EXPLORING GIS DIFFUSION IN ELECTRICITY SUPPLY CORPORATION OF MALAWI

MASTER OF SCIENCE (INFORMATICS) THESIS

SEYANI FORBES BASIKOLO

UNIVERSITY OF MALAWI

CHANCELLOR COLLEGE

MAY, 2017

EXPLORING GIS DIFFUSION IN ELECTRICITY SUPPLY CORPORATION OF MALAWI

MSc. (INFORMATICS) THESIS

By

SEYANI FORBES BASIKOLO
BSc (Electrical Engineering) – University of Malawi

Submitted to Faculty of Science, Department of Computer Science in partial fulfillment of the requirements for the Degree of Master of Science (Informatics)

UNIVERSITY OF MALAWI
CHANCELLOR COLLEGE

MAY, 2017

DECLARATION

I, the undersigned hereby declare that this thesis is my own original work which has not been submitted to any other institution for similar purposes. Where other people's work has been used, acknowledgements have been made.

SEYANI FORBES BASIKOLO

_____

Full Legal Name

_____

Signature

_____

Date

CERTIFICATE OF APPROVAL

The undersigned certify that this thesis represents the student's own work and effort and we approved for its submission.

Signature: _____Date:_____

Kondwani Godwin Munthali, PhD. (Lecturer)

Main Supervisor

Signature: _____Date:_____

Dickson Chinguwo, MSc. (Lecturer)

Co-Supervisor

ACKNOWLEDGEMENTS

In the accomplishment of this thesis, I would like to thank God Almighty for His grace, and extend sincere appreciation to several people for their guidance through my research. I am sincerely and heartily grateful to Dr. Kondwani Godwin Munthali and Mr. Dickson Chinguwo, my supervisors, who helped me to develop my thinking around the suggestion in my initial research proposal into a meaningful study. I will always value the continuing advice and support they provided. I explicitly acknowledge the contribution made to the research by Pastor Patrick Pangani with whom I have worked with on the development of the prototype that has formed a part of this study. I thank my family for the support and sacrifice necessary to allow me to undertake this work. Finally, I express my gratitude to the Electricity Supply Corporation of Malawi (ESCOM) Limited for the financial support.

ABSTRACT

The previous studies on diffusion of innovation indicates that the diffusion of innovation is often very difficult. The end-users do not adopt and implement all technologies that has obvious advantages over others in an organization. This is the case for many technologies, and it is particularly relevant for Geographic Information Systems (GIS). Accordingly, the diffusion of GIS in an organization setting will be subject to the influence of several factors that interact with one another to make it operate. Therefore, the purpose of this research was to explore on the diffusion process towards diffusion of GIS within ESCOM. Using a single case study approach, the research employed a semi- questionnaire and unstructured interview on respondents in influential positions that had direct input into the diffusion of GIS. The results closely mirrored the five stages of Rogers (2003) in the process of innovation within an organization but more broadly defined. To be considered when diffusing GIS in an organization are the following four key factors: Management, Technology, Readiness of the organization and Environment. Each factor represents unique challenge for innovation diffusion. The study concludes that awareness and experience with the GIS is essential for a successful outcome.

TABLE OF CONTENTS

ABSTRACT vi

TABLE OF CONTENTS vii

LIST OF FIGURES x

LIST OF TABLES xi

LIST OF APPENDICES xii

LIST OF ABBREVIATIONS AND ACRONYMS xiii

CHAPTER 1 1

INTRODUCTION 1

1.1 Background 1

1.2 Problem Statement 2

1.3 Purpose 3

1.4 Research Objectives 3

1.5 Research Questions 3

1.6 Overview of the Organization 4

1.7 Contribution to knowledge 6

1.8 Thesis Structure 6

CHAPTER 2 8

LITERATURE REVIEW 8

2.1 The conceptual framework 8

2.1.1 Actor Network Theory 9

2.1.2 The Unified Theory of Acceptance and Use of Technology 11

2.1.3 Diffusion of innovation 12

2.2 Defining GIS 13
2.3 Innovation 14
2.3.1 Innovation process 15
2.3.2 Social system 16
2.4 GIS in an organization 19
2.5 Scenarios for corporate GIS diffusion 21
2.6 GIS in Power Sector 21
2.7 Diffusion of innovation research approaches 23
2.8 Consequences of Diffusion 23
CHAPTER 3 25
RESEARCH METHODOLOGY 25
3.1 Research approach and process 25
3.2 Theoretical approach 27
3.3 Research methods 27
3.4 Research Tools 28
3.5 Data analysis 30
3.6 Prototyping and System Design Methodologies 32
3.7 Quality of Research 33
CHAPTER 4 35
RESULTS AND DISCUSSIONS OF THE STUDY 35
4.1 The progress of GIS diffusion in the organization 35
4.2 Factors enable or inhibit the successful diffusion of GIS in the organization 51
4.2.1 Management 52
4.2.2 Technology 58
4.2.3 Readiness of the organization 62

4.2.4 Organization Environment 65
4.3 Feasible and useful of GIS in management of power system 68
4.3.1 Functional requirements 69
4.3.2 Non-functional requirements 70
4.3.3 Data Collection and Modelling 70
4.3.4 System development 71
4.4 The Prototype Outcome 74
4.4.1 Spatial query 75
4.4.2 Aspatial Query 77
4.4.3 Network Analysis 81
4.4.4 Proximity analysis 83
CHAPTER 5 87
CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS 87
5.1 Conclusion 87
5.2 Research Contributions and Implications 87
5.3 Research limitations 89
5.4 Further research 90
5.5 Recommendation 91
REFERENCES 93

LIST OF FIGURES

Figure 1. The organizational innovation process. 15

Figure 2. The workgroups 41

Figure 3. Base map showing district of the study area. 69

Figure 4. Complete map for the prototype. 71

Figure 5. The initial opening screen of the GIS prototype. 73

Figure 6. Zoomed in map. 74

Figure 7. Transformers that were connected to 2L5 feeder. 76

Figure 8 Zoomed in Transformers that were connected to 2L5 feeder. 77

Figure 9. Location of a specific customer. 79

Figure 10. Zoomed in Location of a specific customer. 80

Figure 11. Customers connected to a specified Transformer. 82

Figure 12. Zoomed in customers connected to a specified Transformer. 83

Figure 13. Buffer zone around the specified Transformer showing an area within permitted voltage drop. 85

Figure 14. Zoomed in buffer zone around the specified transformer showing on area within permitted voltage drop. 86

LIST OF TABLES

Table 1: Definitions of GIS in terms of its elements. 14

Table 2: The Coding Process in Inductive Analysis 30

Table 3: Centralized versus Decentralized diffusion systems. 61

LIST OF APPENDICES

Appendix 1: The Questionnaire for exploring GIS diffusion in Electricity Supply Corporation..... 107

Appendix 2: The list of Sample for the research 125

Appendix 3: The list of respondents to the questionnaire..... 126

Appendix 4: The list of interviewees 129

Appendix 5: The program Source listing..... 130

LIST OF ABBREVIATIONS AND ACRONYMS

AHC	AH Consulting
ANT	Actor Network Theory
CEO	Chief Executive Officer
C-TPB-TAM	Combined theory of planned behavior/technology acceptance model
DoI	Diffusion of Innovation
EMIS	ESCOM Management Information System
ESCOM	Electricity Supply Corporation of Malawi Ltd
GIS	Geographic Information Systems
GoM	Government of Malawi
HV	High Voltage
ICT	Information and Communication Technologies
IDT	Innovation diffusion theory
IT	Information Technology
kV	Kilovolt
kW	Kilowatt
LV	Low Voltage
MCA-Malawi	Millennium Challenge Account - Malawi
MCC	Millennium Challenge Corporation
MIS	Management Information System
MM	Motivational model
MS	Microsoft
MV	Medium Voltage

MVAR	Megavolt Ampere Reactive
MW	Megawatt
PSRA	Power Sector Reform Activity
RAD	Rapid Application Development
SCT	Social cognitive theory
SDLC	System Development Life Cycle
SCADA	Supervisory Control and Data Acquisition System
TAM	Technology acceptance model
TOR	Terms of Reference
TPB	Theory of planned behavior
TRA	Theory of reasoned action
UI	User Interface
UTAUT	Unified Theory of Acceptance and Use of Technology

CHAPTER 1

INTRODUCTION

1.1 Background

The Government of Malawi (GoM) is implementing the Power Sector Reform Activity (PSRA) in partnership with the Millennium Challenge Corporation (MCC) through the Millennium Challenge Account (MCA- Malawi). The MCC/MCA aim is to support the GoM's policy reform agenda and building capacity of sector institutions such as the Electricity Supply Corporation of Malawi (ESCOM) Limited. The PSRA will provide the Malawi energy sector with an opportunity to reinvent itself in a way that will ensure its economic viability going forward. Critical to this reform initiative is the ESCOM Turnaround activity that involves among others, the adoption and implementation of Management Information System (MIS) as part of Malawi's $350.7 million Millennium Challenge Corporation compact. The organization will diffuse the Geographic Information Systems (GIS) as one of the innovations under MIS. The term "diffusion in the organization setting" in this research reflect the broad scope of GIS decisions involving *adoption* and *implementation* in order to achieve the required outcomes. The organization will invest a lot of money in the GIS and to gain more in return, the GIS involved should be well planned and diffused. The GIS diffusion process should aim to provide the important steps that take place during the GIS diffusion and know what issues should be raised and resolved throughout the diffusion

process so that there can allow for better control over the outcome of GIS diffusion. This will increase chances of success of the innovation. The process of GIS diffusion should be optimized for better comprehension of the process involved in diffusion but also be straightforward enough that it should be easily understood by all involved in the diffusion of the GIS.

1.2 Problem Statement

In recent years, ESCOM has been engaging GIS as a component of an enterprise solution that integrates all the business processes into a single point of reference and management, and ensures well alignment of the organization's business processes and information systems to industry best practices. However, case studies of GIS diffusion conducted in different organizations and settings, concludes that there is no formula for this process, and each organization's GIS approach is unique. There is no single key to the successful diffusion of GIS; many factors come into play, hence, must be accounted for. However, simple transfer of these principles to specific environments would likely be futile. Therefore, without implementation strategies, developing and implementing an effective diffusion plan is the challenge the organization is facing. The literature available on GIS diffusion in developing countries is mostly dominated by ad hoc application descriptions from past successes and failures of GIS diffusions. Furthermore, the reports on these cases are in a post hoc manner and after the effects of GIS diffusion. The results also seem biased, due to the effect of time or outcome injected into the researcher's report. With insufficient understanding on the diffusion of innovation process in the organization, it is clear that there is dilemma for the GIS diffusion.

1.3 Purpose

The study seeks to explore the process of GIS diffusion in an organization. Given that, the present study will explore GIS diffusion in ESCOM in their work toward the diffusion of GIS. The aim was to involve empirical investigation of a particular contemporary phenomenon within its real life. In this case, the researcher used ESCOM to draw broader understanding of GIS diffusion process. The research adopted Diffusion of Innovation (DoI) analysis techniques and research methodologies in an attempt to address this knowledge gap. It is hoped that the research will further the knowledge and understanding surrounding the diffusion of GIS both within industry and academia.

1.4 Research Objectives

In light of the aforementioned purpose, the researcher identified three specific objectives to address the focus of the study.

1. To provide insight into how the diffusion of GIS progresses within ESCOM.
2. To provide the qualitative factors that enable and inhibit the process of GIS diffusion to be undertaken in ESCOM.
3. To demonstrate the feasibility and usability of the functionalities of the GIS in management of ESCOM's distribution power system.

1.5 Research Questions

Having set the research objectives, the researcher formulated the three research questions to help address the research objectives.

1. How does diffusion of GIS progress in an organization?

2. To what extent is successful diffusion of GIS enabled or inhibited by the organizational context within which it takes place?
3. How feasible and useful is GIS in management of distribution power system?

1.6 Overview of the Organization

ESCOM is the organization chosen for this research. The organization fulfills the requirements of the research aims. The fundamental building block of ESCOM is the vertically integrated utility, regulated by the public utility commission in Malawi in which the utility operated. In essence, the electricity supply chain has three links: generation, transmission, and distribution.

Malawi's electricity generation mix consists predominantly of large hydro power plants, mainly on the Shire River that flows from Lake Malawi. The Generation comprises of Hydro Power plants at Nkula A, Nkula B, Tedzani I, II and III, Kapichira and Wovwe. In addition, Generation has Diesel Generators situated in Lilongwe City (Central Region) as well as Mzuzu City, Likoma and Chizumulu Islands (Northern Region) of the country (ESCOM Annual Report, 2015). The various generators, which are located large distances from consumption centers, connect to a high-voltage transmission network.

The transmission network operate at Voltages of 66kV and 132kV. The 66 kV Overhead Line Network spans over 1122km with 40% of the network on steel structures and the remainder on wooden poles. The 132kV Overhead Line Network spans for over 1240km with over 63% of the network on steel structures and the

remainder on wooden poles. This transmission network spans across the country and ESCOM has 35 Transmission substations with 18 in the Southern Region, 9 in the Central Region and 8 in the Northern Region (ESCOM Annual Report, 2015). Closer to the point of consumption, the transmission network is connected (through a series of step-down transformers) to a lower-voltage distribution network.

The Distribution Network has High Voltage (HV), Medium Voltage (MV) and Low Voltage (LV) systems with HV operated at Voltages of 33kV and 11kV, MV at 400V and LV at 230V. The entire distribution network run on wooden poles with a general expansion rate of 400km per year (ESCOM Annual Report, 2015). As of February 2015, ESCOM's customer base was around 297,903 of which 92.2% were domestic customers, with the rest being commercial and industrial customers. These Customers are metered using pre-paid and postpaid metering devices (ESCOM Annual Report, 2015).

In essence, the major business of the organization is to generate, transmit, distribute and retail electricity to its customers across the country. Running such a business requires processing and managing volumes of information efficiently and effectively to support decision-making and customer service. Currently, ESCOM's operations are severely constrained. One of the reasons is due to the lack of GIS to fully monitor and manage its assets and result in poor recording of the assets, poor evaluation of the state of the assets, inefficient maintenance schedules, poor tracking of system performance and poor planning for system expansion. This is inefficient and poses several risks to the quality of information available, processed

results, and ultimately decisions made. Because of these challenges and risks, a lot of time is spent executing repetitive operations, rather than managing and improving processes and performance of the business.

While the electricity supply chain has three links: generation, transmission, and distribution, the research took a holistic approach. That is, this research looks at the organization as a whole unit rather than concentrating on a specific link or sector of the organization.

1.7 Contribution to knowledge

The research aims were to generate new knowledge directly from the data through the implementation of a qualitative and inductive research design. The research is novel and demonstrates a contribution to knowledge by contributing to GIS literature specifically in developing countries. The results of this research provide important information to facilitate the diffusion of GIS within an organization through the process of answering the research questions and objectives.

1.8 Thesis Structure

To address the research questions and accomplish the objectives, the researcher organized the thesis as follows:

Chapter One introduces the core research problem, then sets the scene, research questions and research objectives, and outlines the path that one will travel towards the thesis conclusion. The chapter also introduced the organization within which

the research is based on.

Chapter Two reviews the literature on GIS diffusion, explores the context on the topic of the research, identify and address the gap in existing knowledge. It also reviews the theoretical frameworks underpinning the research on diffusion with a view to identify the framework best suitable for this research.

Chapter Three identifies the relevant research approaches and provide reasoning behind the chosen research design and data collection techniques and interpretation of the data.

Chapter Four presents results and discussions of the findings of the research. It further reports on the development of the GIS prototype and demonstrate the feasibility and usability of the functionalities of the GIS in management of power distribution system.

Chapter 5 presents summary, conclusion and Implications of the results of the research and recommendations for practical and further research on the topic.

CHAPTER 2

LITERATURE REVIEW

The literature varies on how to study GIS diffusion process and what variables are necessary for diffusion success, or are responsible for its failure (Larsen, 2003). The literature recorded far fewer systematic GIS diffusion studies in developing countries (Cavric et al., 2003; Karikari et al., 2005; Eria, 2012; Noongo, 2007) as compared to developed countries. However, most of these have focused on GIS in the public and academic sectors, ignoring the private, non-governmental organizations (NGO) and international organizations sectors (Eria, 2012). The author, therefore, felt that more work on diffusion of GIS is required to have a deeper understanding on how to advance the diffusion in organizations.

2.1 The conceptual framework

The conceptual frameworks are important in directing the research process (Neuman, 2006). There are many different models that try to explain diffusion of innovation. Unfortunately, this situation leaves researchers in a state of methodological vacuum and theoretical confusion (Benbasat and Barki, 2007).

Some of the scholars have developed their own theories or extended the existing ones to cater for their research problems.

Widely accepted and popular models like the Actor Network Theory (Noongo, 2007), the Unified Theory of Acceptance and Use of Technology (Sun, 2011) and Diffusion of Innovation (Rogers, 2003) work well in explaining the influencing factors behind innovation diffusion. But, each different model has its merits and demerits. To understand on the stages through which GIS diffusion progresses and constructs in the different stages, the author found it logical to use a theory that put most emphasis on the stages through which innovation diffusion progresses in an organizational setting and put more emphasis on important constructs in the different stages. The most widely cited and most influential theory in the area of diffusion is Rogers' Diffusion of Innovations (DoI). Therefore, this study, adopted DoI to guide the research.

2.1.1 Actor Network Theory

Michel Callon, Bruno Latour, and John Law developed actor Network Theory (ANT) as a concept during the mid-1980s. These authors were the first to use the term "Actor Network Theory" to describe their particular approach to scientific and technical innovations. ANT is referred to an analytical framework, a "tool box" (Law, 2007) used to study the roles of humans and non-humans in the structuring of networks between people, their ideas and technology for the purpose of creating new knowledge (Latour, 2005). Technically, ANT is a disparate family of material-semiotic tools, sensibilities and methods of analysis, mapping relations that are simultaneously material (between things) and semiotic (between concepts). ANT acknowledges that actors build networks combining technical and social elements and that the elements of these networks, including those people who have

engineered the network, are, at the same time, both constituted and shaped within those networks. It assumes that not everything in the social and natural worlds exists separately, but is being generated constantly by relationships between actors in networks (Law, 2009) and nothing has reality or form outside the enactment of those relations. ANT studies explore and characterize the webs and the practices that carry them. Like other material-semiotic approaches, the actor-network approach describes the enactment of materially and discursively heterogeneous relations that produce and reshuffle all kinds of actors including objects, subjects, human beings, machines, animals, nature, ideas, organizations, inequalities, scale and sizes, and geographical arrangements. It is through a series of complex interactions between humans and non-humans and the ways in which they interlock within networks of construction and reconstruction that allow the production of accepted facts or knowledge (McNamara, Baxter and Chua, 2004).

In principle, ANT is suitable as a theoretical framework within the area of diffusion of innovation where potentially can be used for exploring the questions of why and how we have the innovations that we do. Under this framework, the actants (both human and non-human entities) are identified, and networks in which they are embedded are explored, in order to identify ways in which social context is bound up with the different actants. Unfortunately, ANT does not completely follow the actor and avoids the fact that actors tend to provide explanations. The methodological rules of ANT do not easily lend itself to dialectical sociotechnical interpretations (Law, 2007). In this aspect, ANT falls short because research demands to provide explanations to the reader (Mitev, 2009). Analytically, ANT is

considered descriptive rather than foundational in explanatory terms (Law, 2007), which means that it is a disappointment for those seeking strong accounts. Instead, ANT tells stories about 'how' relations assemble or do not. As a form, one of several, of material semiotics, ANT is a toolkit for telling interesting stories about, and interfering in, those relations. The response of a number of researchers has been to combine actor-network theory with other theories, in order to generate greater explanatory power.

2.1.2 The Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) as a concept is the result of the efforts of Venkatesh et al. (2003). The UTAUT is theoretical advancement over existing theories used to examine diffusion related research. The UTAUT draws on the theory of reasoned action (TRA), technology acceptance model (TAM), motivational model (MM), theory of planned behavior (TPB), a combined theory of planned behavior/technology acceptance model (C-TPB-TAM), model of PC utilization (MPCU), innovation diffusion theory (IDT), and social cognitive theory (SCT). The model lessen the burden of future researchers in combining constructs from different models (Williams et al., 2011). By doing so, the authors aimed to develop a unified view by eliminating redundancy and repetitions as several constructs in these theories were common. UTAUT emphases mostly on constructs and characteristics that affect technology acceptance. UTAUT is more suitable to understanding studies affected mostly by human factors. Thus, it is more applicable to users than organizations. Despite the involvement of the characteristics that affect technology diffusion from the Diffusion of Innovation

theory, the authors of UTAUT did not include Innovation Diffusion Process that involves the adoption communication stages through which technology progresses through. Since adoption of technology occurs in a complex environment and affected by a multitude of factors, there is a need to study factors that affect the different stages through which technology adoption occurs. Whereas the constructs that affect acceptance of technology are important, the process through which they pass is equally important for the success of innovation diffusion (Liao et al., 2009).

In principle, UTAUT also falls short for this study as the theory lack the process aspect. Researchers combine UTAUT with external theories and variables (Williams et al., 2011) in order to address weaknesses of the model.

2.1.3 Diffusion of innovation

The literature shows that the DOI theory has a solid theoretical foundation and consistent empirical support (Beatty et al., 2001; Zhu et al., 2006a, b). It is a useful theory for studying a variety of IS innovations. While GIS may have new characteristics compared to previous generations of IS innovations, the process of its diffusion deserve attention, but have not been fully understood in the GIS context (Zhu et al., 2006b). The diffusion research study the innovation process within appropriate contexts and with variables tailored to the specificity of the innovation. Many of the current theories, including the above-mentioned theories, lack the process aspect. This motivates the present study to adopted DoI to guide this study.

This study employs definitions for DoI used in other previous research. DoI is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003). The innovation, communication channels, time, and social system (Rogers, 2003) are the four elements that appear within all diffusion studies independent of discipline (Rogers, 2003). Diffusion of innovation proved useful for understanding the process of GIS diffusion in the context of both developed and developing countries, and organizational and individual levels (Eria, 2012).

2.2 Defining GIS

The previous studies proposed several working definitions of GIS. However, there is no single or universally accepted definition of a GIS. In this regard, people who are learning, applying, developing, and studying GIS are the ones that define it. Each organization that is diffusing GIS should come up with its own common definition of what exactly is a GIS that they are to adopt and implement. The common definition of GIS in any organization is important as it plays a fundamental role in GIS diffusion to stakeholders in the organization. The Stakeholders often base their interpretation of GIS from that of the GIS Managers and Change agent (Chan, 1998). It is not surprising, given the diversity of the field that the field applied many different methods to GIS. The only reasonable way to define GIS is to summarize all the ideas about GIS in a series of views (Carter, 1989; Dueker and Kjerne, 1989). The authors defined GIS in generic terms, including an organizational perspective and take into account the critical component of sustained financial support that is especially relevant to developing

countries (see Table 1).

The two definitions were the ones the author adopted as appropriate for this research in understanding GIS diffusion in an organization within a developing country.

Table 1: Definitions of GIS in terms of its elements

	Authors	**Definitions**
1.	Carter (1989)	GIS is "an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time."
2.	Dueker and Kjerne (1989)	A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth.

2.3 Innovation

The innovation is an idea, practice, or object that is perceived new to an individual or other unit of adoption (Rogers, 2003). The introduction of GIS involves the interaction of people, technology, and organizational structure. The business process of the organization requires re-engineering and the innovations are reinvented, changed, and modified during the process of diffusion. This suggests that both organization and the identity of the innovation changes as diffusion progresses in order to successfully diffusion the innovation.

2.3.1 Innovation process

The study opted for organizational innovation process, a staged approach to describing the process of innovation diffusion in an organization (Figure 1) rather than individual innovation process. The individual innovation process involves probing into the mental process of individuals and as such, it is difficult. The organization innovation process model is presented in two stages: initial adoption and actual implementation. The two stages are separated by a decision to adopt an innovation.

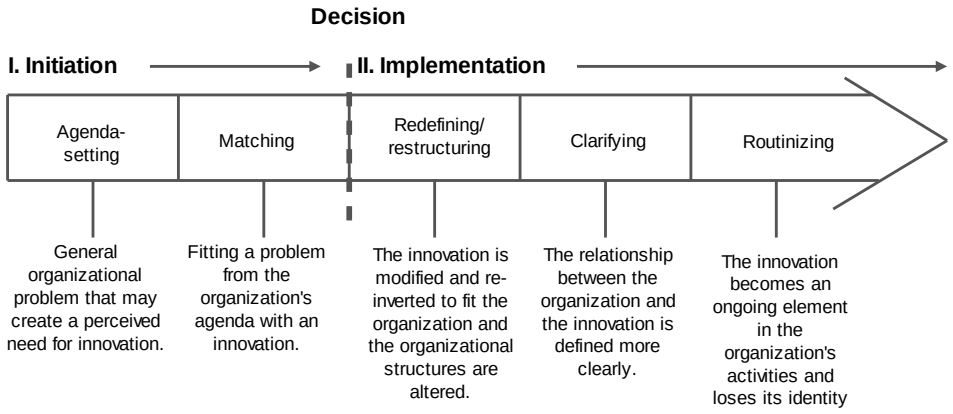

Figure 1. The organizational innovation process

The first stage, *Initiation* is concerned with all the activities, including information gathering, conceptualizing and planning, that the decision makers in an organization conclude to the decision to adopt an innovation. The second, *Implementation* refers to the phase where the decision to diffuse is acted on by taking the practical steps required to implement the innovation. The steps taken after the adoption decision lead to use of an innovation prior to its final institutionalization. The institutionalization reached at the innovation built into the structure of the organization and the organization members think of the innovation as standard operating procedure of doing business. The innovators, change agents, opinion leaders, potential adopters and activities play out major roles and drive the innovation at each stage of the organizational innovation process.

The theories that are critical to diffusion process (Chan and Williamson, 1999) are the performance gap (a performance gap identified in the organization in the form of actual problems or potential areas of improvement) and re-invention theory (the identity of innovation changes together with the organization). The stakeholders that drive the GIS diffusion are all the people affected by the performance gap. The excessive change to the problems addressed in the diffusion process alter both the identity of GIS and the combination of stakeholders. However, on completion of the diffusion, the same set of pre-defined problems established during the initiation stage be addressed to avoid a challenge on many causal relationships of diffusion, which were predicted or identified based on the initial assumptions. The study adopted organizational innovation process model in discussing the results of this research in chapter 5.

2.3.2 Social system

Innovations are diffused in a social system (Rogers, 2003). In this study, the social system is the organization, ESCOM in this case. The members of an organization cooperate to solve a common problem, and seek a common objective or goal. The sharing of a common goal binds the organization together (Rogers, 2003). The organizations operate through their own structures. The structure is the patterned arrangements of the units in a system (Rogers, 2003) and gives regularity and stability to human behavior in an organization. The organization structure can facilitate or impede diffusion of innovation (Rogers, 2003). The characteristics of organization membership consist of socioeconomic status and interpersonal competence (Santrock, 2004; Woolfolk, 2007), innovativeness and adopter

categories, and communication channels. The specific measurements for *socioeconomic status and interpersonal competence* include comparing and analyzing education level, occupation and income, job category, experience and skills, activities and interests, and psychological traits such as intelligence, motivation, personality, attitude, and culture. The *Innovativeness* concerns relative earliness/lateness with which an individual or other unit of adoption can adopt new ideas compared with other members of a system (Rogers, 2003). Rogers (2003) suggested five categories of adopters to standardize the usage of adopter categories in diffusion research. These are innovators; early adopters; early majority; late majority and laggards. The adopter categories allow researchers to understand innovativeness better and the extent to which potential adopters seek new ways to do things, willing to try out new ideas and trust new inventions. The adopters are the ones to blame on the failure to diffuse the innovation (Rogers, 2003) and the diffusion research tends to side with change agencies, technology vendors, International donors, and technocrats in an organization (Eria, 2012) that promote innovations rather than with individuals who are potential adopters.

