Technology and Governance: Enhancing Participation Using Geographical Information Tools (GIS) in Low Income Settlements

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Abstract

This paper explores how the integration of technology based tools (Geographic Information Systems and Remote Sensing) in settlement mapping and subsequent upgrading using has impacted on planning processes particularly with regards to community participation in Kenyan context. Upgrading programmes are designed to address the existing poor infrastructure conditions or lack of secure tenure usually associated with informal settlements. Planning processes have adopted inclusive approaches which are geared towards getting all actors including the resident communities, involved in decision making and planning for interventions. GIS tools offer a platform for integration of spatial and non spatial data as well as visualisation of the settlements. The capabilities offered by these tools have enabled communities to participate especially in the planning and management of new infrastructure as well as settlement upgrading. As development-related decision-making invariably has an explicit spatial context or component, a part of the information processing and exchange will be spatial or geographic information. Participation in development issues therefore involves at least a component of spatial information. The paper examines the context and implication of technology adoption within planning at settlement level within low income settlements of Kenya.

Keywords: GIS, informal settlements, participation
1. Introduction

Information regarding attributes of human settlement is important for decision makers at all levels of planning, as they have to grapple with dynamic environments often associated with settlements. At the local level, it is particularly important for both communities and urban managers to have accurate and reliable information regarding all planning attributes. The use of GIS tools in settlement mapping and upgrading provides a platform for integration of spatial and non-spatial data necessary for planning and decision making. The capabilities offered by these tools such as visualisation have enabled communities to participate in settlement planning and upgrading including the management of new infrastructure.

Information and communication technologies (ICTs) including GIS and remote sensing, are regarded as one way to support integration of local knowledge and scientific information and to support spatial planning (Freitas and Tagliani, 2009; Kyem, 2004). GIS has the capabilities to manage large spatial datasets, while the integrated spatial analysis tools allow decision makers to make more informed decisions with the development of multiple scenarios (Isaak and Hubert, 1997).

Settlement upgrading work carried out in New Rest settlement, Cape Town, South Africa demonstrated how spatial information and GIS was valuable and could be applied in settlement upgrading. In this case spatial data related to the shacks (structures), their occupants and physical conditions was analysed within a GIS environment. A settlement database linking structures, infrastructure and demographic characteristics was developed and used to generate spatial models of the settlement. Aerial photos in this case were used to provide spatial data regarding the settlement. Community surveys and observation methods were used to obtain demographic data and infrastructure data respectively (Abbott, 2002). Abbott maintains that GIS facilitates a visual representation of spatial and attribute data which provides the underpinning technology for informal settlement upgrading, while geospatial information management provides the framework for the wider upgrading to support their negotiations with the local authority. In similar settlement upgrading programmes in Philippines, communities used aerial photos and satellite imagery for data acquisition. Analysis of these images was carried out using a process termed “participatory image interpretation” (Gonzalez, 2000). Images and aerial photographs on settlements are an important instrument in mobilizing residents since they provide an overview of their areas for identifying problem areas and exploring possible solutions together with planners (Nostrand, 1986).

In an upgrading project in Kosovo, data obtained by way of community survey and aerial photos was entered into a database and GIS respectively. Working in a GIS environment allowed for data to be mapped and spatially represented. A unique approach was adopted in this project where data compiled was handed over to the community for authentication and reference. This approach showed a move in the direction of “action oriented” urban planning theory because the data did not remain in the hands of the municipal office, but was given back to the community it represented allowing them to use it for their own as well as other purposes. The case presented here depicts a good example of the collaboration between local community and local organisations and the city / municipal authority and use of GIS tools for informal settlement planning (Garstka, 2009).
It is important to take note of critics concerning use of GIS tools within planning processes and participation. GIS and related tools have the potential to alienate and exclude non geo-information and technology experts. The use of such technology carries the risk of undermining participation rather than promoting it (Craig and Harris, 2002). This may be the case in developing countries and particularly informal settlements where communities have limited access to basic services including information and communication technologies.

