A framework for the adoption of Geographic Information Systems (GIS) in service delivery: A case of Harare city council, Zimbabwe

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Abstract:
Geographic Information System (GIS) can be used to enhance service delivery in local authorities through exploiting geographical features on the earth's surface to efficiently and effectively manage, plan and maintain infrastructure. The proliferation and implementation of GIS has rapidly advanced in developed countries where as in developing countries, the utilisation of spatial technologies has proceeded at a slow pace. The goal of this research was to develop an adoption framework for GIS that can be employed by developing countries culminating in the delivery of quality service to ratepayers. The triangulation research design, which is the use of more than one approach for the investigation of the research questions, was used in this research. Data was analysed using content analysis that identified the emerging themes as well as SPSS for the quantitative data component. The study revealed that there is a link between GIS utilisation and service delivery. A proposed GIS adoption framework that was informed by research findings and literature review/documentary analysis of archival records was then developed. The proposed adoption framework has five important components that need to be addressed for the successful adoption of GIS in local authorities in developing countries. Recommendations on how local authorities in developing countries can successfully adopt/ implement GIS technology were made. Chief among the recommendations is for the local authorities to adopt e-governance, which has become a prominent and critical success factor as well as an important global element in the ease of doing business.

Keywords: GIS; Adoption Framework; Spatial Data; Local authorities.

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1. Introduction

The research is aimed at developing a framework to assist in the adoption of Geographic Information System (GIS) to enhance service delivery for Local Authorities in Developing Countries. According to Dempsey, a Geographic Information System (GIS) is a computer system, or a technological field of geographical science that incorporates geographical features with data. These geographical features are used in order to map, analyse, and assess real-world problems. Dempsey (2018) also states that the key word in GIS is geography, meaning that some portion of the data contain spatial information referenced to some place on the Earth.

It is indeed without doubt that GIS is quite a significant tool that has the potential to assist in managing the planning and maintenance of infrastructure within municipalities or local authorities. How GIS is applied to examine the equity in distribution of public services to various segments of the community is also important in the context of this study. Furthermore, the development and adoption of GIS by different government, parastatals and private organisations worldwide, shows enormous progress in the last two decades (Cavric, 2002). However, most of these positive trends in the GIS global arena has rapidly advanced only in developed countries.

It is so disheartening that in many African countries GIS adoption, diffusion and utilisation of spatial technologies has proceeded at relatively lower rate. Little attention has been given to improve current situation along the line of flexible approaches and efficient organisational frameworks. Numerous factors such as financial, political, technical, technological, educational, organisational, and human behavioural obstacles have restricted the implementation of GIS (Cavric, 2002).

1.1 Problem Formulation

There seems to be no well-defined GIS adoption framework that can be used by institutions in developing countries that can utilise this technology to enhance service delivery. Researchers have used many conceptual frameworks to explain the process of GIS adoption and implementation in various organisational settings. These frameworks differ to a greater or lesser extent in their terminology and approach (Noongo, 2007). GIS has the potential to transform and assist the city in its planning endeavours as well as a municipal decision-making tool that can enhance service delivery to its clients and stakeholders.

Thus, it is against this background that the researcher seeks to establish whether there exists a link between effective utilisation of GIS and service delivery and examine the factors that influence GIS adoption. The research will also interrogate available GIS adoption frameworks leading to the development of a proposed GIS adoption that will be suitable for local authorities in developing countries.

2. Related work

A review of literature suggests that while there have been a number of systematic studies of GIS diffusion in developed countries (Onsrud & Pinto 1991, Masser & Onsrud 1993, Campbell & Masser 1995, Chan & Williamson 1996 & 1999) as cited by Noongo (2007), there has not been enough work in developing countries in the relative sense. Where such studies have occurred, focus has mainly been on critical organisational problems that inhibit successful application of GIS in developing countries (Nkwambe, 1991; Ramasubramanian, 1991; Sahay & Walsham, 1996) as cited in Noongo (2007).