Communication in diffusion concerns the exchange of messages about new ideas to create and share information among the members in order to reach a mutual understanding (Rogers, 2003). The change agent seeks to persuade a client to adopt an innovation, but the reverse is also possible where the client goes to a change agent with a specific problem, and recommend the innovation as a possible solution. The communication network needs to be transparent enough if every person is to understand the inputs and progress made in the diffusion process.

There is limited transparency in communication network if members of a network have problems to identify the relevant persons to transfer information to or from where to obtain the information. This concept is relevant for a team in which change agents possess highly specific expertise (Rogers, 2003) than the members of the organization. It is essential to identify that relevant knowledge to enable efficient diffusion of GIS. Further, diffusion theory emphasizes on *interpersonal* communication (Valente and Saba, 2001) in which it involves interaction of two or more individuals who are either homophilous or heterophilous. In other words, the individuals might be similar or different in certain attributes, such as beliefs, education, social status, and the like (Rogers, 2003). The individual given a choice, have a tendency to homophily, the desire to interact with people who are similar to themselves. The recommended ideal situation for diffusion of innovation involves two individuals who are homophilous in every way (education, socio-economic status and so on), but heterophilous in technical knowledge of the innovation (Rogers, 2003).

Further, the social system is understood based on the interpersonal relationships within the overall social system and how well individuals are integrated into their system (Rogers, 1995). This study also stresses on relationships between Managers and supervisors, supervisors and employees, and peers. The data collected represented the affiliation of particular individuals with others. The other research concern was the established behavioral patterns for the members of a social system (Rogers, 2003). The relationships between networks and norms, provides additional insight into the overall diffusion process. The opinion leadership, the degree to

which an individual is able to influence other individuals' attitudes in a desired way (Rogers, 2003), also pointed at influence as the essence of leadership (Yukl et al., 2002) in social system.

The change agents and professionals that have good technical knowledge communicate about diffusion in the form of concepts that the target social system understands. The change agents develop a need for change, establish an information-exchange relationship, diagnose problems, create an intent in the client to change, translate an intent to action, stabilize adoption and prevent discontinuance and achieve a terminal relationship (Rogers, 1995).

2.4 GIS in an organization

The *organization* is understood to constitute of a stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labor (Rogers, 2003). The organization achieves stability through a high degree of structure imposed on communication patterns through creation of the formal and informal organizational settings. The formal organizational setting is the one that broadly defines the structure of the internal production process to achieve the organizational goals. Rogers (2003) defined that the internal production process forms the four core components of an organization.

1. *Predetermined Goals.* The organizations have their own formal specified aims and methods for achieving their goals. This relates to the definition of a relevant social system in this thesis.
2. *Prescribed Roles*. The organizations formally distribute tasks among the

members according to their duties.

3. *Authority Structure.* The organizations introduced a set authority structure, with a hierarchy that defines who is responsible to who. The organization charts and position descriptions define the formal social structure.
4. *Rules and Regulation*. The organizations have formal set of procedures that specify all decision processes and actions to result in a high level of social control. The rules and regulations affect heavily on the normal communication processes of diffusion. On the other hand, an organization has also an informal setting (Handy, 1993) that also affects major changes for the organization (Benowitz, 2001). The major changes ultimately have to pass the scrutiny of the informal setting before fully accepted in the organization.

The organization is further be divided into two functional parts. One part of the organization represents all the core business functions and the other part represents the associated functions of administration, which provide support functions to the business component. In such a step up, corporate GIS is required (Chan and Williamson, 1995). The corporate GIS consists of module that assumes the role of either an infrastructure or a business process in its particular functional component. The collection of the modules is dynamic because as the formal structure of the organization changes, so do the collection of GIS modules. The organization can take out obsolete modules from the organization, add new modules and modify the existing modules. Therefore, different perspectives of describing GIS will be applicable depending on the stage of diffusion of the corporate GIS.

2.5 Scenarios for corporate GIS diffusion

The corporate GIS can either address a set of highly focused problems in the organization or the problems that are often strategic in nature and have wide implications. The first scenario is called a *focused* scenario and the second a dispersed scenario. In the focused scenario, operationally the composition and technical capabilities of the GIS are early on specified (Chan, 1998). However, when the GIS is developed to address strategic, but vaguely defined problems, as typically is the case of a corporate GIS, these perspectives are inadequate for describing it. Therefore, a new perspective for the corporate GIS should be developed (Chan and Williamson, 1999).

2.6 GIS in Power Sector

Today Power utilities are realizing the benefits of GIS technology in the monitoring and analysis of electrical power system (Osuagwu, 2008). In the words of AL-Ramadan (2013), GIS has been very useful in the electrical power system to solve problems using new methods and specific techniques because of necessity of accurate up-to-date information of the network assets. AL-Ramadan (2013) states that GIS helps utilities discover new things about their investments and risks, and allows the simultaneous assessment of technical, financial, and environmental factors. GIS is a workable system proven to connect database information such as billing, material account, distribution analysis and outage reporting in power utility (Sinha, 2010). Widely, GIS is used for the mapping and modeling of utility network systems (Pickering and Bannister, 1993).

With the help of GIS, software changes in the network can be updated in less time and more accurate on a periodic basis (AL-Ramadan, 2013). Adetoro (2005) talked of the functioning of companies engaged in the transmission and distribution of electricity that they depend on the existence of appropriate electric supply network geo-data. It is estimated more than 80% of data used in a variety of processes (network design process, data input and update, maintenance and various analysis) has geographic (spatial) component.

GIS applications enable connecting various types of information in the spatial context (Ezeigbo, 1998) and generating new information and conclusions based on these connections. It enables fast, accurate and unique presentation of network data. GIS output of electric network can be viewed and easily interpreted compared to any other system output. The GIS technology promises benefits not only in increasing operational efficiency but also in improving policy design, decision-making, communication, and dissemination of information (Kulkarni, 2011).

The characteristic of GIS makes it an unavoidable decision making tool in situations when data relevant to a decision include a spatial component. GIS is by no means a system that will give a final solution to a user, but it will also provide the possibilities for a better and more organized analysis of information, which is a prerequisite for making quality decisions. Above all the greatest supremacy of GIS is visualization. GIS is built from a mapping foundation and creates a visual interface to the data, but its applications in power systems is still in infancy stage (Nga et al., 2012).

2.7 Diffusion of innovation research approaches

There are Factor and Process approaches to GIS diffusion, which conceptualizes the diffusion process in different ways. The Factor approach identifies factors that enable or impede GIS diffusion in a particular organization (Noongo, 2007; Cavric et al., 2003) and the Process approach concerns with the processes organizations go through in implementing GIS (Noongo, 2007). No one method is most appropriate for studying a broad or complex research problem. Each method or combination of methods has advantages and disadvantages as well as different assumptions, biases, and degrees of usefulness. Our purpose in this study is to present mixed methods in GIS research. We hope the GIS field will move beyond Factor versus Process research arguments because, as recognized by mixed methods research, both Factor and Process research are important and useful. The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies. The mixed methods approach is also an attempt to provide knowledge through which organizations can learn to develop the skills necessary to develop more holistic GIS diffusion process.

2.8 Consequences of Diffusion

The Diffusion causes change in the functional structure of a social system (Rogers, 2003) and leading to desirable vs. undesirable, direct vs. indirect and anticipated vs. unanticipated consequences (Rogers, 2003). For efficient diffusion to occur, the uncertainty about the above-expected consequences should reduce to a tolerable level. It is the knowledge about the innovation that helps the adopters to make

informed decisions concerning adoption or rejection of the innovation (Rogers, 2003). The Perceived attributes influence the decision to adopt or reject an innovation. Perceived attributes refers to the opinions of potential adopters who base their feelings about how they perceive that innovation in regard to five key attributes: Relative Advantage; Compatibility; Complexity; Trialability, and; Observability. Relative advantage refers to the degree that an innovation appears to be better than its preceding idea, practice, or object (Rogers, 2003). Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 2003). Complexity is the degree to which an innovation is perceived as difficult to understand and use (Rogers, 2003). Trialability refers to how easily an innovation may be experimented with as it is being adopted (Rogers, 2003) and Observability is the visibility level of the innovation, how much or little others observe the results of an innovation. (Rogers, 2003). In short, these constructs states that people are more likely to adopt an innovation if the innovation offers them a better way to do something, is compatible with their values, beliefs and needs, is not too complex, can be tried out before adoption, and has observable benefits. Perceived attributes are important because they show that potential adopters base their opinions of an innovation on a variety of attributes, not just relative advantage. The efficient GIS diffusion requires strengthening of all the five innovation characteristics.

CHAPTER 3

RESEARCH METHODOLOGY

The chapter explores the research strategy, plan of action, process, or design, lying behind the choice and use of the particular methods used in this research. The chapter further linked the choice and use of methods to get the desired outcomes. The chapter ends with a discussion of issues related to the validity, reliability, and triangulation of the results.

3.1 Research approach and process

This research, attempts to provide a deeper understanding of the social world based on a small-scale sample using qualitative approach. The qualitative approach was preferred to accomplish the overall aim of the study as compared to quantitative studies that lack deeper theoretical analysis (Stokes, 2000). The qualitative approach allowed the use of interactive data collection methods, e.g. interviews, which explored new issues and concepts. This qualitative research was further associated with inductive research designs to allow the research findings to emerge from the significant themes inherent in raw data, without the limitations imposed by structured methodologies. Saunders et al. (2003) noted that the inductive approach gives the chance to have more explanation of what is going on.

The research process started with exploring and collecting data from literature search to explore and provide insight into what was required to achieve successful and widespread diffusion of GIS within organizations. Ultimately, findings were discussed in terms of how they relate to DoI theory that undergirds the study. The case study, further, revealed the factors that enable and inhibit the process of GIS diffusion to be undertaken in an organization. Due to the concern regarding a low awareness of the value of GIS in the organization that hindered the diffusion, a prototype was developed to demonstrate on the feasibility and usability of the functionalities of the GIS in management of power distribution system and create awareness about GIS and its abilities in the organization.

The primary data was collected through semi-structured questionnaire and unstructured interview techniques on respondents in influential positions (Top Management and Managers) that had direct input into the adoption of GIS. The general inductive approach (Creswell, 2009) was used to analyze the qualitative data to identify themes in the text data that were related to the evaluation objectives. Once the data files were cleaned and put into a common format, the analysis commenced with a close reading of the text. During the analysis, specific themes were developed, which in the view of the investigator captured core messages reported by participants. The secondary data was collected from Revenue department of ESCOM. The data collected included spatial and non-spatial data for transformers and customers. This data was used in the development of the prototype.

3.2 Theoretical approach

This research identified the theoretical perspective at the beginning of the investigation to allow others to understand the researcher's vision of the concept so that the research can be criticized where others disagree with the concept. In other words, Yin (2008) states that the case study research design embodies a theory of what is being studied drawn from the existing knowledge base. In this respect, Creswell (2007) noted that theoretical definition clearly states the meaning of the concept and affects the research questions, analysis, and interpretation of findings. The research adopted DoI as an overarching theoretical framework to guide the research in understanding the stages through which technology diffusion progresses, constructs in the different stages and the current "state" of GIS in ESCOM.

3.3 Research methods

This research had been conducted through one primary case study with the aim of investigating the case in both depth and breadth and therefore taking a holistic and exploratory approach. The researcher chose to stay within one research method (qualitative) with the aim of becoming comfortable with it, to learn from it and to keep the study concise, more realistic, more focused and straightforward (Robson, 2002). However, Robson (2002) argues that as the study progresses, features from other research traditions might be useful and in fact characteristics of a flexible research design includes the use of multiple data-collection techniques. This research supported the use of multiple sources of evidence as empirical investigation of a particular contemporary phenomenon within its real life context

(Robson, 2002). Multiple sources of data were used to explore the research questions and also to support the validation of data through triangulation. This in turn was used to produce findings or conclusions that would be more compelling and accurate (Yin, 2003).

3.4 Research Tools

The research utilized a number of data collection techniques to collect the needed data. The approach was not only to ensure the collection of data from multiple sources and perspectives but significantly to reduce bias and increase validity.

Case study. The research used semi-structured questionnaire and unstructured interviewing techniques to collect primary data. The semi-structured questionnaire was designed to address on respondents in influential positions (Top Management and Managers) that had direct input into the adoption of GIS. Pre-test of the survey questionnaires was carried with four departmental Managers within ESCOM and this allowed minor changes to be made to the questionnaire. The researcher selected to use a purposive sampling method to choose the subjects who participated in the research to ensure that the individuals selected had good knowledge on the subject being researched and that all departments were represented (Saunders et al., 2007). The questionnaires were sent out to 55 contact persons through e-mail, eight Top Management and 47 Managers (Appendix 2). In the cases where personal visits were made, it also provided opportunities for broad unstructured interviews with the Subjects.

The number of people who responded to the survey were five Top Management and 30 Managers. Appendix 3 is a list of respondents to the questionnaire.

The unstructured interviewing technique was adopted as a follow up to semi-structured questionnaire. The unstructured interviewing had no predetermined questions but the researcher could ask questions and modify the order based upon the interviewer's perception of what seems most appropriate. Interviewing all the Managers and Top Management was impossible due to the availability of the Subjects and the limited time available for fieldwork. For this reason, the sample is described as a convenience sample. Robson (2002) suggests that an interview last between 30 and 60 minutes. In the research, nine unstructured interviews were undertaken lasting between 45-60 minutes. The list of interviewees met is presented in appendix 4. To remember the conversation, hand-written field notes of the interviewees' responses, were taken throughout the interview. The interviews were transcribed, analyzed and formed part of discussions in chapter 5.

Field survey

A field survey was part of the exercise that was being carried out by the customer verification team at Revenue department and drawing Office of ESCOM. It was required for data collection and mapping of the transformers and customers of the geographical area for the prototyping. The results are presented in chapter 5.

3.5 Data analysis

The data analysis for this qualitative research was an inductive analysis. Lodico et al. (2010) stated that in induction analysis numerous small pieces of data are collected and gradually combined or related to form broader, more general descriptions and conclusions. The process involves preparing the data for analysis, conducting different analyses, moving deeper and deeper into understanding the data (some qualitative researchers like to think of this as peeling back the layers of an onion), presenting the data, and making an interpretation of the larger meaning of the data (Creswell, 2009). The research analyzed the data in relations to Creswell's (2009) stage by stage method of data analysis for qualitative research as a base. An overview of the inductive coding process is shown in Table 2.

Table 2: The Coding Process in Inductive Analysis

Initial reading of text data	Identify specific text segments related to objectives	Label the segments of text to create categories	Reduce overlap and redundancy among the categories	Create a model incorporating most important categories
Many pages of text	→ Many segments of test 30 to 40 categories	→	15 to 20 categories	3 to 8 categories

The first step was the preparation of the raw data files ("data cleaning") for data analysis. The data collection and data analysis happened simultaneously to ensure that important details were not lost. The data was generated through field notes and transcripts. This involved transcribing interviews, typing up field notes and arranging the data into different types depending on the sources of the information.

Once text had been prepared, all data was read through each topic a number of times in order to clarify all possible meanings and to discover and code the main

ideas (concepts and themes). The research utilized thematic analysis (Sandelowski, 2010; Sandelowski and Barroso, 2003) for examining themes within data. The purpose was to move beyond counting explicit words or phrases of the content analysis techniques and focus on identifying and describing both implicit and explicit ideas. The codes developed for themes were then applied or linked to raw data as summary for later analysis. The thematic analysis entails the presentation of the facts in everyday language, whilst emphasizing organization and rich description of the data set to retrieving meaningful information from data to provide straight and plain answers to the research questions. The development and modification of codes reflected techniques of data reduction and clustering.

The reliability of the data analysis in this research was achieved through use of detailed descriptions to convey the findings, providing sufficient details in the theoretical and analytical decision making process to explain the decisions made on description and interpretation. The research also combined the analysis with findings from different data sources (triangulation) by examining the evidence from the sources and build a coherent justification from them as a means to demonstrate trustworthiness in the analysis. The outcome of the study was then presented in descriptive summaries. Some supporting statements from the interviews, comments from the survey responses, the literature and from my own experience were used in interpretations. The interpretation was also derived from comparison of the findings with information gathered from the literature and theory. The results are presented in chapter 4. The interpretation also suggested new research ideas that were not foreseen earlier in the study and are presented in chapter 5.

3.6 Prototyping and System Design Methodologies

The research discovered that there was a low awareness of the value of GIS in the organization. This was attributed to previous low levels of spatial data handling by the professionals, managers and IT staff within the organization. This was influenced by the lack of understanding GIS applications for the needs of the electricity utility, and how departments within the organization could make best use of GIS. The prototype was, therefore, developed to create awareness of the value of GIS in the organization. The research opted for prototyping to provide early functionality of GIS in management of power distribution system. There were several methods the prototype could have been implemented; these includes throwaway, incremental and evolutionary. The study adopted throwaway method. The prototype development was through agile software development methodology called Rapid Application Development (RAD) (Berger and Beynon-Davies, 2009). RAD is a high speed adaptation of the Waterfall Model and addresses the drawbacks as the serious misunderstandings could be made evident early in the lifecycle and made it possible to react to them. The emphasis was on an extremely short development cycle (Pressman, 2002) and focused on issues that were most critical to the diffusion first. The prototype User Interface (UI) was developed in Microsoft Visual Studio 2013 on Windows platform. The system functions like map display, search, map queries, and buffering were built based on Arc Objects which is a developer product for creating custom GIS desktop applications. The prototype development followed System Development Life Cycle (SDLC) in which the author had requirement analysis, design, implementation, testing and evaluation.

3.7 Quality of Research

The validity and reliability of research findings and the way in which supporting evidence was presented supported the credibility of the research (Yin, 2003). The validity was concerned with whether the instruments used for measurement were accurate and whether they were actually measuring what they wanted to measure (Winter, 2000). The undertaking of multiple methods to investigate the problem from different angles was an attempt to achieve validity. The related literature, questionnaire and interviews were all used in the study to cover the issues related to the research. The researcher assessed all secondary sources of data used in the study to determine the validity of the information given before it was used in the study. The questions and procedures used in the interview were reviewed by other individuals who provided their valuable observations and comments. The questions posed in the interviews were all linked to the research's aim and objectives to ensured that the interviews were able to proceed according to plan and to cover all aspects of the topic. The research also made an effort to validate and recheck some of the interview transcriptions with the interviewees to ensure the correctness and the accuracy of the data.

The researcher also checked to which the extent the research findings could be replicated, if another study was undertaken using the same research methods to verify on reliability of the findings. Ritchie and Lewis (2003) stated that the reliability of the findings depends on the likely recurrence of the original data and the way they are interpreted. The research enhanced reliability through an aspect of reflexivity (Jootun et al., 2009) by showing the audience of research studies as

much as possible of the procedures that had led to the set of conclusions. Furthermore, all interview questions were worded clearly and questions were repeated during the interviews in order to enable the interviewee understand what was being asked. Notes were taken and the responses were drafted on separate sheets, which were then sent to the interviewees so they could review what had been said and raise comments about the content. The research adopted data triangulation to strengthen the confidence of the research findings. The data was collected over different times and using multiple methods (Easterby-Smith et al., 2002) to pave the way for more credible and dependable information and overcome most of the weaknesses of each method used (Gray, 2004).

CHAPTER 4

RESULTS AND DISCUSSIONS OF THE STUDY

This chapter presents and discusses the findings of the study in relation to the research objectives, research questions and the conceptual framework.

4.1 The progress of GIS diffusion in the organization

Our results closely mirrored the five stages of Rogers (2003) in the process of GIS diffusion in ESCOM. Rogers (2003) Diffusion of Innovation model provides a useful starting point for situating the progression of GIS in the organization. With the assistance of case study and literature, we were able to figure out the concept in-depth. Researchers have recognized that there are two basic stages of diffusion: adoption (initiation) and implementation (Rogers, 2003). Although there may be overlap between stages and some reiteration of earlier stages later in the process, the stages reflect two higher-level activities. The initiation consists of *Agenda-setting* and *Matching* of an innovation with the organization's agenda. At the end of this period, a decision is made to adopt an innovation in a particular form. The remaining stages in the innovation process represent the implementation period, when the innovation is redefined or reinvented to fit the organization, its role is clarified, and its use finally becomes such a familiar part of the organization's activities that it is no longer recognizable as an innovation. This step-by-step

approach provides a valuable opportunity for accumulating the practical experience needed for understanding GIS diffusion in an organization setting.

Initiation

The Initiation stage involves activities relating to the interest, research and discovery of issues, opportunities, and solutions, leading eventually to the intention to adopt an innovation. Organizational members, typically top management (Gallivan, 2001) learn about the innovation, its capabilities, advantages, disadvantages, and examine the compatibility and suitability of the innovation for the organization (Rogers, 2003). Research shows this stage as resulting in creation of an overall but initial attitude towards the innovation, leading to the conception, and initiation of a plan for the adoption of the innovation (Kamal, 2006).

Agenda Setting

An analysis based on the diffusion of innovations perspective revealed that the *Agenda-setting* occurred as the first phase within the diffusion of innovation management life cycle. Diffusion of innovation begins with exposure to a new idea (Rogers, 2003). GIS was the innovation understudy. The GoM introduced GIS into the organization through the support of an agent, AH Consulting (AHC). This involves the starting up a GIS diffusion process which focused on aligning the GIS diffusion with corporate strategy as part of the approval and initiating processes (Aubry et al., 2007; Meskendahl, 2010). The aim was to get the GIS diffusion prioritized and approved. The purpose was to generate understanding of the GIS proposal. Top Management and the Managers are the innovators and represent the

first 2.5% of adopters who are the first to commit to a new idea (Glaser et al., 1983; Rogers, 2003). The organization seek GIS as remedy for established need. The goal of the GoM was to resolve the energy supply crisis in Malawi through the Malawi's $350.7 million Millennium Challenge Corporation compact. GIS diffusion was proposed within the compact. GIS in the organization was donor driven. The change agent, AHC, recommended an investment towards GIS to develop datasets which would generate information products for use by the organization. The GoM accepted the findings of the change agent, and offered a contract to the change agent to manage the diffusion. The change agent was in-charge of formulating and implementing the organization's detailed GIS strategy. The change agent came up with a clear relationship between GIS benefits and the business need. Also, the change agent proposed scenarios and benefits of adopting GIS, in attempts, to convince Top Management and Managers of organizational strategic importance of GIS diffusion. The potential GIS application may provide strategic improved core business competencies (Schilling, 2013) through cost leadership and differentiation by improving productivity through reducing time and cost to transfer, store and search for information and/or delivering a differentiation competitive advantage (Lopez, 2005). The challenge of Top Management and Managers was to understand GIS, the principles of GIS implementation, the alternatives, the organization's needs, and how to put these components together. Innovators (Top management and managers) play the role of gatekeeper in the diffusion process. They open the door and allow the innovation to reach new audiences outside its initial social circle. They bring the innovation to the rest of the organization.

The study show that the organization recognize how complex it is to diffusion GIS and as such the organization developed its own appropriate GIS governance structure, which established the basic character of GIS operations. The word governance is associated with words like government, governing and control (Klakegg et al., 2008). The governance structure was the management framework within which diffusion decisions were made. Therefore, the role of diffusion governance was to provide a decision making framework that was logical, robust and repeatable to govern an organization's capital investments, in this case, GIS diffusion. In this way, the organization had a structured approach to conducting both its business as usual activities and its business change, activities (Liu and Xie, 2014). The appropriate GIS governance structure for any organization is based on its intended role (Mäkelä, 2012). OECD (2004) view is that governance is a function of management or any entity responsible for making decisions and/or overseeing (controlling) the work of the organization or its diffusions. Each governance practice operates independently from the other and there is no integrated of theory of practice. Since organizations have unique environments, characteristics, goals, requirements, and operations, each organization must develop their own GIS governance structure by drawing from the common GIS structure components and fitting them to their own situations. Sanderson (2012) identifies the main performance problems as a result of misaligned or underdeveloped governance mechanisms, meaning that diffusion actors are unable to provide a sufficiently flexible and robust response to the inevitable turbulence of the diffusion or organizational environment.

The study found Project Management Office (PMO) as the other key element to improve the performance of GIS diffusion and hence create value for organizations. PMO attempts at efficiency through centralization of support and control of the diffusion (Marsh, 2000). PMO had a critical governance support role to ensure that accurate information is available to Top Management, thus maintaining visibility and control on the performance and trends of the GIS diffusion. Specifically, Hobbs and Aubry (2010) emphasize the importance of the PMO's monitoring and controlling of diffusion performance function.

The findings of the study indicate that for the GIS diffusion to continue, the process of persuasion was repeated through a Steering committee within the PMO. The committee consist of the Champion and representatives from Top Management, and Managers, along with workgroups involved in the GIS adoption decision. The PMO structure type was tailored to the specific needs of the organization. The S*teering committee* was responsible for setting the policy for organization wide GIS coordination and implementation. These policy makers made decisions based on input and recommendations from technical and user staff and provide leadership and direction for the organization's GIS *internal diffusion management team* that represent all participants. The appropriate committee composition followed the GIS diffusion definition. Organizational and professional interests was appropriately represented according to the role of GIS in the organization.

Findings from this research indicate that, in a *Workgroup* environment, each *Workgroup* had a clear charter regarding the types of issues it will address. A clear

charter of implementation addressing types of management issues and continuous focus on those issues was a must for each workgroup team. The organizational professional interests were appropriately presented to each team member and enclosed clearly in the implementation charter. The charter also specified the matters to be addressed by the GIS manager and how information, recommendations, approvals, and directives should flow among the workgroups and staff. A workgroup's operating procedures, clearly specified how often a committee meets, how and when special meetings can be called, how the meetings will be run, and how meetings will be documented.

The benefits of governance structure include establishment of the necessary lateral communication channels and management lines across a hierarchical organization (Lunenburg, 2010), formation of team-based workgroups, focus on the GIS diffusion, and identification of a leader for the GIS diffusion. However, the phenomena that provide these benefits, also introduce some problems, including matrix-management problems, delays involved in working with teams, group dynamics and conflicts that develop in a team situation, valuing visibility over progress, and a diffusion manager's agenda with the diffusion priorities. This required the need to understand and analyze the benefits and inherent problems of committee and team environments in the context of this organization. It was useful for the organization to break a large committee into smaller workgroups, presented in Figure 2, each with a mandate to research, analyze, and present recommendations on specific issues.

Figure 2: The workgroups

The committee and workgroup members' resource commitments often go far beyond simply attending meetings. According to Sommers (1998), GIS-related activities could consume 25 to 100 percent of team members' time for significant periods. As such, it was a must for team members to make adequate time commitments. GIS diffusion progress were delayed when committee and workgroup reviews and approvals fall behind schedule because members could not contribute enough time to the GIS diffusion.

