2016

Towards a New GIS Maturity Model: An Organizational Usage Perspective

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by

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A Dissertation submitted to the Faculty of Claremont Graduate University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate Faculty of the Center for Information Systems and Technology

Claremont, California

2016

APPROVAL OF THE DISSERTATION COMMITTEE

This dissertation has been duly read, reviewed, and critiqued by the Committee listed below, which hereby approves the manuscript of Omer Abdulaziz Alrwais as fulfilling the scope and quality requirements for meriting the degree of Doctor of Philosophy.

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Abstract of the Dissertation

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The first condition required for an Information Technology (IT) system to produce value is that it be used by its designated target group of users. Despite the prevalence of “system use” in IS literature, it has been often limited to the individual level. The organizational perspective is rarely considered. This dissertation focuses on system usage in the GIS domain through an organizational lens.

GIS is a technology with the potential to transform government by enhancing business processes and providing a platform to manage spatial and non-spatial data, which is expected to result in better decision-making. However, little is known about how this technology is actually implemented organization-wide and the environment surrounding its use. Current GIS maturity models have not examined this usage broadly or in depth. These models lack empirical validation and measurement tools to diagnose maturity are not readily available.

Based on GIS, maturity models, and system usage literature, this dissertation presents a more comprehensive maturity model for evaluating local government usage of GIS along with a measurement tool. This work followed De Bruin et al., (2005) guidelines for developing maturity models. This new model was discussed with practitioners and academics, was pilot-tested, and then widely tested by Southern California local governments through an online questionnaire.

Results show support for the validity of the proposed maturity model and demonstrate its utility. This dissertation revealed that system, task, user, organization and GIS department are viable dimensions of GIS usage from an organizational perspective. Results suggest that increasing actual GIS usage leads to an increase in GIS value. Results further show that the efficiency and effectiveness benefits of GIS are mostly realized; however, the societal benefits of GIS are small.

DEDICATION

To my wife Norah, for taking the journey abroad and sacrificing for my sake.

To my parents for their support and belief in me.

To my brothers and sisters for their encouragements and care.

Thank you all.

Acknowledgements

First and foremost, I thank Allah (God all mighty) for blessing me with health, knowledge and the time and ability to complete this work.

I would like to thank also my dissertation committee; Dr. Brian Hilton, Thomas Horan and Tamir Bechor for their support, help, resources, guidance, feedback and patience. They have guided this work, added to its meaning and assisted in its delivery.

I deeply thank June Hilton, Javier Aguilar, Nancy Obermeyer, Linda Tomaselli, Stephen Ventura, Greg Babinski, John O'Looney, James Troyer, David DiBiase and John Tangenberg who have commented and suggested modifications to this work.

I would like to thank all of those who have taken the time to participate in this study and complete the questionnaire.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 – INTRODUCTION

The influx of data collection is so rapid and ever increasing that we might soon be drowning in data. In the era of big data and data analytics, IBM claims that 2.5 quintillion (a billion times a billion) bytes of data are generated each day (IBM, 2013). The hardware challenge of storing these data is much easier than the challenge of actually making sense out of it. Part of this generated data is geo-coded (spatially referenced). Images, text, video and mobile phones could all be geographically tagged. Even recent Unmanned Aerial Systems (UAS) or drone technology collects and processes spatial data. As the availability of spatial datasets proliferates demand for maps to visualize these various data types is rising.

The primary technology to generate maps and manage spatial and non-spatial data is Geographic Information System (GIS). GIS can be defined as a "group of procedures that provide data input, storage and retrieval, mapping and spatial analysis for both spatial and attribute data to support the decision-making activities of the organization" (Grimshaw, 1994). GIS first appeared in the 1960s in the Canadian government to manage some of its resources and was pioneered by Roger Tomlinson (Foresman, 1998). Since then GIS has become a standard technology in the IT toolbox of almost every level of government worldwide (Longley et al., 2010). GIS is moving towards a wider variety of customers from the public sector to corporations, grassroots organizations, and non-profit organizations. Optimistic estimates report that up to 80% of data stored in government databases contain a spatial component (Worral, 1991), which makes GIS extremely valuable to government. The potential is high for GIS to exploit digital data and process it for effective decisions, improved services and efficient management of resources. The global GIS industry generates between $150 to $270 billion dollars of revenue yearly (Oxera, 2013). The departments of commerce, defense, health and human services, homeland security, interior and transportation alone estimated that they would spend about $1.3 billion on critical IT investments closely related to geospatial technology in 2015 (Government Accountability Office, 2015). The GIS industry is growing and spending on GIS is increasing in both the public and private sectors. One approach to understanding the developments occurring in GIS is to evaluate current practices in the use of technology organization wide and simultaneously search for its impact over the whole organization and beyond.

Although GIS has become commonplace in government (Longley el al., 2010), GIS still faces many challenges. Organizations are merely scratching the surface of GIS and are only at the tip of the iceberg when it comes to GIS capabilities. Studies have reported that the capability of GIS hasn't been fully exploited in the organizations and departments where it has been used (Azmi, 2000; Budic, 1998; Gudes et al., 2015; MacDonald and Radcliffe, 1997; Turner and Higgs, 2003; Weir and Bangs, 2007; Worrall and Bond, 1997; Ye et al., 2014). The use of GIS remains limited to the core community (planners and engineers) and is underutilized by decision makers (Budic, 1993; Gallaher, 1999; Ventura, 1995; Weir and Bangs, 2007, Ye et al., 2014). There was one exception (Hussain et al., 2010) where they found an impact of GIS on the decision making process of a planning department. Consequently, reported gains about GIS impact and value are mixed and contradictory (Akingbade, 2009). Part of this confusion is due to measuring GIS information use at the individual level (single user) and associating that with "net benefits to the organization" (see for example the work of Eldrandaly et al., 2015). The literature is rich with models, frameworks and studies that explore the link between GIS use (utilization) and GIS value (performance measured as time taken to make decisions and decision accuracy), but at the individual level (single user) [see for example Erskine and Gregg, 2013; Jarupathirun and Zahedi, 2007; Mennecke et al., 2000; Ozimec et al., 2010]. However, post implementation GIS studies that focus on how organizations are using GIS and where GIS is creating value over the whole organization are rare.

Though there could be numerous reasons for unsatisfactory outcomes and expected results related to a GIS (e.g., poor system implementation), system usage should be the factor to consider first. If systems are not used then how can quality, reliability, value, usefulness, ease of use, or user satisfaction be assessed? System usage is the "employment of one or more features of a system to perform a task" (Burton-Jones and Straub, 2006) at the individual, group, or organizational level. In the Information Systems (IS) field, system usage has received substantial focus in relation to IT investments and business value. DeLone and McLean (2003) in their very popular IS success model, acknowledge the association between “system use” and “individual and organizational impact.” Other researchers have also identified system usage in specific settings as a precursor to a system’s impact (Devaraj and Kohli, 2003; Goodhue and Thompson, 1995; Markus, 2004). This research places an emphasis on GIS use at the organizational level and at the same time examines gained GIS value at the organizational level.

Post implementation understanding of GIS usage is needed. Without properly understanding current GIS usage practices, improvement is difficult, as the “as is” state is not known. Thus, aiming for a specific GIS value without satisfying first certain levels of organizational usage of GIS seems unfeasible. The multi-user, multi-purpose nature of GIS makes it difficult to assess organizational usage of the technology. The environment surrounding GIS (whether supporting or hindering usage) is complex and has not been deeply examined and is often overlooked.