This paper illustrate how the application of technology based GIS tools has enhanced community participation within informal settlement upgrading programmes in Kenya. This is done by presenting a case study where GIS tools were used within Mukuru Informal settlement located in Nairobi city, Kenya. This is one of the largest informal settlements in Nairobi and home to over 100,000 people. The living conditions within the settlement are poor. Majority of the households have no access to clean water, sanitation and live within crowded environments. This is typical of many informal settlements within urban areas in Kenya.

1.1 The actors, participation, decision making and GIS tools

Four main actors or stakeholders play a crucial role in the urban upgrading process. These include; the community, local authority, non-governmental and community based organisations, and the international donor community.

The International Association for Public Participation - (IAFPA) 2006 articulated five levels of public participation – inform, consult, involve, collaborate, empower. Each level enabled a participant with increasing and meaningful impact on the overall process. The use of information tools such as maps, aerial photographs and interactive Web sites for public comments was common within the lower levels of participation (inform, consult). The higher levels of participation (involve, collaborate, empower) required analytical tools for “what-if” simulations of decision impacts in addition to utilizing informational and communication tools.

McCall (2003) presents a perspective regarding effective participation. He sees facilitation at one end, empowerment on the other, and mediation and collaboration somewhere in the middle. Different groups of public intersected with different types of participatory processes pose different requirements for technological support including GIS. Understanding the domain in which the participation takes place is essential to the credibility, efficacy, and theoretical foundation of such participation. Internet GIS for example, is suited to internet-savvy public, but disadvantageous to those who did not have access to the use of the tool (Schlossberg and Shuford, 2005).

“Large-scale, replicable upgrading of informal settlements is only possible through the use of spatial information technologies. The primary objective of upgrading has to be the social and economic development of the community. For GIS is to be used effectively, it has to support this process. It is not simply a technical tool to underpin physical development...it should be seen as a tool that liberates local authorities, communities and professionals...and allows for the interaction between the spatial and physical elements on the one hand, and the social and
The use of Geo-information technologies for informal settlement upgrading and related urban planning activities is widely recognised (Hasan, 2006; Aksoylu, 2005; Barry, 2005; Glöckner, 2004; Sliuzas, 2004; Ceccato, 2000). The starting point is the recognition that large-scale, replicable upgrading of informal settlements is only possible through the use of spatial information technologies (Abbott, 2003). The successful implementation of GIS tools for slum upgrading depends on the tool supporting improvement of social, economic and environmental conditions within the settlements concerned. GIS tools are seen as tools that liberate local authorities, communities and professionals from the constraints of paper-based space, and allows for the interaction between the spatial and physical elements on the one hand, and the social and economic opportunities on the other, in a three-dimensional virtual environment. This then allows all parties to work in a much more interactive way to address the multi-faceted nature of informal settlements (Abbott, 2003).

1.2 Technology integration and upgrading process

In the upgrading process model by Acioli, the potential of GIS tools integration is clear within the community mapping and enumeration stage. Community mapping, enumeration and survey may use GIS tools. Spatial data regarding settlement layout may be obtained from remote sensing images whereas GIS tools provide a platform for analysis and visualisation of settlement data captured during survey or enumeration carried out with the assistance of resident community members. Data collection using community surveys or enumeration, aerial photography or satellite imagery, yield raw data defining settlement characteristics. Enumeration using questionnaires and checklists for example provides data that is not collectable using remote sensing sources (imagery and aerial

Figure 1: Informal Settlement Upgrading Cycle (Source: Acioly, 2009)
This data (non spatial) may include access to basic services and population characteristics. A GIS platform is able to analyse spatial and non spatial data sets and provide information and visual models regarding the existing situation. The models obtained after GIS analysis provide useful information in the form of indicators about the situation or challenges existing. These indicators provide planners and decision makers with information for decision making towards addressing issues to improve the living conditions or infrastructure status within a settlement. Data to be collected and analysed is determined by the objective of the project or intervention strategy. This process may be driven by development partners or communities themselves in-order to gain a better understanding of their environment. The information generated may also be used as a tool for bargaining with local authorities, thereby empowering communities.