Matching

Having the business problem or opportunity identified, a solution defined, and a GIS diffusion team appointed to build and deliver the solution, the organization moves into what Rogers describes as *matching*. At this second stage in the

innovation process, conceptual matching of the problem with the innovation occurs in order to establish how well they fit (Rogers, 2003). The results show that *Matching* focuses on defining the total scope of the GIS diffusion effort, defining and refining the objects and developing the plans to meet those objectives. All of the efforts of the organization within *Matching* were geared toward developing a diffusion schedule and identifying how the diffusion would be completed. The development of the planning documentation was a dynamic process. As more and more information was gathered and developed, the planning documents continued to be updated based on the newly obtained information. A diffusion schedule was developed to help identify potential resources constraints or conflicts with other diffusion priorities. It also helped to communicate the timing of activities to the Diffusion Sponsor and Stakeholders and set expectations for when the diffusion would be completed. Also a Communication Plan was developed to help identify who needs to see what and when, regarding diffusion updates and status report. In this phase of GIS diffusion, how the diffusion will be completed is not as important as what the diffusion is about and who will be involved. To have a direction, the organization defined strategic vision for GIS role within the organization, its scope and its relationship to business operations. These strategies would solve all of the disputes or at least it would decrease the degree of conflicts in the large scale of GIS base and provide full understanding share of GIS privilege for the system. Sharing and understanding the vision and scope of GIS in large scale application might consume time and effort but understanding the benefits behind it would make it possible and achievable.

Due to the results of the study, the bottom line in devising a GIS strategic vision was responsiveness to business needs. The development of strategic vision and role definition was a top-down process. With regard to GIS diffusion perceived as a top-down driven innovation, some interviewees stated that they had little opportunity to contribute their professional expertise to change processes and practices that were regulated from above. The Top Management defined the purpose and role of the GIS from the perspective of the business process it will serve. The Management stress that this need for a customized fit was a reason why following the example of a different organization or a prescribed generalized approach would rarely work as effectively as developing a system designed specifically for their particular organization.

With the stressed importance of diffusion of innovation, the organization at this stage determines the goodness-of-fit between the need and the GIS. The process included anticipating implementation problems and assessing possible consequences. Assessing organizational risk at the outset of a GIS diffusion can increase the chances for success (Croswell, 1991). Croswell (1991) comes to this conclusion because of his observation that organizational culture, lack of understanding of GIS, and unpreparedness are often cited as obstacles to GIS implementation. The Change agent clearly defined the diffusion plan, how the plan will be managed and monitored to accomplish the diffusion. The Top Management identified the financial backing and marketed the technology to the stakeholders, both the GoM and employees. The Top Management approved the change agent plan and allocated required resources for the GIS diffusion to succeed. Part of the

plan included an identification of Opinion leaders and target on those opinion leaders. It was this workforce connection that gave the plan the political support it required.

The Management claim that the over-riding intent of this phase was to prepare all stakeholders to make the decision to adopt GIS. The GIS diffusion was therefore a business diffusion and driven by business goals. The initiation phase ended with the decision to adopt the GIS. The remaining stages in the innovation process represent the *implementation* period.

Implementation

The trigger to the beginning of the *implementation* phase was the completion and approval of the initiation phase. The *implementation* process began with developing an appropriate implementation process based on the various alternatives. It is argued that implementing GIS is unique, or in other words it is customized based on the nature of each organization. So, there is no one best way to implement or no one best way to manage implementation. Many GIS implementation efforts have failed in organizations because large number of organizations simply adopt a prescribed methodology and set themselves directly on that path without preliminary planning and analysis of their situation. Organizations blindly followed a process or advice that was used in another organization's situation. In fact, the GIS in one organization, could be very different from that in another.

The stage involves developing an effective GIS implementation strategy for an organization which includes redefine of GIS role in the organization and its scope.

The result provides fairly clear guidance regarding the implementation approach and management strategies that were most appropriate and effective and indicates the types of organizational issues that were important. The time involved in specifying the role and scope of GIS in the organization was expected to reduce problems, delays, and failures later in the implementation process.

Redefining/Restructuring

In the *Redefining/Restructuring* stage, steps were taken to begin to adapt the organization to be appropriate for implementation of GIS. Initially, *Redefining/Restructuring* stage of implementation phase marks the start of the buy-in process from the key participants. The Diffusion Kick-off meeting and Diffusion Definition document identify at a high-level what the diffusion is all about. The Diffusion Definition document helps to set expectations with the Sponsor, Stakeholders and the diffusion team. The Top Management provides overall guidance for the implementation and took responsibility of the diffusion sponsorship. The implementation process was described as “top down” and “hit and miss.” The Top management, itself, used the “top down” phrase in describing the implementation techniques.

As an aspect of Rogers’ *Redefining/Restructuring* stage, the aim was to build awareness about the GIS. As Kraemer and Dedrick, 1997 points out, the personnel within organizations possess very different skills and views of the type of activities for which information systems are useful as well as differences in their willingness and inclination to use technology. This means that the continuation of GIS

awareness, skills, and knowledge from the adoption stage must continue to the implementation stage. As individuals are being persuaded about the innovation, the organization mounts an implementation campaign. To this end, several strategies were developed. Firstly, the users and all stakeholders were sensitized of the GIS and requirement of their involvement. The diffusion process integrated theory and practice at every stage of the implementation. The involvement of users brought in many different interests, application needs, data needs, priorities, organizational issues, and political interests to the GIS implementation. Strategies were needed to address these varied interests and to develop the necessary compromises. The knowledge level of users' personal innovativeness assisted the champion to create a different support structure to motivate those who were less innovative and utilize those who were more enthusiastic about the innovation. The involvement of the users gave them an opportunity to be active participants and build diffusion ownership.

Findings of this study demonstrates that to usefully participate in the GIS effort, the participants needed adequate information regarding the innovation and the diffusion goals. It is a must that all involved parties, future users as well as committee members, be kept in the communication network from the time they were first contacted through the entire implementation period. Users and committee members were informed of diffusion developments and received GIS education and updates regularly. Diffusion Management also remain open to users' concerns and additional requests. As users develop new requirements, they were analyzed, even if their implementation was postponed. Adequate diffusion staff resources were

made available to provide the communications required to support the GIS committees and users. The users were provided with the right kind and amount of education and information at the right times. The type of information the CEO requires differ greatly from that required by Finance representative, and the Finance representative's needs differ from those of Human Resources. GIS education and orientation were tailored to the specific audience, which often requires conducting several events for different groups from various applications areas, professional backgrounds, and levels in the organization.

The interpersonal communication was encouraged and it provided opportunities for two-way communication. This was useful in influencing individuals' strongly held opinions about the innovation. The interpersonal relationships between the users and the technical specialists had a significant impact on the development of the system (Campbell, 2005; Yeh, 2005). This means that some staff with computer knowledge and skill in the organisation were interested in the design of GIS. They were actively involved in the implementation process of GIS in the organisation. They acted in accord with their perceptions of what other members regards as desirable so as to avoid harming their career prospects. It is assumed that the introduction of GIS changes work experience by altering the work environment and the nature of job skills, and affecting the quality of social interaction within the organisation (Campbell, 2005; Yeh, 2005). This suggests that the introduction of GIS in the organisation had both positive (job satisfaction and interest in their work) and negative effects (level of stress and pressure) on individual users. However, the negative effect, which was the level of stress and pressure among

users, was seen as less important in ESCOM as more users become familiar with the use of GIS.

In the implementation process, any identified changes to the GIS and the combination of the stakeholders due to excessive change to the problems being addressed within the organization were noted and incorporated in the implementation.

The study developed a prototype that provided an opportunity for a preliminary evaluation of the GIS system's usability and usefulness. The prototype serves as trials for the users.

Clarifying

Clarification of the relationship between the organization and the innovation began with describing which business units will be using the application, how their business processes will work with GIS incorporated, and how their results will be affected provides more information regarding managerial and organizational implications. These implications include business process redesign, organizational changes, changes in management reporting and decision making, changes in employee evaluation and rewards standards, and many other related issues. The GIS fit with the organization was adjusted based on the social construction of organization members. The meaning of the innovation was agreed and accepted within departments. One of the obstacle that was apparent among the users was luck of technical knowledge about the GIS. Related problem was a shortage of locally trained GIS professionals and the heavy dependence on expatriates. As the

participants become more knowledgeable about GIS, their need for additional information grows (Somers 1995a). Without properly trained personnel with the vision and commitment to GIS implementation little is to be achieved. The lack of adequately trained personnel had been highlighted on a number of occasions and although a number of education and training initiatives had been undertaken within the organization, much remained to be done before the skill shortage is alleviated. Andreu and Jauregui (2005) showed the importance of training programs to the successful adoption of the technologies by employees. Training develops practical understanding of ICT application use. Most participants received training conducted by a trainer (with a clear and practical understanding of the ICT application's use) before their 'live' use to avoid learning by trial-and-error. The significance of the people involved in GIS was often overlooked by those with a more technological focus.

The research also noted that the MCC/MCA funding was for the specified period and therefore diffusion elimination was a threat. Lobbying efforts by the Top Management was identified as a major factor influencing securing funding. The organized force of the Top Management's lobbying efforts was described by managers as continuous, hard, and fervent. The department units served as a mechanism to disseminate information between the opinion leaders and the other members of the organization. The opinion leaders represented a reliable source of information among the members and they influenced the decision-making process within the departments. Because the opinion leader is approachable, communication with others flows naturally. The implementation plan reached

innovators, and early majority adopters. These categories comprised about only half of the population in the organization. The late majority adopters and laggards made up 50% of the remaining population. These last two categories were to be provided with additional computing support and computer training as strategies to draw them into the diffusion.

Routinizing

The findings indicate that *Routinizing* occurred at different rates at different layers of adoption. At the organizational level, routinizing began when the powerful diffusion infrastructure was put in place. Nonetheless, the absence of the contractor on the ground to implement the system, indicate that implementation was far from completion and that each stage will need to be revisited as one of the one of the Managers commented "I noted that up to now, procurement of the system is not done and there are no implementers engaged". The results of the study show that the implementation is at procurement stage. This bring to new understanding of innovation in organizations. It is argued that innovation is a process during which clarification, redefinition, and reinvention occur and recur. It has never been a liner process as assumed. Furthermore, because innovation is a process, and implementation a sub-process within it, a diffusion that is considered a success at one point in time may not be a success in the long term. There are some issues difficult issues associated with innovation that need to be reviewed and resolved before an innovation such as GIS becomes routine. Some of the issues including organizational redesign and redesign of reward systems. Rather than being limited to initial pilot implementation, the GIS diffusion is guided by the organization's

business vision. The GIS diffusion is therefore a long-term process with goals that would be achieved only when the organization's wider, business goals of supplying stable and quality power is met.

4.2 Factors enable or inhibit the successful diffusion of GIS in the organization

Our research clearly highlights that diffusion success is dependent on a number of factors and it is beyond the control of any given actor or set of actors to simply ensure that these elements are aligned. The central unit of analysis is the organization whose innovative behavior is under scrutiny. Much of the research is concerned with how the structure of organizations affects their ability and willingness to innovate (e.g. Damanpour, 1988, 1991). Despite this focus, no definitive set of characteristics for differentiating more from less innovative organizations had yet emerged from the research. The insights gained from the semi-structured questionnaire and unstructured interviews resulted to identification of a strong contribution of the socio-technical factors to an understanding of GIS diffusion. The factors are clustered into themes, the process of which was described in chapter three. The factors are: Management, Technology, Readiness of the organization and Organization environment. It has been proven that the manner in which these factors interact with GIS determines the processes which affect the diffusion of the GIS. This study has demonstrated that a situation of mutual dependency whereby these factors influence the diffusion of GIS, has various impacts (benefits and problems) on the organization to diffuse GIS and staff involved. Thus, the identification of the appropriate factors and the manner in which they interact enable greater understanding of the processes affecting the

effective diffusion of GIS in the organization.

4.2.1 Management

The research shown the influence of management and organizational support and GIS professional development to be in a pivotal position to strongly influence the initiation and implementation stages of GIS diffusion. First, two types of leadership were identified: someone to manage the GIS implementation and operation and someone to provide support and influence at the policy level. The first kind of leadership is of a diffusion manager who coordinates the network of committees and participants. The diffusion manager was to manage this complex environment, work with diverse individuals and groups, manage teams, educate, motivate, and lead. All are critical to the success of the GIS.

A second kind of leadership of GIS diffusion effort is a diffusion champion who provides executive-level support and influence. The need for such leadership is cited repeatedly when discussing successful GIS diffusions, but many diffusions still lack this key ingredient. The success or failure of diffusions is not entirely within the control of the diffusion manager and diffusion team. Lack of support, conflicting objectives and other contextual issues in the domain of senior and executive management can influence the progress and outcomes of diffusions negatively. This is related to lack of governance (Crawford et al., 2008; Sargeant, 2010). The diffusion manager can function in a dual role as an effective diffusion champion only if he or she is high enough in the organization. This was not the case in this research.

In a major study in the management of large complex diffusions, Miller and Hobbs (2002) showed that the capabilities of the diffusion sponsor have an important impact on diffusion performance. As such, the diffusion sponsor is a critical link between the executive and strategic levels of the organization and the effective delivery of the benefits the diffusion/program was created to facilitate. A diffusion sponsor represents the client and acts in the interest of the commissioning (client) organization in the day to day management of the diffusion (Hall et al., 2003). The findings indicate that the diffusion sponsor's support and efforts ensure continued political and financial support in the face of pressures that otherwise would erode the diffusion's resources and delay its implementation. The study shows that obtaining the understanding and support of Top Management was a crucial first step in the GIS diffusion process. Diffusions lacking effective senior management support cannot deliver the expected business benefits to an organization. The success or failure of diffusions is, therefore, dependent on the top management support (Lechler and Cohen, 2009; Unger et al., 2012). Top Management support was manifested through assigning a top-level sponsor (DOF), actively participating in establishing a vision and strategy for the GIS and communicating support for its diffusion. This means the sponsor is accountable to higher-level management for directing the diffusion with a 'cradle to grave' responsibility to ensure that the benefits for the organization are realized. This includes ensuring that the diffusion always makes sound business sense, approving key deliverables and making decisions or recommendations at critical points in the diffusion's life as required in the diffusion management plan. However, the function can be confused and

challenging, in practice, to those involved and to those interfacing with it (Sense, 2013), so roles and responsibilities of diffusion sponsor need to be clearly delineated.

The Top Management was motivated by the ability of GIS to address the performance gap in the organization. This contributed to as a successful trigger for development of a common purpose amongst the departments in the organization. This is evidenced by the following extracts:

> *"We view GIS as a new idea and exciting. Our underlying feeling is that GIS is useful and required for the day to day operations"* [one of the Managers]
>
> *"Everybody's feels that GIS could have been implemented long time ago…We feel GIS is part of the solution. We are late adopting up the GIS and late starting its implementation"* [One of the Engineering Managers]

The Top Management first move was for the GIS to first gain official recognition through the formal setting through proper justification or feasibility study. Reading the report from the change agent, the need to resolve the energy supply crisis in the country was justification enough for the organization to seriously pursue diffusion of GIS. Without the business justification the GIS diffusion or any other serious diffusion could not start. In this case, the Top Management secured external funding for the GIS and this is a reason enough for the GIS diffusion to start. The GIS was introduced to the organization by recommendation from the GoM through a change agent. In this view, it is also reasonable to conclude that the need for GIS diffusion was not necessarily initiated from organizational needs, but rather from a

perceived need by other sources. The study observed that due to the funding process undertaken by this GIS diffusion, stipulated by MCC through MCA, there was insufficient time to fully explore each departments' requirements and expectations of the diffusion. It was shown that it had been difficult gaining an appreciation into the expectations, requirements and perspectives of all different departments in the organization. It was, however, important that key objectives and deliverables for the GIS diffusion be defined at the start of the diffusion. The reason being that departments had different needs and requirements for the diffusion and most importantly different expectations of the other departments. This made the GIS diffusion process far more complex than if the departments were the same. Additionally, collaboration and integration were difficult as the differences could be conflicting and therefore needed to be addressed. As the following comments imply, the final GIS solution was uncertain:

> *"I always feel the change agent is missing something. The change agent is obviously doing the best he can but I always have this terrible feeling that there's going to be a gap between the final GIS system to be delivered and what our expectations are"* [One of the Top Management]

Though, the funding was political in nature, the GoM could not influence in the diffusion decision. Top Management was the one that shows authority in the GIS diffusion. There is need to recognize that the diffusion decisions were hastily made in order to seek legitimacy. While the diffusion was at first related to the prospect of improved performance in the organization, as the innovation process starts, the study on how the departments would potentially benefit greatly from the GIS had to be done in order to seek acceptability.

The research found that there was lack of understanding of the capabilities of GIS within the organization. Even some of the Top Management indicated that though GIS was being implemented, they do not know exactly what it was capable of doing and/or what it was used for.

> *"we might think we know the capability of the GIS system, but it might actually turn out that we don't know exactly what the GIS system we are supplied with can do and by then we would already have supplied up and implemented the system"* [One of the Top Management]

The fact that the organization was not knowledgeable about GIS in general, it showed that they were also lacking in specific knowledge about how best GIS could be diffused. The Change agent identified entire organization as having the potential to benefit greatly from the GIS. However, it had been established that some Managers of none technical divisions thought that their divisions being not technical did not need GIS. These Managers said that GIS was only for technical people. They also believed that the kind of work they carry out were not GIS related.

> *"We hear about GIS today… but the fact is, our department has functioned all along without GIS and it has never been a problem. We definitely can do without this so called GIS. I don't believe GIS will give us something new. I feel the diffusion is just a waste of resources."* [Comment from one of the Managers of none technical department].

Those Managers were not too motivated to spread about the GIS though their

departments had been identified as potential beneficiaries of GIS. The Managers of those departments did not see the alignment of GIS with the vision of their departments. The Managers highlighted that there was lack of proper marketing of GIS from the Change agent and the Top management.

> *"I do not have more information about this GIS. Can you tell me more about it?"* [One of the Managers]

This was despite constant effort from the Change agent and the Top Management in raising GIS awareness within the organization. According to the Managers, the Change agent places more effort on technical issues and little on the value and benefits of GIS. The Managers feel that if they knew more about the benefits of GIS, they would not question about the technology. One manager explained:

> *"There is no openness in this diffusion. Openness is a key here. We must be able to see clear evidence that GIS will bring benefits to our work. Not just to the organization, but I mean to our work."*

The study illustrates that there were structures and regulations setup for GIS diffusion in the organization. This meant that there was specific organizational vision for the GIS diffusion. On several occasions, Change agent had requested the creation of the GIS steering committee but the Top Management took too long to approve. This situation, according to the Managers made the diffusion of GIS a complicated task in a sense that users were limited to what they could and could not do. The power user Managers were not even being involved in the decision for diffusion of GIS, as such they had no ownership of the GIS.

The study reveal that the departmental Managers consistently had a high level of

impact on the diffusion of both infrastructure and business process GIS while the Top Management was found to have a high level of impact on the diffusion of business process GIS. The crucial role played by the Managers and the Top Management in the diffusion process was confirmed by the observation in the case study. The Managers at the departmental level normally tackled the technical issues while the Top Management tackled funding and other organizational issues. The result was the plan for the GIS that would serve several business functions, and the entire organization. The challenge was to manage the different visions to strike a compromise for the benefit of the organization as a whole. The findings from the case study confirm the need for management and organizational support and GIS professional development influence as crucial to success of GIS diffusion in an organization.

4.2.2 Technology

The technological issue (Spekman & Sweeney, 2006) of GIS technology focuses on the nature of the innovation and influence of technology characteristics such as functionality and accessibility. It appears that the benefits of the GIS innovation have been oversold, and adoption of GIS technology has been lagging. As with any technological innovation, the key factor in the success of the technology, is how it is applied to solve the organization's business problems. The classic theory of DOI attributes diffusion of innovation in an organization to its characteristics. Assumptions concerning the nature of innovation are fundamental in order to understand the issues involved in the diffusion and use of computer-based systems in organizations. Longley et al., (2005) argue that the developments in computer

technology have been a major contributor to the rapid advances of GIS. The following major characteristics are proposed by Rogers (2003): relative advantage, the degree to which an innovation can bring benefits to an organization; compatibility, the degree to which an innovation is consistent with existing business processes, practices and value systems; complexity, the degree to which an innovation is difficult to use; observability, the degree to which the results of an innovation are visible to others; and trialability, the degree to which an innovation may be experimented with. There are also other characteristics identified like: costs, communicability, divisibility, profitability and social approval.

Among them, relative advantage, compatibility and costs were found to be the most frequently identified factors for innovation diffusion among organizations (Tornatzky & Klein, 1982). This is the case for many technologies, and it is particularly relevant for GIS. But several GIS characteristics differentiate it from other technologies and necessitate specialized organizational and management approaches. These issues include the characteristics of geographic data and their role in the organization's business operations, the current state of GIS technology and its future directions, the relationship of GIS technology with other technologies in the organization, and the multi-use nature of GIS data.

When GIS is introduced into an organization, the organizational impacts and implications must be addressed as carefully as the technological ones. The findings indicate that the organization reactions to the innovation appear to be shaped by the

nature of the innovation. GIS was perceived a better innovation and was found very much consistent with the values, past experience and needs of the organization. Basically, control and management of GIS may be centralized or decentralized. In an enterprise GIS, an organizational unit may be established to manage the GIS environment and run the core system, whereas its usage is decentralized. In an environment in which GIS is used occasionally by various users, it may be set up as a separate service with a designated group that manages the GIS and also controls users' applications services. In an environment in which GIS is used as a business tool, management and control may be decentralized to the user business units.

The research revealed that all decisions about which innovations to diffuse, to whom and by what means were made centrally (Top-down direction) within the organization. Though the organization did not anticipate any problems with this approach, a centralized approach could lead to unnecessary bureaucracy and inefficiency. Rogers (2003) challenged the adequacy of this center-periphery model. He argued that, in practice, there is often no clear center and that the diffusion process is frequently more decentralized and iterative in nature (innovations evolve as they are diffused). In highly decentralized systems there is wide sharing of power and control among members of the diffusion system, peer diffusion of innovations is through horizontal networks and there is a high degree of local adaptation as innovations diffuse among adopters. According to Kraemer and Dedrick (1997), the centralization and decentralization of computer-based information systems in organizations are important in order to encourage end-users to adopt information technology. Table 3 summaries the overall advantages and

disadvantages of centralized and decentralized systems of diffusion.

Table 3: Centralized versus Decentralized diffusion systems

1	**Centralized systems** • Provide central quality control over which innovations to diffuse • Can diffuse innovations for which there is as yet no felt need *but* • Can encounter user resistance to central control • May result in inappropriate adoption because of low adaptation to local circumstances.
2	**Decentralized systems** • Users tend to like such a system • Promotes closer fit between innovations and user needs and problems *but* • Ineffective innovations may be diffused due to lack of quality control • Depends on local users, who control the system, having knowledge about other users' problems and about the innovations available that could solve them.

The study noted that the organization opted for reinvention where any technical and organizational problems arose. The organization thought reinvention was a desirable quality. The past studies had indeed shown that reinvention truly increased the likelihood of adoption and also reduced the likelihood of

discontinuance. However, it was also suggested that when the level of reinvention was quite high, then the outcome of the service would change very little and the innovation would change substantially. In general, this research does not favor reinvention. Reinvention is considered as a distortion of the original technology and made it more difficult to measure the impact of the innovation.

The findings also shown that the strength of evidence on whether GIS diffusion would lead to improved effectiveness does not seem to be the main factor that influenced diffusion decisions. Practically, assessment of GIS effectiveness was not easy to measure at this stage of the study because there were no benchmarks at which to compare the results. For a more practical investigation, GIS effectiveness could be assessed as a measure of success of the solution that was proposed and agreed upon at initial stage. The findings also pointed that the level at which an innovation was perceived to be compatible, triable and observable all appear not to be more important in influencing uptake.

4.2.3 Readiness of the organization

The readiness of the organization is crucial to assure successful implementation of the technology. The readiness of the organization in diffusion considers, individual readiness of the organization members, and financial and technical readiness of the organization and support. In this study, financial readiness was defined as the financial resources available to diffuse and maintain the technology. The technical readiness was referred to the organizations' technical complexity to develop and diffuse the innovation. Individual readiness focuses on the influence of

personal/individual characteristics such as IT skill, capability to learn, and pervious experience of IT. The findings indicated that ESCOM relied much on the external change agent in planning for the diffusion of GIS. This was understandable because none of the organization power users were GIS experts. So far, no any staff had previously trained in GIS. The study discovered that the organization had planned to transfer knowledge to users through the developers and consultants after the initial GIS establishment. The knowledge transfer would be through GIS manuals, hands-on experience and short training courses. It was not surprising then that the Managers raised a concern regarding the external change agent.

> *"MCC has just imposed the change agent on us. We question whether or not the GIS diffusion really calls for the external change agent"* [One of the Managers]

The findings of the study show that there were no GIS experts within the organization trained to take over early enough from the external contractors. This is the issue that most frequently mentioned in the field of GIS. As Yeh (2005) predicted, lack of training and understanding of GIS potentials seem likely to impede the diffusion of GIS. This also explains why the users still needs to acquire more training on GIS in order to gain the appropriate skills in GIS at the advanced level. The fact that GIS is a relatively new technology means that staff with GIS training and skills are in high demand and beyond the reach of most existing departmental budgets in retraining. The technical training of the GIS system was entirely in the hands of the external contractors as there were no professionals within the organization. The GIS awareness was promoted through structured training, organizational meetings and short trainings. Other than needing advanced

skills in GIS, the users also needs to learn about the nature of computer-based system.

The study showed that the initial funding was not the problem for the organization. The reason is that the GIS was a direct recommendation from the GoM, the change agent and funding agent, MCC through MCA. The diffusion being donor funded received very little (if any) financial commitment from the organization. It was discovered through the study that donor funding was of short-term support and it could be phased out before the GIS diffusion was fully implemented. This presented a challenge where after the diffusion has been ended, the GIS activities might be discontinued for mere reason that there could be no provision of financial support. In this cases, this might result to abandoned facilities.

> *"MCC has indicated that after the diffusion is officially closed, funding will be the responsibility of the organization. Now, if the organization will not adequately fund the GIS, most of the GIS equipment will not be in use…This might be a complete abandonment of the GIS technology".* [Concerned manager]

The organization should be prepared to fund the GIS once MCC/MCA diffusion shall be phased out. Future lack of funding would make the updating of equipment impossible and maintenance thereof difficult. Also to note was that human resource development would suffer if funding would not be available. This would be true for training and even more important for developing applications that would promote the significance of GIS to the organization.

Finally, a critical, yet often overlooked factor in GIS implementation is the handling of the transitions between the phases of the implementation process, which can be more difficult and more critical to success than the steps of implementation themselves. Although, many GIS diffusion managers are capably of planning the technical tasks and transitions, the organizational aspects are often disregarded largely because they are not well understood or are underestimated. Delivering a technical tool to an organization that has not been properly prepared can cause a technically sound GIS to fail.

4.2.4 Organization Environment

Organization Environment focuses on the influence of the workplace environment. When implementing GIS in an organization, it is important that the environment of the organization be prepared in many respects. The four critical areas of the organizational environment are: the level of information systems distribution in the organization, the maturity of the organization and its information systems, the GIS implementation roles, and the participants' attitudes toward GIS and each other. Because the GIS implementation process can take a long time, particularly with respect to technology and environmental changes, flexibility is crucial to success. The GIS implementation manager must be able to adjust to arising constraints and problems and take advantage of new opportunities.

The GIS diffusion triggers some unplanned modification in the conducts and procedures of the organizations. The study had shown that once GIS would be diffused, its position within the organizational structure would became an issue.

Changes in the organizational structure and consequent shifts in the paths of information flow are therefore fundamental disruptions in the functioning of the organization and are justifiably interpreted as threats to the organization itself (Campbell and Masser, 1995). The changes in position within an organization cause changes in the balance of power among units (Campbell, 1994). Though no any alterations had occurred in the structure and function of the organization due to the diffusion of the GIS but more opinion leaders were recruited within the organization to spread about GIS and develop new competencies and skills to reduce organizational conflict and user resistance. The Managers' general consensus was that having a dedicated division or unit responsible for all GIS operations within the organization would greatly enhance the productivity of the GIS which in turn would benefit the organization. For that reason, the organization would establish organizational structures and plans that would help coordination of GIS diffusion. Top Management support and action was crucial with regard to the establishment of those enabling procedures. As was the case, the bureaucratic nature of the organization was not hindering the effective GIS diffusion. The organization plans to employ a group of personnel to effectively run the GIS division once the division has been established. The establishment of the GIS division would bridge the gap between the management and the user staff. In a sense, it would enable an active dialogue across the organizational hierarchy.