Maturity models are “conceptual multistage models that describe typical patterns in the development of organizational capabilities” (King and Teo, 1997). Maturity models can be used to “assess the current state of competence, to set a roadmap for organizational improvement, and to assess the effects of Development” (Mäkelä, 2012). Maturity models assume linear progression from a less mature state to a more mature one in a manner that cannot be easily reversed or skipped (Lavoie and Culbert, 1978). Maturity is depicted as quality of a process, growth in some factor or an improvement in a capability (Mettler, 2011). The first maturity model developed for IT was the “stages of growth” model developed by Gibson and Nolan in 1974 and refined in 1979 where they proposed a four stage progression of IT expenditure that follows an S curve from initiation, contagion, control to integration (Gibson and Nolan, 1974). By far the most influential maturity model in the field is the ‘Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMMI), proposed by the Software Engineering Institute in 1993 to evaluate the quality of the software design process (Paulk et al., 1993). Maturity models were developed in academia and then utilized by practitioners and consultancy firms because of their ability to simplify complex reality, making them helpful for diagnosing an organization’s maturity. Generally speaking, maturity is intended to refer to the maturity of processes, objects, technologies, or an individual's capabilities. In this research, maturity is confined to GIS usage that this research defines as the "extent of usage and absorption of GIS within an organization." This research utilizes the approach of maturity models to understand the levels of organizational usage of GIS. IT maturity models evaluate the organization comprehensively as one unit to assess its maturity. This approach aligns perfectly with the objective of this research in assessing organizational use of GIS. This research aims at identifying the different stages of progression that organizations go through in using GIS and the value gained in each stage of development.

1.1 Problem Statement

Organizations both private and public are constantly under pressure to reduce costs and improve services. GIS is a technology with the potential to transform an organization by enhancing business processes and providing a platform to manage spatial and non-spatial data, which is expected to result in better decision-making. However, little is known about how this technology is actually used organization-wide, the environment surrounding its use, and the organizational benefits of GIS.

Maturity models in general face a core problem with "maturation, that is, the process of becoming more mature, has been understood rather vaguely as a term that is associated with organizational development toward the better" because the theoretical foundation is weak (Poeppelbuss et al., 2011). This research has a clear conception of maturity as it relates it to system usage. Although there have been more than 128 new maturity models developed over the past years (Wendler, 2012), this research was able to identify only one paper in the IT maturity literature that discussed usage maturity (Holland and Light, 2001).

Even current GIS maturity models haven't given organizational GIS usage sufficient focus. Current GIS maturity models have not examined usage broadly or in depth, lack empirical validation, and the measurement tools to diagnose maturity are not readily available. Although GIS maturity models do exist, they focus on the design (infrastructure, architecture, technology or data), process or the organizational aspect of managing GIS. Moreover, the value created as a result of GIS use hasn't been yet considered as part of the GIS maturity cycle. Most of the models introduced are conceptually formed. Even if empirically validated, measurement is lacking.

Current GIS maturity models don’t have a clear definition of GIS maturity. Although these models aim at describing the maturity of GIS, it was not always clear what was “maturing.” Is it the technology, infrastructure, process, management of GIS, or service provided by GIS? Some of these models contain a component describing use of GIS; however, their benchmark variables (process area, critical success factors, or best practices) don’t correspond closely with GIS usage. Some of those models cover such a wide range of perspectives that it’s questionable to label it as a maturity model, where in fact they are more of an IT/GIS management or governance framework. The purpose of maturity models is to develop a simple yet comprehensive method of diagnosing an organization’s maturity (Wendler, 2012). Except for URISA’s model (Babinsky, 2013), none of the other models disclose the measurement tool. Table 1 provides some of the limitations in existing GIS maturity models. Models in Table 1 assess the capability to use GIS but not actual usage. Some of these models are not tested empirically beyond the cases that formed the model. Another issue is that the measurement tool is missing which limits its practical use. Except for Exprodat’s model, use of GIS is not considered part of maturity. Even Exprodat’s model does not provide details about how to measure GIS usage. Another important issue is that some of these models assess the state or countrywide maturity of GIS (SDI) while in this research the scope is the individual city or municipality using GIS. These models emphasize to a great extent the infrastructure, technology, data, management activities, and policies associated with GIS yet they place little emphasis on evaluating the actual usage and application of GIS. The organizational usage of GIS and the environment surrounding it has not been sufficiently studied and, to date, no measurement tool exists to measure the organizational usage of GIS. The view of this research is that having a state-of-the-art quality operational GIS alone is not sufficient to indicate maturity. This research asserts that the actual use of GIS resources by the organization is a more accurate indicator of GIS maturity and thus it attempts to develop such a model.

The literature on the construct “system usage” has relied on different measures (e.g. extent of use, frequency of use, duration of use, variety of use) to operationalize the construct at the individual level. System use studies employ individual measures in their behavioral models. Proxies such as user satisfaction were also used to measure usage. This has led to mixed results in the literature about the impact of system usage on other constructs. The system usage construct isn't well understood on the individual or the organizational level (Burton-Jones and Gallivan, 2007). Although individual measures for GIS use do exist (e.g. Eldrandaly et al., 2015), organizational use isn't simply the "aggregation of individual behavior" (Burton-Jones and Gallivan, 2007), as GIS might be used from outside the organization (citizens and business for example) and the information of GIS might be used by individuals who don't have direct contact with the system.

Studies that examined GIS usage focused on the individual level. The majority of the related literature has not surpassed anecdotal recommendations and best practices for successful implementation based on limited case studies (see for example Alrwais and Hilton, 2014; Antenucci et al., 1991; Komarkova, 2010; Nedovic-Budic and Godschalk, 1996). The majority of the studies in this stream of research were focused on the factors facilitating or hindering adoption/diffusion and use of GIS (Brown 1996; Gocmen and Ventura, 2010; Ventura, 1995). Case studies are used to present the experience of one organization using GIS (Alrwais and Hilton, 2014; Borgesa and Sahayb, 2000; Hussain et al., 2010; Neufeld and Griffith, 2000), and surveys are used to provide a report on the extent of use (Azmi, 2000; Higgs et al., 2005; Olafsson and Skov-Petersen, 2014; Weir and Bangs, 2007). The majority of these studies are "subjective accounts describing the benefits of GIS from a single-user perspective" (Brown, 1996); a few have looked at the organizational level. Portions of them are old and conducted outside the United States, which calls into question their current validity. More importantly, this research did not find any effort to consolidate the findings of these studies into classifying GIS usage.

The business value of GIS when considered (Babinski et al., 2012; Smith and Tomlinson, 1992; Trapp et al., 2015) is mostly derived by financial measures (such as return on investment), assuming an organization is profit driven, but the public sector isn't necessarily profit driven. Benefits of GIS are mostly measured at the process level (Pick and Shin, 2008) but rarely at the organizational level. This research will evaluate objective GIS benefits (tangible and intangible) at the organizational level and examine its relationship with organizational GIS usage.