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2.1 Link between GIS Utilisation and Service Delivery

GIS is being used to provide solutions in numerous branches of government service as well as in businesses and industry to enhance service delivery. Geo-information technology is being used in surveying, engineering, planning and logistics for the collection, processing, management and presentation of spatial information. The main reason organisations are investing in GIS is their potential to increase efficiency. These systems can be used to help develop and deliver new types of services such as better transportation and service information for citizens.

According to a white paper by ESRI, Local Governments, whether large or small, have departments that perform hundreds of business functions in providing services to the community. Most of these business functions have location as an aspect of their operation. The effectiveness and efficiency in the delivery of information and services can be improved by taking advantage of GIS (ESRI, 2007).

The digitalisation of maps and other forms of spatial information opens up new possibilities for GIS to be used to visualise geographic knowledge and to transform geographic information. They provide users with a range of analytical tools that are only provided by GIS to explore spatial relationships in data, including data collection, data modelling, data manipulation, data analysis and data storage. This combination of both basic and advanced spatial data analysis functions is not found in generic information systems. The functionality offered by GIS is often required to understand and to manage activities and resources for highly specific purposes.

2.2 The applications of GIS

According to GISCENTER as cited in Azaz (2011), GISs have been used for several years in the natural resources, forestry, and environmental industries, only recently have they begun to be used for a broader array of business and management functions such as logistics, site and facilities management, marketing, decision making, and planning. GIS can help a retail business locate the best site for its next store. It helps marketers find new prospects. It allows you to view understand, question, interpret, and visualize your data in ways simply not possible in the rows and columns of a spreadsheet (Azaz, 2011).

GIS technology may be seen as a means to automate spatial operations or as a tool for obtaining better information about business operations. For example, the Harare Water Department will use GIS to support routine maintenance of water and sewer pipe networks. Thus, the ability by the Engineers to expeditiously locate a burst pipe or a hydrant is critical to their ability to continue to provide a satisfactory service to the clients. GIS based technology can be used to automate the search procedure for pipe or hydrant location, thereby making operations more efficient.

2.3 Factors that influence GIS adoption

Accurate and timely spatial and socioeconomic data are difficult to obtain and, as a result, require a significant financial investment by any organisation seeking to use GIS. Furthermore, in most cases an investment in GIS hardware, software, and data will not lead to tangible benefits until long after the initial investment is made (Deichmann, 1996) as cited in Mennecke (2001)).

Another resource constraint that developing countries face is that of the availability of trained personnel. Training is not only expensive and time consuming, but it also can lead to retention problems.

Organisational politics have been observed to have a significant impact on the implementation of GIS in public sector organisations in the United States (Pinto, 1996) as cited in Mennecke (2001)) and it is to be expected that this influence is not unique to developed countries only.

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3. Theoretical Frameworks

The research will be founded on the theoretical underpinnings of the Technology-Organisation-Environment framework or model (TOE) theory. The theoretical framework will form the basis or reference point upon which the GIS adoption or implementation framework will be developed.