The GIS diffusion had affected organizational lines of communication and reporting and collaboration between the departments. The findings indicated the development of a network of power users in the organization to share problems

experienced in the diffusion and seek solutions together. It was an effort to increase the information flow between departments. Based on the sample, there was a certain degree of heterophily among the individuals, covering two sets of socially dissimilar individuals in the organization. If there were two sets of individuals that were technically equal, no diffusion could occur because no new information could be exchanged (Rogers, 2003).

There was also considerable change in job descriptions of not only the power users but the Managers too, to include the operation and management of the GIS into the official duties of those personnel. Change as a result of GIS diffusion was required at all levels including the individual scale. The influence of social factors directly affected GIS diffusion and this was seen as a barrier. The organizational level of relationship between individuals (Managers and supervisors, supervisors and employees and peers) for knowledge transfer with respect to GIS, particularly peer-to-peer relationships played a major influence.

The findings also demonstrated that Top Management was the primary source of the organizational change and their alignment was crucial for GIS diffusion. The diffusion could not proceed until the Top management had aligned their interest with the technology. The diffusion process proceeded because of alignment of the support from the Top management despite the managers and operational staff not being involved in the initial introduction and support of GIS diffusion. This confirmed that alignment of key influential Top management was more critical than others in the organization.

Similarly, adoption of GIS in the organizations was seen as a change initiation process. GIS diffusion within an organization requires change management to facilitate and encourage people to adopt diffusion initiatives. Organizations can do this through: motivating staff; providing appropriate training and technical support; and ensuring supervisor support for an open discussion sharing environment. In principle, the environment affects technology adoption more than the technical factors.

4.3 Feasible and useful of GIS in management of power system

Challenges faced by early adopters of GIS technology in ESCOM according to diffusion analysis includes: a lack of awareness about the importance of GIS technology. The study shows that there was little or no knowledge about the GIS abilities and relevance to the organization in the early stage of the research. According to Lewin's model, the change process is a sequence of three core stages: unfreezing, changing, and freezing (Lewin, 1952). The research perceives the second stage (change), corresponds to arriving at the decision based on trials and experimentation with the innovation, in that aspect application prototype was developed as part of this study. There are many use cases of GIS in power utility. However, for the time constrain the author chose to develop the most important requirements which were relevant to the scope of the thesis. The study area selected for this prototype is the three traditional authorities within Blantyre district. Blantyre district is located in the southern region of Malawi (Figure 3).

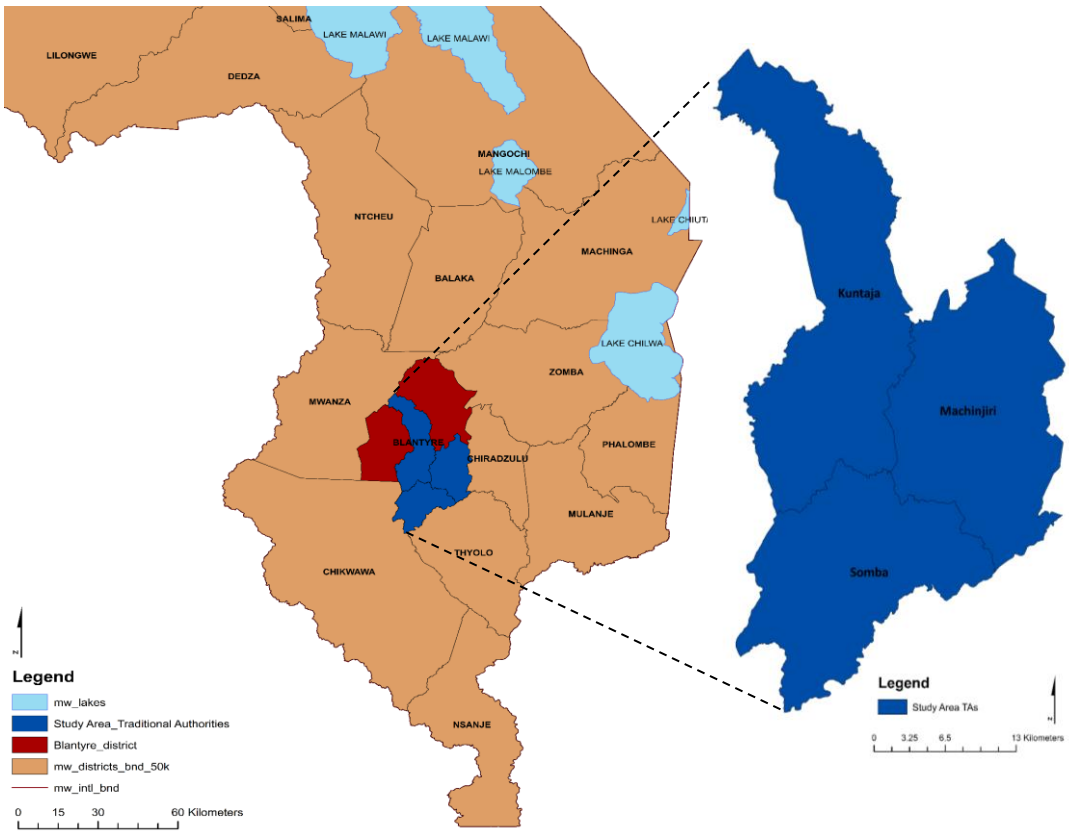

Figure 3: Base map showing district of the study area.

4.3.1 Functional requirements

- To search and display all existing distribution transformers connected to a particular feeder.
- To determine the location of a given facility with a known attribute.
- To determine all customers that could be affected, in the event of a fault on any feeder section.
- To determine on average, how far was one set of customers from the closest transformer.

4.3.2 Non-functional requirements

- The mapping was done in ArcGIS 10.1
- The UI was developed using Microsoft Visual Studio 2013 on Microsoft Windows platform.

4.3.3 Data Collection and Modelling

The spatial and non-spatial data (Raghav, 2006) used in the study was collected from the customer verification team at Revenue department and drawing Office of ESCOM. The spatial data included geographic locations for transformers and customers. On the other hand, non-spatial data collected included transformer and customer attributes. The information existed in Microsoft excel. The excel spreadsheet data was then imported into a GIS software (ArcGIS 10.1). This step simplified attribution by eliminating manual data entry. Both spatial data and attribute data formed the GIS database (ESRI, 1990) and thereby making it ready for the analysis (Fischer, 2003). Figure 4 shows a complete map for the prototype.

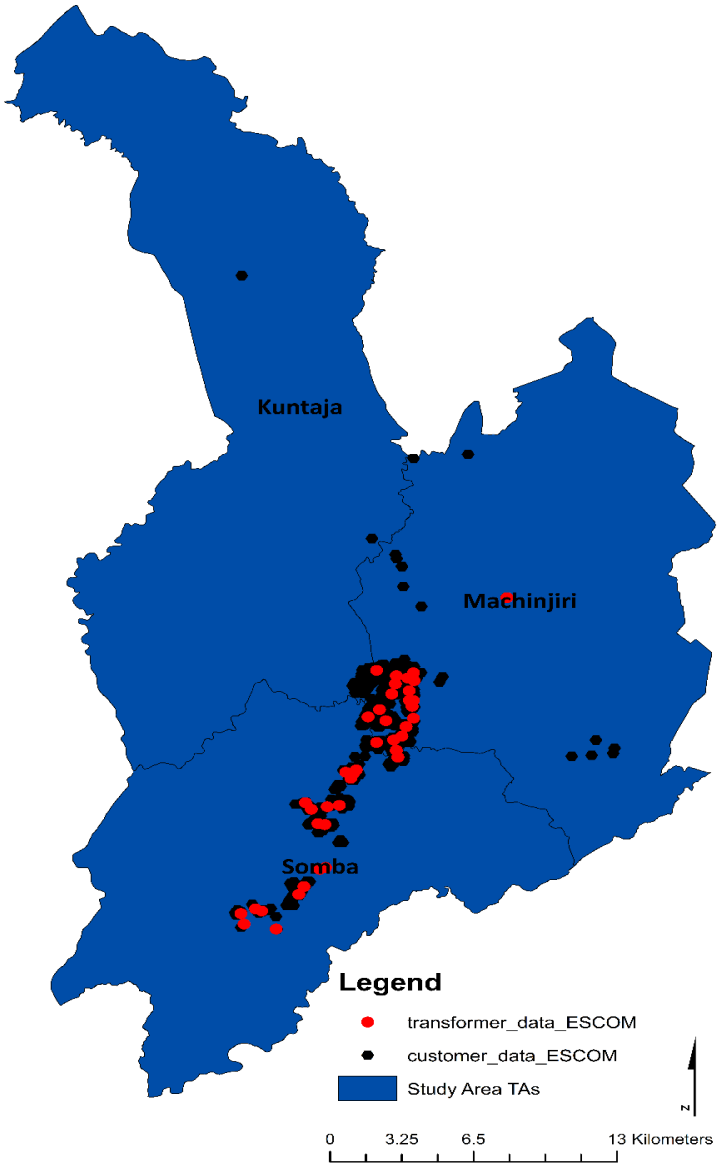

Figure 4: Complete map for the prototype.

4.3.4 System development

The functional and nonfunctional requirements (Rainardi, 2008) influenced the overall architecture of the system. The development language of choice was Microsoft Visual studio on Windows platform and ArcGIS 10.1. The programming in Microsoft Visual studio 2013 was to produce User Interface (UI) that was self-explanatory, efficient, and user-friendly for the users to experience GIS

functionalities. The aim was to eliminate the complexity of directly using the ArcGIS toolsets. This made the ArcGIS toolsets almost invisible to the user. Rapid application development (RAD) was the software development methodology that was adopted and this used minimal planning in favor of rapid prototyping. The GIS prototype was called POWER GIS monitor. The program source listing extract is shown at Appendix 2.

Figure 5 shows a screenshot of the initial opening screen of the GIS application prototype. The transformers were mapped with red color dots and customer premises with black dots. In the upper left hand corner of the UI were tools available for analysis

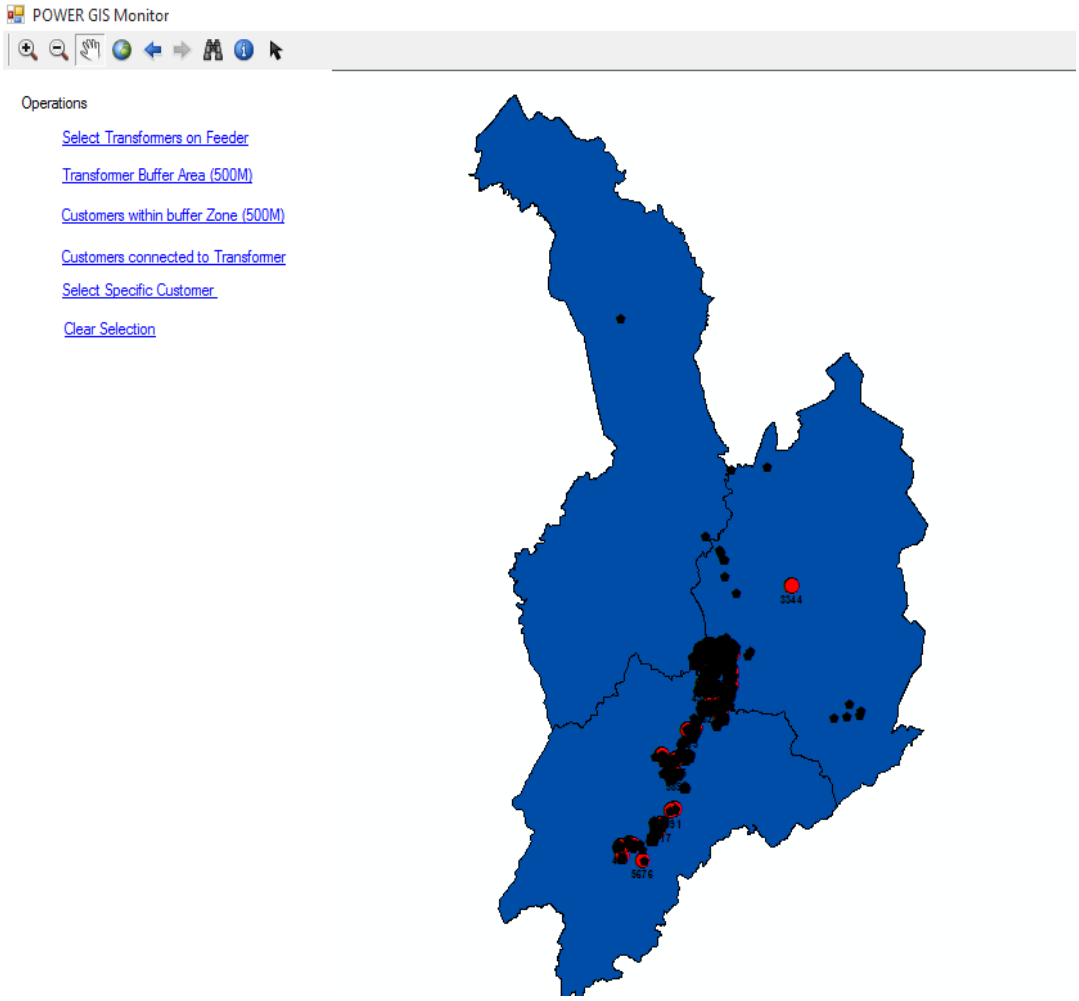

Figure 5: The initial opening screen of the GIS prototype.

The map can be zoomed in or zoomed out by clicking a point or dragging a box. Figure 6 shows zoomed in Map.

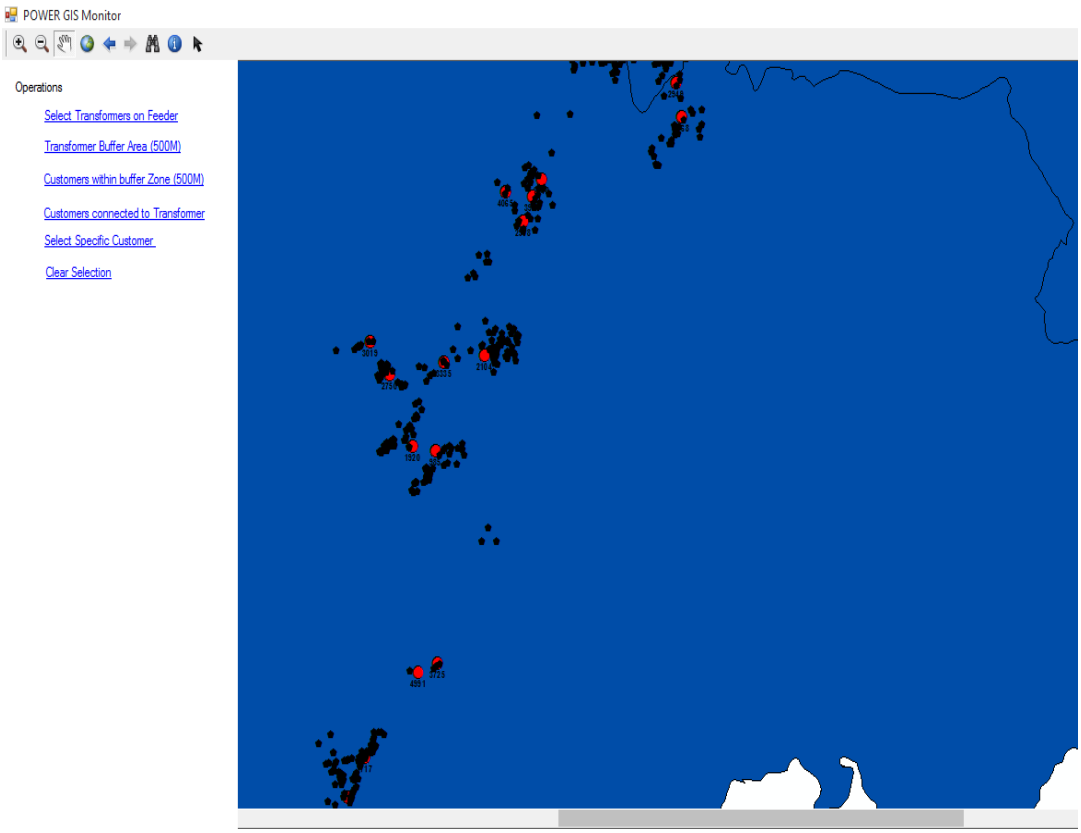

Figure 6: Zoomed in map.

4.4 The Prototype Outcome

Prototyping was the ideal for this study to evaluate this research from two different point of views. First, as a Proof-of-concept: It was based on developing simple prototype to show the feasibility of the solution in terms of some specific properties under specific circumstances. Second, as a Proof-by-demonstration: In this approach, the product was evaluated in practice (not in real-world) but applying restricted context. The purpose of which is to verify that the GIS concept have the potential for real-world application. The requirement set for the prototype was to demonstrate the feasibility and usability of the functionalities of the GIS in management of electricity distribution network. The goal was to provide a system with overall functionality so that the user could get an actual feel of the GIS and

experience GIS functionalities.

4.4.1 Spatial query

The first requirement set was to search and display all existing distribution transformers connected to a particular feeder. The power network used in the prototype was connected to 1L5 and 2L5 feeders from Blantyre West substation. Using Select Transformers on feeder tool on the prototype UI, the system query displayed all the transformers connected to the specific feeder selected. The system operators could use the information to approximate the loading on the feeder. Lack of information on the loading and health status of the transformers and its associated feeders is one primary cause of inefficient power distribution. If the loading on the transformers and its associated feeders is not monitored, overloading occurs (Senthamarai and Krishnan, 2008). The overloading results in low voltages at the customer end and increases the risk of frequent breakdowns of transformers and feeders (Brown, 2008). The system operators could use the knowledge about transformer and feeder loading as a guide to know where they could control the system loading based on the distribution of power. The result of the query can also be used to determine how to carry out load shedding, which can be used to reduce the load on a transformer that is already overloaded. The transformers displayed in yellow dots in Figure 7 and 8 shows all transformers that were connected to 2L5.

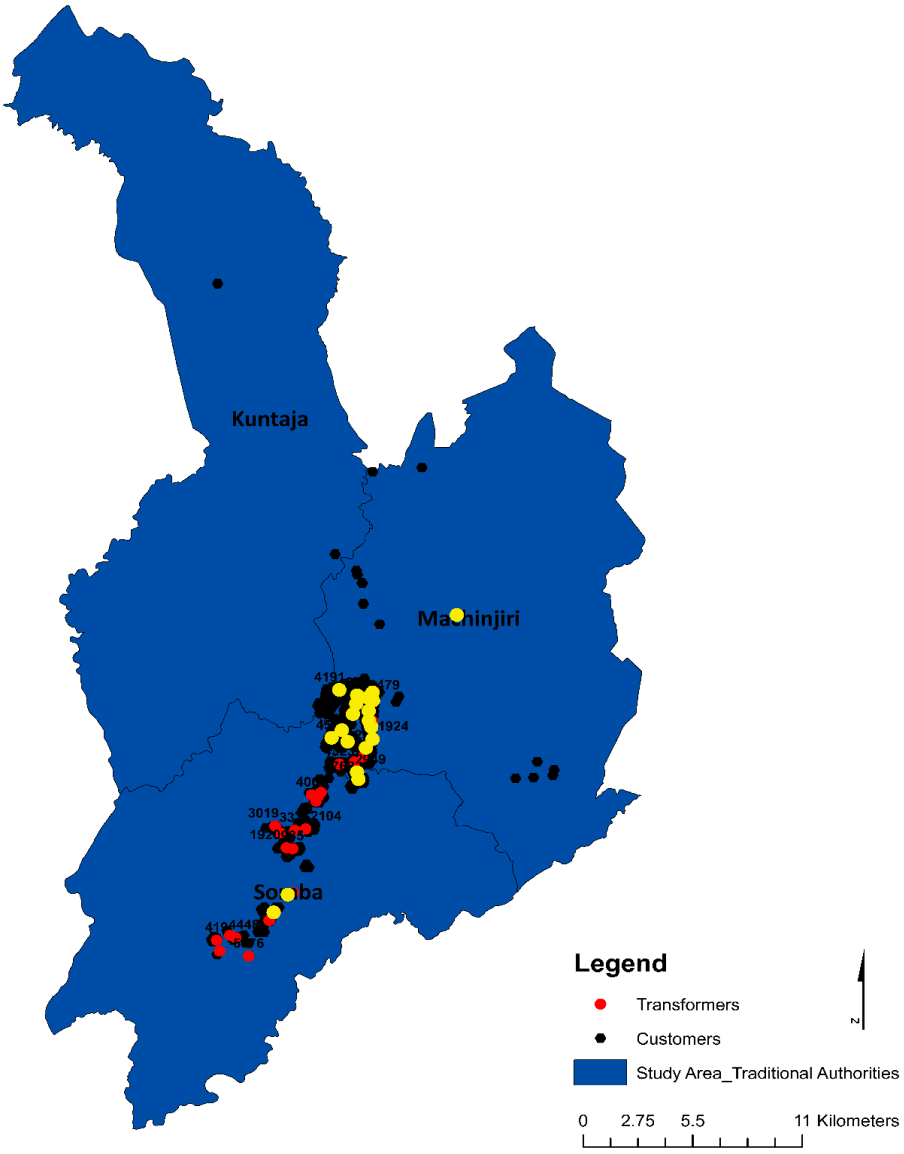

Figure 7: Transformers that were connected to 2L5 feeder.

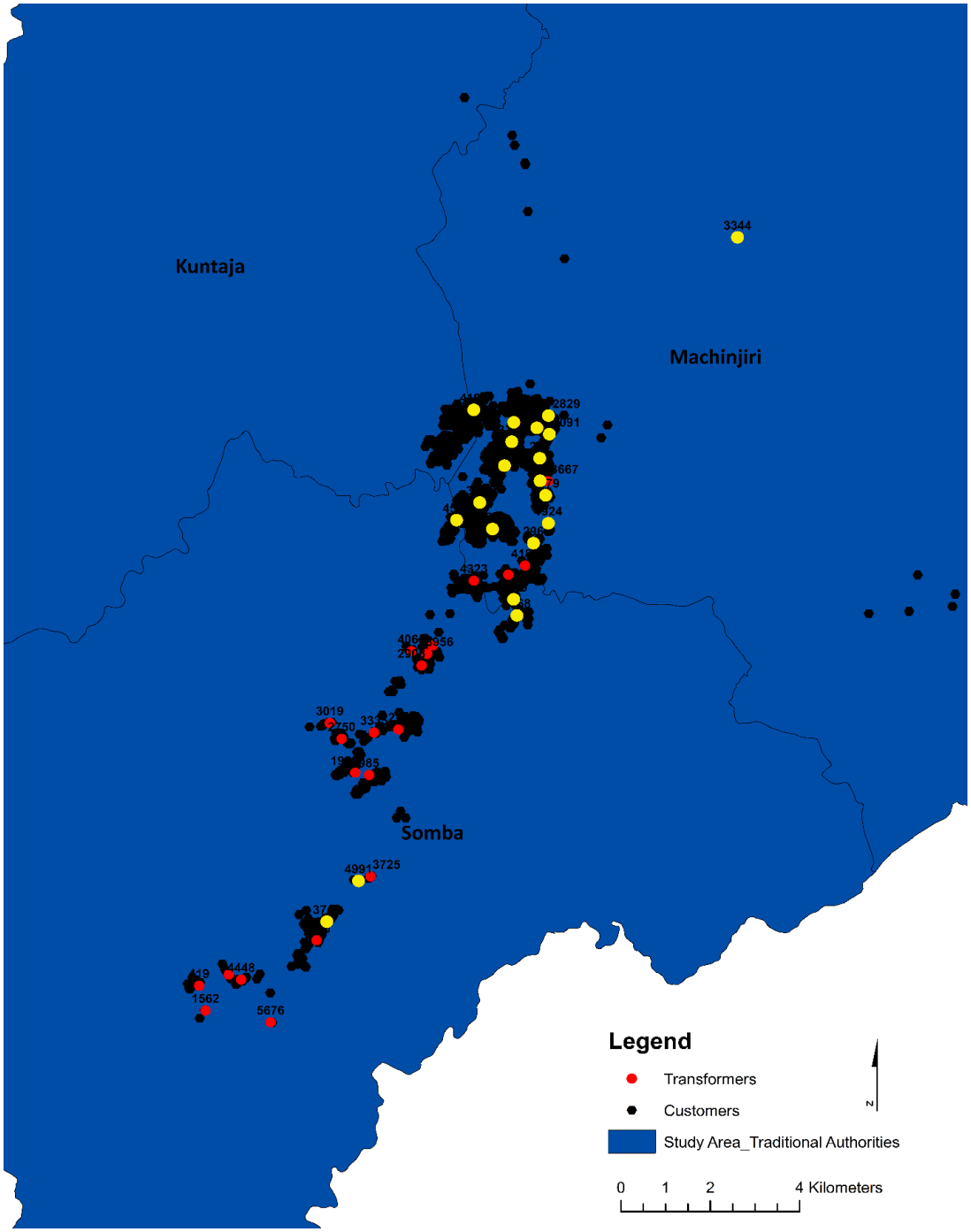

Figure 8: Zoomed in Transformers that were connected to 2L5 feeder

4.4.2 Aspatial Query

The second requirement set was to determine the location of a given facility with a known attribute. The organization should fully monitor and manage its assets to

know what assets it has, where they are, their condition, how they are performing, and how much it costs to provide its services (Emengini, 2004). The knowledge could help the organization to effectively run an efficient day-to-day operation, manage and develop its services to make strategic and operation decision (Alamu and Ejiobih, 2002). According to them, the well maintained utility information infrastructure gives up-to-date information on what is where and the state of it. According to Ayeni et al (2003), the knowledge is very essential to economic planning and national development.

Using Select specific customer tool in the prototype UI, a particular customer was allocated. The ability of the organization to allocate its customers in time and could help the organization restore power to the customers with speed and efficiency during unplanned outages. The traditional approach used for restoring power was through dispatching maintenance crews to the fault location following customer calls. This took several hours to complete, depending on how quickly customers reported the power outage and the maintenance crew located and solved the problem. Instead of relying on maintenance crews to locate sites of power cuts, the organization may significantly reduce power restoration time and equipment damages through GIS system. The customer's account number was used to query for location of a customer.

The result showing location of a customer with account number 01329925810 is shown in Figure 9 and 10.