2. Methodology

2.1 Study context

Silanga village is located within Kibera informal settlement in Nairobi City. Nairobi city started as the capital of the British East Africa Protectorate during the construction of the railway line to Uganda in the 19th century. The city like many others within sub-Sahara and developing countries is characterised by formal and informal setting with regards to human settlements. Informal settlements have grown over time to house the increasing urban population largely due to rural urban migration and natural growth causes. Informal settlements are growing at a rate of about 5 percent per year and
accommodate a total population estimated at over 1.5 million (representing approximately 60 percent of the population of Nairobi Informal settlements, occupying approximately 5 percent of the total residential land area (Syagga, Mitulla and Gitau, 2002; World Bank, 2006). Most significantly two-thirds of slum populations survive on less than one dollar per day (APHRC, 2002).

There are six main informal settlements that trace the evolution of slum informal settlements in the city of Nairobi. These are: Kibera, Mathare Valley, Mukuru, Dagoretti, Kawangware and Korogocho. However, the provision of basic urban services within these settlements has not kept pace with their rapid growth. In 1993, just 45 percent of the city’s residents had access to potable water, and only 63 percent had access to regular waste collection (World Bank, 1999).

3.2 Study objective

The main objective of the study was to develop a settlement information model or system based on geographical information system (GIS). The expected outcome would be used a base for future monitoring efforts and also one that is operated by the community itself. Other objectives included;

- Determining the current levels of infrastructure within the settlement including water supply points, toilets, and roads of access,
- Mapping relevant attribute data such as population, ownership characteristics, housing and land use patterns,
- Provide outputs and information that may be used by community and development partners for decision making,
- Develop a model that may be implemented and improved upon for monitoring slums within the city of Nairobi and country as a whole.

To develop a settlement information system, Geographic Information Systems (GIS) and Remote Sensing tools were used. A settlement image was obtained from a high resolution satellite image (1 meter resolution). From this image spatial objects / features were delineated. Other information obtained from the image included structures / buildings, roads, vegetation, rivers and streams, and other infrastructure like power lines.
3.3 Data collection

Data was collected by use of a checklist and as well as observation methods. The data collectors were drawn from the settlement and comprised social workers and youth group members. This was done in conjunction with staff members of a Practical Action (Non Governmental Organisation) in order to develop capacity within the residents of the settlement. The residents who were trained on enumeration skills were expected to collect data on a continuous basis to support future monitoring activities.

Attribute data was collected on the following aspects;

- water supply,
- lighting and cooking energy sources,
- solid and human waste disposal methods,
- accessibility,
• population and structure ownership,
• housing conditions, and
• economic / small scale economic activities.

This data was inputted into a Geographic Information system (GIS) for analysis and generation of outputs.

3.3.1 Role of the community
This was done with the help of community members from the settlement. The direct involvement of the community was justified given that they had first knowledge regarding the settlement and related developments. The process of integrating community members started with sensitization and information dissemination. It was necessary to inform the wider community on the purpose and objective of the exercise. This initial phase prepared residents to expect enumerators and data collectors in their homes. Training on structure identification using the settlement image was provided by members of Practical Action and the consultant / researcher. Having lived in the settlement for considerable periods, the residents were able to orient easily and identify key landmarks. During this phase, each structure on the ground was given a unique identification number which corresponded with the number in the GIS statistical database.

3.3.2 Tools: visual interpretation, observation and questionnaires and checklists
Visual interpretation was used to identify structures on the image and locate them on the ground. With local knowledge, the trained enumerators were able to locate structures on the image and locate their precise location using landmarks like roads and open spaces. Attribute data pertaining to the structure was obtained by posing questions to the structure owners and tenants alike. Observation methods were used to collect data relating to the structures. Data regarding building materials used, availability of water and sanitation facilities was gathered by way of observation. To determine population numbers per structure, a physical count was conducted. Where residents were absent, neighbours would be used to collaborate and verify numbers of persons residing within a particular structure. Questionnaires were used to gather information on structure ownership, rent, and other infrastructure availability and use.
3.3.3 Data integration and analysis