3.1 Technology- Organisation-Environment (TOE) Framework

Technology-Organisation-Environment framework or model (TOE) depicted in Figure 1, is an Information System theoretical framework proposed by DePietro (1990) to analyse adoption of technological innovations by firms and organisations. According to DePietro (1990), the TOE framework states that: adoption of information technology by organisations is influenced by three different contextual groups namely; technological, organisational, and environmental contexts.
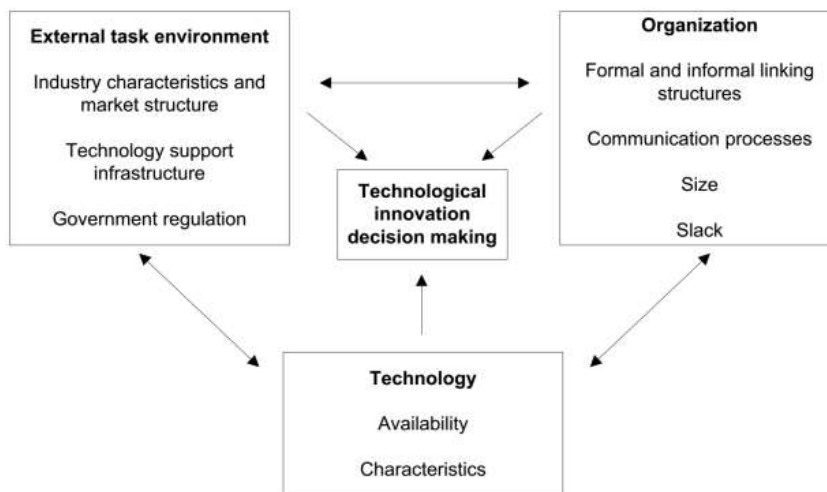

Figure 1: Diagram or Schematic of TOE Theory

Source: DePietro et al. (1990)

TOE emphasizes the context of an innovation. Technological Context is defined as both the existing technologies in use and new technologies relevant to an organisation. Organisational Context could be described as descriptive measures about the organisation such as scope, size and the number of slack resources available internally. Environmental Context refers to the arena in which an organisation conducts its business - its industry, competitors and dealings with government (DePietro, 1990).

4. Research Methodology

A combination of qualitative and quantitative research design was used. The quantitative method was employed in the study so as to quantify respondent's answers in defined variables to draw statistical conclusion and comparisons. The research process is depicted in Figure 2. The researcher used an interview guide, observations, questionnaire and archival records (documentary review) as research instruments for collecting qualitative and quantitative data.

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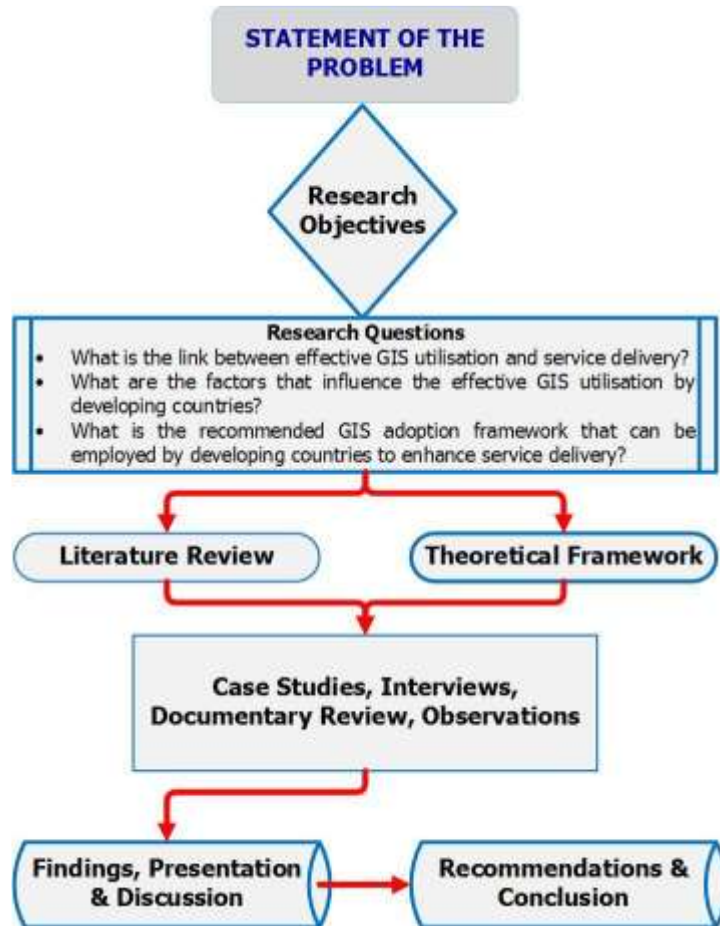

Figure 2: Research Process

Source: Kwaramba (2012)

The research population was derived from Land Information Officers, Cartographers, ICT personnel, Town planners, Surveyors, Environmentalists and relevant university students.