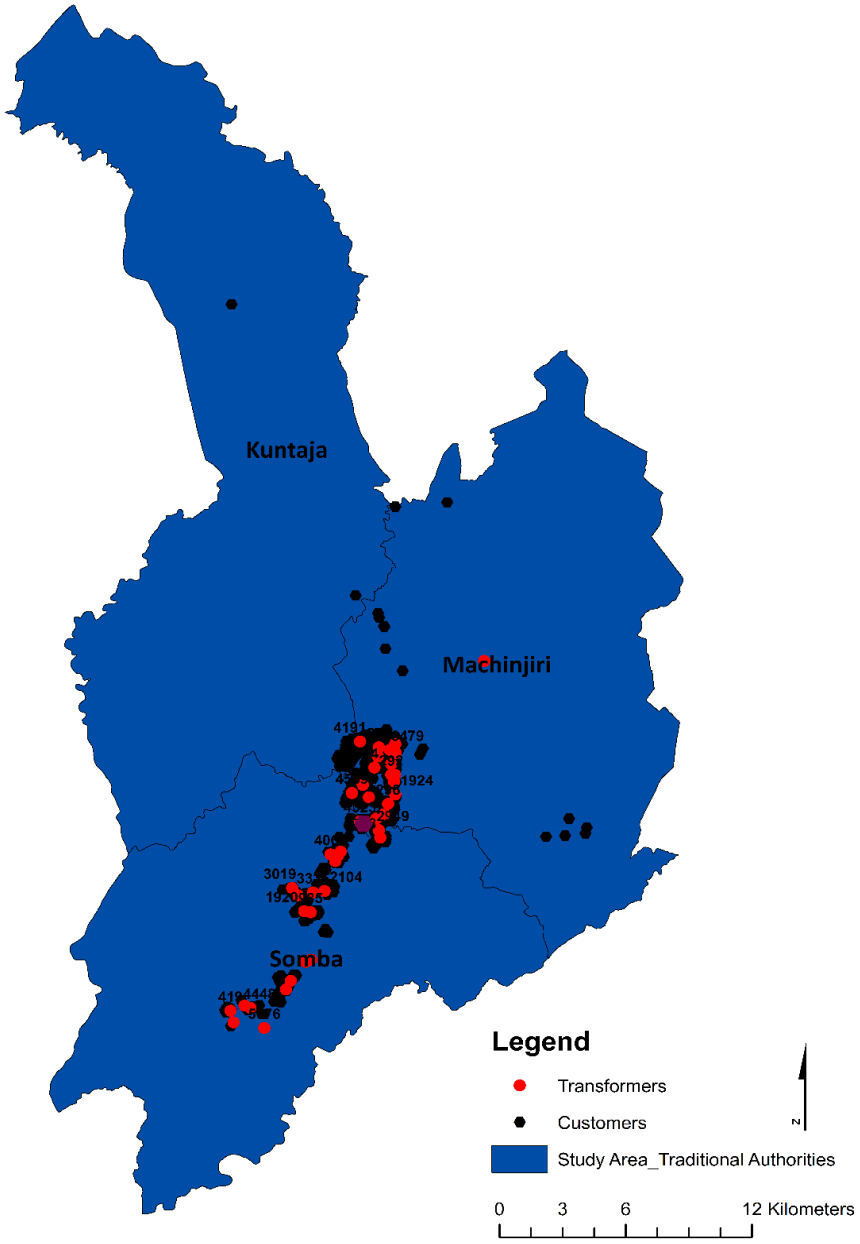

Figure 9: Location of a specific customer.

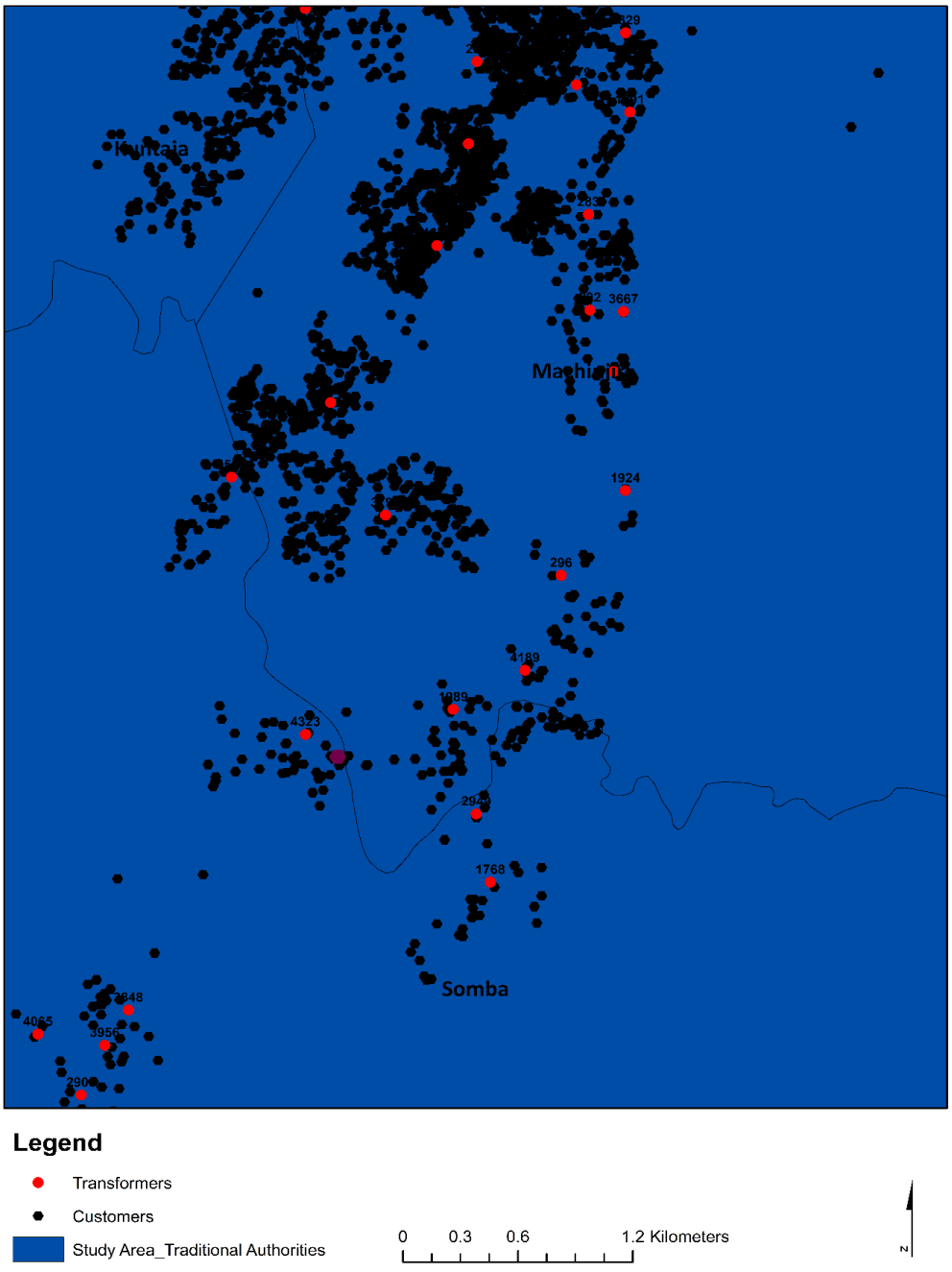

Figure 10: Zoomed in location of a specific customer.

4.4.3 Network Analysis

The third requirement set was to carry out network analysis to determine all customers that could be affected in the event of a fault on any feeder section. The faults on a feeder section causes power outage over a large section of the distribution network. During a power outage, citizens should receive regular updates about the incident, and when it will be resolved. In a situation where the customers affected are precisely identified, the organization would communicate properly with the public on the power outage. The study identified that the biggest problem the organization faces, as seen in all major outages, was not the restoration problem but in the failures to communicate properly with the public. In the event of a major outage, the customers experiencing an outage wants to know was how long it would take before power would be restored. The GIS system would be used to precisely identify the customers affected and the organization would communicate properly with the affected customers on the power failure. The system was queried to locate customers that could be affected if transformer number 283 was taken out of services. The result is as shown in Figure 11 and 12.

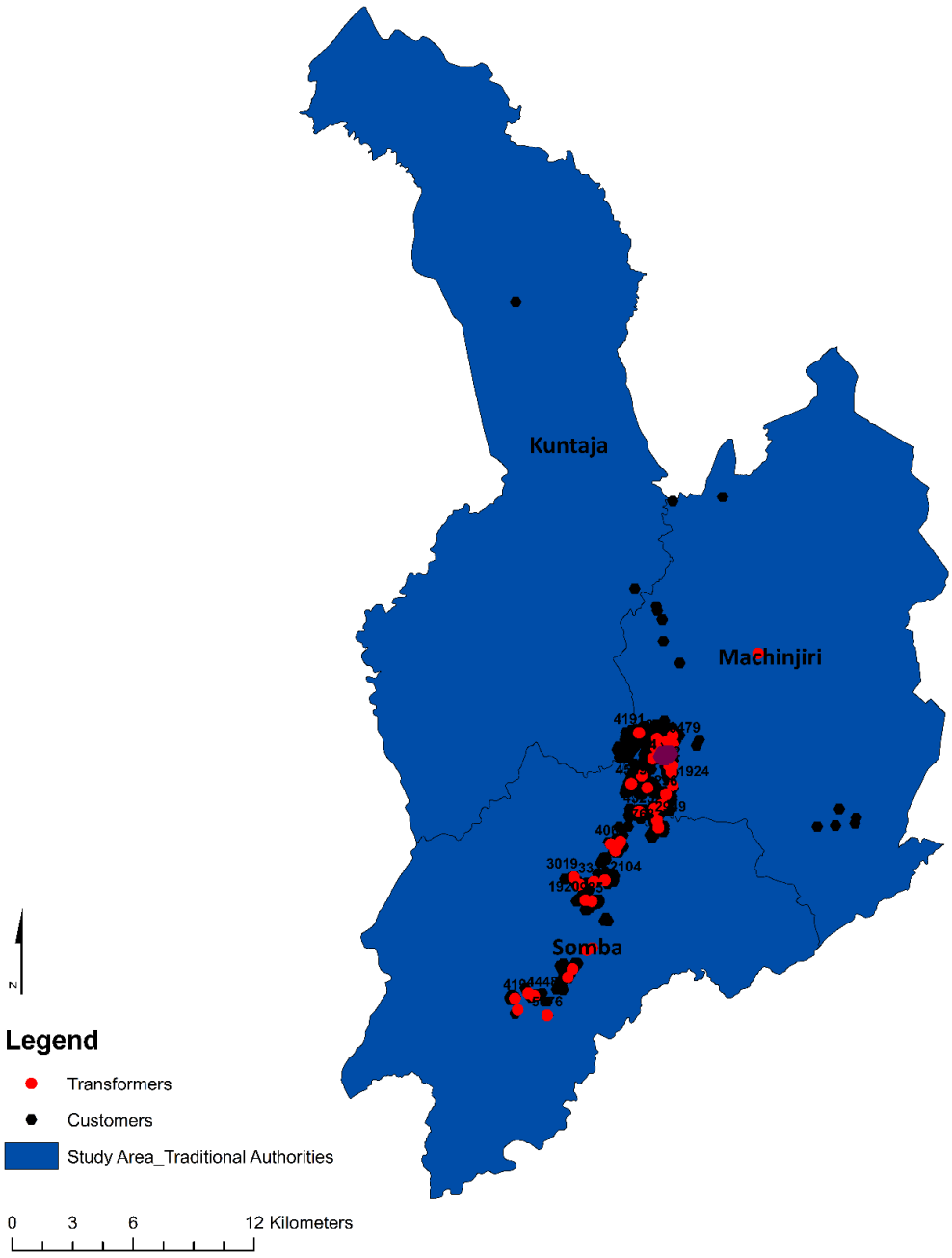

Figure 11: Customers connected to a specified Transformer.

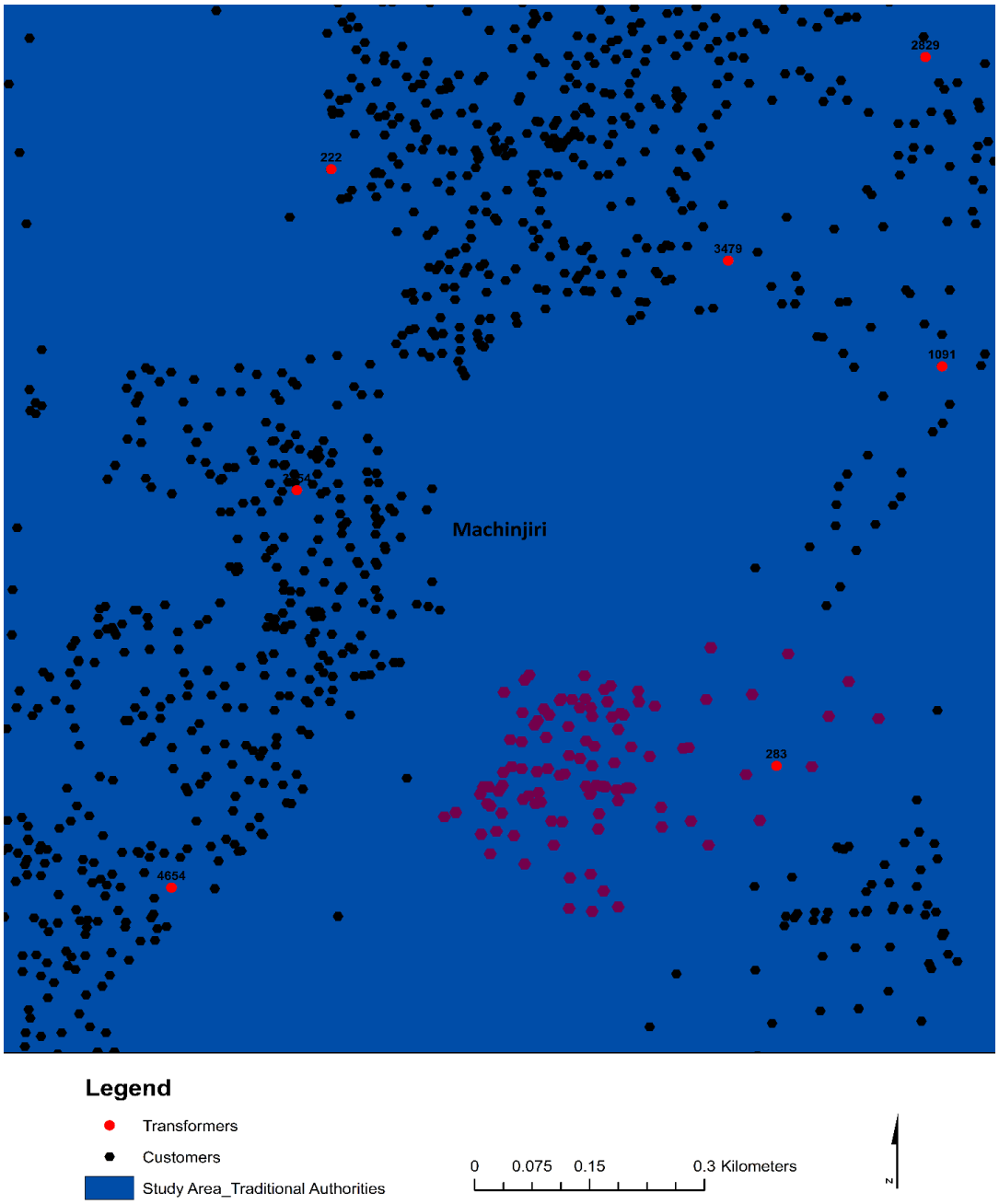

Figure 12: Zoomed in customers connected to a specified Transformer.

4.4.4 Proximity analysis

The forth requirement set was to carry out proximity analysis (Goodchild et al.,

1992) to determine on average, how far was one set of customers from the closest transformer. This determined the pattern of the supply in terms of voltages within a given radius of a transformer. The result was a polygon vector layer, a buffer zone.

The results showed all customers within the transformer buffer zone and all customers outside the intended service area of the buffer zone of the transformer. The buffering analysis helps to determine the shortest possible length of connection as voltage drop may be permitted due to long distance covered in the distribution of power. This also help us to compute voltage drop and the power loss at a particular length as the exact distance of coverage can be determine from the buffering analysis. With the help of buffering analysis, the transformer can be centrally located with respect to the load area being served as this minimizes the length of the distribution lines connecting the transformer to the load and also reduce the numbers of electric pole. Cost of cable is reduced and also distribution losses will be minimized. The customers that were within the buffer zone of the transformer in Figure 13 and 14 were considered experiencing quality supply and those that were outside the buffer zone experience low voltage. The farther the customers were connected to a distribution transformer, the customers experienced the voltage drop in power supply. The proximity analysis could help in the design of distribution network for a given customer. The planning engineers would consider that the distribution system should meet the acceptable operating range of the grid. The acceptable operating range of the grid was within the radius of the 500m of the given transformer which was within the buffer zone.

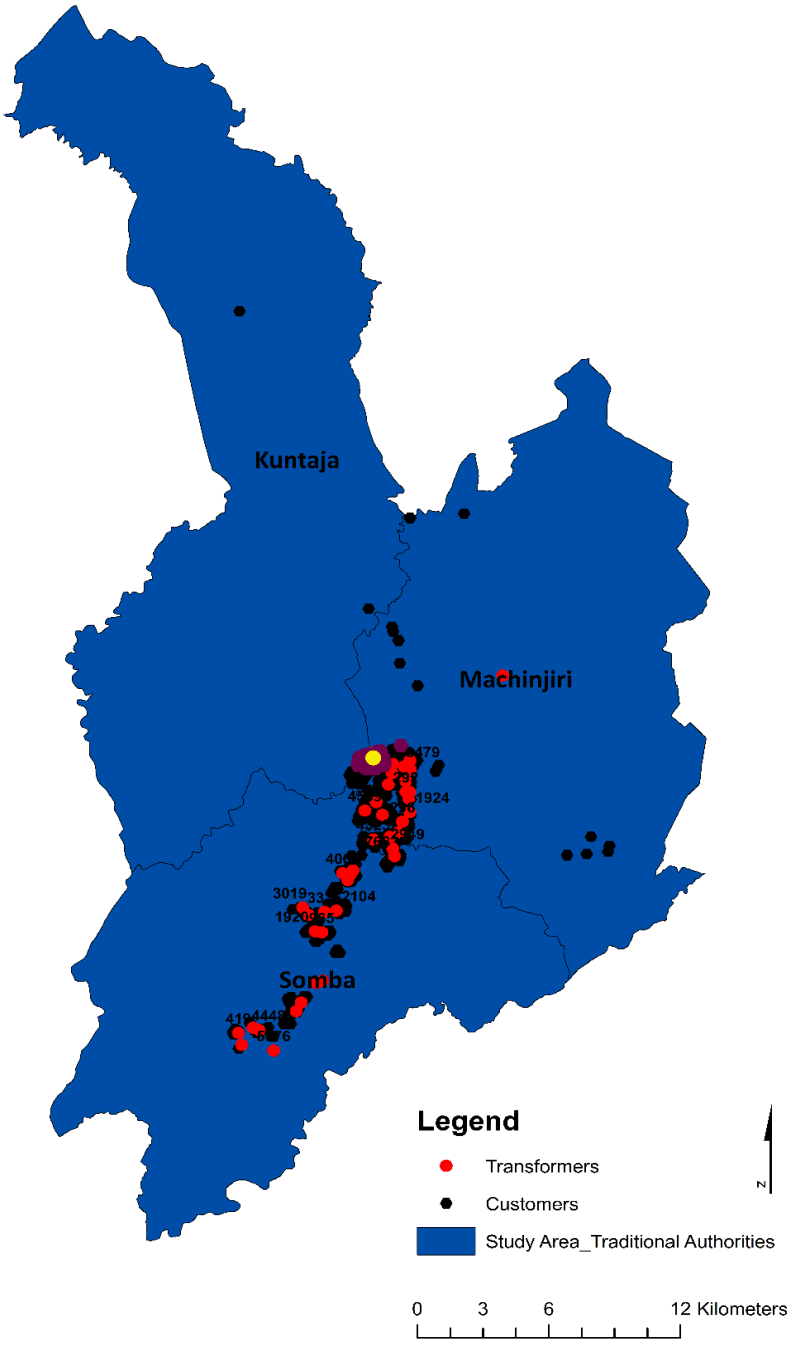

Figure 13: Buffer zone around the specified Transformer showing an area within.

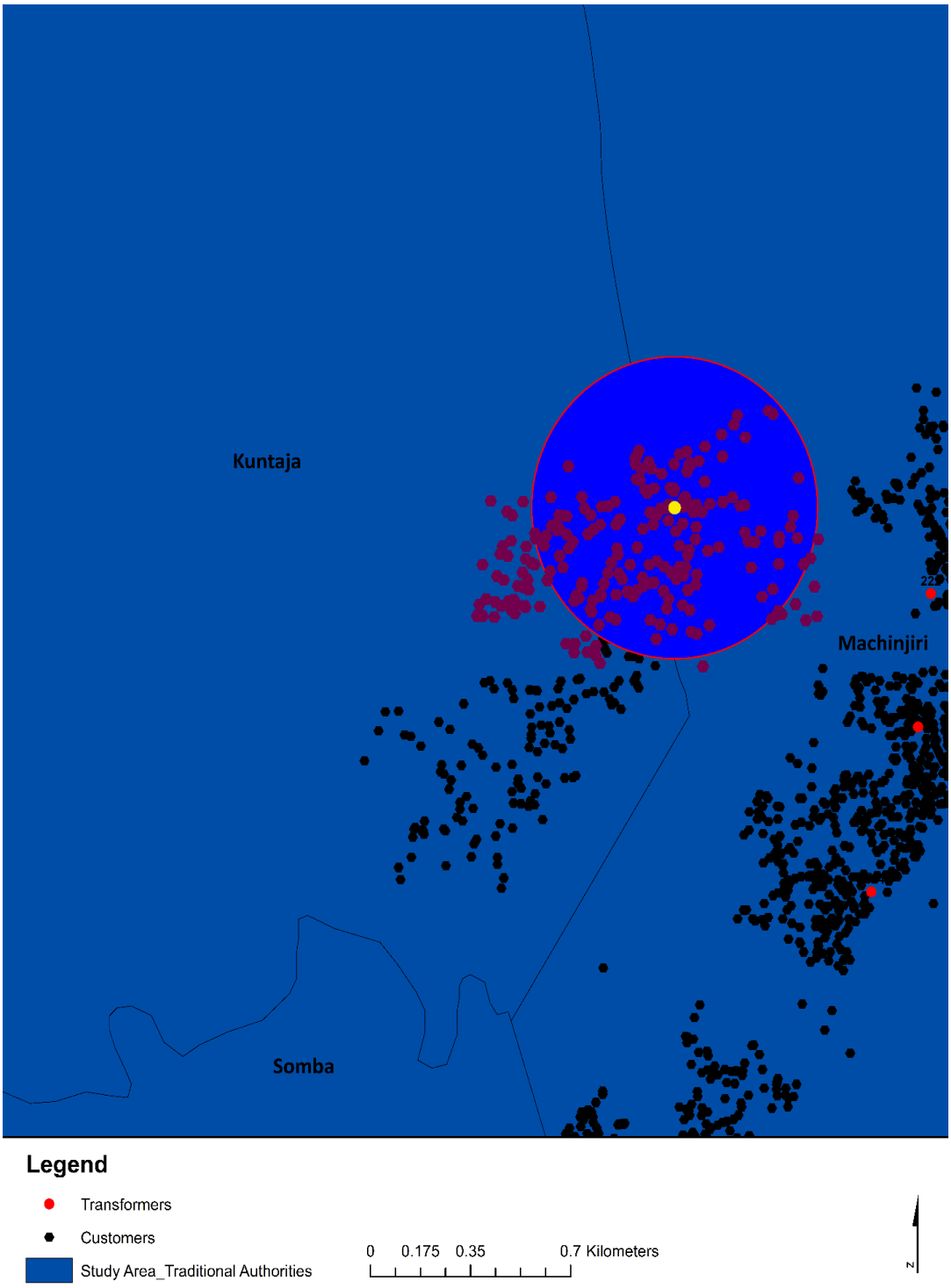

Figure 14: Zoomed in buffer zone around the specified transformer showing on area within permitted voltage drop.

CHAPTER 5

CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Conclusion

This research paper explored the approach of GIS diffusion that an organization undertakes (ESCOM in this study). The results were discussed in view of the theoretical framework used. The thesis has also presented and discussed various qualitative factors that enable and inhibit the process of GIS diffusion to be undertaken. Further to this, the research developed a GIS application prototype to create awareness of the value of GIS in the organization. This chapter concludes the research efforts by presenting the research contributions, Implications, limitations, further research areas, and recommendations.

5.2 Research Contributions and Implications

Throughout the research, the aim has been to provide results that can inform the process of GIS diffusion in practice. The results of this study were especially relevant to those interested in the diffusion of GIS. This research has agreed that most of the widely used perspectives on GIS implementation fall short in properly addressing the multifaceted process of innovation diffusion. One of the serious problems was the lack of agreement on a model of the process for GIS diffusion. The findings of this research contribute to our understanding to the process of GIS diffusion. Based on the argument in Chapter three, Rogers' model of organizational

innovation process has been used to depict the process of GIS diffusion in an organization (ESCOM in this case). The model had been proven to be valuable in the discussion of diffusion of a corporate GIS in this research. It appears Roger's model provides a rich and potentially fruitful area for further research, and contribution to knowledge. It has practical implications for organizations, managers, administrators and the employees concerned with taking up innovation in the organization. Rogers' model has great potential in assisting future research into GIS diffusion.

The thesis has also presented and discussed various qualitative factors that enable and inhibit the process of GIS diffusion to be undertaken. This thesis argued in favor of prototyping as a research tool. This was influenced by the lack of understanding GIS applications for the needs of the electricity utility, and how departments within the organization could make best use of GIS. The prototype was the first step to created awareness of the value about GIS in the organization. It was found that no single systematic research relating to GIS implementation was ever done in ESCOM before. It is hoped that this research goes some way towards filling this gap. As seen in the literature review and throughout the depth of the analysis presented in this thesis, this type of study has also not been carried out in many other developing country contexts. Therefore, most of the findings may be applicable to the implementation of GIS in other developing countries.

5.3 Research limitations

This study is not without its limitations. While current GIS study has shed valuable light on GIS diffusion, it was hampered by several drawbacks.

The DoI organization decision process only indicates that the technology passes through linear stages yet in real life the situation does not occur that way. The integrated theoretical framework could have been adopted to provide a better guide to the research.

From a conventional standpoint, our research could be considered limited in terms of the "generalization" of the results, once the results are based on a single case study. The approach has not been widely accepted as a reliable, objective and legitimate research strategy. One of the criticisms directed to this approach relate to the difficulty in generalizing the findings to a larger population (Thomas, 2003). The best approach could be undertaking of multiple-case study designs which is expensive and time consuming (Yin, 2003). However, if the research could not be limited to a single-organizational-type of study but include additional power utilities in Africa, additional contributing factors could arise and would allow reap results which could be more generalized within the industry. The adoption of in-depth unstructured interviews is also criticized for its inability to be replicated by a different researcher due to the personal interactions between the researcher and participant. The author suggested that if focus groups or group interviews were used, this would give rise to better discussions that could potentially yield additional insight into certain factors. The second challenge the use of qualitative

data collection methods that generated large amounts of information regarding a small number of sample setting. The results of this research could be challenged for lack of objectivity and generalizability than quantitative research where large numbers of participants could have been used. The participants were chosen through purposeful sampling techniques and that the participants chosen were on the basis that they had direct input in the diffusion of the GIS and their choice was largely affected by availability. The author suggested that a more random sampling technique would likely yield more generalizable results than the technique used in this study. Further, the research adopted the use of data interpretative approach with the aim to increase understanding of phenomena within a specific social context. This also provided a limitation to the research considering that the interpretations developed from this particular case analysis could not be generalized to other settings because of the inherently contextual nature of this knowledge.

Time constraint was also considered a limitation to the research. The time could not allow delivery of a detailed prototype that covered all essential areas in management of distribution power network. The prototype could not be used as an online monitoring or network analysis and reporting tool.

