The Effectiveness of Geographic Information System (GIS) Application in Land Use Planning at Mufulira Municipal Council, Copperbelt Province, Zambia

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Abstract

This paperexamines the effectiveness of GIS application in land use planning at Mufulira Municipal Council after the adoption of GIS in 2008.

Data was collected using semi-structured questionnaires, recorded interviews, Council GIS spatial data and written documents prepared on GIS.Comparative Analysis used to analyse collected data through the process of data documentation, conceptualization, categorization and examination.

Results show that before the adoption of GIS, land use planning in Mufulirawas ineffective due to inadequate equipment.GIS implementation has therefore built capacity in the municipal council to prepare land use layout plans and control development in the municipality. TheCouncil'splanning department uses GIS on about 75 per cent of its physical planning functions.

The paper concludes that despite GIS implementation having to some extent improved land use planning in Mufulira, poor maintenance has negatively affected the operations and expansion of the GIS unit. It is therefore recommended that the council invests in employing more GIS personnel, linking the GIS software to all departments of the council and acquiring a GIS server for effective land use planning.

Keywords: Geographic Information System (GIS), Land Use Planning, Mufulira Municipal Council.

1.0 Introduction

In recent years, a growing interest amongst municipalities has been evident concerning the use of Geographic Information System (GIS) in daily operations (Dekolo, 2001). It is widely accepted that many different factors influence the successful introduction and deployment of GIS within a municipality. Dekolo (2001) shows that the effectiveness of GIS is dependent on how well it is integrated into the operations of the municipality as a whole. He guides that the use of GIS technology should be integrated into the overall strategy of the municipality by using GIS as a vehicle to attain strategic benefits (Dekolo, 2001).

Research provides different experiences of GIS implementation in land use planning from developed and developing countries. Campbell (1994) showed that, for British local governments, the success of GIS implementation depends on the organisational culture of local governments. In JimetaTown, Adamawa State of Nigeria, Vachaku, et al (2013) showeda new method of handling spatial data to enhance effective planning and decisionmaking process on land use.The study identified the area coverage (in hectares and percentage) of seven land uses and 12 wards in Jimeta. Thepotentials of GIS in planning and decision making have also beendemonstrated by detecting areas not served with a particular service. Proposals are therefore made for the provision of newhealth centers, police stations, fire service stations, banks,commercial areas, schools and recreational centers using theminimum service radius standards (Vachaku, et al, 2013).

In Japan, Kohsaka (2001) showsthat the most successful GIS application in the local government is an inquiry system on the content of urban plan decision. Mappy, Urban Plan Information Inquiry System developed by Yokohama City, is introduced as an example. The register management treats the registers for urban planned road, urban park, and urban open space, and the receipt book for development permission application (Kohsaka, 2001).Dushaj et al (2009) present a case studyof GIS application for medium-term land useplanning in communal level. The study providednot only the basic spatial database in communallevel, but also evaluated the land suitability, landuse, land use changes, function of irrigation anddrainage systems and agricultural landurbanization as well.

From the studies carried out, it can be stated that land use planning has become a central prerequisite for any spatial development that aims at social, ecological, and economic sustainability. Dhlamini (2011) stated that for a sustainable land use plan, nowadays, land use planning approach requires more and more data integration, multi-disciplinary and complex analysis, and needs faster or more precise information for the participants in the land use planning approaches (Dhlamini, 2011).

In Zambia, provincial, city, and municipal planning authorities carry out urban land use planning. Zambia has 10 Provincial Planning Authorities,4 cities and 15 Municipal Planning Authorities. Planning authorities such as Lusaka City, Eastern Province, Mazabuka, and Mufulira have acquired the GIS software and equipment to enhance land use planning. Ng'omba (2012) shows that land use planning in Zambia has been associated with piecemeal planning and lack of updated township land use plans. Lack of updated plans has contributed to land encroachments, uncoordinated and disorderly development, and further contributes to the establishment of unplanned settlements(Ngómba, 2012).

The Ministry of Local Government and Housing (MLGH) in partnership with *Deutsche Gesellschaft fur Internationale Zusammenarbeit* (GIZ), an international organization owned by the German Federal Government identify spatial planning as one of the four focus areas under the "decentralization for development" project, which runs from 2015 to 2018. The goal of the project is to ensure that "the multi-level system for the provision of devolved local government services is improved." The expected result for spatial planning is that the "capacities of local governments to apply GIS as a tool in land use planning and revenue enhancement are improved" (GIZ, 2015).

In 2008, Mufulira Municipal Council signed a memorandum of understanding (MOU) with GIZ to establish a GIS unit at the Council. The objective of the MOU was to build staff capacity; enhance land use planning and revenue collection. GIZ supported the Council with a GIS technical expert to spearhead setting of a GIS Unit. The GIS unit has been operating since 2008 and the planning department manages it (Mufulira Municipal Council, 2011).

2.0 The Study Area

Mufulira is located on the Copperbelt Province and lies on latitude 12 degrees 32 minutes south of the Equator. It shares borders with several districts in the Province namely; Kitwe, Kalulushi, Ndola, Chingola and Chililabombwe as depicted in figure 1.The district is connected to major towns and cities in Zambia through a railway network, tarred roads, and aerodrome services. Mufulira covers an area of 1,637 Square Kilometers (Mufulira Municipal Council, 2013).

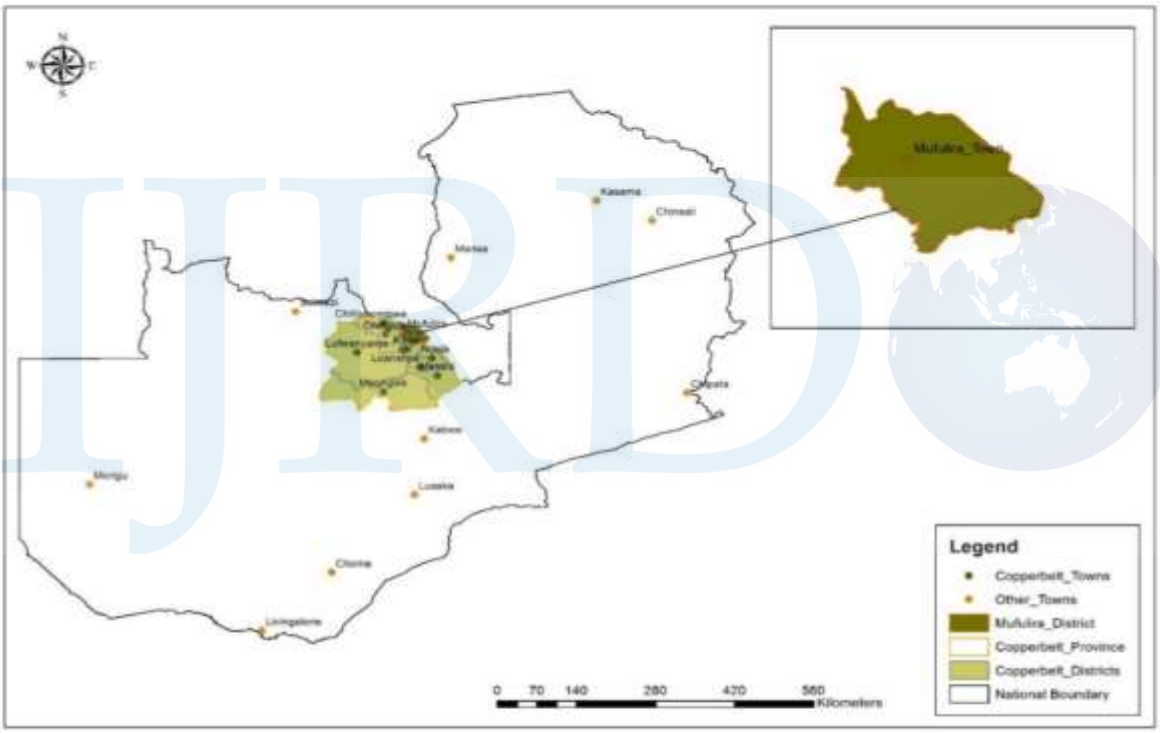
According to the 2010 Census of Population and Housing of the Population, the population of Mufulira District stands at 162,889 with an average annual rate of population growth of

1.2%. The Population is segregated as 81,355 Males being 49.9% of the Population and 81,534 Females being 50.1% of the Population.

