlolongo.

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 digital image land-use map of the study area . The map generally identifies the various categories of land use types, such as residential commercial and industrial developments.
2. Using a hand-held GPS set and existing topo-cadastral maps of the area, perimeter 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 and produce the model development (prototype) plan for Mlolongo Township .

Note that Mlolongo Town has no official development plan, and majority of plots lacks legal title deeds. Hence the above approach can be easily used by the Mavoko Municipality to replan and regularize land use and tenure registration, and quickly prepare a comprehensive structural development plan for the township.

Note that the model purposely ignored some of the existing haphazard developments so as to create space for missing facilities such as schools, health centres, play grounds and other infrastructure services in a well organized manner. 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 **,** the actual process would have cost not more than one million Kenya Shillings (Approx. US$. 12,500) and taken about two months to complete.

5. Conclusions and Recommendations

The findings from the above investigation therefore candidly indicate that, if and when properly embraced GITs-based approach effectively provide viable alternative for efficient mapping, planning / re-planning, land-use and tenure management for the numerous unplanned settlements in Nairobi and other urban areas in the country.

Hence it is highly recommended that there is urgent need for official acceptance and adoption and use of the rapidly advancing digital geo-technologies (GITs), namely; Remote Sensing (RS), Global Positioning Systems (GPS), Geographic Information Systems (GIS) and the Internet as alternative tools, so as to meet the current spatial mapping,

development planning and management demands in Kenya today, both national and county levels.

Therefore, when properly embraced GITs-based mapping/planning models can effectively provide viable alternatives for efficient mapping/planning/re-planning, and regularization of land-use and tenure for the numerous unplanned settlements in Nairobi and other urban areas in the country. Mlolongo Township may by all means, be considered as a typical informal settlement that urgently needs such alternative interventions since it lacks the necessary local zone and structural development plan (s) despite its rapid spatial growth within the vicinity of Central Nairobi.

Note: The paper is based on actual real case research study carried out by the author for his PhD Degree Programme in 2010, at the University of Nairobi, Kenya.

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