5.4 Further research

Rogers' model of organizational innovation process adopted in the study only indicates that the technology passes through linear stages, yet complex technologies do not disseminate in linear stages. In addition, the constructs of Diffusion of Innovation are not likely to be strong predictors in situations where adoption of technologies is compulsory like in complex organization settings. This research put

most emphasis on the stages through which technology diffusion progresses and put emphasis on important constructs in the different stages. Future research on GIS diffusion should endeavor to use an integrated theoretical framework, which blends the DoI organizational innovation process and other theories like Venkatesh, et al. (2003) unified theory of acceptance and use of technology. Although DoI is incorporated in UTAUT, the innovation decision process was not considered, that is, the stages through which an innovation progresses to be adopted. The integrated theoretical framework will provide a better understanding of the diffusion process and constructs that affect the process of innovation diffusion.

5.5 Recommendation

The following were recommendations to ESCOM to increase the success of diffusion of the GIS.

Despite that a powerful diffusion infrastructure is put in place but due to that the funding is only for a limited time (5 years), the author recommends that ESCOM should secure annual funding through its own budget for the GIS.

As also it was noted that there were no GIS professionals within the organization to take over early enough from the external contractors. The author recommends that the organization should train its own staff to participate fully in the actual implementation of the GIS system, and those were the ones to take over from the external contractor.

The author further recommends that the technical training should not be the only training to be provided by the external contractor but formal and comprehensive GIS educational programs at the potential institution that offers GIS training. The training should be comprehensive training that is focused on individual professional growth and tailored to meet organization business needs.

Lastly, the author recommended that ESCOM develop training programs from all staff members focused on improving computer literacy and also all future hiring strategies in the organization should have a minimum level of computer literacy for employees. It should be in the best interest of the organization to maintain a computer literate workforce as workers will become more productive and keep up with technological changes and to self-teach about such changes during their tenure at the organization and be able to apply their knowledge to new situations without experiencing hardship.

REFERENCES

Adetoro, S.A. 2005, *Developing Geographic Information System for Utility management: A case study of Electrical Distribution Line and Transformer stations in Obafemi Awolowo University, Ile-Ife*. Proceeding of the technical session of the 37th Annual General Conference and meeting of Nigeria Institution of surveyors, Owerri, Imo-State, Nigeria, pp. 57-62

Alamu, E.O. and Ejiobih H.C. 2002, *Utility Information Infrastructure Needs in Utility Organisations in Nigeria: A Case Study of Niger State Water Board.* Proceedings of the Technical Session of the 37th Annual General Conference and Meeting of Nigerian Institution of Surveyors, Owerri, Imo State, Nigeria, pp. 85-88.

AL-Ramadan, B.M. 2013, *Applications of GIS in Electrical Power System*, Available at: http://faculty.kfupm.edu.sa/crp/bramadan/crp514/Termpapers/Term122/6%20-%20Term122%20-%20Report%20-%20Abdulrahman%20Al-Sakka.pdf

Andreu, R. and Jauregui, K. 2005, Key factors of e-learning, *Journal of Information Technology Education*, 4(20), pp. 12-9.

Aubry, M., Hobbs, B. and Thuillier, D. 2007, A new framework for understanding organisational diffusion management through the PMO, *International Journal of Diffusion Management*, 25(1), pp.328-336.

Ayeni, O.O., Kufoniyi, O. and Akinyede J.O. 2003, *Towards a National Geospatial Information Policy for Nigeria*. Proceeding of the Technical Session of the 38th Annual General Conference and Meeting of Nigeria Institution of Surveyors, Lokoja, Kogi State, Nigeria, pp. 21.

Beatty, R.C., Shim, J.P. and Jones, M.C. 2001, Factors influencing corporate web site adoption: A time-based assessment, *Information & Management*, 38 (6), pp. 337-354.

Benbasat, I. and Barki, H. 2007, Quo vadis TAM? *Journal of the Association for Information Systems*, 8(4), pp.211-218.

Benowitz, E.A. 2001, *Principles of Management*, Cliffs, New York.

Berger, H. and Beynon-Davies, P. 2009, The Utility of a Rapid Application Development (RAD) approach for a large complex Information Systems Development, *Information System Journal*, 19 (6), pp. 45-56.

Brown, R.E. 2008, *Electric power distribution reliability*, CRC press, London.

Campbell. H.J. 1994, How Effective are GIS in Practice? A Case Study of British Local Government, *International Journal of Geographic Information Systems*, 8(3), 309-325.

Campbell, H.J. 2005, Institutional Consequences of the use of GIS, In Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (Eds.), Geographical Information Systems (2nd edn), pp. 621-31. London, John Wiley & Sons, Inc.

Campbell, H., and Masser, I. 1995, *GIS and Organizations: How Effective are GIS in Practice?* New York, Taylor Francis Ltd.

Carter, J.R. 1989, On defining the Geographic Information System, In Ripple, WT (Ed.), *Fundamentals of Geographic Information Systems: A Compendium*. Virginia, University of Virginia.

Cavric, I., Nedovic-Budic, Z. and Ikgopoleng, H. 2003, Diffusion of GIS Technology in Botswana: Process and Determinants, *International Development Planning Review*, 25(2), pp.195-219.

Chan, T.O. and Williamson, I.P. 1995, *A review of the planning methodology for Victoria: its relevance to real life situations*. Singapore: Institute of Surveyors and Valuers.

Chan, T. O. and Williamson, I. P. 1996, *A model of the decision process for GIS adoption and diffusion in a government environment*, Salt Lake City, URISA.

Chan, T.O. and Williamson, I.P. 1997, Definition of GIS: the manager's Perspective, In Proceedings, the International Workshop on *Dynamic and Multi-Dimensional GIS*, Hong Kong.

Chan, T.O. 1998, *The dynamics of Diffusion of Corporate GIS* (Doctoral Thesis), The University of Melbourne.

Chan, T.O. and Williamson, I.P. 1999, The different identities of GIS and GIS Diffusion, *International Journal of Geographical Information Science*, 13(3), pp. 267-281.

Creswell, J.W. 2002, *Educational Research. Planning conducting and evaluating quantitative and qualitative approaches to research*, Pearson Education, Upper Saddle River, New Jersey, USA.

Creswell, J.W. 2007, *Qualitative Inquiry Research Design: Choosing among Five Approaches*, 2nd edn., Sage Publication, California.

Creswell, J.W. 2009, *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage Publications, California.

Crotty, M. 1998, *The foundations of social research: Meaning and perspective in the research process*, Sage Publications, California.

Crawford, L., Cooke-Davies, T., Hobbs, B., Labuschagne, L., Remington, K. and Ping, C. 2008, Governance and support in the sponsoring of diffusions and programs, *Diffusion Management Journal*, 39, pp.43-55.

Dueker, K.J. and Kjerne, D. 1989, *Multipurpose Cadastre: Terms and Definitions*, Technical Papers, 1989 ACSM-ASPRS Annual Convention, 5, pp. 94-103.

Easterby-Smith, M., Thorpe, R. and Lowe, A. 2002, *Management Research: An Introduction*, 2nd edn., Sage, London.

Emengini, E.J. 2004, *Application of Geographic Information System (GIS) to Utility Information Management: A Case Study of Onitsha-North L.G.A, Anambra State: Nigeria* (Master's Thesis), Nnamdi Azikiwe University, Awka, Anambra State: Nigeria.

Eria, S. 2012, *The state of GIS in developing countries: a diffusion and GIS & society analysis of Uganda, and the potential for mobile location-based services*, Available at: https://conservancy.umn.edu/handle/11299/142282

ESCOM 2015, *Annual Report*, Available at: http://www.escom.mw/documents/ESCOM_2015%20Annual%20Report_FINAL_for%20web.pdf.

ESRI 1990, *Understanding GIS: The ARC/INFO Method*, ESRI, Redlands.

Ezeigbo, C. U. 1998, *Application of Geographic Information System (GIS) to Utility Mapping*, Available at: http://www.eijst.org.uk/images/frontImages/gallery/Vol._4_No._8/10._81-95.pdf

Fischer 2003, *Network analysis*, Available at: https://www.scribd.com/document/264949349/NetworkAnalysis-Fischer-2003

Gallivan, M. J. 2001, Organizational Adoption and Assimilation of Complex Technical Innovations: Development and Application of a New Framework, *Database for Advances in Information Systems*, 32, pp.51-85.

Gray, D.E. 2004, *Doing Research in the Real World*, Sage, London.

Goodchild, M., Haining, R. and Wise, S. 1992, Integrating GIS and spatial data analysis: problems and possibilities, *International Journal of Geographical Information systems*, 6(5), pp.407-423.

Handy, C.B. 1993, *Understanding Organizations*, Penguin, Harmondsworth.

Hassan, S., Mourad, M. and Tolba, A. 2010, Conceptualizing the influence of lead users and opinion leaders on accelerating the rate of innovation diffusion, *Int. J Technology Marketing*, 53, pp. 203-218.

Havelock, R.G. and Zlotolow, S. 1995, *The change agent's guide*, 2nd edn., Educational Technology Publications, Inc., New Jersey, USA.

Hobbs, B., Aubry, M. 2010, *The project management office (PMO): a quest for understanding*, Project Management Institute, England.

Hughes, J. 2006, GIS combines Geography and information for effective utility Management, *American Water Works Association Journal*, 32(12), pp.10-11.

Jain, R. 2011, *Managing research, development and innovation: Managing the unmanageable*, Wiley, New York.

Jootun, D., McGhee, G. and Marland, G. 2009, Reflexivity: promoting rigour in qualitative research, *Nursing Standard*, 23 (23), pp.42-46.

Kamal, M. M. 2006, IT innovation adoption in the government sector: identifying the critical success factors, *Journal of Enterprise Information Management*, 19, pp.192-222.

Karikari, I., Stillwell, J. and Carver, S. 2005, The application of GIS in the lands sector of a developing country: Challenges facing land Administrators in Ghana, *International Journal of Geographical Information Science*, 19(3), pp.343-362.

Kraemer, K.L. and Dedrick, J. 1997, Computing and Public Organizations, *Journal of Public Administration Research and Theory,* 7 (1), pp.89-112.

Klakegg, O.J., Williams, T., Magnussen, O.M., Glasspool, H. 2008, Governance frameworks for public project development and estimation, *Project Management Journal*, 39, pp.27-42.

Kulkarni S. S. 2011, *Improving Efficiency of power sectors by using GIS*, Wise Books, RSA.

Larsen, K.R.T. 2003, A Taxonomy of Antecedents of Information Systems Success: Variable Analysis Studies, *Journal of Management Information Systems*, 20(2), pp.169-246.

Latour, B. 2005, *Reassembling the Social: An Introduction to Actor-Network Theory*, Oxford University Press, New York.

Law, J. 2007, *Actor-Network Theory & Material Semiotics*, Available at: http://www.heterogeneities.net/publications/LawANTandMaterialSemiotics.pdf

Law, J. 2009. Actor Network Theory and Material Semiotics, In: Bryan S. Turner (Ed.), *The New Blackwell Companion to Social Theory*, pp.141-158, Blackwell Publishing, Oxford.

Lechler, T.G. and Cohen, M. 2009, Exploring the role of steering committees in realizing value from project management, *Project Management Journal*, 40, pp.42-54.

Lewin, K. 1952, *Group Decision and Social Change*, Henry Holt and Company, New York.

Liao, C., Palvia, P. and Chen, J.-L. 2009, Information technology adoption behavior life cycle: Toward a technology continuance theory (TCT), *International Journal of Information Management*, 29, pp.309-320.

Liu, X. and Xie, H. 2014, Pillars and Principles of the Project Governance, *Advanced Materials Research*, 10(3), pp. 93-6.

Lodico, M.G., Spaulding, D.T. and Voegtle, K.H. 2010, *Methods in educational research: From theory to practice*, Wiley, San Francisco.

Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. 2005, Geographical Information Systems, John Wiley, New York.

Lopez, S.V. 2005, Competitive advantage and strategy formulation the key role of dynamic capabilities, *Management Decision*, 43(5), pp.661-669.

Lunenburg, C. F. 2010, Models of decision making. Sam Houston State University, *Focus on Colleges, Universities and Schools*, 4(1), pp. 61-9.

Lyons, B. and Henderson, K. 2005, Opinion leadership in a computer-mediated Environment, *Journal of Consumer Behaviour*, 4, pp. 319–329.

Marsh, D. 2000, The programme and project support office, In: Turner, R.J., Simister, S.J. (Eds.), *Handbook of project management*, pp. 131-144, Gower, Aldershot.

England, Mäkelä, J. 2012, *Model for assessing GIS maturity of an organization*, Wise Books, New York.

Masser, I. and Onsrud, H.J. 1993, *Diffusion and Use of Geographic Information Technologies*, Kluwer, Dordrecht.

McNamara, C., Baxter, J. and Chua, W. F. 2004, Making and Managing Organizational Knowledge, *Management Accounting Research*, 15(1), pp.53-76.

Meskendahl, S. 2010, The influence of business strategy on project portfolio management and its success-A conceptual framework, *International Journal of Project Management*, 28, pp.807-817.

Miles, M.B. and Huberman, A.M. 1994, *Qualitative data analysis: an expanded sourcebook*, 2nd edn., Sage Publications, Thousand Oaks.

Miller, R., Hobbs, B. 2002, A framework for analyzing the development and delivery of large capital projects, In Slevin, D., Cleland, D.I. and Pinto, J. (Eds.), *The frontiers of project management research*, Project Management Institute, Newton Square, PA.

Mitev, N. 2009, In and out of actor-network theory: a necessary but insufficient journey, *Information Technology & People*, 22(1), pp.9 – 25.

Nawi, H.A.S., Rahman, A.A. and Ibrahim, O. 2011, Government's ICT Project Failure Factors: A Revisit Paper presented at the international Conference *on Research and Innovation in Information Systems*, Kuala Lumpur, Malaysia.

Neuman, W.L. 2006, *Social Research Methods: Qualitative and Quantitative Approaches*, Pearson, Toronto.

Noongo, E. N. 2007, *The Implementation of Geographic Information Systems in Namibia,* University of Joensuu, Sweden.

OECD 2004, *OECD Principles of Corporate Governance*. OECD Publication Services, Paris.

Onsrud, H.J. and Pinto, J.K. 1991, Diffusion of geographic information innovations, *International Journal of Geographical Information Systems*, 5(4), pp.447–467.

Osuagwu C.C. 2008, *Geo-spatial Information System for monitoring and analysis of Electricity Distribution in Osogbo, South-Western Nigeria*, SAGE, California.

Pal, R., Sengupta, A. and Bose, I. 2008, Role of Pilot Study in Assessing Viability of New Technology Projects: The Case of RFID in Parking Operations, *Communications of the Association for Information Systems*, 23(1), pp. 257-276.

Pankowska, M. 2012, *User Participation in Information System Development*. Paper presented at the i-Society 2012, International Conference on Information Society, Sdney, Australia.

Peter, J.E. 2009, Managing Project Uncertainty, *International Journal of Managing Projects in Business*, 2 (4), pp. 12-22.

Pickering, D.J.M. and Bannister, D.H. 1993, *Utility Mapping and Record Keeping for Infrastructure*, Jacobs Press, Milan.

Pressman, R.S. 2000, Software Engineering: A Practitioner's Approach (European Adaptation). 5th edn. adapted by Darrel Inc. McGraw-Hill.

Rainardi, V. 2008, *Building a Data Warehouse*, Springer-Verlag, New York.

Raghav. 2006, *Electrical Network Mapping and Consumer Indexing using GIS*, Cambridge University Press, UK.

Ritchie, J. and Lewis, J. 2003, *Qualitative Research Practice*, Sage Publications, London.

Robson, C. 2002, *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*, 2nd ed., Blackwell, Oxford.

Rogers, E.M. 1995, *Diffusion of innovations*, 4th edn., Free Press, New York.

Rogers, E.M. 2003, *Diffusion of innovations*, 5th edn., Free Press, New York.

Sahin, I. 2006, Detailed review of Rogers' diffusion of innovations theory and educational technology-related studies based on Rogers' theory, *Turkish Online Journal of Educational Technology, TOJET,* 52, pp. 14-23.

Santrock, J.W. 2004, *Child development*, 10th edn. McGraw-Hill, New York.

Sandelowski, M. 2000, Whatever happened to qualitative description? *Research in Nursing & Health*, 23(4), pp. 334-340.

Sandelowski, M. and Barroso, J. 2003, Classifying the findings in qualitative studies, *Qualitative Health Research*, 13(7), pp. 905-923.

Sanderson, J. 2012, Risk, uncertainty and governance in megaprojects: A critical discussion of alternative explanations, *International Journal of Project Management*, 30, pp.432-443.

Sargeant, R. 2010, *Creating Value in Project Management Using PRINCE2*, Queensland University of Technology, Brisbane.

Saunders, M., Lewis, P. and Thornhill, A. 2003, *Research method for business students*, 3rd edn, Prentice Hall, New York.

Schilling, M. A. 2013, *Strategic management of technological innovation*, International edn., McGraw-Hill, USA.

Sense, A.J. 2013, A project sponsor's impact on practice-based learning within projects, *International Journal of Project Management*, 31, 264-271.

Senthamarai, C. and Krishnan, A. 2008, Grid Computing Based Model For Remote Monitoring Of Energy Flow And Prediction Of Ht Line Loss In Power Distribution System, *Journal of Theoretical & Applied Information Technology*, 4(1), pp. 63-72.

Sharma, R. and Yetton, P. 2003, The Contingent Effects of Management Support and Task Interdependence on Successful, *Information Systems implementation MIS Quarterly*, 27(4), pp. 533-555.

Sinha, J. 2010, *GIS Application in power distribution utility*, Wiley, New York.

Sommers, R. 1998, Developing GIS management strategies for an organization, *Journal of Housing Research*, 9(1), pp.157-178.

Spekman, R. E., & Sweeney, P. J. 2006, RFID: From Concept to Implementation, *International Journal of Physical Distribution and Logistics Management*, 36, pp.736-754.

Stokes, D. 1999, *Small Enterprise in the Public Sector, the Marketing of Primary School* (Doctoral thesis), Kingston Business School, Kingston University.

ThaoPhia, V. 2008, *User resistance to information technology: A case study of the Hmong American partnership* (DBA Dissertation), Capella University.

Thomas, R.M. 2003, *Blending qualitative & quantitative research methods in thesis and dissertations*, Corwin Press, USA.

Tschirky, H. 2011, *Managing innovation-driven companies: Approaches in Practice*, Palgrave, New York.

Unger, B.N., Kock, A., Gemünden, H.G. and Jonas, D. 2012, Enforcing strategic fit of project portfolios by project termination: An empirical study on senior management involvement, *International Journal of Project Management*, 30, pp. 675-685.

Valente, T.W. and Saba, W.P. 2001, Campaign Exposure and Interpersonal Communication as Factors in Contraceptive Use in Bolivia, *Journal of Health Communication*, 64, pp. 303-322.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. 2003, User acceptance of information technology: Toward a unified view, *MIS Quarterly*, 27(3), pp. 425-478.

Williams, M., Rana, N., Dwivedi, Y. and Lal, B. 2011, *Is UTAUT really used or just cited for the sake of it? A systematic review of citations of UTAUT's originating article*, ECIS, Helsinki, Finland

Winter, G. 2000, A comparative discussion of the notion of validity in qualitative and quantitative research, *The Qualitative Report*, 4, pp. 3-4.

Woolfolk, A. 2007, *Educational psychology*,10th edn., Allyn and Bacon, Boston.

Sun, Y. 2011, *Factors influencing the diffusion of the GIS technology by SBD Qingdao: an [sic] UTAUT approach* (Doctoral thesis), Massey University, Manawatu, New Zealand.

Yang, H.L. and Tang J.H. 2004, Team structure and team performance in IS development: A social network perspective, *Information Management*, 41, pp. 335–349.

Yeh, A. G-O. 2005, Urban Planning and GIS. In Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (Eds.), *Geographical Information Systems*, (2nd edn., pp. 877-88, John Wiley & Sons, New York.

Yin, R.K. 2008, *Case Study Research, Design and Methods*, Sage Publication Inc., California.

Yukl, G., Gordon, A. and Taber, T. 2002, A hierarchical taxonomy of leadership behavior: Integrating a half century of behavior research, *Journal of Leadership & Organizational Studies*, 91, pp.15-32.

Zeiler, M. 1999, *Modeling our world: The ESRI guide to geodatabase design*, ESRI Press, California.

Zhu, K., Dong, S.T., Xu, S. and Kraemer, K.L. 2006a, Innovation diffusion in global contexts: Determinants of post-adoption digital transformation of European companies, *European Journal of Information Systems*, 15 (6), pp. 601-616.

Zhu, K., Kraemer, K.L. and Xu, S. 2006b, The process of innovation assimilation by firms in different countries: A technology diffusion perspective on e-business, *Management Science*, 52(10), pp. 1557-1576.

APPENDICES

Appendix 1: The Questionnaire for exploring GIS diffusion in Electricity Supply Corporation.

This appendix presents the questionnaire questions that were asked to ESCOM Managers, Senior Managers and Top Management during the case study.

University of Malawi, Chancellor Collage
P.O Box 280
Zomba.
ESCOM Limited
BOX 2047
Blantyre.

Dear Sir/Madam

Survey on exploring GIS diffusion in Electricity Supply Corporation of Malawi.

This survey forms part of Masters of Informatics thesis in partial fulfilment of the requirements for the degree of Master of Science in Informatics undertaken at University of Malawi. The survey is designed to undertake a case study within Electricity Supply Corporation of Malawi to explore GIS diffusion in the organization. The study suggest that diffusion should be an umbrella concept of the process of moving an innovation starting from the initiation to implementation. To the best of my knowledge, no extended exploration has taken place with regard to the status quo of GIS diffusion in ESCOM. Hence, this survey questionnaire.

I wish to invite you to participate in this study by filling up the questionnaire. Most of the questions in this survey questionnaire are answered by checking the appropriate boxes, except a few. The survey will take approximately 20-25 minutes. All information provided will be treated in the strictest confidence. Data from the survey will be aggregated and used solely for research purposes.

I am aware of your busy schedule and your participation is very much appreciated. It is important that you possibly complete this survey as the knowledge will create an awareness of diffusion issues within the organization and provides a baseline for improvement efforts on the subject matter.

You may send back the completed questionnaire via email. Thank you for participating in this survey.

Seyani Basikolo ***Kondwani Godwin Munthali (PhD)***

MSc Informatics Student Senior Lecturer in Computer Science

The Questionnaire for understanding the development and diffusion of Geographic Information System (GIS) in a power utility.

Section A - Record of the interview

Code number: Date of Interview:	

Section B – Information on the current organization/department setting and GIS diffusion.

1	What is the total number of staff for the department? Please provide the approx. #	
2	How did you hear about GIS?	
Knowledge/capability about the innovation (GIS)		
3	What is your level of experience/understanding with GIS	☐ Expert ☐ Mid-level ☐ Beginner ☐ None

4	Do you believe that the GIS is do-able and provide genuine benefits?	☐ Very much ☐ Some how ☐ Very little ☐ Not at all
5	What is the capability of the department to adopt and implement GIS?	☐ Good ☐ Fair ☐ Poor ☐ Very poor
6	Would the diffusion be a problem for the employees of the department?	☐ Very much ☐ Some how ☐ Very little ☐ Not at all Please explain
7	What is the existing technical capabilities within the individuals to	☐ Very good ☐ Good ☐ Fair

	absorb GIS?	☐ Poor ☐ Very poor
8	I understand that education levels vary greatly and the front line staff tends to be of very low education levels. How would you see that affecting diffusion process?	☐ Extremely ☐ Very ☐ Slightly ☐ Not at all
9	Are there any organizational arrangements to encourage sharing of GIS capabilities?	☐ Centralised identification of opportunities ☐ Paid visits to GIS sharing sites/conferences ☐ Centralised building of infrastructure ☐ Budgetary incentives ☐ Others, Please specify
Funding for the GIS development and diffusion		
10	What are the funding strategies for GIS diffusion?	☐ Funding available ☐ No means for funding at the mean time

		☐ Future funding is likely ☐ No plans for funding
11	Who is planning to fund the GIS diffusion?	☐ External funding ☐ Internal funding ☐ No funding
Decision to develop and diffuse the GIS for the organization		
12	How is the decision made to diffuse GIS?	☐ Collectively ☐ Authority
13	Which group of people are the most influential in the GIS diffusion?	☐ Directors (Executive Management) ☐ Managers (Senior Managers and Manager) ☐ Others (Professionals, Supervisors and Artisans)
14	What kind of interpretations people expressed about the organizational dynamics that surrounds the intention to introduce GIS in the	☐ Very much required ☐ Required ☐ Less required ☐ Can do without

	organization/department?	
Underlying reasons as well as the intended goals for the GIS development and diffusion		
15	What led to the decision for the organization/department to seriously pursue diffusion for GIS?	Please explain
16	Is GIS used to address a performance gap which is identified in the organization/department in the form of actual problems of potential area of improvement?	☐ Extremely ☐ Very ☐ Slightly ☐ Not at all
17	In what ways the GIS intended to solve the problem/fulfill the need?	Mark √ to all applicable ☐ GIS to provide an information and operations framework for a major portion of the activities and applications within the organizations ☐ GIS for mapping and analysis ☐ GIS as a business tool

		☐ None
18	Which are the justification for the organization to seriously pursue to introduce GIS into the organization?	Mark √ to all applicable ☐ Part of the project funded from outside organization./department. ☐ It is essential technology for a project ☐ Benefits identified- tangible and intangible ☐ comprehensive cost-benefit analysis ☐ a complete business case ☐ Matched the priorities in the mind of management ☐ Other competing projects are not attractive enough ☐ Other, please specify
Vision for the GIS development and diffusion		
19	With the introduction of a new system, the organization needs to set up structures and regulations to diffuse	☐ Yes ☐ No ☐ Being developed

	GIS. Is there a specific organizational/departmental vision for GIS diffusion?	
20	What facilitating conditions would the organization implement to facilitate the GIS diffusion process?	Mark √ to all applicable ☐ GIS demonstrations ☐ Hand-on-experience ☐ Short training courses ☐ GIS materials/newletters ☐ GIS conferences, workshops and seminars ☐ None ☐ Other If other, please specify
21	Would the conditions the organization set up be a direct effect on diffusion of GIS?	☐ Yes ☐ No Please explain

22	Do the organization/department have GIS diffusion team?	☐ Yes ☐ No
23	How were the members chosen?	☐ Seniority ☐ Randomly ☐ Represents each section of the department ☐ Visionary, imaginative innovators
24	Is GIS Champion hired from outside the corporation?	☐ Yes ☐ No
25	Are the duties added to someone else within the organization/department?	☐ Yes ☐ No
26	If the duties added to someone else within the organization, what is his position in the organization?	☐ Director ☐ Senior Manager ☐ Manager ☐ Other If other, please specify

27	In what way is the GIS champion qualified for the job?	☐ Very qualified ☐ Moderately qualified ☐ Slightly qualified ☐ Not at all qualified
Management of the different interests of diffusion stakeholders		
28	Are the stakeholders of the GIS broadly defined by virtue of their relationship with the problems?	☐ Yes ☐ No
29	Do you see the following stakeholders affecting the diffusion of GIS?	Mark √ to all applicable ☐ Board of directors ☐ Executive management ☐ Senior Managers/Managers ☐ Users ☐ Others who may have vested interest in GIS diffusion Please Specify
30	What is the position of the stakeholders on GIS diffusion?	☐ Positive ☐ Negative ☐ Neutral
31	Are there any directives from the stakeholders for the GIS diffusion?	☐ Yes ☐ No ☐ No idea

Perceived characteristics of the innovation		
32	Is GIS a better innovation	☐ Very much ☐ Some how ☐ Not at all
33	Is GIS consistent with the values, past experience and needs of the organization/ department	☐ Very much ☐ Some how ☐ Not at all
34	Is GIS easy to understand	☐ Very much ☐ Some how ☐ Not at all
35	Could you find it easy trying a GIS system?	☐ Very much ☐ Some how ☐ Not at all
Management of the diffusion process		
36	How is the GIS diffusion going to be managed?	☐ Instant change-over from old system to the new one ☐ The old system will run in parallel with the new one ☐ The change will be introduced slowly over a period of time ☐ A small-scale implementation with one group or dept. will be used to test the change.