5. Research Findings and Results

5.1 What is the link between effective GIS utilisation and service delivery?

It emerged from both the findings and results that indeed there is a link between effective GIS utilisation and service delivery. Respondents indicated that GIS can improve the efficiency and effectiveness in service delivery for Local Authorities. This view is also supported by literature review. According to (ESRI, 2007), the effectiveness and efficiency in the delivery of information and services can be improved by taking advantage of GIS since most of these business functions have location as an aspect of their operation.

The research results and findings are consistent with the findings by (Azaz, 2011), who established that with geo-data on a map, you can ask more questions. You can ask where, why, and how, all with the location

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information on hand. You can then make better and informed decisions to improve service delivery with the knowledge that geography and spatial analysis presents.

5.2 What are the factors that influence effective GIS utilisation by developing countries?

It emerged from the key informant interviews, documentary review and semi-structured questionnaires that successful GIS adoption can be influenced by a number of factors that include staff compliment and training, availability of resources, top management support, planning and communication among many other factors. These findings are discussed in detail below:

5.2.1 Staff Compliment and Training

The research results and findings established that most Local Authorities do not have the required qualified personnel to help in the adoption and implementation of the GIS system. The Local Authorities should make deliberate efforts to train their staff, sending them to national, regional and international seminar/workshops or conventions where they are equipped and exposed to relevant and modern skills. Another suggestion was made for Local Authorities to collaborate with First World Cities through twinning arrangements and they could establish or initiate exchange programs for knowledge sharing and transfer.

5.2.2 Availability of Financial Resources

The research also established that there should be allocation of financial resources and other logistical support for GIS adoption to be operational. A suggestion was made from the findings that local authorities should include major Information Systems like GIS in their long-term financial planning through allocation or provision of a reasonable budget.

The research findings are consistent with a study conducted by Aminuzzaman (2010) in Bangladesh that revealed that some of the critical institutional challenges facing service delivery at the level of Local Authorities include limited work force and financial resources. He further elaborated that considering the workload and responsibilities, local authorities are understaffed. GIS undoubtedly consists of proponents that leads to improved geographic distribution of services as well as efficiency and effectiveness in service delivery.

However, evidence from various countries has revealed that GIS adoption or implementation without supporting resources from the government as well as local sources of revenue will not improve services delivery. City of Harare should be commended for making deliberate efforts in allocating resources towards the adoption and implementation of GIS, this is attributed to a $500 000 GIS strategy project as reported in The Herald dated 11 November 2016.

5.2.3 Top Management Support

In the research findings, the respondents argued that GIS adoption and implementation involves substantial investment in hardware and software infrastructure thus, there is need to have a strong buy-in or support from the top management so that financial resources and other resources can be channelled towards this worthy cause.

5.2.4 Planning

The research findings revealed that Information Systems like GIS technology requires Local Authorities to capture them in their strategic planning documents and the source of funding should also be identified followed by a work or project plan.

There is evidence from literature by Aminuzzaman (2010) who found out that there is a problem of lack of planning and coordination between local authorities and extension service delivery workers of the government

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at the field level. This was established to be the same case with City of Harare vision drivers, employees and the relevant stakeholders.

It was noted that there are no formal links between stakeholders. Such isolation makes lots of the services of local authorities dysfunctional and ineffective. Poor planning of processes therefore brings a lot of confusion in day-to-day operations especially pertaining to roles and responsibilities of various stakeholders in the GIS adoption process.