Having been known to be a mining town, the District has a Mining Company called Mopani Copper Mines Plc where Copper Ore is mined.

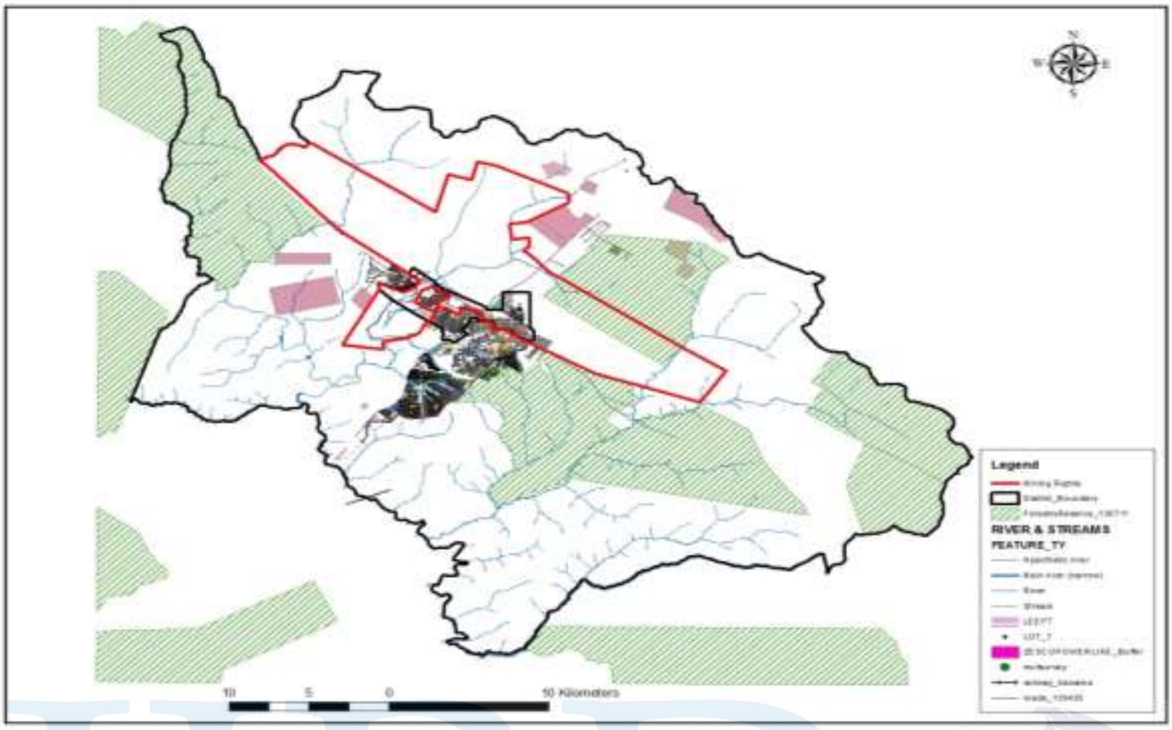
Land in Mufulira is allocated for various uses as depicted in figure 2. The land is held state directly or through the council, by Mopani Copper Mines Limited and, in private hands. The district does not have traditional forms of tenure of land held by Chiefs nor Communal grazing lands.

Figure 1: Location of Mufulira District, the Study Area



Source: Generated by author from national GIS data

Figure 2: Land Use Distribution in Mufulira District



Source: Mufulira Municipal Council GIS Data, 2016

2.1 Research Methods

A case study approach was used to derive an in-depth understanding of how GIS implementation has affected land use planning in Mufulira. The target population was Mufulira Municipal Council staff in all the six departments of the council, involved in the implementation and use of GIS.

Purposive sampling was used to select key informants. Descombe (2010) supports that with purposive sampling, the sample is ‘hand-picked' for the research on the basis of relevance and knowledge (Denscombe, 2010). Therefore, key informants arrived at were based on the knowledge that they have the authority to influence decisions on land use planning based on their institutional mandates and responsibilities.

Interviews were conducted with the following key informants: (i) Town Clerk (ii) Director of Planning, GIS, and Physical Planning units (iii) Director of Finance and Head of IT section (iv) Director of Engineering and Civil Engineering Section (v) Director of Environment and Head of Housing Section (vi) Director of Human Resource and Administration and Head of Deeds and Registry Section.

Semi-structured questionnaires and recorded interviews were used to collect primary data on land use planning before and after the adoption of GIS.Data collected usingquestionnairesand recorded interviews was documented, transcribed, and categorized in table form for comparative analysis. Table 1 shows data collected using questionnaires and recorded interviews.

Table 1: Comparison of Land Use Planning Practices Before and After GIS adoption

S/N	Practice	Before GIS Adoption (Methods/Tools/Plans)	After GIS Adoption (Methods/Tools/Plans)
1	Collection of spatial data	-Identify undeveloped land on the Mufulira Development Plan -Conducting site visits for verification	-Land assessment with overlay of GIS layers -Conduct Reconnaissance Survey with Global Navigation Satellite System Receiver
2	Stakeholder engagement	-No involvement of stakeholders during the planning process	-Consultation with relevant stakeholders such as Electricity, Water and Sewerage service providers
3	Analysis of collected spatial data	-Visual Analysis separate land use maps	-GIS Spatial analysis of integrated spatial data
4	Land use planning tools	-A0 Drawing board -Tracing paper and white paper -Drawing pens, Crayons, Stencils and Scale Rules -Ammonia Printing Machine	-A0 Plotter -White paper -Desktop Computers -ArcGIS software
5	Type of land uses plans	-Site, location, change of use and layout plans on Blueprint and White Papers	-Enhanced site, location, change of use and layout plans on White paper
6	Type of spatial database	-Hardcopy land records -Hardcopy land use plans	-GIS spatial data sets (cadastre, satellite Images, scanned plans)

Source: Field Data, 2016

It is important to recognize that GIS implementation within a municipality, whether large or small, represents a significant investment in staff resources and funding as an Information Technology (IT) project. The implementation must therefore be managed like any major IT project to achieve benefits.Semi-structured questionnaires and written council reports on GIS were used to collect data on the GIS implementation approach at Mufulira Municipal Council. Collected data was generated into concepts,arranged in categories and examined to assess GIS implementation approach. Table 2 shows a summary of data collected on the GIS implementation approach. The Councils GIS implementation approach was assessed against the best approach for successful GIS implementation in Municipal Councils.