		☐ A mixture of strategies whose common theme are evolution and local, user-led design.
Deployment of the innovation		
37	How is GIS to be deployed in the organization/department?	☐ Completely centralised ☐ Completely distributed ☐ Partly centralised and partly distributed
38	What are the nature of technical and organizational problems this configuration might create?	☐ Major problem ☐ Minor Problem ☐ Not a problem
39	Where the GIS diffusion meet any problem, what is the likely solution?	☐ abandon the diffusion ☐ re-invention
Involvement, awareness, communication channels		
40	Are there any effort to promote GIS awareness?	☐ Yes ☐ No
41	What communication channels are put in place to GIS diffusion awareness? Please	Mark √ to all applicable ☐ Organizational / departmental Meeting ☐ Short training courses ☐ GIS materials/newletters

	provide	☐ GIS conferences, workshops and seminars ☐ None ☐ Other If other, please specify
42	Do you feel the influence of social factors will directly affect the introduction of GIS?	☐ Yes ☐ No Please Explain
43	Do you see this a barrier to the introduction of GIS?	☐ Yes ☐ No Please explain
	Spread of knowledge/ Networks	
44	With the introduction of new system, the organization will need to set up support and train the employees on the GIS. What type of the schemes has/would ESCOM set up?	Mark √ to all applicable ☐ Structured Training programmes ☐ Reward programmes ☐ Strict regulations ☐ None ☐ Other I f other, Please explain

45	Have you or your staff attended any GIS training?	☐ Yes ☐ No If yes, Please describe
46	In what manner is the knowledge going to be transferred from the developers/change agent to the users?	Mark √ to all applicable ☐ GIS demonstrations ☐ Hand-on-experience ☐ Short training courses ☐ GIS materials/newletters ☐ GIS conferences, workshops and seminars ☐ None ☐ Other If other, please specify
47	Is this going to be effective?	☐ Yes ☐ No

48	What is the level of relationship between individuals (Managers and supervisors, supervisors and employees and peers) within the organization/department for knowledge transfer with respect to GIS? Please explain	☐ Very Good ☐ Good ☐ Fair ☐ Poor ☐ Very poor
49	What about the effects of social influences, do you think it will play a factor	☐ Major influence ☐ Minor influence ☐ No influence

	on the GIS diffusion, particularly peer-to-peer relationships.	
Impact of the innovation/consequences		
50	Is there any alterations occurs in the structure and function of the organization/department due to plans to diffuse GIS?	☐ desirable ☐ undesirable ☐ direct ☐ indirect ☐ anticipated ☐ unanticipated
51	How is the organization/ department planning for organizational conflict and user resistance to GIS diffusion?	Mark √ to all applicable ☐ Come up with a change process ☐ Create vision to direct the change effort ☐ Communicate the vision ☐ Empower others to act on the vision ☐ Plan for and create short term wins ☐ Develop new competencies and skills ☐ Reinforce desired behaviour ☐ Do nothing ☐ Other If other, please specify

52	Does the organization/department have professionals that represents change agencies?	☐ Yes ☐ No
53	Do the organization/department have opinion leaders recruited to spread about GIS?	☐ Yes ☐ No
Routinizing		
54	Did you see GIS becoming part of the organization?	☐ Yes ☐ No
55	What are the indicators?	Please specify
56	Please you may provide anything else that you want to mention that will affect the diffusion of GIS in the organization. (Feel free to use examples)	

The End. Thank you for participating in the study.

Appendix 2: The list of Sample for the research

No	Member
	Top Management
1.	Chief Executive Officer
2.	Director of Finance
3.	Director of Generation
4.	Director of Transmission
5.	Director of Distribution
6.	Director of Corporate Services
7.	Director of Projects and Developments
8.	Director of Procurement
	Senior and Junior Managers
1.	Senior Risk Manager
2.	Chief Internal Auditor
3.	Chief Technical Auditor
4.	Public Relations Manager
5.	Senior Optic Fiber Communications Manager
6.	Senior Monitoring & Evaluation Manager
7.	Financial Controller (Revenue)
8.	Financial Controller (Expenditure)
9.	Financial Controller (Projects and Management Accounting)
10.	Chief Accountant (Financial Accounting)
11.	Chief Revenue Accountant (South)
12.	Chief Revenue Accountant (Centre)
13.	Chie Revenue Accountant (North)
14.	Chief Accountant (Revenue)
15.	Chief Accountant (Projects and Management Accounting)
16.	Senior Procurement Manager
17.	Senior Human Resources Manager
18.	Human Resources Manager (Employment Services)
19.	Human Resources Manager (Planning, Supply and Maintenance)
20.	Senior Administration and Logistics Manager
21.	Transport Manager
22.	Senior ICT Manager
23.	Corporate Services Manager
24.	Legal Services Manager
25.	Controller of Security Services Manager
26.	Senior Generation Manager (Nkula)

27.	Senior Generation Manager (Tedzani)
28.	Senior Generation Manager (Kapichira)
29.	Generation Manager (Wovwe)
30.	Peaking Plants and Mechanical Services Manager
31.	Chief Maintenance Engineer (Nkula)
32.	Senior Transmission Manager
33.	Senior Technical Services Manager
34.	System Operations and Power Trading Manager
35.	Regional Manager (South)
36.	Regional Manager (Centre)
37.	Regional Manager (North)
38.	Senior Customer Services Manager
39.	Construction Manager
40.	Revenue Protection Manager
41.	Malawi Rural Electrification Project (MAREP) Manager
42.	Senior Projects and Development Manager
43.	Senior Projects and Procurement Manager
44.	Chief Structural Engineer
45.	Chief System Planning Engineer
46.	Senior System Planning Manager
47.	HIV and Gender Manager

Appendix 3: The list of respondents to the questionnaire

No	Member
	Top Management
1.	Chief Executive Officer
2.	Director of Generation
3.	Director of Transmission
4.	Director of Distribution
5.	Director of Projects and Developments
	Senior and Junior Managers
1.	Chief Technical Auditor
2.	Public Relations Manager
3.	Senior Optic Fiber Communications Manager
4.	Senior Monitoring & Evaluation Manager
5.	Financial Controller (Revenue)
6.	Financial Controller (Expenditure)
7.	Financial Controller (Projects and Management Accounting)
8.	Chief Revenue Accountant (Centre)
9.	Chief Accountant (Projects and Management Accounting)
10.	Senior Procurement Manager
11.	Senior Human Resources Manager
12.	Senior Administration and Logistics Manager
13.	Transport Manager
14.	Senior ICT Manager
15.	Controller of Security Services Manager
16.	Senior Generation Manager (Tedzani)
17.	Senior Generation Manager (Kapichira)
18.	Peaking Plants and Mechanical Services Manager
19.	Chief Maintenance Engineer (Nkula)
20.	Senior Transmission Manager
21.	Senior Technical Services Manager
22.	System Operations and Power Trading Manager
23.	Regional Manager (South)
24.	Senior Customer Services Manager
25.	Construction Manager
26.	Revenue Protection Manager
27.	Senior Projects and Developments Manager
28.	Chief Structural Engineer
29.	Chief System Planning Engineer

30.	Senior System Planning Manager

Appendix 4: The list of interviewees

No	Member
	Top Management
1.	Chief Executive Officer
2.	Director of Project and Developments
	Senior and Junior Managers
1.	Chief Technical Auditor
2.	Senior Procurement Manager
3.	Senior Human Resources Manager
4.	Senior ICT Manager
5.	Senior Generation Manager (Kapichira)
6.	Senior Transmission Manager
7.	Senior Projects and Developments Manager

Appendix 5: The program Source listing

FieldPropertyDescriptor.vb

```
' Copyright 2008 ESRI
'
' All rights reserved under the copyright laws of the United States
' and applicable international laws, treaties, and conventions.
'
' You may freely redistribute and use this sample code, with or
' without modification, provided you include the original copyright
' notice and use restrictions.
'
' See use restrictions at /arcgis/developerkit/userestrictions.
'

Imports System
Imports System.Collections.Generic
Imports System.Text
Imports System.ComponentModel
Imports ESRI.ArcGIS.Geodatabase
Imports ESRI.ArcGIS.GeomeTry


'<summary>
'This class provides a PropertyDescriptor for a single field of an IRow
'</summary>
'<remarks>
'This class can be used by an ITypedList implementation to provide a property
'description for a single field in an ITable.
'</remarks>
Friend Class FieldPropertyDescriptor
    Inherits PropertyDescriptor
#Region "Private Members"
    '<summary>
    'Store the index of the IField that this property descriptor describes
    '</summary>
    Private wrappedFieldIndex As Integer

    '<summary>
    'Store the .NET type of the value stored in the IField this property
    'represents
    '</summary>
    Private netType As Type

    '<summary>
    'This is used to store the actual .NET type of a field that uses a CV
    'domain. It retains the type allowing as to restore it when the UseCVDomain
    'property is false;
    '</summary>
    Private actualType As Type

    '<summary>
    'Store the esri type of the value stored in the IField this property
    'represents
    '</summary>
    Private esriType As esriFieldType
```

```
    '<summary>
    'Indicates whether this field is editable or not.
    '</summary>
    '<remarks>
    'This will determined by looking at the Editable property of the IField
    'and the type of the field. We currently don't support the editing of
    'blob or geometry fields.
    '</remarks>
    Dim isEditable As Boolean = True

    '<summary>
    'Used to start and stop editing when adding/updating/deleting rows
    '</summary>
    Private wkspcEdit As IWorkspaceEdit

    '<summary>
    'The coded value domain for the field this instance represents, if any
    '</summary>
    Private cvDomain As ICodedValueDomain

    '<summary>
    'This will be true if we are currently using the string values for the
    'coded value domain and false if we are using the numeric values.
    '</summary>
    Private useCVDomain As Boolean

    '<summary>
    'This type converter is used when the field this instance represents has
    'a coded value domain and we are displaying the actual domain values
    '</summary>
    Private actualValueConverter As TypeConverter

    '<summary>
    'This type converter is used when the field this instance represents has
    'a coded value domain and we are displaying the names of the domain values
    '</summary>
    Private cvDomainValDescriptionConverter As TypeConverter
#End Region

#Region "Construction/Destruction"
    '<summary>
    'Initializes a new instance of the <see cref="FieldPropertyDescriptor"/> class.
    '</summary>
    '<param name="wrappedTable">The wrapped table.</param>
    '<param name="fieldName">Name of the field within wrappedTable.</param>
    '<param name="fieldIndex">Index of the field within wrappedTable.</param>
    Public Sub New(ByVal wrappedTable As ITable, ByVal fieldName As String, ByVal fieldIndex As
Integer)
        : MyBase.New(fieldName, Nothing)

        wrappedFieldIndex = fieldIndex

        'Get the field this property will represent. We will use it to
        'get the field type and determine whether it can be edited or not. In
        'this case, editable means the field's editable property is true and it
        'is not a blob, geometryor raster field.
        Dim wrappedField As IField = DirectCast(wrappedTable.Fields.Field(fieldIndex), IField)
        esriType = wrappedField.Type
        isEditable = wrappedField.Editable AndAlso _
          (esriType <> esriFieldType.esriFieldTypeBlob) AndAlso _
          (esriType <> esriFieldType.esriFieldTypeRaster) AndAlso _
```

```
        (esriType <> esriFieldType.esriFieldTypeGeometry)
      actualType = EsriFieldTypeToSystemType(wrappedField)
      netType = actualType
      wkspcEdit = DirectCast((DirectCast(wrappedTable, IDataset)).Workspace, IWorkspaceEdit)
    End Sub

#End Region

    '<summary>
    'Gets a value indicating whether the field represented by this property
    'has a CV domain.
    '</summary>
    '<value>
    '          <c>true</c> if this instance has a CV domain; otherwise, <c>false</c>.
    '</value>
    Public ReadOnly Property HasCVDomain() As Boolean
      Get
        HasCVDomain = Not (Nothing Is cvDomain)
      End Get
    End Property

    '<summary>
    'Sets a value indicating whether [use CV domain].
    '</summary>
    '<value><c>true</c> if [use CV domain]; otherwise, <c>false</c>.</value>
    Public WriteOnly Property SetUseCVDomain() As Boolean
      Set(ByVal Value As Boolean)
        useCVDomain = Value
        If (Value) Then
          ' We want the property type for this field to be string
          netType = GetType(String)
        Else
          ' Restore the original type
          netType = actualType
        End If
      End Set
    End Property

#Region "Public Overrides"
    '<summary>
    'Gets the type converter for this property.
    '</summary>
    '<remarks>
    'We need to override this property as the base implementation sets the
    'converter once and reuses it as required. We can't do this if the field
    'this instance represents has a coded value domain and we change from
    'using the value to using the name or vice versa. The reason for this is
    'that if we are displaying the domain name, we need a string converter and
    'if we are displaying the domain value, we will need one of the numeric
    'converters.
    '</remarks>
    '<returns>A <see cref="T:System.ComponentModel.TypeConverter"></see>
    'that is used to convert the <see cref="T:System.Type"></see> of this
    'property.</returns>
    '<PermissionSet><IPermission class="System.Security.Permissions.SecurityPermission,
    'mscorlib, Version=2.0.3600.0, Culture=neutral, PublicKeyToken=b77a5c561934e089"
    'version="1" Flags="UnmanagedCode"/></PermissionSet>
    Public Overrides ReadOnly Property Converter() As TypeConverter
      Get
        Dim retVal As TypeConverter = Nothing
```

```
            If Not (Nothing Is cvDomain) Then

               If (useCVDomain) Then
                  If (Nothing Is cvDomainValDescriptionConverter) Then
                     ' We want a string converter
                     cvDomainValDescriptionConverter = TypeDescriptor.GetConverter(GetType(String))
                  End If

                  retVal = cvDomainValDescriptionConverter
               Else
                  If (Nothing Is actualValueConverter) Then
                     ' We want a converter for the type of this field's actual value
                     actualValueConverter = TypeDescriptor.GetConverter(actualType)
                  End If

                  retVal = actualValueConverter
               End If

            Else

               ' This field doesn't have a coded value domain, the base implementation
               ' works fine.
               retVal = MyBase.Converter
            End If

            Converter = retVal
         End Get
      End Property

      '<summary>
      'Returns whether resetting an object changes its value.
      '</summary>
      '<param name="component">The component to test for reset capability.
      'This will be an IRow</param>
      '<returns>
      'true if resetting the component changes its value; otherwise, false.
      '</returns>
      Public Overrides Function CanResetValue(ByVal component As Object) As Boolean
         CanResetValue = False
      End Function

      '<summary>
      'Gets the type of the component this property is bound to.
      '</summary>
      '<value></value>
      '<returns>A <see cref="T:System.Type"></see> that represents the type of
      'component this property is bound to. When the
      '<see cref="M:System.ComponentModel.PropertyDescriptor.GetValue(System.Object)"></see>
      'or                                                                                    <see
   cref="M:System.ComponentModel.PropertyDescriptor.SetValue(System.Object,System.Object)"></see>
      'methods are invoked, the object specified might be an instance of this type.</returns>
      Public Overrides ReadOnly Property ComponentType() As Type
         Get
            ComponentType = GetType(IRow)
         End Get
      End Property

      '<summary>
      'Gets the current value of the property on a component.
      '</summary>
      '<param name="component">The component (an IRow) with the property for
```

```
'which to retrieve the value.</param>
'<remarks>
'This will return the field value for all fields apart from geometry, raster and Blobs.
'These fields will return the string equivalent of the geometry type.
'</remarks>
'<returns>
'The value of a property for a given component. This will be the value of
'the field this class instance represents in the IRow passed in the component
'parameter.
'</returns>
Public Overrides Function GetValue(ByVal component As Object) As Object
   Dim retVal As Object = Nothing

   Dim givenRow As IRow = DirectCast(component, IRow)
   Try
      ' Get value
      Dim value As Object = givenRow.Value(wrappedFieldIndex)

      If (Not (Nothing Is cvDomain) AndAlso useCVDomain) Then
         value = cvDomain.Name(Convert.ToInt32(value))
      End If


      Select Case esriType
         Case esriFieldType.esriFieldTypeBlob
            retVal = "Blob"
            Exit Select
         Case esriFieldType.esriFieldTypeGeometry

            retVal = GetGeomeTryTypeAsString(value)
            Exit Select
         Case esriFieldType.esriFieldTypeRaster

            retVal = "Raster"
            Exit Select
         Case Else

            retVal = value
            Exit Select
      End Select


   Catch e As Exception
      System.Diagnostics.Debug.WriteLine(e.Message)
   End Try

   GetValue = retVal
End Function

'<summary>
'Gets a value indicating whether this property is read-only or not.
'</summary>
'<value></value>
'<returns>true if the property is read-only; otherwise, false.</returns>
Public Overrides ReadOnly Property IsReadOnly() As Boolean
   Get
      IsReadOnly = Not isEditable
   End Get
End Property

'<summary>
```

```
    'Gets the type of the property.
    '</summary>
    '<value></value>
    '<returns>A <see cref="T:System.Type"></see> that represents the type
    'of the property.</returns>
    Public Overrides ReadOnly Property PropertyType() As Type
        Get
            PropertyType = netType
        End Get
    End Property

    '<summary>
    'Resets the value for this property of the component to the default value.
    '</summary>
    '<param name="component">The component (an IRow) with the property value
    'that is to be reset to the default value.</param>
    Public Overrides Sub ResetValue(ByVal component As Object)
    End Sub

    '<summary>
    'Sets the value of the component to a different value.
    '</summary>
    '<remarks>
    'If the field this instance represents does not have a coded value domain,
    'this method simply sets the given value and stores the row within an edit
    'operation. If the field does have a coded value domain, the method first
    'needs to check that the given value is valid. If we are displaying the
    'coded values, the value passed to this method will be a string and we will
    'need to see if it is one of the names in the cv domain. If we are not
    'displaying the coded values, we will still need to check that the given
    'value is within the domain. If the value is not within the domain, an
    'error will be displayed and the method will return.
    'Note that the string comparison is case sensitive.
    '</remarks>
    '<param name="component">The component (an IRow) with the property value
    'that is to be set.</param>
    '<param name="value">The new value.</param>
    Public Overrides Sub SetValue(ByVal component As Object, ByVal value As Object)
        Dim givenRow As IRow = DirectCast(component, IRow)

        If Not (Nothing Is cvDomain) Then
            ' This field has a coded value domain
            If (Not useCVDomain) Then
                ' Check value is valid member of the domain
                If (Not (DirectCast(cvDomain, IDomain)).MemberOf(value)) Then _
                  System.Windows.Forms.MessageBox.Show(String.Format( _
                    "Value {0} is not valid for coded value domain {1}", value.ToString(),
(DirectCast(cvDomain, IDomain)).Name))
                Return
            Else
                ' We need to convert the string value to one of the cv domain values
                ' Loop through all the values until we, hopefully, find a match
                Dim foundMatch As Boolean = False
                Dim valueCount As Integer
                For valueCount = 0 To cvDomain.CodeCount - 1 Step valueCount + 1
                    If (value.ToString() = cvDomain.Name(valueCount)) Then
                        foundMatch = True
                        value = valueCount
                    End If
                    Exit For
                Next
```

```
            ' Did we find a match?
            If (Not foundMatch) Then
               System.Windows.Forms.MessageBox.Show(String.Format( _
               "Value {0} is not valid for coded value domain {1}", value.ToString(),
(DirectCast(cvDomain, IDomain)).Name))
               Return
            End If
         End If
      End If

      givenRow.Value(wrappedFieldIndex) = value

      ' Start editing if we aren't already editing
      Dim weStartedEditing As Boolean = False
      If (Not wkspcEdit.IsBeingEdited()) Then
         wkspcEdit.StartEditing(False)
         weStartedEditing = True
         ' Store change in an edit operation
         wkspcEdit.StartEditOperation()
         givenRow.Store()
         wkspcEdit.StopEditOperation()
      End If
      ' Stop editing if we started here
      If (weStartedEditing) Then
         wkspcEdit.StopEditing(True)
      End If

   End Sub

   '<summary>
   'When overridden in a derived class, determines a value indicating whether
   'the value of this property needs to be persisted.
   '</summary>
   '<param name="component">The component (an IRow) with the property to be examined for
   'persistence.</param>
   '<returns>
   'true if the property should be persisted; otherwise, false.
   '</returns>
   Public Overrides Function ShouldSerializeValue(ByVal component As Object) As Boolean
      ShouldSerializeValue = False
   End Function

#End Region

#Region "Private Methods"
   '<summary>
   'Converts the specified ESRI field type to a .NET type.
   '</summary>
   '<param name="esriType">The ESRI field type to be converted.</param>
   '<returns>The appropriate .NET type.</returns>
   Function EsriFieldTypeToSystemType(ByVal field As IField) As Type
      Dim esriType As esriFieldType = field.Type

      ' Does this field have a domain?
      cvDomain = TryCast(field.Domain, ICodedValueDomain)
      If (Not (Nothing Is cvDomain) AndAlso useCVDomain) Then
         EsriFieldTypeToSystemType = GetType(String)
         Exit Function
      End If
```

```
        Try
            Select Case esriType
                Case esriFieldType.esriFieldTypeBlob
                    'beyond scope of sample to deal with blob fields
                    EsriFieldTypeToSystemType = GetType(String)
                Case esriFieldType.esriFieldTypeDate
                    EsriFieldTypeToSystemType = GetType(DateTime)
                Case esriFieldType.esriFieldTypeDouble
                    EsriFieldTypeToSystemType = GetType(Double)
                Case esriFieldType.esriFieldTypeGeometry
                    EsriFieldTypeToSystemType = GetType(String)
                Case esriFieldType.esriFieldTypeGlobalID
                    EsriFieldTypeToSystemType = GetType(String)
                Case esriFieldType.esriFieldTypeGUID
                    EsriFieldTypeToSystemType = GetType(Guid)
                Case esriFieldType.esriFieldTypeInteger
                    EsriFieldTypeToSystemType = GetType(Int32)
                Case esriFieldType.esriFieldTypeOID
                    EsriFieldTypeToSystemType = GetType(Int32)
                Case esriFieldType.esriFieldTypeRaster
                    'beyond scope of sample to correctly display rasters
                    EsriFieldTypeToSystemType = GetType(String)
                Case esriFieldType.esriFieldTypeSingle
                    EsriFieldTypeToSystemType = GetType(Single)
                Case esriFieldType.esriFieldTypeSmallInteger
                    EsriFieldTypeToSystemType = GetType(Int16)
                Case esriFieldType.esriFieldTypeString
                    EsriFieldTypeToSystemType = GetType(String)
                Case Else
                    EsriFieldTypeToSystemType = GetType(String)
            End Select
        Catch ex As Exception
            System.Diagnostics.Debug.WriteLine(ex.Message)
            EsriFieldTypeToSystemType = GetType(String)
        End Try
    End Function

    '<summary>
    'Gets the geometry type as string.
    '</summary>
    '<param name="value">The value.</param>
    '<returns>The string equivalent of the geometry type</returns>
    Private Function GetGeomeTryTypeAsString(ByVal value As Object) As String
        Dim retVal As String = ""
        Dim geomeTry As IGeometry = TryCast(value, IGeometry)
        If Not (geomeTry Is Nothing) Then
            retVal = geomeTry.GeometryType.ToString()
        End If
        GetGeomeTryTypeAsString = retVal
    End Function
#End Region
End Class
```

frmSelectOne.Designer.vb

```
<Global.Microsoft.VisualBasic.CompilerServices.DesignerGenerated()> _
```

```
Partial Class frmSelectOne
    Inherits System.Windows.Forms.Form

    'Form overrides dispose to clean up the component list.
    <System.Diagnostics.DebuggerNonUserCode()> _
    Protected Overrides Sub Dispose(ByVal disposing As Boolean)
        Try
            If disposing AndAlso components IsNot Nothing Then
                components.Dispose()
            End If
        Finally
            MyBase.Dispose(disposing)
        End Try
    End Sub

    'Required by the Windows Form Designer
    Private components As System.ComponentModel.IContainer

    'NOTE: The following procedure is required by the Windows Form Designer
    'It can be modified using the Windows Form Designer.
    'Do not modify it using the code editor.
    <System.Diagnostics.DebuggerStepThrough()> _
    Private Sub InitializeComponent()
        Me.btnCancel = New System.Windows.Forms.Button()
        Me.btnOk = New System.Windows.Forms.Button()
        Me.lblDescription = New System.Windows.Forms.Label()
        Me.cboItem = New System.Windows.Forms.ComboBox()
        Me.SuspendLayout()
        '
        'btnCancel
        '
        Me.btnCancel.DialogResult = System.Windows.Forms.DialogResult.Cancel
        Me.btnCancel.Location = New System.Drawing.Point(329, 45)
        Me.btnCancel.Name = "btnCancel"
        Me.btnCancel.Size = New System.Drawing.Size(66, 27)
        Me.btnCancel.TabIndex = 3
        Me.btnCancel.Text = "Cancel"
        Me.btnCancel.UseVisualStyleBackColor = True
        '
        'btnOk
        '
        Me.btnOk.Location = New System.Drawing.Point(257, 45)
        Me.btnOk.Name = "btnOk"
        Me.btnOk.Size = New System.Drawing.Size(66, 27)
        Me.btnOk.TabIndex = 2
        Me.btnOk.Text = "Ok"
        Me.btnOk.UseVisualStyleBackColor = True
        '
        'lblDescription
        '
        Me.lblDescription.AutoSize = True
        Me.lblDescription.Font = New System.Drawing.Font("Microsoft Sans Serif", 9.75!,
System.Drawing.FontStyle.Bold, System.Drawing.GraphicsUnit.Point, CType(0, Byte))
        Me.lblDescription.Location = New System.Drawing.Point(12, 15)
        Me.lblDescription.Name = "lblDescription"
        Me.lblDescription.Size = New System.Drawing.Size(77, 16)
        Me.lblDescription.TabIndex = 4
        Me.lblDescription.Text = "Feeder ID"
        '
        'cboItem
        '
```

```
        Me.cboItem.DropDownStyle = System.Windows.Forms.ComboBoxStyle.DropDownList
        Me.cboItem.FormattingEnabled = True
        Me.cboItem.Location = New System.Drawing.Point(134, 12)
        Me.cboItem.Name = "cboItem"
        Me.cboItem.Size = New System.Drawing.Size(261, 21)
        Me.cboItem.TabIndex = 3
        '
        'frmSelectOne
        '
        Me.AutoScaleDimensions = New System.Drawing.SizeF(6.0!, 13.0!)
        Me.AutoScaleMode = System.Windows.Forms.AutoScaleMode.Font
        Me.CancelButton = Me.btnCancel
        Me.ClientSize = New System.Drawing.Size(402, 79)
        Me.ControlBox = False
        Me.Controls.Add(Me.btnCancel)
        Me.Controls.Add(Me.btnOk)
        Me.Controls.Add(Me.lblDescription)
        Me.Controls.Add(Me.cboItem)
        Me.FormBorderStyle = System.Windows.Forms.FormBorderStyle.FixedDialog
        Me.MaximizeBox = False
        Me.MinimizeBox = False
        Me.Name = "frmSelectOne"
        Me.StartPosition = System.Windows.Forms.FormStartPosition.CenterScreen
        Me.Text = "frmSelectOne"
        Me.ResumeLayout(False)
        Me.PerformLayout()

    End Sub
    Friend WithEvents btnCancel As System.Windows.Forms.Button
    Friend WithEvents btnOk As System.Windows.Forms.Button
    Friend WithEvents lblDescription As System.Windows.Forms.Label
    Friend WithEvents cboItem As System.Windows.Forms.ComboBox
End Class
```