5.3 Utilisation of GIS Technology by Zimbabwean Local Authorities

Figure 3 shows responses given by the respondents on the current utilisation of the GIS technology by Zimbabwean local authorities. The majority of respondents suggested that the technology is not being fully utilised with also a considerable number of respondents accepting that they did not know anything on the utilisation of this technology.
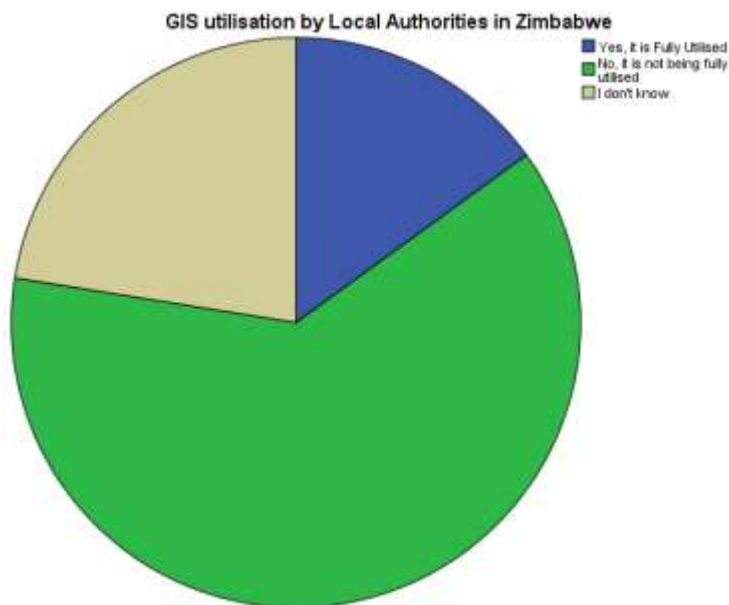

Figure 3: GIS Utilisation of GIS by Zimbabwe Local Authorities

5.4 Link between Service Delivery and GIS Technology

As show in the bar chart below, 71.8% of the respondents suggested that there is a link between GIS technology and service delivery.

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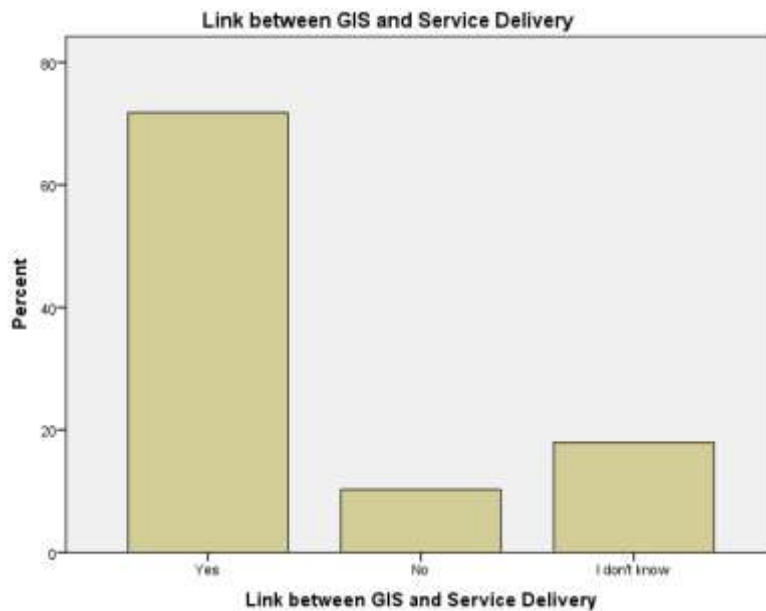

Figure 4: Link between GIS and Service Delivery

6. Proposed GIS Adoption Framework

The proposed GIS adoption framework is depicted in Figure 5. Development of the proposed GIS adoption framework was influenced by research findings and results as well as literature review on the TOE theoretical framework and the existing GIS adoption frameworks. The researcher believes that for successful adoption or implementation of the GIS technology, there are five components that should be satisfied, namely:

6.1 Organisational Setting

This component is the cornerstone in the GIS adoption or implementation matrix. It consists of the organisation's vision, mission and values. The organisation should make deliberate efforts to align its vision and or objectives with its Information System (IS) strategy. The alignment process will set the tone for allocation of IS budgeting and top leadership support in the adoption and subsequent implementation of the GIS technology and other ISs that could improve productivity, competitiveness and the generally accepted service delivery standard in Local Authorities. Recruitment and training of staff to equip them with relevant skills and knowledge is also of significant importance.