Table 2: GIS Implementation Approach

S/N	Requirement	Best Approach	Approach of Mufulira Municipal Council
1	GIS Project Manager	Project Manager to oversee the GIS implementation	Employed a full-time GIS advisor to spearhead the projectimplementation
2	Active Project Steering Committee	Implementation needs to be guided by a Steering Committee that represents key stakeholder groups	Had a GIS steering committee, which consisted of senior management staff
3	Phased Implementation	Implementation takes place according to a phased plan that provides for short term deliverables that are limited in scope	A five year implementation plan was prepared with specific targets to be achieved every year from 2009 to 2013
4	Appropriate Evaluation of Technologies	Technologies selected for GIS implementation are capable of being tightly integrated within the corporate IT environment of the municipality	GIS software is linked to with land database in Excel and billing system of planning and finance departments'respectively. GIS software is only accessed by the physical planning, GIS and Revenue units of the Council and to all departments
5	Use of Data Standards	Municipality should set out relevant data format standards in the early stages of the project	A geodatabase for land use planning was designed using the Arc1950 coordinate systems where all data collected was stored
6	GIS skills capacity	Municipality should have adequate staff skilled in GIS	Council has four (4) officers with GIS skills and has shortfall of 2 GIS officers

Source: Field Data, 2016

Availability of GIS spatial data plays a critical on effective land use planning. The more GIS data is acquired, the more informed land use planning becomes. GIS spatial data on land use planning was collected in various formats and loaded on ArcGIS for analysis to determine the extent GIS has improved land use planning in Mufulira. The Council's land use planning functions were examined in comparison the availability and use of GIS data to improve land use planning. Table 3 and 4 show the collected data on Municipal Council GIS Data Sets and physical planning functions respectively. Completed land use plans were also collected and examined to extract information on improved land use planning.

Table 3: Mufulira Municipal Council GIS Data Sets

S/N	Land Use Planning GIS data sets	Description	Data Format
1	District Boundary	Gazetted District boundary of Mufulira	Vector data
2			
3	Cadastre	Register of surveyed properties with ownership status	Attribute Data CAD Data
4	Topographic Maps	Scanned and georeferenced topo maps of scale 1:50,000	Raster Data
4	Satellite Image	Scanned and georeferenced high resolution image	Raster Data
5	District Development Plan	Scanned and georeferenced land spatial development map	Raster Data
6	Lease Plan	Scanned map of all properties on 99 year lease titles	Raster Data
7	General Plans	Layout Plan of surveyed properties labelled with angles and distances	CAD Data
8	Land Uses	Layout plan showing different land uses such as residential, commercial and industrial	Polygon Vector and Attribute Data
9	Built up areas	Map showing properties developed with buildings	Polygon Vector Data
9	Mining Rights	Boundary showing area acquired for mining rights	Polygon Vector Data
10	Water Bodies	Areas captured as rivers and streams	Polygon Vector Data
11	Protected Forests	Areas captured as protected national streams	Polygon Vector Data
12	Layout Plans	GIS based prepared land use plans	JPEG and PDF Data

Table 4: Municipal Physical Planning Functions

S/N	Municipal Land Use Planning Functions
1	Creation of site, location and layout plans
2	Zoning of land uses
3	Land Dispute Resolutions
4	Cadastral Survey Works

5	Integrated Development Planning
6	Township Land Use Mapping
7	Land Auditing
8	Transportation Planning
9	Disaster Risk Reduction
10	Informal Settlement Upgrading
11	Roads and Street Naming
12	Mapping of Utility Services

3.0 Results and Discussion

3.1 Land Use Planning before and after Adoption of GIS

3.1.1 Identification of Areas for Planning

The study established that between 2001 and 2008, the common practice by planners was the use of the hardcopy Mufulira Development Plan of 1973 to identify free parcels of land to for planning and conducted site visits for verification purposes. Planners also used the hard copy topographic maps to assess the terrain and existing physical features of a particular area.

With GIS, the planning department uses the ArcGIS software to add multiple land use layers to identify land suitable for planning and development. In addition, reconnaissance surveys are carried out, which involve collecting of spatial information of physical features of specific areas on the ground. The spatial information is then added to ArcGIS software to assess the existing conditions and enhance decision-making.

3.1.2 Stakeholder Engagement

Before the adoption of GIS, the Council conducted land use planning without involving key stakeholders such as the utility service providers. The council instead gave stakeholders final copies of land use plans for implementation. This, therefore, contributed to the problems of land encroachments and disputes.

With the GIS-based land use planning, planners make consultations at the initial stage with identified relevant stakeholders and collect required spatial information.

3.1.3 Land Use Planning Equipment

Before the adoption of GIS, the council used several types of office and field equipment. The field equipment comprised of the 100-meter measuring tape, and theodolite to measure, demarcate plots, and determine the extent of areas earmarked for planning. Office equipment comprised of drawing pens and HB pencils, drawing board, crayons, tracing paper, stencils, triangular scale rules and the ammonia printing machine. A significant feature of the manual tools is that the creation of land use plans involved rescaling of the planning area from the topographic map and developing a new detailed plan on tracing paper. The council used the ammonia printing machine to make copies of the land use plans.

The council has adopted GIS as the main tool to conduct their land use planning in the district.The GIS system is made of personnel, office, and field equipment. The GIS system comprises of the ArcGIS version 10.0 software installed on desk and laptop computers, one set of Global Navigation Satellite System (GNSS) Receiver (Differential GPS) and the A0 colour plotter. Planners use the GNSS Receiver (with a centimeter level accuracy) to collect spatial information that is fed into the GIS software. The AO plotter is used for printing land use plans on large paper sizes such as AO, A1, and A2.

3.1.4 Preparation of Land Use Plans

Before the adoption of GIS,the planners drew land use plans manually using drawing boards on both white and tracing paper. The types of land use plans drawn were site plans (that depict the location and size of a particular plot), change of use plans (that depict the proposed change of land use from its zoned use) and layout plans (that depict the created number of plots and category of land uses).Planners assigned different land uses on drawing board-based plans using land use symbols as was provided for in the repealed Town and Country planning Act. Figure 3 shows a blue print layout plan of medium cost plots created for Kamuchanga stage thirteen in 2008. The figure shows the entire layout plan drawn in pencil to scale and labeled using a stencil. The part marked in red depicts the created and numbered plots.

Figure 3: Ordinary Layout Plan

Source: Mufulira Municipal Council, 2016

After the adoption of GIS in 2009, creation of land use plans has become more efficient and time saving since GIS enables integration of all required spatial layers, which makes it easier to manipulate, analyze and create the land use plans that reflect what is on the ground. The study revealed that GIS-based land use plans have been enhanced with the detail of spatial information as opposed to ordinary drawing board-based plans. For example, a layout plan generated in GIS has a location base map, which shows the topography and terrain, spatial reference as well as coordinates which the old plans did not contain. Figure 4 shows a GIS-based Layout Plan of Rock View high-cost residential area created in 2015. The colored parcels depict the different land uses with residential (in yellow) being the most created plots. The middle area (in light brown) is a buffer zone for the power lineway leave as labeled on the plan. In addition, the buffered streams on the bottom left and right corners of the layout show areas along the streams with specific distances, which should not be developed but preserved. Other details include a comprehensive title block, the coordinate system used to created layout plan, north arrow, and the legend. The red circle shows the provision of the type of coordinate system used to create the layout plan.