	Kurwakumire 2014	Exprodat 2013	URISA 2013	Makela 2012	Giff 2012	Loenen 2008	Keel 2008	O'Flaherty 2005	Tomaselli 2004	Chan 2000	Grimshaw 1996	Marr 1996
Model name	Public sector GIS evaluation methodology	GIS maturity model	GIS capability maturity model	GIS maturity model	Online self assessment methodology for SDI	SDI assessment	MM for Enterprise GIS	Stage model for GIS & SDI	Enterprise model of GIS	3-stage dev. of corporate GIS	GIS mgmt. strategies	GIS maturity & integration
Unit of analysis	Public orgs.	Business orgs.	Local gov't	Public orgs.	Local SDI members	SDI	Business orgs.	Local gov't	An organization	Business orgs.	Business orgs.	An organization
Dimensions explored	- Info. - Availability of data - Access to data	- Business awareness & governance - Spatial data mgmt. & integration - tech. - Training - Use of GIS - Support	-Tech. - Data - Process - Staff -Org. structure	-Architectures - Services & processes - Capabilities	-Org. structure - Info. mgmt. -Tech. -Process -Customer service	Org. settings	-Alignment -Data mgmt. -Accessibility -Integration -Sustainability	N/A	N/A	N/A	-Strategy -Structure -Systems -Staff -Style -Skills -Shared values	N/A
Empirically tested?	Yes, but results are not presented	N/A	Yes	Yes	Yes, but results are not presented	No	N/A	No	No	Yes	Yes	Yes
Measurement tool disclosed?	No	No	Yes	No	No	No	No	No	No	No	No	No
Major findings	A value driven GIS evaluation model of intangible benefits	Comp-rehensive framework for a GIS strategy	Complete documented model with resources	A model with rich content	+200 indicators of maturity	Adds to SDI the Org. component	Definitions & characteristics of stages towards enterprise GIS	Describe interplay between GIS & SDI mgmt. activities	Description of enterprise GIS, components its barriers & implications	Long term patterns in the dev. of GIS	Different GIS strategies for each stage of maturity	Computational amalgamated indicator of maturity
Maturing object	GIS benefits	GIS strategy	GIS capabilities (operation)	Competence in using spatial data	Utilization of SDI	Org. structure	GIS capabilities (operation)	N/A	N/A	GIS mgmt.	GIS mgmt. strategies	Use of GIS
Stage names	1)Grass-root 2)Intermediate 3)Mature 4)Integrated	1)Initial 2)Recognizing 3)Defining 4)Managing 5)Optimizing	1)Ad-hoc 2)Repeat-able 3)Defined 4)Managed 5)Optim-ized	1)Decided case-specifically 2)Separately governed 3)Concentratedly coordinated 4)Comprehen-sively managed 5)Strategically optimized 6)Innovative	Level1 Level2 Level3 Level4 Level5 Level6	1)Stand-alone 2)Exchange 3)Intermediary 4)Network	1)Enthusiasts 2)Departmen-tal 3)Central 4)Integration 5)Enterprise	1)Early implement-tation 2)Growth 3)Control 4)Stability	1)Awareness 2)Develop-ment 3)Acknow-ledgment 4)Support 5)Enterprise	Stage1 Stage2 Stage3	1)Opt-out 2)St&-alone 3)Linking 4)Opportun-istic 5)Corporate	1)Paper-based 2)Move towards GIS 3)Integrated GIS 4) Integration of corporate data resources

Table 1. GIS Maturity Models

MM: maturity model, SDI: spatial data infrastructure, N/A: not available

To conclude, organizational use of GIS is a multifaceted construct with no measurement tool available to measure it. GIS maturity models have overlooked this important variable. GIS usage components are dispersed, fragmented, and studied in isolation. There is no systematic approach to synthesize relevant research in GIS usage into a cohesive model of maturity. The association between GIS usage and GIS value at the organizational level hasn't been investigated yet.

1.2 Research Framework

1.2.1 GIS Usage

In order to pull together the relevant dimensions encompassing GIS usage, this research relies on the literature of system usage. Burton-Jones and Straub (2006) provided the most comprehensive work related to the construct of system usage. They outlined three dimensions (system, user and task) deemed to be pivotal to the understanding of system usage at the individual level (Burton-Jones and Straub, 2006). This research follows this line of thinking but applies it to the organizational level. In a quest to understand the boundaries of the environment that a system operates in, this research followed the logic of the systems approach (Churchman, 1979), which means that in order to understand a system you have to inspect the elements that make up the system and the environment within which the system operates and the linkages between them. Ariav and Ginzberg (1985) utilize this theory to understand the characteristics of the environment that a Decision Support System (DSS) operates within. This research follows the same approach in studying the GIS usage environment.

Marriage between the concepts of "system usage" and "maturity models" hasn't occurred often. Holland and Light (2001) proposed a usage maturity model for enterprise resource planning (ERP) use where they examined the consequences of maturity (result) instead of examining the antecedents of maturity (process, capability or infrastructure). Holland and Light (2001) proposed five dimensions for ERP usage maturity (strategic use of IT, organizational sophistication, penetration of the ERP System, drivers and lessons and vision) over three stages of maturity. This research uses the Holland and Light maturity model as a foundation for building the GIS usage maturity model. This research also considers relevant research in GIS maturity models and GIS studies in forming the model.

1.2.2 GIS Value

The taxonomy used in this research for classifying GIS value is based entirely on the work of Akingbade et al. (2009). The researchers reviewed the literature on GIS impact from different disciplines. Akingbade et al. (2009) categorize GIS value into gains in efficiency, effectiveness and societal well-being. They define efficiency as a "ratio of outputs to inputs … expressed as cost savings, cost avoidance or productivity gains" (Nedovic-Budic, 1999), effectiveness as "improvement in the performance of an organization's fundamental duties" (Tulloch and Epstein, 2002), societal well-being as "how GIS technology has transformed society and its way of dealing with human problems" (Akingbade et al., 2009). Akingbade et al. (2009) claim that a Cost and Benefit Analysis (CBA) would be inadequate as it captures only the tangible benefits of GIS and thus they draw upon the related work of Clapp et al. (1989) and Danziger and Anderson (2002) to propose a taxonomy of GIS impact. The societal impact of GIS is an important category as the ultimate goal of GIS is to benefit the society (Nedovic-Budic, 1999) and as such, public organizations may have different goals from private corporations which don't apply to this category. The classification of Akingbade et al. (2009) captures the tangible and intangible benefits of GIS at the organizational level and thus constitutes a suitable measure to evaluate the value gained from using GIS at public organizations.

1.3 Research Design

The objective of this work is to design a comprehensive GIS usage maturity model for benchmarking and evaluating local government efforts in utilizing GIS technology and to examine the benefits gained from GIS. The maturity model would be used to diagnose the current "as is" state of using GIS in local governments through a simple and quick measurement tool.

1.3.1 Research Questions

This study seeks to answer the following questions:

RQ1 What are the dimensions necessary to include in developing a usage-based GIS maturity model? How would usage maturity be measured? What would be the scoring method?

RQ2 How is GIS maturity associated with GIS value?

The research will evaluate these questions by examining the state of GIS maturity in Southern California local governments using the proposed maturity model.

1.3.2 Methodology

Although earlier maturity models were developed without a consistent process, lately several methods and guidelines for designing maturity models have gained support in academia. De Bruin et al. (2005) were the first to propose a development method that has a clear logic and sequence between the phases. They do not limit their method to a specific research design, and their method has been used widely. For these reasons, this research followed the De Bruin method in designing the GIS Usage Maturity Model, except in the last phase as it relates to the long-term management of the model, which is outside the scope of this study. The methodology of De Bruin et al. (2005) is summarized in Figure 1.

1) Scope	Determine domain	Determine Stakeholders	Comparison with existing models	Determine the Purpose
2) Design	Determine model structure to strike balance between complex reality and model simplicity	Specify number of levels or stages Label stages Define each stage	Determine the approach	
3) Populate	Develop a priori components and sub components as the content	Validate by expert interviews, case studies or focus group	Develop instrument to measure the model	
4)Test	Relevance and rigor : test the construct of the model and the model instruments for validity, reliability			
5) Deploy	Verify the extent of the model's generalizability			

Figure 1. The five phases of De Bruin method

The first phase undertaken in this research was to review exhaustively the related literature to form the basis for the new model and the associated instrument. The second phase was to seek expert opinion about the model and its instrument. The third phase was to do a pilot study using the instrument and modify it accordingly. The fourth was to test the model on a large scale. The last phase was to perform the needed statistical tests, compute the maturity score, analyze the data, and report the findings.

1.4 Guide to this Dissertation

Chapter 2 includes a thorough review of the related literature. The nature of this research draws upon diverse but related research. The chapter covers the research on business value of IT, system usage, organizational system usage, IT maturity models, GIS maturity models, GIS studies at local government and the literature on GIS impact. The objective of this chapter is to establish the need for a new GIS maturity model and extract relevant variables for measuring GIS usage and GIS value at the organizational level.

Chapter 3 describes the new GIS usage maturity model. The chapter outlines the definition of the proposed stages of the model and the dimensions and the content of the model. The chapter also includes the taxonomy used for classifying GIS value. The chapter concludes with the propositions of this research.

Chapter 4 deals with research design, including the methodology, research timeline, questionnaire, IRB process, sample, pilot study and data collection process.

Chapter 5 is assigned for data analysis. The response rate of the questionnaire is reported along with the reliability and validity tests. Descriptive statistics are provided for the participants, cities and for the variables. Correlations are reported between the research variables. Maturity of the participating cities is reported along with the calculation method. Statistical tests are performed to analyze the relationship between GIS usage maturity and GIS value. Chapter 5 concludes with discussion of the results.