6.2 Stakeholder Engagement or Participation

Stakeholders are important in any organisational setup. Their engagement, involvement and participation in the operations of the organisation is key. This component consists of consultations with key stakeholders, twinning arrangements and exchange programs that can foster knowledge transfer.

6.3 Enabling Infrastructure

This component consists of setting up of networks for connectivity and internet services, hardware that may include servers, desktop computer and GIS related infrastructure. The software is also equally important and it needs to be procured e.g., ArcGIS for drawing maps by Cartographers.

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6.4 Government Support

The research findings and results were very clear on the involvement of government in GIS technology adoption and implantation. The government should create an enabling environment for Local Authorities to execute their mandate as spelled out in the Urban and Rural Councils Acts. There is need for the State to formulate IS policies that could be used by Local Authorities to attract foreign direct investments or Private Public Partnerships (PPPs). Over and above the highlighted roles government should play, the State should also provide municipal grants to Local Authorities for the procurement or setting up of GIS related or enabling infrastructure.

6.5 Conducive Environment

According to DePietro (1990), the environmental context includes structure of the industry, competitors, and government's regulations and policies. DePietro further highlighted that the relationship between organisations and trading partners, competitors, government, pressure from trading partners, and industrial community may affect adoption decisions.

7. Conclusion

7.1 Framework of Operation

All the identified five competing and equally important components highlighted above, feeds into the government Framework of Operation (FoP). The FoP defines the role of GIS in the organisation its kind and level. Thus, these elements combined, will help the Local Government to make an informed decision that will lead to the generation of a technologically inspired innovation. The Technological Innovation will then lead to GIS Design or GIS Application Design and the design could be that of an Urban Planning GIS, Surveying GIS to mention but just a few. The framework of operation is presented in Figure 5.
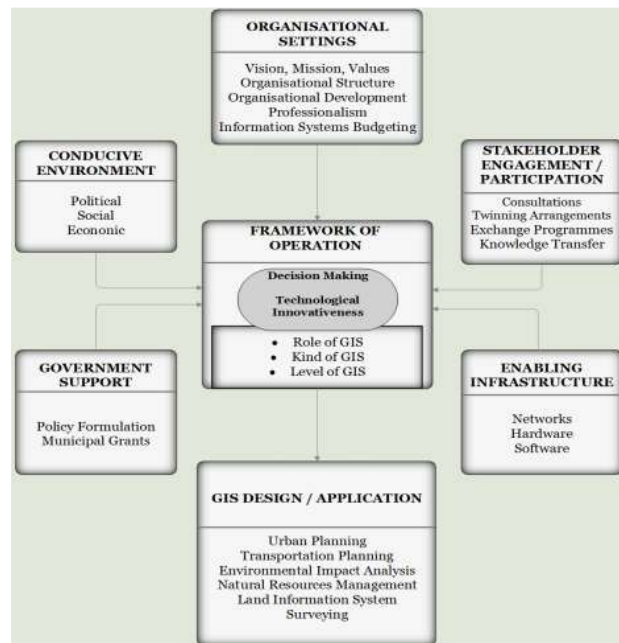

Figure 5: Proposed GIS Adoption Framework

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7.2 Implications of the study

The research study contributed to the development of a GIS adoption framework that can be used by local authorities in developing countries to enhance service delivery. The study established that there was indeed a link between GIS technology and service delivery even though a number of factors determined its successful adoption. The study established that the success of GIS adoption or implementation is heavily dependent on top management support and availability of key resources like skills and finances within the local authorities.

Conflict of Interest Statement

The authors declare no conflict of interest in the conduct of this study.

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