This was done within a GIS environment where attribute and spatial data was combined to give more information about the settlement. A database of all the attributes was developed and using Statistical Package for Social Scientists (SPSS) frequencies and descriptive statistics were generated. Below is a graphic presentation showing data integration model.
3.3.4 Discussion of Results

Documenting and mapping informal settlements and their attributes has important repercussions for urban policy, planning and infrastructure investment, and provides a platform for people’s involvement in development. The analysis of various indicators provided a detailed picture of the situation within Silanga settlement. For each variable, a spatial model was generated showing which areas and structures within the settlement had access to a particular infrastructure like water and sanitation. This information enabled decision makers and interventionists, including NGOs to determine which locations deserved attention / infrastructure supply. The overall objective was to improve livelihoods locally and achieving the Millennium Development Goals locally and nationally.

3. Sector based analysis

Spatial analysis and models were produced for each of the attributes were data was collected. Settlement models based on data pertaining to infrastructure availability, land use and population were developed.

Upon spatial analysis and modelling, pockets of residents without access to water and sanitation were identified. Water and sanitation are regarded as central components of many slum upgrading programmes.

The lack of adequate sanitation and clean water was seen as a major source of public health problems within Silanga settlement. Diseases like diarhoea and dysentery are easily spread in environments with poor drainage and sanitation facilities. Poor excreta disposal will lead to the contamination of water sources as well as the general environment.

Within Silanga, only 16% of the structures had on site pit latrines while 84% did not have the facility within the compound. Residents relied on facilities located far from household. The available toilets within the settlement were shared and at times residents would pay for the use of the latrines.

![Figure 4: Toilet facilities within Silanga](image)
Silanga Village
Access to Toilet facilities

30m Buffer from toilet cluster

Silanga Village
Water Supply Points

NB: Buffer Distance 40m
Buffers indicate nearness to water sources
4.1 Using the results for decision making

Based on the results of the spatial mapping of attributes, residents were asked to identify suitable areas for construction of new toilet blocks to provide better access. In this case, GIS supported tools and outcomes facilitated communities to participate in decision making. The results of their selected areas was influenced and supported by the settlement spatial models.

As part of the intervention strategy, residents were asked to identify suitable sites for new toilet blocks. The selected sites were superimposed on the settlement spatial model to determine their suitability. After analysis of the sites, areas deemed to be well served were identified. A buffer or access distance of 50 meters was used to determine areas to be served by the new toilet blocks. With the spatial model showing new and existing sites, areas that required intervention were identified. This helped programme officers and residents in determining areas to address and invest in new toilet infrastructure, to ensure all residents had access to services.
Community identified toilet sites
4.2 Enhancing participation using GIS in low income settlements

If technology based tools including GIS and Remote Sensing are to have in impact within informal settlements and enhance participation, the following issues need to be addressed. There is need to ensure the settlement database is regularly updated to reflect the dynamic situation within settlements. Informal settlements owing to continuous population growth are bound to grow vertically or horizontally where space permits. This is bound to increase demand on existing infrastructure. Stakeholders need to consider access to information. Specifically, communities should be able to access databases, information and spatial models (whose construction has community input) for various use including advocacy and future planning. To ensure sustainability of settlement information systems, the stakeholders must make sure these models address community needs such as planning data. The primary goal of any urban upgrading project is to meet the needs and vision of the local residents. Therefore, a settlement information system based on GIS should provide information to land owners and tenants within the settlements for planning.

A settlement information system model is presented below, which outlines the key stages to be followed with regards to integrating GIS tools within upgrading informal settlements. The model is divided into two phases, the primary and secondary phases, where the former is entails legal procedures of notification, base map development and sensitization of landlords and tenants. The secondary phase entails data (spatial and attribute) management, data analysis and output generation, and communication, feedback and planning aspects. In all these phases the community is well integrated and involved. This ensures the process is inclusive and provides an opportunity for communities to participate in the decision making.