The last chapter (Chapter 6) is for reporting the findings of this research. The chapter includes a discussion of the research contribution, practical contribution, limitations of the study and future research opportunities.

CHAPTER 2 – LITERATURE REVIEW

This chapter examines related work to the research. The nature of this research draws upon diverse but related research streams. The literature review is performed with an "organizational lens" both for GIS usage and GIS value. First, "'system use" and "business value of IT" literature is reviewed to establish the association between system usage and system impact (performance). The systems theory is presented to understand how a system can be studied. The review outlines the complexities with measuring the system usage construct. The literature on system usage is examined to understand the scope of this construct and what needs to be measured. Secondly, IT maturity models are reviewed to argue that "usage maturity" has been neglected. GIS maturity models are reviewed to identify current progress and shortcomings in available models and stress the need for a new model. The research then turns to studies of GIS usage, especially at local government level, to show how this construct has been studied in the past, and to understand the context that surrounds GIS and what variables are associated with GIS use. Lastly, studies on GIS impact are reviewed to form a classification of GIS value. The objective of this chapter is to establish the need for a new GIS maturity model on the basis that current maturity models assess the "capability to use GIS" not actual GIS use and extract relevant variables for measuring GIS usage and GIS value at the organizational level. The objective of this chapter isn't to locate every article in the related research streams but rather to provide an overview of the direction of existing research, identify existing problems and integrate the findings to serve the purposes of this research.

Related work was found using the databases of ProQuest ABI/INFORM Global; EBSCOhost Business Source Complete; ScienceDirect; IEEE Xplore; AIS library; ACM Digital Library and Google Scholar using keywords such as GIS usage; GIS use; system use; system usage; ICT usage; GIS maturity; GIS maturity models; usage maturity; GIS success; GIS evaluation; post adoption; post implementation; IS usage; system utilization; usage patterns; usage construct; organizational usage; organizational use; IT benchmarking; business value of IT; IT payoffs; GIS impact; GIS value; GIS business value; GIS benefits, and examining the cited and citing works.

2.1 Business Value of IT

This stream of IS research seeks to examine the association between IT investments and firm performance. Melville et al. (2004) defines business value of IT as “the organizational performance impacts of IT at both the intermediate process level and the organization-wide level, and comprising both efficiency impacts and competitive impact” (Schryen, 2013). The business value of IT (BVOIT) has long been a central topic of interest for IS researchers and is expected to remain so (Schryen, 2013). Robert Solow, a Nobel prize winner, observed in the 1990s that “you can see the computer age everywhere but in the productivity statistics,” which was later called the “productivity paradox” (Kraemer and Dedrick, 2001). Empirical work performed at that time (Harris and Katz, 1991; Hitt and Brynjolfsson, 1996) supported the paradox when researchers failed to find a clear correlation between the increase in IT spending and the increase in productivity or performance gains. Researchers have commented on research performed at that period, and pointed out that the US economy as a whole experienced a slowdown and low productivity. There was a lag time for IT value to occur, however inappropriate measures for IT benefits were used; granular analysis instead of intermediate canceled out IT benefits and there was mismanagement of IT resources (Brynjolfsson, 1993). Given the doubts about IT and the dot-com burst at that time, Nicholas Carr published a controversial article diminishing the importance of IT by claiming that IT had become a commodity that couldn’t provide competitive advantage (Carr, 2003). These instances and negative comments about IT sparked a surge in IS research to demonstrate the value of IT.

Since then, research has accumulated a critical mass of empirical studies to assert a causal link between IT resources and some measure of firm performance (Daulatkar and Sangle, 2015; Kohli and Grover, 2008; Schryen, 2013), however effect size varies. Theories used in the literature to explain the IT value process include Porter’s value chain process, resource based view and its extension the dynamic capabilities, technology-organization-environment framework, and accounting and economic theories (e.g. transaction cost, contingency theory, theory of production). The resource-based view (RBV) of the firm has been used the most in the literature to claim that competitive advantage occurs when a firm possess IT resources that are valuable, rare, imperfectly imitable and non-substitutable (Barney, 1991). RBV paints a static view of the firm while its extension the dynamic capabilities (Teece et al., 1997) acknowledges the changing nature of the firm by focusing on the interaction between resources and capabilities that yields firm performance. The central tenant of these theories links some aspect of IT with organizational impact. Table 2 provides a summary of empirical studies in the field between 2012 and 2015.

Study	**Unit of analysis**	**Theoretical bases**	**Investigated variables**	**Technology component**	**Key findings**
Zhang, Huang, and Xu, 2012	Firm level	Related literature	The impact of ERP implementation on firm performance	ERP	Lag time of four years before ERP investments have an effect on Tobin's Q (market indicator).
Yeow and Goh, 2012	Process level	Related literature	The impact of health information technology on the efficiency of healthcare resource allocation (allocation of physicians, consultation time and number of patients)	Telemedicine	The use of telemedicine is associated with shifts in resource allocation but not always in a cost efficient manner. Senior physicians after implementation see more patients and perform the diagnose in shorter time (more efficient) however less experienced physicians after implementation took more patients and used more time to arrive at a diagnoses (less efficient).
Hadaya and Cassivi, 2012	Industry level	Relational view of the firm (co-creation of value with its partners)	The association between partner specific IT investments, the use of supply chain collaborative systems, operational and strategic benefits.	Supply chain collaborative systems	The greater partner-specific IT investments made by the firm, the greater its use of supply chain collaborative systems (SCCSs) with those partners, and the greater the firm uses SCCSs with partners, the greater its benefits, through the generation of relational rents. IT investments alone don't generate value. The use of IT is a better predictor of firm benefits.
Xue, Ray and Sambamur, 2012	Industry level	IS–business strategy alignment literature	Moderating effect of industry type on the relationship between IT and the efficiency or innovation of the organization.	IT budget	In stable industries, IT assets are associated with gains in efficiencies while IT in dynamic environments are associated more with innovativeness.
Mithas, Tafti, Bardhan, and Goh, 2012	Firm level	Resource-Based View	Effect of IT investments over firm profitability	IT budget	IT has a positive impact on growth but not on cost reduction The effect of IT investments on performance is higher than advertising and RandD
Kohli, Devaraj and Ow, 2012	Firm level	Related literature	Effect of IT investments over firm market value	IT budget	Granularly, IT has a positive impact on firm's market value but IT investments don't show an association with accounting measures such return on assets (ROA) or operating income

Zhao and Jiang, 2013	Process level	Resource-Based View	How e-supply chain capabilities are realized by usage of inter-firm IT resources integration and how business value of IT is co-created in multi-firm environments	Supply chain systems	Process improvements are realized first, then financial performance then network benefits are realized from the use of e-procurement systems
Setia, Venkateshan d Joglekar, 2013	Process level	Dynamic capabilities	Effect of information quality on customer orientation capability and customer response capability	All IT resources at the disposal of the customer service unit (CSU)	By focusing on the customer-side digital business strategy, the study finds a positive impacts of a CSU's information quality on its customer service capabilities. Effectiveness of information quality in building customer service capabilities is contingent on the sophistication of the CSU's customer service process.
Anand, Wamba and Sharma, 2013	Process and firm level	Resource-Based View and Dynamic capabilities	The mediating effects of process performance on the relationship between firm IT capabilities and firm performance.	IT management capability, IT personnel expertise and IT infrastructure flexibility	Effect of firm IT capabilities on firm performance is mediated through performance at the process level
Liu, Ke, We, W and Hua, 2013	Process and firm level	Dynamic capabilities	How IT capabilities affect firm performance through absorptive capacity and supply chain agility in the supply chain context	Flexible IT infrastructure and IT assimilation	Absorptive capacity and supply chain agility fully mediate the influences of IT capabilities on firm performance. No direct path was found between IT capabilities and firm performance.
Davis, Mora-Monge, Quesada, and Gonzalez, 2014	Firm level	Resource-Based View and contingency theory	The influence of cross-cultural differences on the value creation process from e-business systems in the supply chain	Supply chain systems	Value creation process from e-business systems use is significantly enhanced in companies operating in national cultures that emphasize cooperation and interdependence, and promote group-level interests over individual interests.
Quaadgra, Weill and Ross, 2014	Firm level	Dynamic capabilities	The influence of IT capabilities over business goals and financial performance	Strategic choice making, development of digital platform, working smarter and action oriented assessment	Firms which are more effective in making IT commitments have higher business impact from IT, which in turn correlates with higher financial performance.