mapViewer.vb

```
Imports ESRI.ArcGIS.Carto
Imports ESRI.ArcGIS.Controls
Imports ESRI.ArcGIS.Display
Imports ESRI.ArcGIS.Geometry
Imports ESRI.ArcGIS.SystemUI
Imports ESRI.ArcGIS.esriSystem
Imports ESRI.ArcGIS.Framework
Imports ESRI.ArcGIS
Imports ESRI.ArcGIS.Geodatabase
Imports ESRI.ArcGIS.DataSourcesFile
Imports ESRI.ArcGIS.Geoprocessor
Imports ESRI.ArcGIS.AnalysisTools

Public Class mapViewer
    'data Path
    'The pop-up menu.
    Private m_pToolbarMenu As IToolbarMenu
    'The envelope drawn on the MapControl.
    Private m_pEnvelope As IEnvelope
    'The symbol used to draw the envelope on the MapControl.
    Private m_pFillSymbol As ISimpleFillSymbol
```

```
'The PageLayoutControl's focus map events.
Private m_pTransformEvents As ITransformEvents_Event
Private visBoundsUpdatedE As ITransformEvents_VisibleBoundsUpdatedEventHandler
Private strDatapath As String
Private WithEvents fSelectFeeder As frmSelectOne
Private WithEvents fSelectAllCustomersonXFR As frmSelectOne
Private WithEvents fSelectBufferTXID As frmSelectOne
Private WithEvents fSelectBufferALLCUSTOMERS As frmSelectOne
Private WithEvents fSelectCustomer As frmSelectOne



Private Sub mapViewer_Load(sender As Object, e As EventArgs) Handles Me.Load
    fSelectFeeder = New frmSelectOne
    fSelectAllCustomersonXFR = New frmSelectOne
    fSelectBufferTXID = New frmSelectOne
    fSelectBufferALLCUSTOMERS = New frmSelectOne
    fSelectCustomer = New frmSelectOne


    ESRI.ArcGIS.RuntimeManager.Bind(ESRI.ArcGIS.ProductCode.Engine)

    'Add map navigation commands.
    AxToolbarControl1.AddItem("esriControls.ControlsMapZoomInTool", -1, -1, True, 0,
esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapZoomOutTool", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapPanTool", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapFullExtentCommand", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapZoomToLastExtentBackCommand", -1, -1,
False, 0, esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapZoomToLastExtentForwardCommand", -1,
-1, False, 0, esriCommandStyles.esriCommandStyleIconOnly)
    'Add map inquiry commands.
    '   AxToolbarControl1.AddItem("esriControls.ControlsMapIdentifyTool", -1, -1, True, 0,
esriCommandStyles.esriCommandStyleIconOnly)
    AxToolbarControl1.AddItem("esriControls.ControlsMapFindCommand", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)
     AxToolbarControl1.AddItem("esriControls.ControlsMapIdentifyTool", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)

    AxToolbarControl1.AddItem("esriControls.ControlsSelectTool", -1, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)

    'Add map inquiry commands.

    'Create a new ToolbarMenu.
    m_pToolbarMenu = New ToolbarMenuClass()
    'Share the ToolbarControl's command pool.
    m_pToolbarMenu.CommandPool = AxToolbarControl1.CommandPool
    'Set the hook to the PageLayoutControl
    m_pToolbarMenu.SetHook(mcMAP)


    'Create a new ToolbarPalette.
    'Dim pToolbarPalette As IToolbarPalette = New ToolbarPaletteClass()
    'Add commands and tools to the ToolbarPalette.
    'pToolbarPalette.AddItem("esriControls.ControlsNewMarkerTool", -1, -1)
    'pToolbarPalette.AddItem("esriControls.ControlsNewLineTool", -1, -1)
```

```
        'pToolbarPalette.AddItem("esriControls.ControlsNewCircleTool", -1, -1)
        'pToolbarPalette.AddItem("esriControls.ControlsNewEllipseTool", -1, -1)
        'pToolbarPalette.AddItem("esriControls.ControlsNewRectangleTool", -1, -1)
        ' pToolbarPalette.AddItem("esriControls.ControlsNewPolygonTool", -1, -1)
        'Add the ToolbarPalette to the ToolbarControl.
        'AxToolbarControl1.AddItem(pToolbarPalette, 0, -1, False, 0,
esriCommandStyles.esriCommandStyleIconOnly)

        'Add commands to the ToolbarMenu.
        m_pToolbarMenu.AddItem("esriControls.ControlsPageZoomInFixedCommand", -1, -1, False,
esriCommandStyles.esriCommandStyleIconAndText)
        m_pToolbarMenu.AddItem("esriControls.ControlsPageZoomOutFixedCommand", -1, -1, False,
esriCommandStyles.esriCommandStyleIconAndText)
        m_pToolbarMenu.AddItem("esriControls.ControlsPageZoomWholePageCommand", -1, -1, False,
esriCommandStyles.esriCommandStyleIconAndText)
        m_pToolbarMenu.AddItem("esriControls.ControlsPageZoomPageToLastExtentBackCommand", -1,
-1, True, esriCommandStyles.esriCommandStyleIconAndText)
        m_pToolbarMenu.AddItem("esriControls.ControlsPageZoomPageToLastExtentForwardCommand",
-1, -1, False, esriCommandStyles.esriCommandStyleIconAndText)

        '//set buddy controls
        'Set label editing to manual.
        'AxTOCControl1.SetBuddyControl(AxPageLayoutControl1)
        AxToolbarControl1.SetBuddyControl(mcMAP)
        "//Sdet the base data path
        strDatapath = Application.StartupPath & "\gisdata\"

        Dim strFileName As String = strDatapath & "powergis.mxd"

        Try
            'Load a pre-authored map document into the PageLayoutControl using realative paths.
            If mcMAP.CheckMxFile(strFileName) Then
                mcMAP.LoadMxFile(strFileName)
                mcMAP.ActiveView.Extent = mcMAP.ActiveView.FullExtent
            Else
                MsgBox("There is a problem loading the MXD File. Please make sure the files are in [app
path]\gisdata\")
                End
            End If
        Catch ex As Exception
            MsgBox("There is a problem starting the application.")
            Close()
        End Try


    End Sub


    Private Sub OnVisibleBoundsUpdated(ByVal sender As IDisplayTransformation, ByVal sizeChanged
As Boolean)
        'Set the extent to the new visible extent.
        m_pEnvelope = sender.VisibleBounds
        'Refresh the MapControl's foreground phase.
        mcMAP.ActiveView.PartialRefresh(esriViewDrawPhase.esriViewForeground, Nothing, Nothing)
    End Sub


    Private Sub mapViewer_ResizeBegin(sender As Object, e As EventArgs) Handles Me.ResizeBegin
        'Suppress data redraw and draw bitmap instead.
        ' AxMapControl2.SuppressResizeDrawing(True, 0)
        'AxPageLayoutControl1.SuppressResizeDrawing(True, 0)
```

```
    End Sub

    Private Sub mapViewer_ResizeEnd(sender As Object, e As EventArgs) Handles Me.ResizeEnd
        mcMAP.Dock = DockStyle.Fill
        mcMAP.Refresh()
        mcMAP.ActiveView.Refresh()
        'Stop bitmap draw and draw data.
        ' AxMapControl2.SuppressResizeDrawing(False, 0)
    End Sub


    Private Sub AxMapControl2_OnMouseDown(sender As Object, e As
IMapControlEvents2_OnMouseDownEvent)
        'Pop-up the ToolbarMenu.
        If e.button = 2 Then
            m_pToolbarMenu.PopupMenu(e.x, e.y, mcMAP.hWnd)
        End If
    End Sub


    Private Function getLayer(layerName As String) As IFeatureLayer
        Dim flayer As IFeatureLayer = Nothing
        Dim icount As Integer


        For icount = 0 To mcMAP.LayerCount - 1
            flayer = mcMAP.get_Layer(icount)
            If flayer.Name = layerName Then
                Exit For
            End If
        Next
        Return flayer
    End Function



    Private Sub fSelectFeeder_itemSelected(itemValue As String) Handles fSelectFeeder.itemSelected
        "//Selecte all transformers that have this feeder Number
        Try
            Dim fLayer As IFeatureLayer = getLayer("transformer_data_ESCOM")
            'Dim result As ISelectionSet
            clearSelection()
            Dim pFeatSelection As IFeatureSelection = fLayer
            Dim queryFilter As IQueryFilter = New QueryFilterClass()
            queryFilter.WhereClause = "FEEDERID='" & itemValue & "'"
            pFeatSelection.SelectFeatures(queryFilter,        esriSelectionResultEnum.esriSelectionResultNew,
False)
            mcMAP.Refresh()
            mcMAP.ActiveView.Refresh()
            Text = "[POWER GIS Monitor] - View all transformers connected to Feeder " & itemValue


            'mdocument.UpdateContents()
        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
    End Sub

    Private Sub fSelectAllCustomersonXFR_itemSelected(itemValue As String) Handles
fSelectAllCustomersonXFR.itemSelected
        Try
```

```
        Dim fLayer As IFeatureLayer = getLayer("customer_data_ESCOM")
        'Dim result As ISelectionSet
        clearSelection()
        Dim pFeatSelection As IFeatureSelection = fLayer
        Dim queryFilter As IQueryFilter = New QueryFilterClass()
        queryFilter.WhereClause = "TXID='" & itemValue & "'"
        pFeatSelection.SelectFeatures(queryFilter,        esriSelectionResultEnum.esriSelectionResultNew,
False)
        mcMAP.Refresh()
        mcMAP.ActiveView.Refresh()
        Text = "[POWER GIS Monitor] - View all customers connected to Transformer " & itemValue


      Catch ex As Exception
        MsgBox(ex.Message)
      End Try
    End Sub


    Public Sub CreateBuffer(txID As String, ByVal distance As System.Double)
      Dim myMap As IMap
      myMap = mcMAP.Map
      'parameter check
      '  If activeView Is Nothing OrElse distance < 0 Then
      'Return
      'End If
      Dim fLayer As IFeatureLayer = getLayer("transformer_data_ESCOM")
      'Dim result As ISelectionSet

      Dim pFeatSelection As IFeatureSelection = fLayer
      Dim queryFilter As IQueryFilter = New QueryFilterClass()
      queryFilter.WhereClause = "TXID=" & txID


      'Dim map As ESRI.ArcGIS.Carto.IMap = activeView.FocusMap
      ' Clear any previous buffers from the screen

      pFeatSelection.SelectFeatures(queryFilter, esriSelectionResultEnum.esriSelectionResultNew, True)

      ' Verify there is a feature(s) selected
      Dim graphicsContainer As ESRI.ArcGIS.Carto.IGraphicsContainer = CType(myMap,
ESRI.ArcGIS.Carto.IGraphicsContainer) ' Explicit Cast
      graphicsContainer.DeleteAllElements()

      If myMap.SelectionCount = 0 Then
        Return
      End If

      ' Reset to the first selected feature
      Dim enumFeature As ESRI.ArcGIS.Geodatabase.IEnumFeature = CType(myMap.FeatureSelection,
ESRI.ArcGIS.Geodatabase.IEnumFeature) ' Explicit Cast
      enumFeature.Reset()
      Dim feature As ESRI.ArcGIS.Geodatabase.IFeature = enumFeature.Next()

      ' Buffer all the selected features by the buffer distance and create a new polygon element from each
result
      Dim topologicalOperator As ESRI.ArcGIS.Geometry.ITopologicalOperator
      Dim element As ESRI.ArcGIS.Carto.IElement
      Do While Not (feature Is Nothing)
        topologicalOperator = CType(feature.Shape, ESRI.ArcGIS.Geometry.ITopologicalOperator) '
Explicit Cast
```

```
        element = New ESRI.ArcGIS.Carto.PolygonElementClass()
        element.Geometry = topologicalOperator.Buffer(distance)
        Dim pFillShapeElement As IFillShapeElement
        pFillShapeElement = element
        Dim pFillSymbol As IFillSymbol
        pFillSymbol = pFillShapeElement.Symbol
        Dim pColour As IColor
        pColour = pFillSymbol.Color
        'pColour.RGB = 6
        pColour.Transparency = 255
        ' Set transparency
        'pColour.Transparency = 3 ' Only 0 or 255 is support
        pFillSymbol.Color = pColour
        pFillShapeElement.Symbol = pFillSymbol

        graphicsContainer.AddElement(element, 0)

        feature = enumFeature.Next()
    Loop

End Sub


Private Sub fSelectBufferTXID_itemSelected(itemValue As String) Handles
fSelectBufferTXID.itemSelected
    Text = "[POWER GIS Monitor] - Mark out buffer Zone (500 Metres) for Transformer " &
itemValue
    clearSelection()
    CreateBuffer(itemValue, 500)
    mcMAP.Refresh()
    mcMAP.ActiveView.Refresh()
End Sub

Private Sub lnkFeeder_LinkClicked(sender As Object, e As LinkLabelLinkClickedEventArgs)
Handles lnkFeeder.LinkClicked
    With fSelectFeeder
        .myLayer = getLayer("transformer_data_ESCOM")
        .populate("FEEDERID")
        .setDescription("Select Feeder", "Feeder ID:")
        .ShowDialog(Me)
    End With

End Sub

Private Sub lnkXfrBuffer_LinkClicked(sender As Object, e As LinkLabelLinkClickedEventArgs)
Handles lnkXfrBuffer.LinkClicked
    With fSelectBufferTXID
        .myLayer = getLayer("transformer_data_ESCOM")
        .populate("TXID")
        .setDescription("Select Transformer ID", "Transformer ID:")
        .ShowDialog(Me)

    End With


End Sub

Private Sub lnkCustomerOnXfr_LinkClicked(sender As Object, e As
LinkLabelLinkClickedEventArgs) Handles lnkCustomerOnXfr.LinkClicked
    fSelectAllCustomersonXFR.myLayer = getLayer("customer_data_ESCOM")
    fSelectAllCustomersonXFR.populate("TXID")
```

```
        fSelectAllCustomersonXFR.ShowDialog(Me)

    End Sub

    Private Sub lnkCustomerBuffer_LinkClicked(sender As Object, e As
LinkLabelLinkClickedEventArgs) Handles lnkCustomerBuffer.LinkClicked
        With fSelectBufferALLCUSTOMERS
            .myLayer = getLayer("customer_data_ESCOM")
            .populate("TXID")
            .setDescription("Select Transformer ID", "Transformer ID:")
            .ShowDialog(Me)
        End With

    End Sub

    Private Sub fSelectBufferALLCUSTOMERS_itemSelected(itemValue As String) Handles
fSelectBufferALLCUSTOMERS.itemSelected
        clearSelection()
        CreateBuffer(itemValue, 500)
        Text = "[POWER GIS Monitor] - View All customers in and out of Transformer " & itemValue & "
Buffer Zone (500M)"
        Try
            Dim fLayer As IFeatureLayer = getLayer("customer_data_ESCOM")
            Dim pFeatSelection As IFeatureSelection = fLayer
            Dim queryFilter As IQueryFilter = New QueryFilterClass()
            queryFilter.WhereClause = "TXID='" & itemValue & "'"
            pFeatSelection.SelectFeatures(queryFilter, esriSelectionResultEnum.esriSelectionResultNew,
False)
            mcMAP.Refresh()
            mcMAP.ActiveView.Refresh()

        Catch ex As Exception
            MsgBox(ex.Message)
        End Try
        mcMAP.Refresh()
        mcMAP.ActiveView.Refresh()
    End Sub

    Private Sub clearSelection()
        Dim graphicsContainer As ESRI.ArcGIS.Carto.IGraphicsContainer = CType(mcMAP.Map,
ESRI.ArcGIS.Carto.IGraphicsContainer) ' Explicit Cast
        graphicsContainer.DeleteAllElements()
        mcMAP.Map.ClearSelection()
    End Sub

    Private Sub lnkClearSelection_LinkClicked(sender As Object, e As LinkLabelLinkClickedEventArgs)
Handles lnkClearSelection.LinkClicked
        clearSelection()
        mcMAP.Refresh()
        mcMAP.ActiveView.Refresh()
        Text = "[POWER GIS Monitor]"
    End Sub

    Private Sub lnkSelectCustomer_LinkClicked(sender As Object, e As
LinkLabelLinkClickedEventArgs) Handles lnkSelectCustomer.LinkClicked
        With fSelectCustomer
            .myLayer = getLayer("customer_data_ESCOM")
            .populate("ACCOUNTNUM")
            .setDescription("Select Customer Account Number", "Account Number:")
            .ShowDialog(Me)
        End With
```

```
    End Sub

    Private Sub fSelectCustomer_itemSelected(itemValue As String) Handles
fSelectCustomer.itemSelected
        Try
            clearSelection()
            CreateBuffer(itemValue, 500)
            Text = "[POWER GIS Monitor] - Select Customer Account Number " & itemValue

            Dim fLayer As IFeatureLayer = getLayer("customer_data_ESCOM")
            Dim pFeatSelection As IFeatureSelection = fLayer
            Dim queryFilter As IQueryFilter = New QueryFilterClass()
            queryFilter.WhereClause = "ACCOUNTNUM='" & itemValue & "'"
            pFeatSelection.SelectFeatures(queryFilter, esriSelectionResultEnum.esriSelectionResultNew,
False)
            mcMAP.Refresh()
            mcMAP.ActiveView.Refresh()
            mcMAP.Refresh()
            mcMAP.ActiveView.Refresh()
        Catch ex As Exception
            MsgBox("Could not Locate the customer on the Map", vbCritical, "Error")
        End Try

    End Sub
End Class
```

TableWrapper.vb

```
' Copyright 2008 ESRI
'
' All rights reserved under the copyright laws of the United States
' and applicable international laws, treaties, and conventions.
'
' You may freely redistribute and use this sample code, with or
' without modification, provided you include the original copyright
' notice and use restrictions.
'
' See use restrictions at /arcgis/developerkit/userestrictions.
'

Imports System
Imports System.Collections.Generic
Imports System.Text
Imports System.Runtime.InteropServices
Imports System.ComponentModel
Imports ESRI.ArcGIS.Geodatabase

'<summary>
'This class provides a wrapper for an ITable that allows it to be bound to
'a .NET control.
'</summary>
'<remarks>
'This class inherits from <see cref="BindingList"/> to provide a default
'implementation of a list of objects that can be bound to a .NET control.
```

```
'For the purposes of this sample, it is easier to use BindingList and add
'IRows to it than it is to implement all the interfaces required for a
'bindable list. A more correct implementation would allow direct access to
'the wrapped ITable rather than simply adding all of its rows to a list.
'The class also implements <see cref="ITypedList"/> to allow a control to
'query it for any properties required to correctly display the data in a
'control. Normally properties are determined by using reflection. We want
'the individual fields in the given ITable to look like properties of an
'IRow. As this is not the case, we need to create a collection of 'fake'
'properties with one for each field in the ITable. This is contained in the
'fakePropertiesList member and is used by the ITypedList implementation.
'</remarks>
<Guid("5a239147-b06a-49e5-aa1c-e47f81adc10e")> _
<ClassInterface(ClassInterfaceType.None)> _
<ProgId("ArcDataBinding.TableWrapper")> _
Public Class TableWrapper
   Inherits BindingList(Of IRow)
   Implements ITypedList
#Region "Private Members"
   '<summary>
   'Reference to the table we are wrapping
   '</summary>
   Private wrappedTable As ITable

   '<summary>
   'This is a list of <see cref="PropertyDescriptor"/> instances with each one
   'representing one field of the wrapped ITable.
   '</summary>
   Private fakePropertiesList As List(Of PropertyDescriptor) = New List(Of PropertyDescriptor)

   '<summary>
   'Used to start and stop editing when adding/updating/deleting rows
   '</summary>
   Private wkspcEdit As IWorkspaceEdit
#End Region

#Region "Construction/Destruction"
   '<summary>
   'This constructor stores a reference to the wrapped ITable and uses it to
   'generate a list of properties before adding the ITable's data to the binding
   'list.
   '</summary>
   '<param name="tableToWrap">ITable that we wish to bind to .NET controls</param>
   Public Sub New(ByVal tableToWrap As ITable)
      wrappedTable = tableToWrap
      GenerateFakeProperties()
      AddData()
      wkspcEdit = DirectCast((DirectCast(wrappedTable, IDataset)).Workspace, IWorkspaceEdit)
      AllowNew = True
      AllowRemove = True
   End Sub
#End Region

#Region "ITypedList Members"

   '<summary>
   'Returns the <see cref="T:System.ComponentModel.PropertyDescriptorCollection"></see>
   'that represents the properties on each item used to bind data.
   '</summary>
   '<param name="listAccessors">An array of <see
cref="T:System.ComponentModel.PropertyDescriptor"></see>
```

```
    'objects to find in the collection as bindable. This can be null.</param>
    '<returns>
    'The <see cref="T:System.ComponentModel.PropertyDescriptorCollection"></see>
    'that represents the properties on each item used to bind data.
    '</returns>
    Public Function GetItemProperties(ByVal listAccessors As PropertyDescriptor()) As
PropertyDescriptorCollection Implements ITypedList.GetItemProperties
        Dim propCollection As PropertyDescriptorCollection = Nothing
        If (Nothing Is listAccessors) Then
            ' Return all properties
            propCollection = New PropertyDescriptorCollection(fakePropertiesList.ToArray())
        Else
            ' Return the requested properties by checking each item in listAccessors
            ' to make sure it exists in our property collection.
            Dim tempList As List(Of PropertyDescriptor) = New List(Of PropertyDescriptor)
            Dim curPropDesc As PropertyDescriptor
            For Each curPropDesc In listAccessors
                If (fakePropertiesList.Contains(curPropDesc)) Then
                    tempList.Add(curPropDesc)
                End If
            Next
            propCollection = New PropertyDescriptorCollection(tempList.ToArray())
        End If

        Return propCollection
    End Function

    '<summary>
    'Returns the name of the list.
    '</summary>
    '<param name="listAccessors">An array of <see
cref="T:System.ComponentModel.PropertyDescriptor"></see>
    'objects, the list name for which is returned. This can be null.</param>
    '<returns>The name of the list.</returns>
    Public Function GetListName(ByVal listAccessors As PropertyDescriptor()) As String Implements
ITypedList.GetListName
        GetListName = (DirectCast(wrappedTable, IDataset)).Name
    End Function

#End Region

    Public WriteOnly Property UseCVDomains() As Boolean
        Set(ByVal Value As Boolean)
            Dim curPropDesc As FieldPropertyDescriptor
            For Each curPropDesc In fakePropertiesList
                If (curPropDesc.HasCVDomain) Then
                    ' Field has a coded value domain so turn the usage of this on or off
                    ' as requested
                    curPropDesc.SetUseCVDomain = Value
                End If
            Next
        End Set
    End Property

#Region "Protected Overrides"
    '<summary>
    'Raises the <see cref="E:System.ComponentModel.BindingList`1.AddingNew"></see> event.
    '</summary>
    '<remarks>
    'This override sets the NewObject property of the event arguments parameter
    'to be a new IRow.
```

```
    '</remarks>
    '<param name="e">An <see cref="T:System.ComponentModel.AddingNewEventArgs"></see>
    'that contains the event data.</param>
    Protected Overrides Sub OnAddingNew(ByVal e As AddingNewEventArgs)
        ' Check that we can still add rows, this property could have been changed
        If (AllowNew) Then
            ' Need to create a new IRow
            Dim NewRow As IRow = wrappedTable.CreateRow()
            e.NewObject = NewRow

            ' Loop through fields and set default values
            Dim fieldCount As Integer
            For fieldCount = 0 To NewRow.Fields.FieldCount - 1 Step fieldCount + 1
                Dim curField As IField = NewRow.Fields.Field(fieldCount)
                If (curField.Editable) Then
                    NewRow.Value(fieldCount) = curField.DefaultValue
                End If
            Next

            ' Save default values
            Dim weStartedEditing As Boolean = StartEditOp()
            NewRow.Store()
            StopEditOp(weStartedEditing)

            MyBase.OnAddingNew(e)
        End If
    End Sub

    '<summary>
    'Removes the item at the specified index.
    '</summary>
    '<remarks>
    'This override calls the Delete method of the IRow that is being removed
    '</remarks>
    '<param name="index">The zero-based index of the item to remove.</param>
    Protected Overrides Sub RemoveItem(ByVal index As Integer)
        ' Check that we can still delete rows, this property could have been changed
        If (AllowRemove) Then
            ' Get the corresponding IRow
            Dim itemToRemove As IRow = Items(index)

            Dim weStartedEditing As Boolean = StartEditOp()

            ' Delete the row
            itemToRemove.Delete()

            StopEditOp(weStartedEditing)

            MyBase.RemoveItem(index)
        End If
    End Sub
#End Region

#Region "Private Methods"
    '<summary>
    'Generates 'fake' properties.
    '</summary>
    '<remarks>
    'We need this method to create a list of properties for each field in the
    'ITable as an IRow does not have a property for each field.
    '</remarks>
```

```
Private Sub GenerateFakeProperties()
   ' Loop through fields in wrapped table
   Dim fieldCount As Integer
   For fieldCount = 0 To wrappedTable.Fields.FieldCount - 1 Step fieldCount + 1
      ' Create a new property descriptor to represent the field
      Dim fieldName As String = wrappedTable.Fields.Field(fieldCount).Name.ToString()
      Dim newPropertyDesc As FieldPropertyDescriptor = New FieldPropertyDescriptor( _
      wrappedTable, fieldName, fieldCount)
      fakePropertiesList.Add(newPropertyDesc)
   Next
End Sub

'<summary>
'Adds the data to the binding list.
'</summary>
'<remarks>
'Note that this is a pretty inefficient way of accessing the data to be
'bound to a control. If we implemented each of the interfaces required for
'a bindable list rather than using BindingList, we could write code that
'only reads rows from the ITable as they need to be displayed rather than
'reading all of them.
'</remarks>
Private Sub AddData()
   ' Get a search cursor that returns all rows. Note we do not want to recycle
   ' the returned IRow otherwise all rows in the bound control will be identical
   ' to the last row read...
   Dim cur As ICursor = wrappedTable.Search(Nothing, False)
   Dim curRow As IRow = cur.NextRow()
   While Not (Nothing Is curRow)
      Add(curRow)
      curRow = cur.NextRow()
   End While
End Sub

'<summary>
'Starts an edit operation.
'</summary>
'<remarks>
'This method is used to start an edit operation before changing any data.
'It checks to see if we are in an edit session or not and starts a new
'one if appropriate. If we do start an edit session, the method will return
'true to indicate that we started an edit session and should therefore also
'stop it.
'</remarks>
'<returns>True if we started an edit session, false if we didn't</returns>
Private Function StartEditOp() As Boolean
   StartEditOp = False

   ' Check to see if we're editing
   If (Not wkspcEdit.IsBeingEdited()) Then
      ' Not being edited so start here
      wkspcEdit.StartEditing(False)
      StartEditOp = True
   End If

   ' Start operation
   wkspcEdit.StartEditOperation()
End Function

'<summary>
'Stops the edit operation.
```

```
    '</summary>
    '<remarks>
    'This method stops an edit operation started with a call to
    '<see cref="StartEditOp"/>. If the weStartedEditing parameter is true, this
    'method will also end the edit session.
    '</remarks>
    '<param name="weStartedEditing">if set to <c>true</c> [we started editing].</param>
    Private Sub StopEditOp(ByVal weStartedEditing As Boolean)
        ' Stop edit operation
        wkspcEdit.StopEditOperation()

        If (weStartedEditing) Then
            ' We started the edit session so stop it here
            wkspcEdit.StopEditing(True)
        End If
    End Sub
#End Region
End Class
```