Figure 4: Enhanced GIS-Based Layout Plan

Source: Mufulira Municipal Council, 2016

3.1.5 Spatial Databases

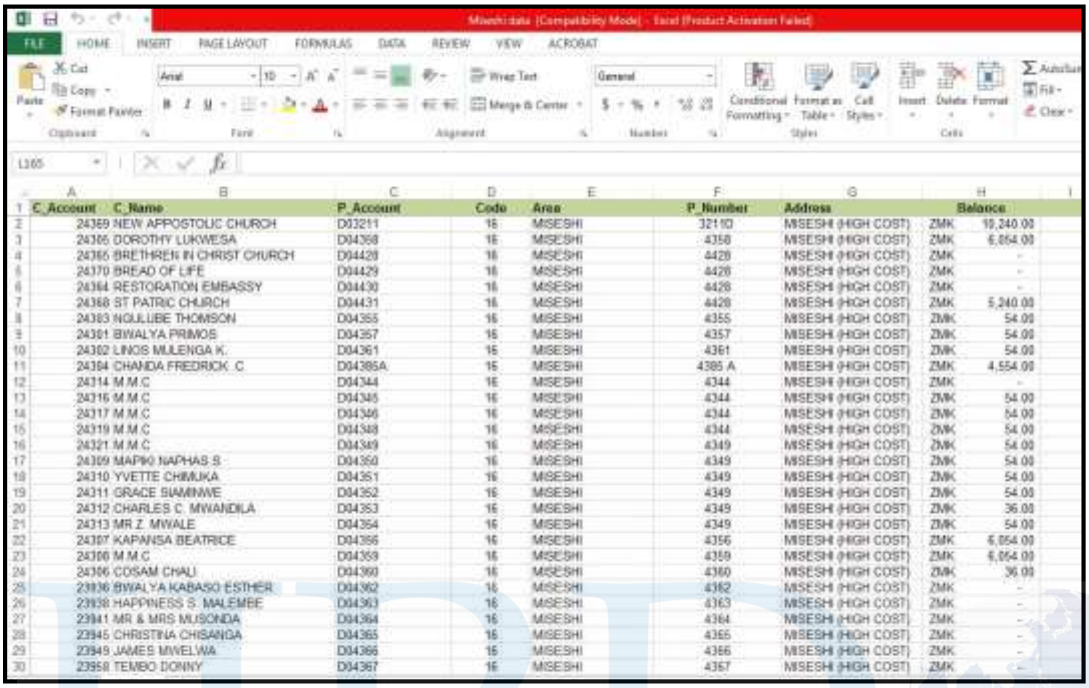
Before the implementation of GIS, the Council's spatial database was in the form of hardcopy tracing paper and blue print filed land use plans. The land use plans were kept by the planning department while the land ownership records were kept by the lands and deeds registry unit under the of administration department. Figure 5shows the cabinet filing system of ordinary land records in a range of plot numbers as highlighted in the red circle.

Figure 5: Cabinet Filing System of Land Records

Source: Mufulira Municipal Council, 2016

The adoption of GIS has enabled the integration of land use plan and land ownership records.The GIS spatial database mainly consists of excel attribute data, GIS shape files with attribute data and other GIS data sets such the Mufulira Development Plan and Lease Plan converted from analogue to digital. Figure 6 displays the excel data land database for Miseshi high-cost residential area which is linked with GIS using the join and relate function. The database indicates the customer account and name, plot account, plot number, the name of area as well as amount of plot premium paid and the balance. This type of record keeping makes it easy to retrieve information about a particular plot and keeps the data secured.

Figure 6: Excel Plots Database



C_Account	C_Name	P_Account	Code	Area	P_Number	Address	Balance
24369	NEW APPOSTOLIC CHURCH	D03211	16	MISESHI	32110	MISESHI (HIGH COST)	ZMK 10,240.00
24366	DOROTHY LUKWESA	D04358	16	MISESHI	4358	MISESHI (HIGH COST)	ZMK 6,054.00
24365	BRETHREN IN CHRIST CHURCH	D04428	16	MISESHI	4428	MISESHI (HIGH COST)	ZMK -
24370	BREAD OF LIFE	D04429	16	MISESHI	4428	MISESHI (HIGH COST)	ZMK -
24364	RESTORATION EMBASSY	D04430	16	MISESHI	4428	MISESHI (HIGH COST)	ZMK -
24368	ST PATRIC CHURCH	D04431	16	MISESHI	4428	MISESHI (HIGH COST)	ZMK 5,240.00
24303	NGULUBE THOMSON	D04355	16	MISESHI	4355	MISESHI (HIGH COST)	ZMK 54.00
24301	BWALYA PRIMOS	D04357	16	MISESHI	4357	MISESHI (HIGH COST)	ZMK 54.00
24302	LINOS MULENGA K.	D04361	16	MISESHI	4361	MISESHI (HIGH COST)	ZMK 54.00
24304	CHANDA FREDRICK .C	D04385A	16	MISESHI	4385 A	MISESHI (HIGH COST)	ZMK 4,554.00
24314	M.M.C	D04344	16	MISESHI	4344	MISESHI (HIGH COST)	ZMK -
24316	M.M.C	D04345	16	MISESHI	4344	MISESHI (HIGH COST)	ZMK 54.00
24317	M.M.C	D04346	16	MISESHI	4344	MISESHI (HIGH COST)	ZMK 54.00
24319	M.M.C	D04348	16	MISESHI	4344	MISESHI (HIGH COST)	ZMK 54.00
24321	M.M.C	D04349	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 54.00
24309	MAPIKI NAPHAS S	D04350	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 54.00
24310	YVETTE CHIMUKA	D04351	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 54.00
24311	GRACE SIAMINWE	D04352	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 54.00
24312	CHARLES C. MWANDILA	D04353	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 36.00
24313	MR Z. MWALE	D04354	16	MISESHI	4349	MISESHI (HIGH COST)	ZMK 54.00
24307	KAPANSA BEATRICE	D04356	16	MISESHI	4356	MISESHI (HIGH COST)	ZMK 6,054.00
24308	M.M.C	D04359	16	MISESHI	4359	MISESHI (HIGH COST)	ZMK 6,054.00
24306	COSAM CHALI	D04360	16	MISESHI	4360	MISESHI (HIGH COST)	ZMK 36.00
23936	BWALYA KABASO ESTHER	D04362	16	MISESHI	4362	MISESHI (HIGH COST)	ZMK -
23938	HAPPINESS S. MALEMBE	D04363	16	MISESHI	4363	MISESHI (HIGH COST)	ZMK -
23941	MR & MRS MUSONDA	D04364	16	MISESHI	4364	MISESHI (HIGH COST)	ZMK -
23945	CHRISTINA CHISANGA	D04365	16	MISESHI	4365	MISESHI (HIGH COST)	ZMK -
23949	JAMES MWELWA	D04366	16	MISESHI	4366	MISESHI (HIGH COST)	ZMK -
23958	TEMBO DONNY	D04367	16	MISESHI	4367	MISESHI (HIGH COST)	ZMK -