Piccoli, and Lui, 2014	Firm level	Information system success model	The influence of information systems on sustained competitive performance	Hotel check in self-service kiosk
Habjan, Andriopoulos and Gotsi, 2014	Process and firm level	Related literature	Ability of (GPS) adoption to transform operational decision making and foster differential firm performance	Global Positioning System (GPS) in transportation vehicles
Turel and Bart, 2014	Firm level	Resource-Based View and contingency theory	The potential of the oversight of boards of directors in IT matters to influence organizational performance	Board-level IT governance (ITG)
Chen, Wang, Nevo, Jin, Wang and Chow, 2014	Process and firm level	Resource-Based View and Dynamic capabilities	The mediating role of business process agility and the moderating roles of environmental factors on business value of IT	IT infrastructure, IT business partnerships, business IT strategic thinking, IT business process integration, IT management and external IT linkage
Chae, Koh and Prybutok, 2014	Firm level	Resource-Based View	Link between information technology capability and firm performance,	IT infrastructure, technical and managerial IT skills, knowledge assets, customer orientation, and synergy
Xu, Ou and Fan, 2015	Firm level	Technology organization environment (TOE) framework	The relationship between ERP, organizational factors and the environment on ERP assimilation and ERP value.	ERP
Wang and Cavusoglu, 2015	Firm level	Resource-Based View	manufacturing firm's performance on a B2B electronic marketplaces is determined by online marketing capability, flexible manufacturing capability and content management capability. these enabling capabilities are in turn determined by the firm's IT capability	business-to-business electronic marketplaces
Someh and Shanks, 2015	Process and firm level	Resource-Based View	Influence of business analytics over analytical capability of the firm and informational benefits which ultimately leads to firm performance	Business Analytics (BA)

Table 2. Recent studies on IT business value

Although this review isn't exhaustive, Table 2 illustrates continued interest in the topic where 20 empirical studies were performed in the last four years. The vast majority of the studies reviewed do find an association between IT and some measure of performance with the exception of Chae at al. (2014). Reviewed literature almost agrees that process improvements from IT are more significant and quicker to realize than firm performance. It can be observed from Table 2 the inconsistencies in operationalizing IT investments (IT budget, IT infrastructure, specific system, IT related capabilities, use of system and contextual and organizational factors), which leads to mixed results and vagueness about where and how IT creates value. Schryen (2013) calls for disaggregating IT investments to understand how specific systems impact firm performance and to be able to compare results of empirical studies. There is a growing interest in the reviewed literature to measure the extent of IT use and correlate that with firm performance. In fact, Hadaya et al. (2012) asserts that IT investments alone don't generate value and that the use of IT is a better predictor of firm benefits. Moreover, Zhu et al. (2005) states that the business value of IT stems from the degree of IT use in core competencies of the firm's value cycle and that "the greater the usage, the more likely the firm is to develop unique capabilities from its core IT infrastructure" (Mishra et al., 2007). Kumar (2004) also argues for considering system usage in BVOIT as he explains "it is important to consider IT usage in measuring IT value instead of using the dollar value of investments, since value depends on usage of IT and not on investment alone."

After clarifying the path between IT and business value, in the next section the research narrows the focus more towards related work examining the effect of GIS specifically on individual performance.

2.2 GIS Impact on Individual Performance

Studies in this class of research examine the effect of spatial information presentation on the performance of the decision making process and problem solving. Although researchers in this class mightn't be cognizant about it, their research is an extension of the business value of IT but with a narrow focus on GIS and its impact is limited to the decision making process at the individual level (single decision maker). The premise of these studies is that GIS can be combined with DSS to produce Spatial Decision Support Systems (SDSS) capable of making better spatial decisions within a short period of time (Keenan, 2006). Cognitive fit (Vessey, 1991) and task technology fit (Goodhue and Thompson, 1995) are the two most used theories in this class of research. The cognitive fit theory predicts decision performance based on the match between the complexity of the problem and problem representation (Dennis and Carte, 1998). Likewise the task technology fit theory requires fit to happen between the task complexity and the technology characteristics (Jarupathirun and Zahedi, 2007) before performance impact or utilization can occur. Jarupathirun and Zahedi (2001) utilize the aforementioned theories in their SDSS performance model (Figure 2).

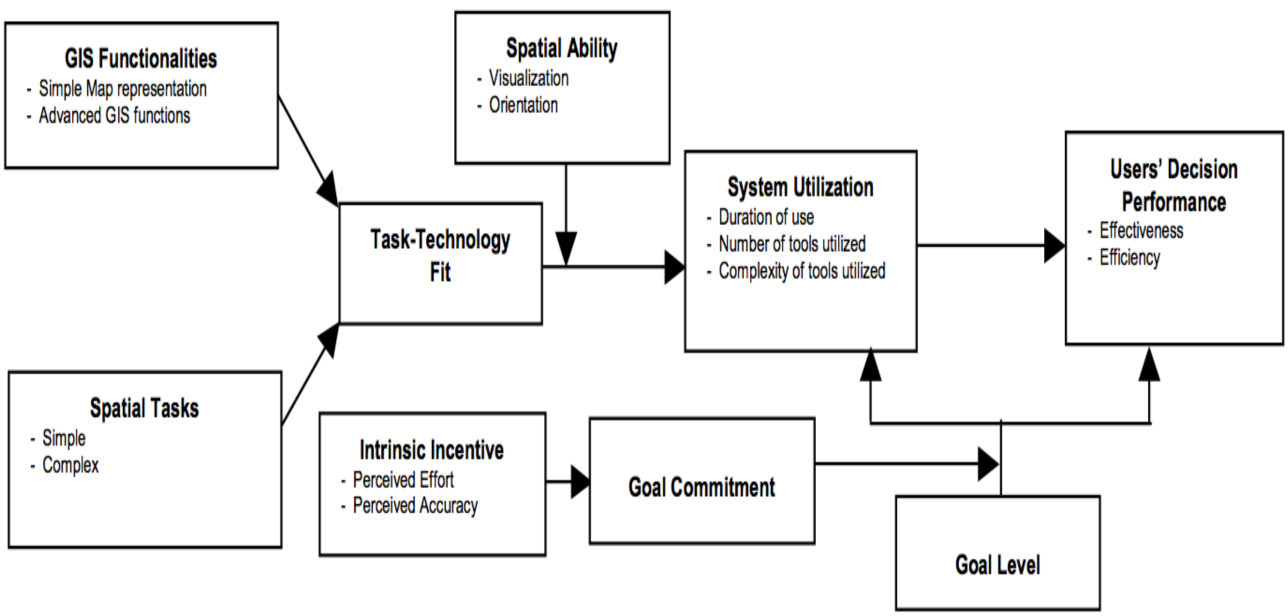


Figure 2. A model for SDSS utilization and Decision Performance (Jarupathirun and Zahedi, 2001)

The notion is that GIS generates optimal impact when advanced functionalities are matched with complex tasks and simple functions are used only with simple tasks. Table 3 provides a summary of selected publications in this class of research.