Examples of GIS tools facilitating and enhancing participation by communities have been documented. In the Pune (India) and Karachi (Pakistan) slum mapping, marginalised men, women and youth from these settlements participated in data collection and other mapping processes which illustrate the importance of communities in the development process (Hasan, 2006; Joshi, 2002). The participation by community members helped to increase the legitimacy of the data collected and mapping process adopted. Communities through elected committees are able to voice their concerns to higher levels of decision making organs as well as lobbying for resources for development. In South Africa, development partners, local authorities in partnership with the communities developed a GIS based approach to informal settlement upgrading which aimed at empowering the community, both through the provision of detailed information on the community and then by the use of that information to support their negotiations with the local authority (Abbott, 2003).
4.2.1 Model for settlement information system development

**Primary stage**

(Introduction, notification and justification, planning of approach consensus building, data collection, training of data collection teams)

- Introduce purpose and objective of scheme
  - **Actors**: Settlement Committee, provincial administration and interested NGOs
- Consensus building
  - Nomination of members from each zone into sub-committee
  - Development of a structure numbering system or adopt existing one
  - **Actors**: Community and settlement committee
- Definition of settlement boundaries
  - Spatial data acquisition
  - **Actors**: NGO representatives and settlement committee
- Expound on the purpose of the scheme
  - Address benefits of the scheme to all
- Identification of actor roles
  - **Actors**: Structure owners, tenants, and committee
- Nomination of youth or settlement members preferably 2-4 from each zone for data collection
- Introduction to data collection tools (Checklist/questionnaire)
- Training on spatial data interpretation
- Training on attribute data collection
- **Actors**: Community, settlement committee, and NGO’s

**Secondary stage**

(Data analysis, output generation, feedback session, problem identification, planning, and sustainability issues)

- Open a register for all structures
- Data entry
- Identification of information gaps
- Data collection to fill in identified gaps if any
  - **Actors**: Sub Committee, select group of data collectors, NGO’s
- Data analysis
  - Mapping of attributes using GIS tools
  - Output generation
  - **Actors**: Select group, sub-committee, NGO’s
- Demonstration of generated outputs and feedback sessions
- Problem identification (magnitude)
  - Preliminary identification of intervention scenarios
  - **Actors**: Entire community, and NGO’s
- Problem identification based on data collected and outputs generated
  - Propose suitable interventions
  - Consensus building
  - Implementation strategies
  - Way forward
  - **Actors**: Tenants, structure owners, groups(women, youth, environmental), NGO’s, Administration
4. Conclusion

The potential uses of GIS tools to enhance participation by communities within informal settlements in planning and decision making processes are significant. Information poor environments hinder actors including communities to participate in decision making processes. The setting within informal settlements where marginalised communities cannot access information and basic services results in exclusive practices and more marginalisation. The integration of GIS tools in planning and decision making processes enables “all” actors have equal access to information regarding their environments. In particular, the participation of women and youth in mapping and data collection exercises provides an avenue for them to better understand their world. Participatory GIS practices within informal settlements provide avenues for communities to communicate horizontally and vertically with peers and policy makers in an effort to address challenges within the settlements.

The risk of exclusion with the introduction of GIS tools is a possibility where communities are not information or technology driven. To avoid this sensitization and communication strategies should be tailored to offer soft landing for all actors. The communities within informal settlements have the advantage of local knowledge and experiences which may be tapped into to support settlement mapping processes. The decision making process is bound to benefit from local knowledge if again communities are involved in making decisions based on outcomes they have contributed towards. The use of spatial models developed by data generated by community led enumerations for decision making validates the planning process. Project support and sustainability is likely to be achieved under these conditions.

Much as the integration of GIS tools within slum upgrading has the potential of providing communities and development partners with better information and visualisation capabilities, there is need to consider continuous data updating. This is necessitated by the dynamic settlement environment where vertical and horizontal developments as well as population increase due to in-migration occur by the day. Communities should be encouraged to take up settlement monitoring and use the outcomes to plan for interventions and address new challenges that may arise. This however calls for the support of all partners especially the local government whose mandate includes providing basic services to residents.

References