Source: Mufulira Municipal Council GIS Spatial Data, 2016

3.2 GIS Implementation

3.2.1 Implementation Strategy

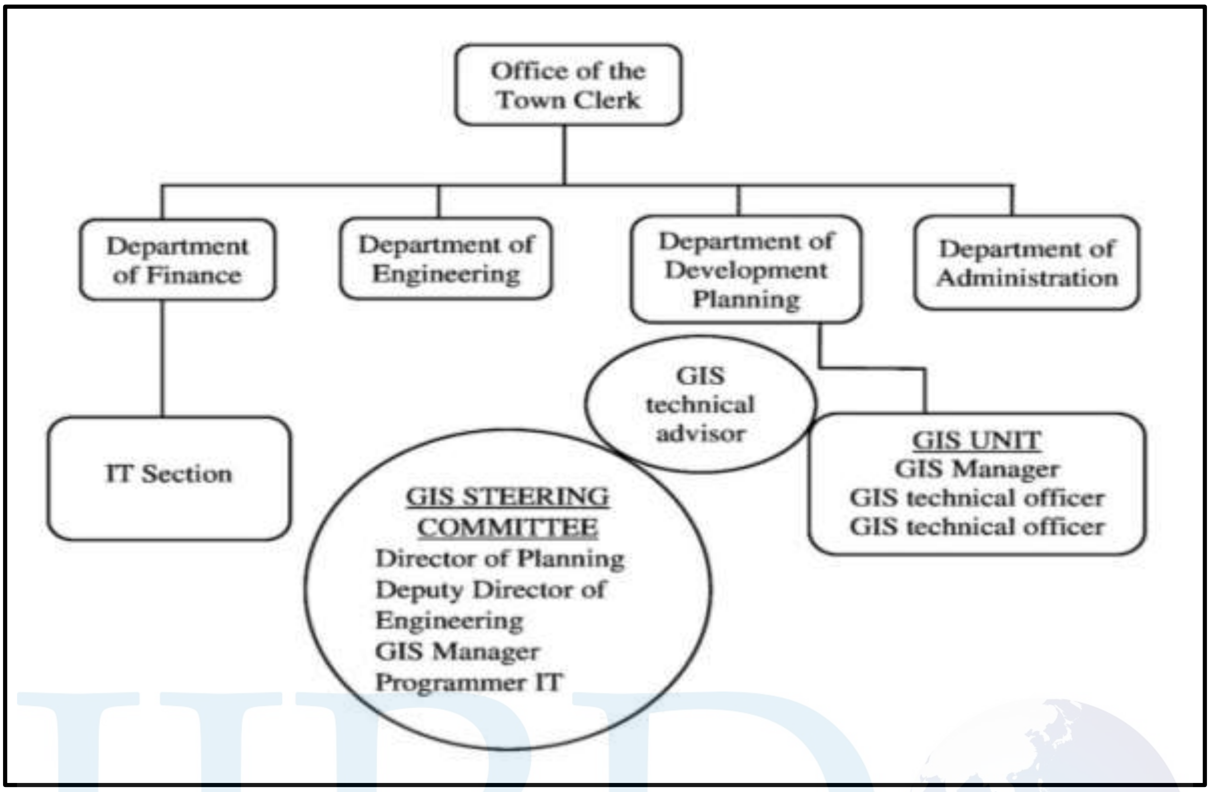
The study established that Mufulira Municipal Council with assistance from the German Development Cooperation (GIZ) through the Ministry of Local government and Housing (MLGH) employed a full-time GIS advisor to spearhead the project of setting up of a Geographic Information System (GIS) in July 2008. The GIS advisor was stationed at the council for a period of 6 years (2008-2013). During the period of their work, the GIS advisor supported the operational work of the GIS unit on a daily basis and provided technical advice to the GIS steering committee of the council. Focus of GIS Implementation was on the District Planning Unit for Physical Planning. At the beginning of the project, the council seconded four officers (3 from planning department and 1 from engineering) to work on the project due to lack of qualified GIS staff. The officers included two Town Planners, one Social Economic Planner, and one Architect. The seconded officers underwent everyday training by the GIS advisor on how to use GIS through practical and theoretical lessons.

After one year, the formed workgroup of four officers from the department of development planning and engineering failed to deliver because they got overloaded with GIS tasks, in addition to their substantive position duties. This made it difficult for seconded officers to engage themselves as required. In 2010, the council decided to establish a GIS unit and employed two GIS technical officers on a permanent basis to focus on establishing the GIS at the Council. These were qualified staff with the necessary experience in developing and maintaining GIS resources in future. After 6 months of work, one of the two employed GIS officers resigned and since then only one GIS officer has remained working in the unit.

The council also developed a functional composition within the council administrative structure as depicted in Figure 7. The council built a GIS unit under the department of development planning. The GIS unit consists of three positions: The GIS manager and two GIS technical officers. This forms the operational unit, which involves the actual work of digitizing features and building up databases. The GIS unit provides comprehensive services including spatial analysis, cartographic production, data conversion, and data distribution to various departments.

The Council had a GIS steering committee, which consisted of the acting deputy director department of engineering and acting director as well as senior GIS manager department of development planning. The committee was formed to meet regularly to discuss the management of resources (personnel, funds, time, knowledge, and expertise), strategy, decision-making, planning, coordination and the monitoring and evaluation of the GIS activities (Mufulira Municipal Council, 2011). However, the study revealed that the committee was not active. In the organizational unit, the GIS manager is the link to the operational unit and ensures that the GIS is built according to the decisions made by the steering committee. The acting director department of development planning forms the link to management and the office of town clerk.

Figure 7: Organizational Set-up of the GIS Unit



Source: Mufulira Municipal Council, 2011

3.2.2 GIS Skills Capacity

The council's planning department has four officers with technical knowledge in GIS. Out of the four officers, three officers fall under the physical planning unit while one officer falls under the GIS unit.These officers include the deputy director of development planning who also performs the function ofGIS Manager, one GIS technical officer, and two town planners. The study revealed that all the four officers have received some level of GIS training and utilize GIS in their daily work activities. According to the structure of the unit, the GIS unit has a shortfall of two permanent GIS officers. The shortage of GIS officers has prompted planners to take up other GIS related tasks, which in turn has negatively affects the performance of the department.