Study	Theoretical bases	Independent variable/s	Dependent variable/s	Moderating/ Mediating variables	Key findings
Smelcer, and Carmel, 1997	Cognitive fit Proximity Compatibility Principle	Media type (map, table) Geographic relationship (adjacency, proximity, containment) Task difficulty (low, medium, high) User (spatial visualization ability)	Problem solving time Problem solving accuracy	None	Maps generally produced faster problem solving (time) than tables. Spatial visualization ability had no effect on decision performance.
Dennis and Carte, 1998	Cognitive fit	Media type (map, table) Geographic relationship (adjacency, containment)	Decision time Decision accuracy	None	Decision makers using a map-based presentation made faster and more accurate decisions when working on a geographic task in which there were adjacency relationships among the geographic areas. Decision makers using a map-based presentation made faster but less accurate decisions when working on a geographic task in which there were no relationships among the geographic areas.
Swink and Speier, 1999	Complexity theory	Task (problem size, data dispersion, data aggregation) User (Spatial orientation)	Decision time Decision quality	None	Spatial orientation ability was significantly correlated with decision quality. Decision performance was superior for smaller problems.
Mennecke el al., 2000	Cognitive fit	Subject characteristics (professionals, students) Media type (SDSS, No SDSS) Problem complexity (low, medium, high)	Decision time Decision accuracy	Need for cognition	SDSS increased the efficiency of users working on more complex problems. Professionals were found to be more accurate but less efficient than students; however, professionals who used the SDSS were no more accurate than professionals using paper maps

Jarupathirun and Zahedi, 2007	Task technology fit (TTF) Goal setting Self-efficacy	Spatial Abilities Perceived difficulty of goal Expected decision quality Expected decision efficiency Self efficacy	Decision satisfaction SDSS technology satisfaction Perceived decision quality Perceived decision efficiency	Perceived task technology fit Perceived goal commitment	Perceived task technology fit and perceived goal commitment have a major role to play in the perceived performance of SDSS, decision satisfaction, SDSS satisfaction, perceived decision quality, and perceived decision efficiency. Spatial abilities do not have any impact on perceived TTF.
Gu and Wang, 2009	Task technology fit Big Five personality traits	Extraversion Neuroticism Agreeableness Conscientiousness Openness	Perceived decision quality Perceived decision efficiency	Perceived task technology fit	Perceived task technology fit determines perceived decision efficiency. Openness trait influences perceived task technology Agreeableness trait influences perceived task technology
Ozimec, et al., 2010	Sign system Gestalt theory Guided search theory	Type of map Type of Symbol	Decision efficiency Decision accuracy	Symbol overload handling Task complexity User characteristics Time pressure	Type of symbolization strongly influences decision performance. Graduated circles are appropriate symbolizations for geographical information systems thematic maps, and their successful utilization seems to be virtually independent of personal characteristics, such as spatial ability and map experience. This makes circle symbolizations particularly suitable for effective decision making and cross-functional communication
Erskine, and Gregg, 2013	Cognitive fit	Geospatial reasoning ability Perceived task technology fit	Decision time Decision accuracy	Task complexity	Geospatial reasoning ability impacts decision-performance positively. Problem complexity and presentation complexity impact decision-performance

Table 3. Studies of decision making performance utilizing GIS

With variation in effect size, studies in Table 3 demonstrate that GIS improves spatial decision making in terms of duration (time to arrive at a decision) and quality (accuracy of decision) especially for more complex and unstructured decisions. Results are conflicting regarding the effect of spatial skills on decision performance. While studies in Table 3 emphasize the positive effects of GIS, they are limited to the individual level and focus on the decision making process only. Next, the research turns to the "system use" literature to understand how "GIS use" can be studied and what dimensions are relevant for studying this construct.

2.3 System Usage

Peter Drucker, a prominent management scholar, often said, "if you can't measure it, then you can't manage it." The initial goal of any computer system is to be used by its designated targets. To assess that goal, system usage should be measured. System usage (system use, IT usage or sometimes called IS usage) deals with a core pillar of the "information systems" discipline, the system. System usage has been a central theme of discussion in the discipline for decades (Bokhari, 2005). System usage is a key construct used in a plethora of theories, frameworks and models in the discipline as a dependent, independent, moderating or mediating variable (Burton-Jones and Straub, 2006).

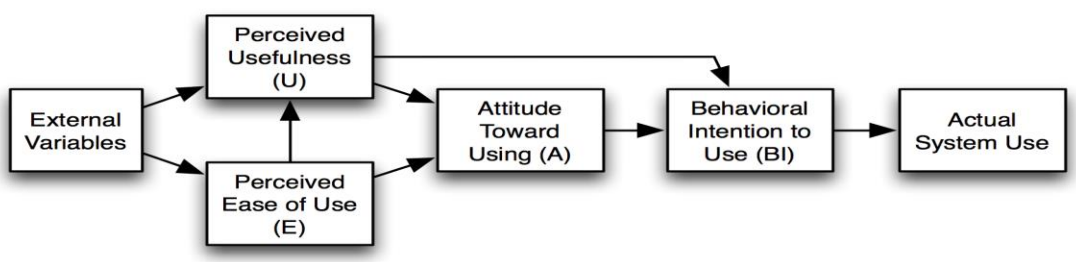


Figure 3. Technology Acceptance Model (Davis, 1989)

System usages have been applied in the domain of IS success, IS implementation, IS decision performance, technology acceptance and system performance (Burton-Jones and Straub, 2006). System usage is a "pivotal construct in the system-to-value chain that links upstream research on the causes of system success with downstream research on the organizational impacts of information technology" (Doll and Torkzadeh, 1998). System usage has been applied in the Technology Acceptance model (TAM) as the dependent variable (Figure 3) while in the IS success model system use is an independent or mediating variable (Figure 4). System use is also a key construct on the IT artifact nomological network (Benbasat and Zmud, 2003).

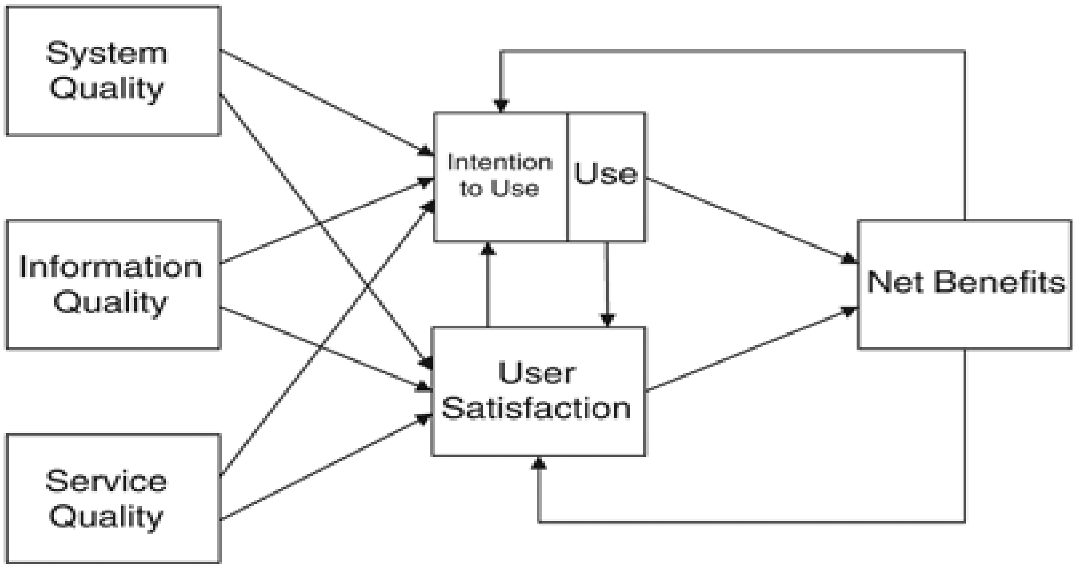


Figure 4. Updated IS Success Model (DeLone and McLean, 2003)

Despite the extended use of the construct in the literature, there is no agreed upon definition of system usage. DeLone and McLean (1992) define system use as the "recipient consumption of the output of an information system" where they focus on the output (information). Davis (1989) defines system use as the "intention to use a system" focusing on the intentions rather than actual use. Goodhue and Thompson (1995) define system use as the "behavior of employing technology in completing tasks" highlighting the technology and task dimensions of system usage. Burton-Jones et al. (2006) provide a more comprehensive definition of system usage from the individual level as an "individual user's employment of one or more features of a system to perform a task."