3.2.3 Development of GIS Database

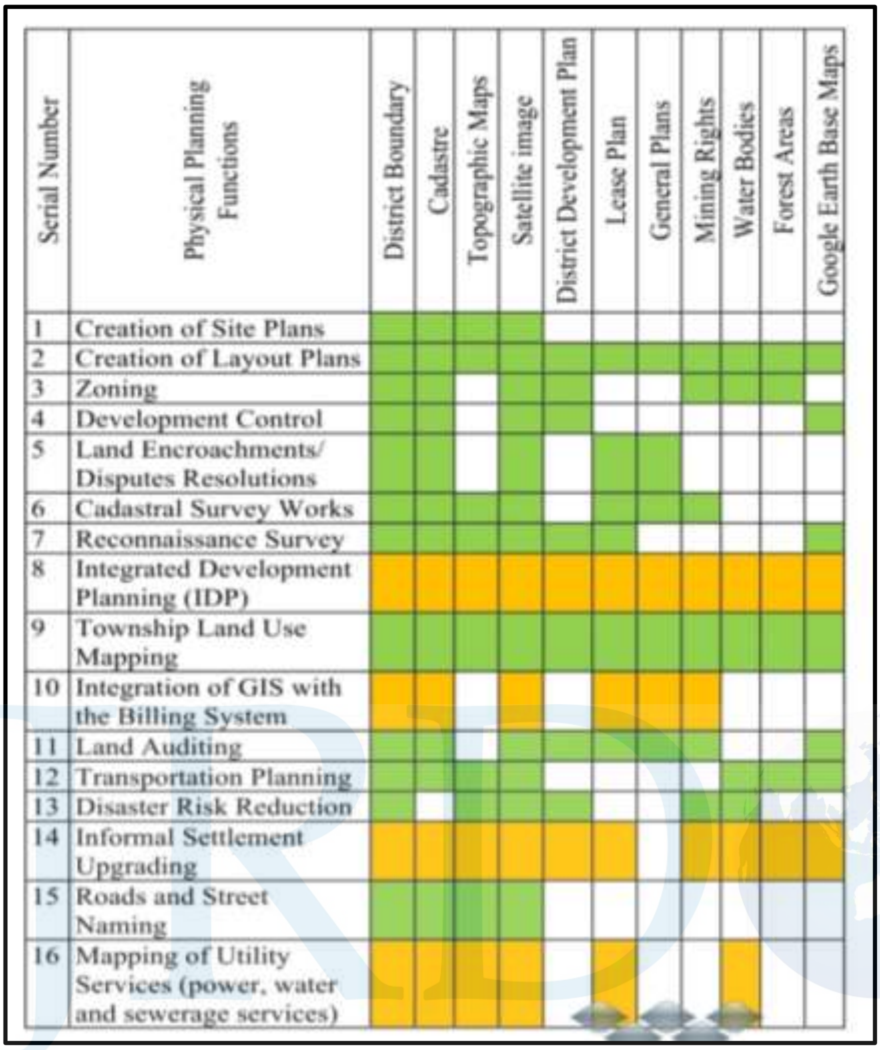
The GIS software was installed on five desktop computers and laptops used by the officers. This also involved defining the coordinate system and datum. In developing the GIS database, the unit collected information from various institutions. Mopani Copper Mines provided the Council with scanned ortho-maps, geo-referenced for digitizing of contours and physical features. The unit scanned all the hardcopy static layout plans and paper maps filed in the cabinets and geo-referenced those using accurate coordinates. The ministry of lands provided the Council with topographic maps, Mufulira District Development Plan, general plans, and the lease plan. The council also procured a high-resolution geo-referenced worldview 2 image used for digitizing existing features in the township including buildings, roads, rivers etc.

3.3 Extent of GIS improving Land Use Planning in Mufulira

3.3.1 Municipality Core Spatial Data Sets and GIS Application Functions

The Mufulira Municipal Council Strategic Plan of 2013 to 2017 provides a framework for improvement of GIS and enhancement of land use planning in the municipality under the department of development planning. The main objectives of the planning department are to ensure the meaningful physical development of the district, to enhance land use planning and management and to upgrade informal settlements in the District(Mufulira Municipal Council, 2013). The study established that all spatial information is included and managed with GIS. The council has about ten GIS core spatial datasets and the planning department uses GIS on about 75 per cent of its physical planning functions.Figure 8 shows the municipality GIS core spatial data sets utilised (green) and not utilised (orange) in different physical planning functions.The green color displays the available spatial data used in specific physical planning functions in the municipality planning department. The orange color displays the available spatial data with GIS application functions not being utilized for other functions. For example, among the spatial data sets, the first, second and fourth columns are mostly green; this implies that the widely used spatial data sets are the district boundary, cadastre, and high-resolution Satellite Image in most of the department's GIS application functions. The eighth and fourteenth row under the GIS application functions are mostly orange, it means that the department has not undertaken the preparation of the district Integrated Development Plan and the upgrading of any informal settlement as projected in the council strategic plan, despite having the required spatial data. The ninth row is mostly green, which means that most of the spatial data sets are used for development of the township land use plan.

Figure 8: Physical Planning Functions and GIS Core Spatial Data Sets

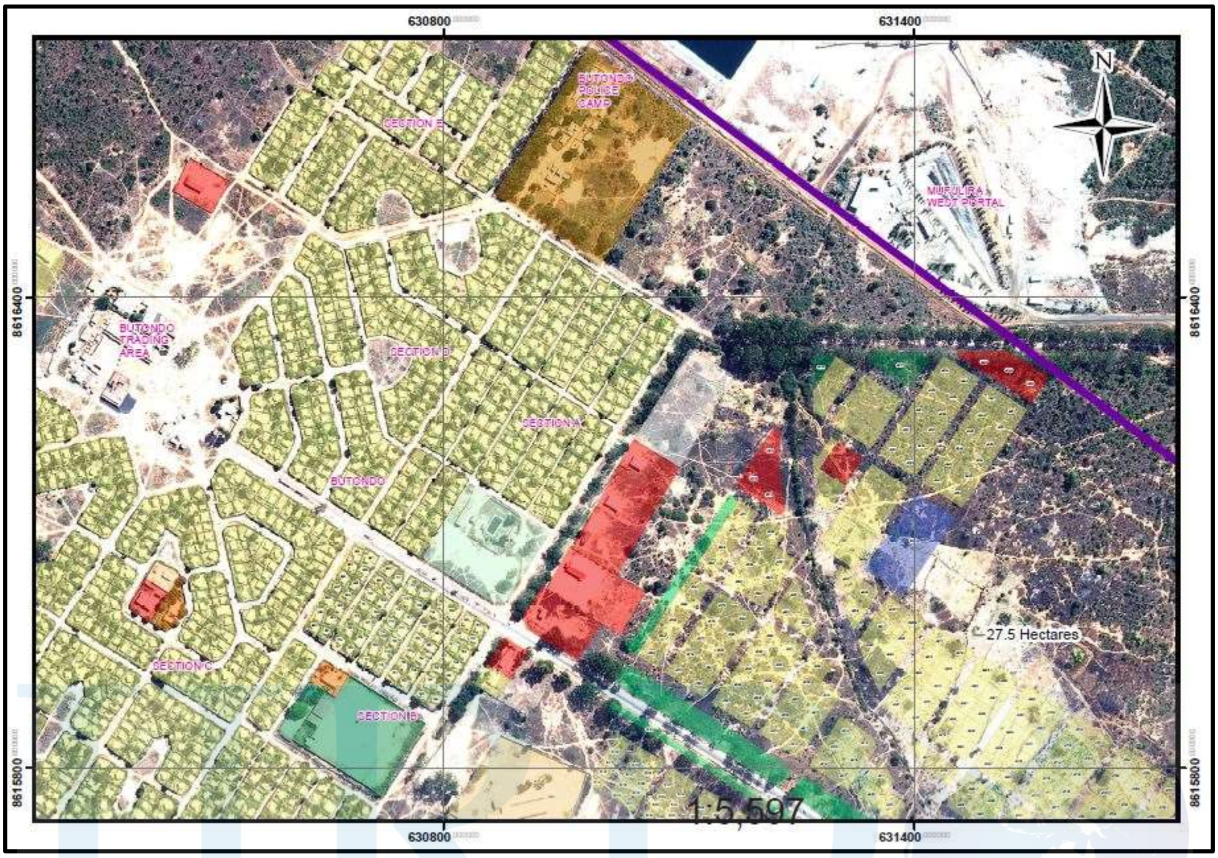


Source: Field Data, 2016

3.3.2 Integration of Ordinary Layout Plans into GIS

Implementation of GIS has assisted the Council in harmonizing of old layout plans with new GIS layout plans. One significant feature highlighted is that ordinary layout plans (drawing board-based) were often not reflecting the situation on the ground. To incorporate into GIS, ordinary layout plans are scanned, geo-referenced and digitized. This implies that the planning department is able to provide services related to land in both old and newly planned areas. Figure 9 shows an existing old, planned, and built-up area known as Butondo, mapped with various existing land uses and its plan incorporated into GIS.

Figure 9: Integrated Ordinary Layout Plan



Source: Mufulira Municipal Council GIS Spatial Data, 2016

3.3.3 GIS-Based Layout Plans

The study established that GIS-based layout plans created by the Council are aligned with the existing situation on the ground. This helps prevents land encroachments and further reduce the number of land dispute cases in future. Furthermore, this implies that the size of plots created will not be affected by the actual cadastral survey. Figure 10 shows a newly created layout plan of Miseshi high-cost residential area, with yellow and green parcels as residential and other social amenities. The layout plan depicts the railway line and its reserve (white line on the southwestern side), the road network is shown (red lines) before every created plot parcel. A high-resolution satellite image is included as a base image to display the existing conditions on the ground.

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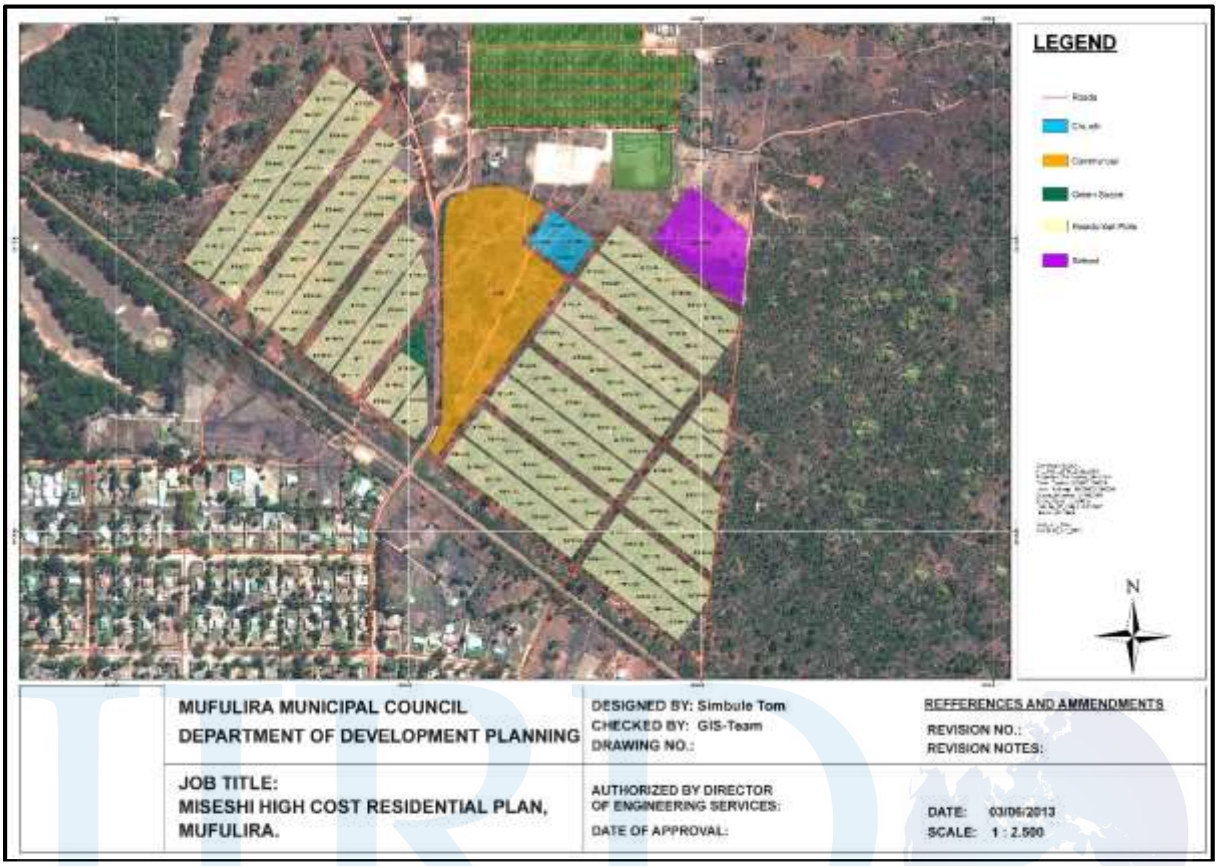
Figure 10: GIS Layout Plan Reflecting the Situation on the Ground



Source: Mufulira Municipal Council GIS Data, 2016

3.3.4 Mapping of Built-up Areas

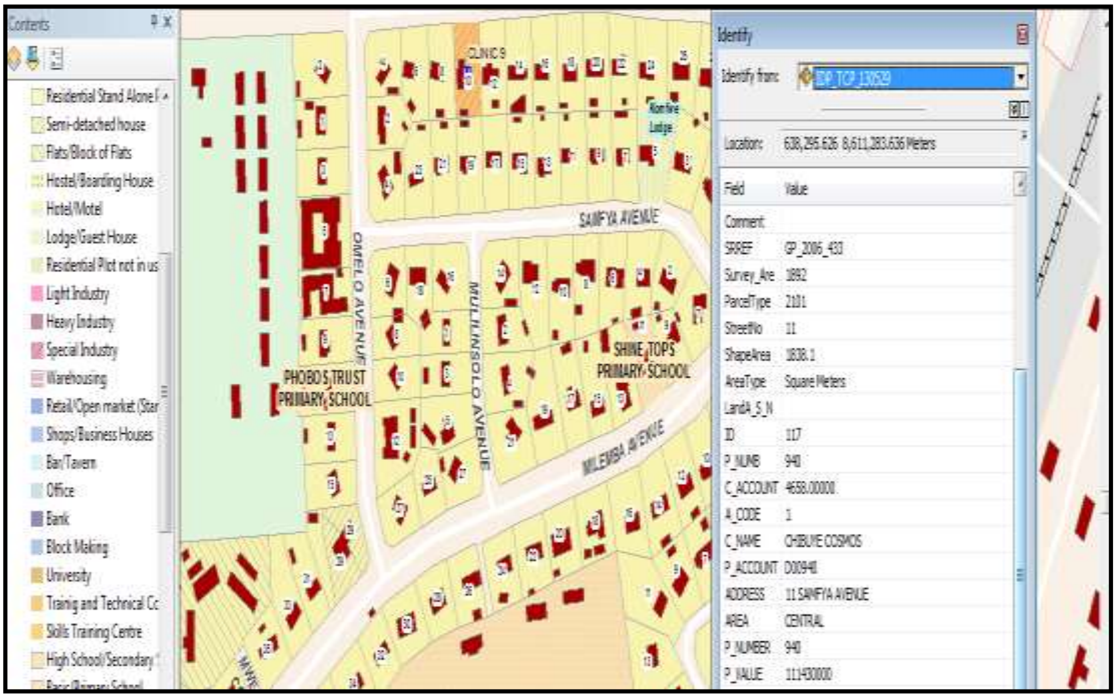
The Council also uses GIS to map Built-up areas to individual parcel level with different building type feature classifications such as lodges, banks, schools, clinics etc. Detailed information based on each parcel such as the name of a place, type of building, house and plot numbers is captured as attribute data and the information can be easily be retrieved using the identifier tool. Figure 11 shows the building footprints (as red polygons), the streets (as white lines) including the street names, the railway line (black hash line) and the railway reserve (as gray area). The table of contents on the left side of the figure shows other types of buildings mapped in the township such as lodges, offices, and commercial banks.