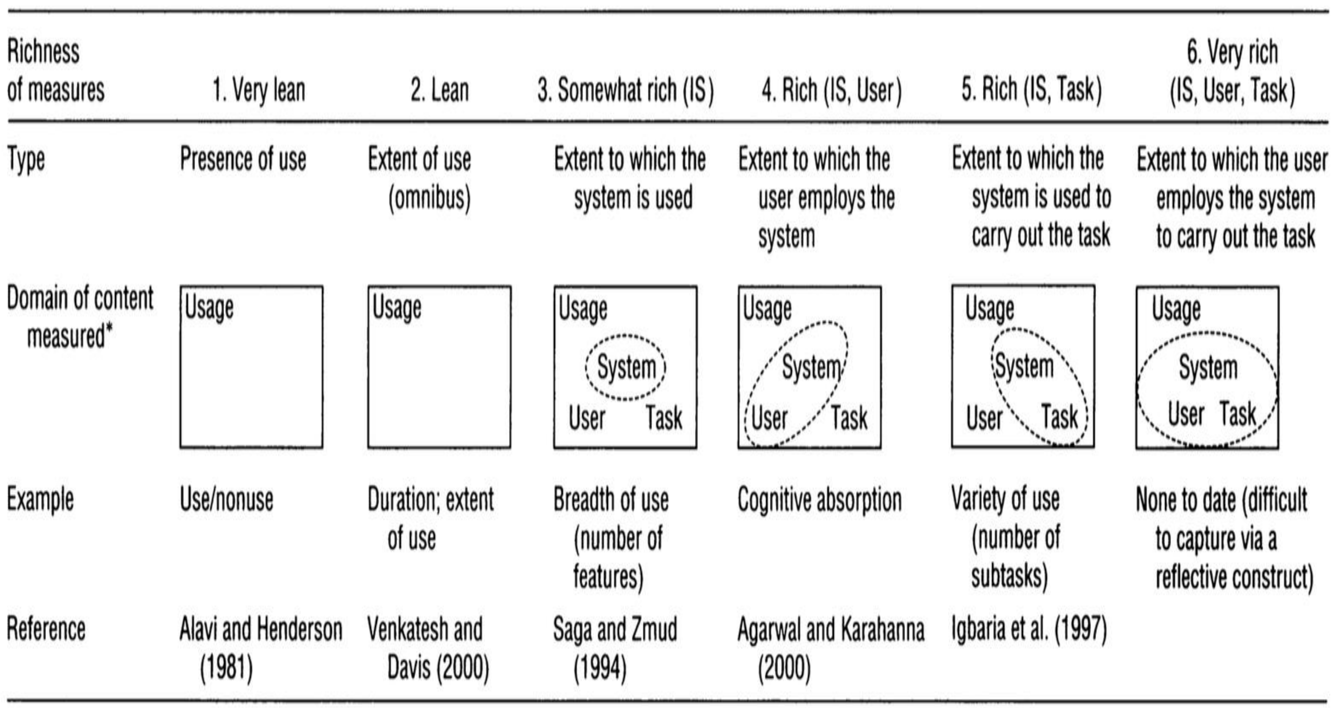
Diversity of definitions, interpretations and conceptualizations of system usage led to diversity of measurements. Table 4 illustrates some of the measures used for system usage in the literature. Most of these were behavioral studies measuring use at the individual level for technology acceptance and success.

Measurement	**Operationalization**
Extent of Use	Number of reports or searches requested; number of information systems, sessions, messages; users' reports on light and (or) heavy users
Frequency of Use	Frequency of report requests; frequency of information system Use: daily, weekly and so forth
Proportion of Use	Number of applications of information system used; total number of visits per Use; percentage of times information system is used to perform a task; percentage of Use of a particular information system
Duration of Use	Amount of time spent; connect hours; how many times a day and (or) week; duration of Use via system logs
Productivity of Use	Number of projects completed
Recurrence of Use	Use the system repeatedly; number of times of reuse of the system
Nature of Use	Types of reports requested; general versus specific Use; appropriate Use; type of information used
Method of Use	Direct versus indirect or chauffeured Use
Decision to Use	Use versus no Use
Voluntariness of Use	Voluntary versus mandatory
Variety of Use	Number of business tasks supported by the information system; the variety of applications
Specificity of Use	Specific versus general Use; utilitarian versus hedonic Use; interpretive versus exploratory Use
Appropriateness of Use	Appropriate versus inappropriate Use
Acceptance of Use	How system is accepted; how reports are accepted
Dependence on Use	Degree of dependence on Use
Intensity of Use	Perceived intensity of using the system Motivation levels
Motivation of Use	Use versus no Use

Table 4. Measures of system use at the individual level (adapted from Felix, 2010)

As can be seen from Table 4, researchers have adopted a wide range of measures depending on the context and technology under study. This diversity of measures led to conflicting results on the impact of system usage on other constructs (Bokhari, 2005). Ten years after publishing their model, Delone and Mclean (2003) acknowledge the issues with measuring system use as they explain, “the problem to date has been a too simplistic definition of this complex variable” and call for more research that incorporates the different dimensionality of the construct. Devaraj and Kohli (2003) explain the inconsistency of system usage studies by noting that measurement relies mostly on self-reported usage, which is subject to many limitations, especially weak correlations with actual usage. A trend can be seen in recent publications to favor objective measures of system usage rather than subjective measures (perceived usage).

Recently, several researchers have offered suggestions for refining the system usage construct (Burton-Jones and Straub, 2006; Jasperson et al., 2005; Mclean et al., 2011; Sun and Zhang, 2005). Jasperson at al. (2005) points to the underutilization of IT systems and calls for incorporating system features in the operationalization of system usage research. Burton-Jones and Straub, in a widely cited paper, made an attempt at reconciling the literature on system usage by outlining three dimensions of system usage. Their conceptualization of system use is based on the assumption that it is a multidimensional and complex construct. The first dimension is called the user defined as an “individual person who employs a system in a task” (Burton-Jones and Straub, 2006). The second is the task “goal directed activity provided by the user” (Burton-Jones and Straub, 2006), and the third dimension is the system “artifact that provides representation of one or more task domains” (Burton-Jones and Straub, 2006) on a scale from lean to rich (Figure 5) depending on the objective of the research (Burton-Jones and Straub, 2006). Although their work is limited to the individual level, it can be further extended to the group or organizational level.



Richness of measures	1. Very lean	2. Lean	3. Somewhat rich (IS)	4. Rich (IS, User)	5. Rich (IS, Task)	6. Very rich (IS, User, Task)
Type	Presence of use	Extent of use (omnibus)	Extent to which the system is used	Extent to which the user employs the system	Extent to which the system is used to carry out the task	Extent to which the user employs the system to carry out the task
Domain of content measured*	Usage	Usage	Usage System User Task	Usage System User Task	Usage System User Task	Usage System User Task
Example	Use/nonuse	Duration; extent of use	Breadth of use (number of features)	Cognitive absorption	Variety of use (number of subtasks)	None to date (difficult to capture via a reflective construct)
Reference	Alavi and Henderson (1981)	Venkatesh and Davis (2000)	Saga and Zmud (1994)	Agarwal and Karahanna (2000)	Igbaria et al. (1997)	

Figure 5. System use measures (Burton-Jones and Straub, 2006)