Figure 11: Mapping of Building Structures

Source: Mufulira Municipal Council GIS Data, 2016

In addition, the councils plot GIS data related to land is linked with the Finance department billing system. This helps Council manage its payments and issue bills to customers on time thereby improving service delivery.Figure 12 shows that the GIS database for the parcels also contains information from the Council's Finance Department billing system. Meaning that for every individual parcel, it is possible among other included attributes to identify the owner, the plot area and address, the property value and the supposed amount of rates to pay as depicted by the identifier window on the right side of figure 12.

Figure 12: Parcel Land use Information

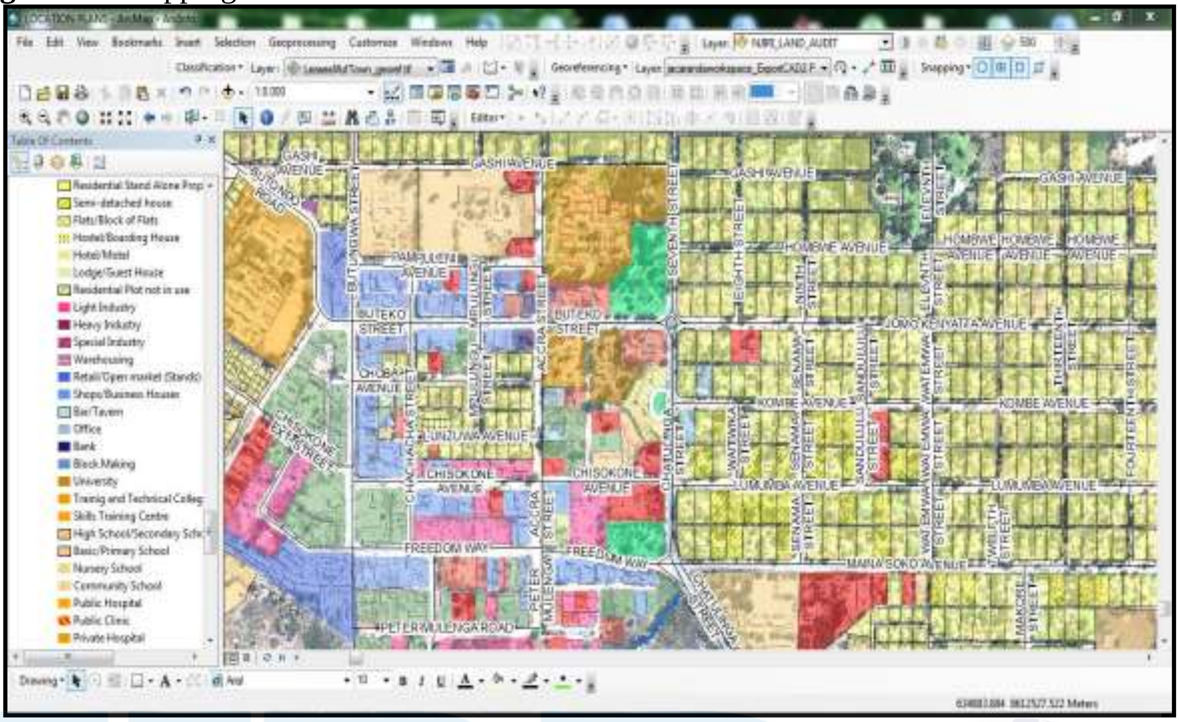


Source: Mufulira Municipal Council GIS Data, 2016

3.3.5 Mapping of Land Uses

The study further established that GIS has assisted the council in updating the existing township land use plan by using the high-resolution worldview-2 satellite image and the symbology function. This has, in turn, enabled the Council to manage its land and control development. Figure 13 shows a section of the Mufulira Central Business District (CBD) of the mapped land uses. The table of contents on the left side of the figure depicts the various mapped land uses in the township. For example, yellow which is the most dominant color on the figure represents residential areas, areas highlighted blue are mixed-use commercial areas while those in light purple are light industrial areas. In addition, all gazette roads are labeled for easy location and identification. This also helps in processing the change of land use applications, as information is readily available in GIS. The layer of land uses is made transparent to enhance the detail on the high-resolution satellite image layer underneath.

Figure 13: Mapping of Land Uses



Source: Mufulira Municipal Council GIS Data, 2016

3.4 Challenges of GIS Maintenance

In addition to the effort made to improve land use planning, the Council still experiences challenges of building and maintaining GIS. The challenges faced are highlighted as follows;

a) Inadequate support from Council Management

Since it is very costly to acquire the GIS hardware and software, the study established that Council management has been reluctant to buy a licensed software and pay for the repair of the damaged office equipment such as the A0 plotter. The council IT unit has not been unable link the GIS to other departments because of not having a licensed GIS software. The planning department has presented several progress reports to management and Plans Works and Real estate Development (PWDRE) committee of the council to lobby and make management/Council understand and appreciate the benefits of GIS, but no action or feedback has been given. There has also been inertia of using GIS by other council officers who perceive the tool to be too technical.

b) Transfer of officers with GIS skills

Transfer of officers who are skilled in GIS by the Local Government Service Commission (LGSC) has negatively affected the GIS implementation. This case, therefore, shows that the LGSC does not seem to take into consideration of the GIS skills that the Mufulira Council's officers possess that other Councils do not yet have. Hence, the department has a shortage of qualified GIS officers to work on building GIS at the Council. This has also negatively affected the implementation of the GIS Strategic Plan projects, which include development planning, development control, and Mufulira Integrated Development Planning.

4.0 Conclusion and Recommendations

The study has made obvious the power in GIS Technology to perform effective land use planning, which is useful in planning, and decision-making.Its importance inland use planning and managementshould therefore not be overemphasized. Adoption of GIS at Mufulira Municipal Council has possessed characteristics as accuracy, efficiency, economy, flexibility, large data storage, analytical power, speed and easy retrieval of information are all benefits derived from the use of GIS. It is clear here that it is better off than the manual method of data handling. This work, therefore, opens a new door of possibilities for planning authorities. GIS implementation at the council has therefore to some extent improved land use planning.

Recommendations are therefore made that:

Council management to support the planning department with required financial and human resources to build capacity and improve GIS operations: A GIS requires a complete system to function properly. There is the need for council management to ensure that the planning department is provided with financial resources to build and conduct routine maintenance of the GIS. The damaged plotter requires urgent attention to ensure continuity of service delivery. In addition, council management should request for employment of two more GIS officers from the LGSC whose primary focus will be building and maintaining the GIS at the council.

Council to work on linking the GIS software to other council departments: Restricting the use of GIS to the planning department only limits the access of spatial information by other departments and promotes inefficiency in service delivery. The ArcGIS software should be linked to other council departmentssuch as administration, finance, housing, and engineering departments that directly deal with land-related services through a central server to improve service delivery and access to spatial information.

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