Research on organizational system usage is scarce. Organizational system usage investigates the collective use of a system by the organization as one unit. Massetti and Zmud (1996) offered a comprehensive operationalization of organizational usage in the context of Electronic Data Interchange (EDI) as volume (extent of documents exchanged via EDI), diversity (types of business documents handled by EDI), breadth (EDI connections with trading partners), and depth (business process tied with trading partners through ED). Other researchers have picked up this conception and utilized it for ERP (Jonas and Bjorn, 2011) and mobile commerce usage (Picoto et al., 2014). This research uses the ideas of Massetti and Zmud (1996) and adapts them to GIS in the manner of Jonas and Bjorn (2011) by focusing on the functions and products of GIS utilized (diversity); percentage of core and support processes supported by GIS as well as ratio of users and departments using GIS (volume); usage agreements with outside agencies (breadth); and level of management supported by GIS (depth). Igbaria et al. (1996) among many casual links, examined the association between organizational usage and system usage (individual use of a microcomputer). They measured organizational usage narrowly by asking individuals to rate the level of microcomputer usage by their supervisors, peers and subordinates on a scale from 1 (very low) to 5 (very high). Weak connection was found between organizational use and individual use (Igbaria et al., 1996). Other researchers represented organizational usage in a performance related manner as “how extensively systems are used by individuals to perform certain organizationally relevant functions” by measuring the extent of using IT for decision support (problem solving and decision rationalization), work integration (horizontal and vertical) and customer service (Doll and Torkzadeh, 1998). Tu (2001) utilizes Doll and Torkzadeh (1998) measure in the manufacturing context which system usage becomes a measure of operational decision support, strategic planning support, internal integration and external integration. Devaraj and Kohli (2003) take a distinct approach by examining objective measures of individual use. Devaraj and Kohli (2003) defined organizational usage as the aggregate of individual use specified as the number of reports generated, number of records accessed, and CPU processing time (monthly data) to assess the payoff of a DSS for hospitals. It was found that “technology usage [DSS] was positively and significantly associated with measures of hospital revenue and quality, and this effect occurred after time lags” (Devaraj and Kohli, 2003). Chang et al. (2010) echoes Jasperson’s et al. (2005) line of thought, and employs an organizational system usage measure exclusively focused on a real estate system features. Ruivo et al. (2012) used the ideas of Devaraj and Kohli (2003) in the context of ERP where they measured organizational system usage by the number of employees using the system daily, percentage of time per day that employees spend on the system, and the number of reports generated per day. A positive link was found between ERP use and ERP value (Ruivo et al., 2012). These measures establish good grounds to understand organizational usage, however they apply more to the private sector and in this research the focus is on public organizations. Thus, a new measure is needed that benefits from these existing measures and applies them to the public sector, which this research provides.

From a different angle, Pearson and Shim (1995) follow the logic of Ariav and Ginzberg (1985) to understand the environment in which a DSS system is used and the factors that form this environment. Ariav and Ginzberg (1985), advocate for a systematic view in order to understand the design of DSS. Ariav and Ginzberg utilize the systems theory proposed in part by Churchman West in 1979. The premise of the systems theory is that a system is composed of “environment, role, components, arrangement of components, and the resources required to support the system" (Ariav and Ginzberg, 1985 referencing Churchman, 1979). Ariav and Ginzberg call for a "holistic" view that integrates all the relevant environmental elements surrounding a system in an "outside-in" fashion. They stress the need to provide the characteristics of the environment that a system will operate within. They claim that the "systems perspective" has been forgotten in "much of the DSS literature" (Ariav and Ginzberg, 1985). Their main contribution is that the design of a system is contingent upon the environment it operates in and that, only after identifying this environment, can a system and its components be developed. According to Ariav and Ginzberg, the surrounding environment is made up of two dimensions: task characteristics and access pattern (Figure 6). Task characteristics incorporate the structure of the task supported (structured, semi-structured or unstructured), level of management supported, the decision phase supported, and the functional area implemented in (Ariav and Ginzberg, 1985). Access pattern involves mode of user interaction; number of users; experience with computers; experience in the problem area; role in the decision process; and level of integration with other systems (Ariav and Ginzberg, 1985). This research believes the systems theory and Ariav and Ginzberg's (1985) work is necessary for understanding the environment in which a GIS operates and gets used. Ariav and Ginzberg's (1985) work contains a mix of individual and organizational DSS environment factors; this research will employ only organizational environment factors.

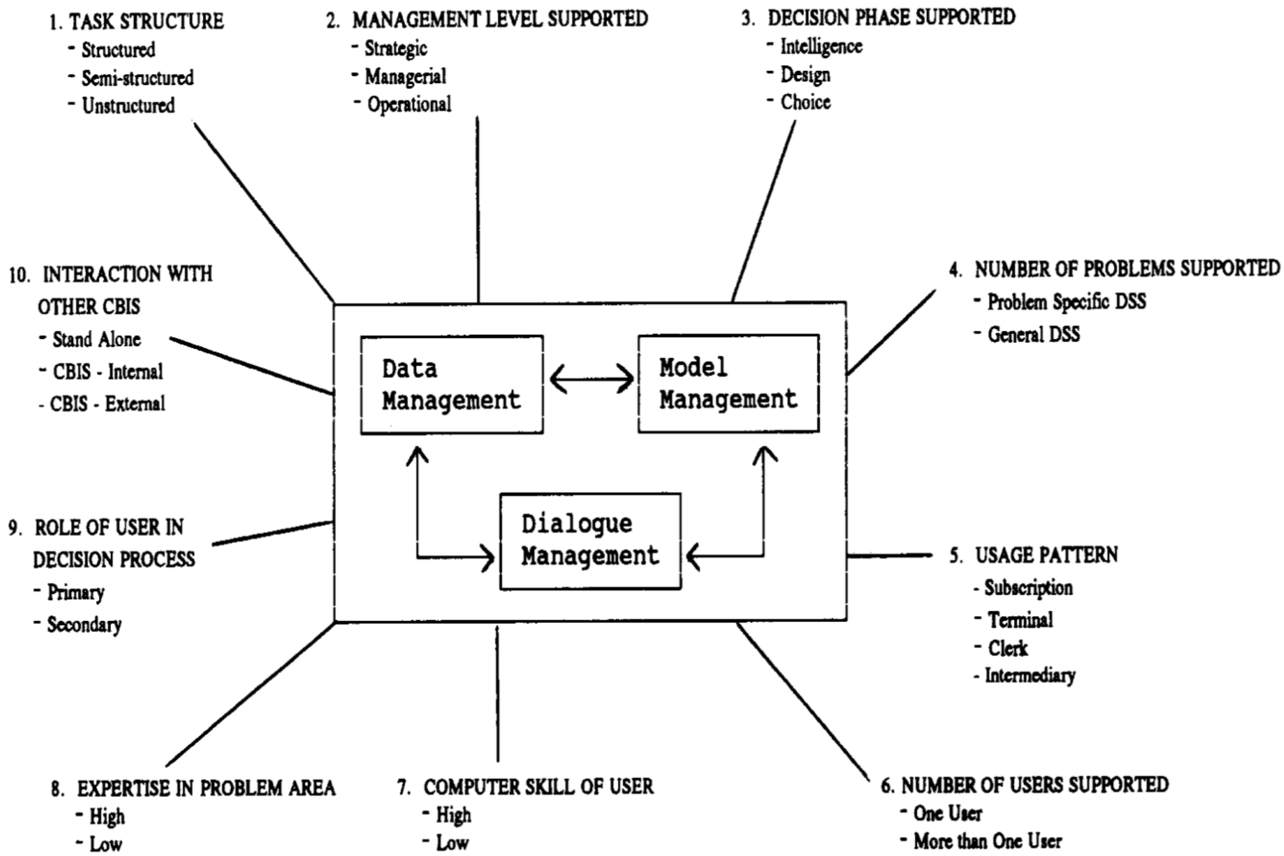


Figure 6. DSS environment (adopted from Pearson and Shim, 1995)

The research moves next to the literature of maturity models. This literature is relevant because the unit of analysis in maturity models is mostly the organization. In addition, the purpose of this research isn't to assign a single score of usage in a casual model but rather to identify the different levels of GIS usage. System usage literature failed to provide a comprehensive measure of organizational system usage thus we turn to maturity models to see if this field has considered organizational system usage.

2.4 Maturity Models

Oxford dictionary defines maturity as the "state of being mature; fullness or perfection of development or growth" (Wendler, 2012). Maturity models "describe and determine the state of perfection or completeness (maturity) of certain capabilities" (Wendler, 2012). Maturity models assume linear progression from a less mature state to a more mature one in a manner that can't be easily reversed or skipped (Lavoie and Culbert, 1978). Maturity models can be used to "assess the current state of competence, to set a roadmap for organizational improvement, and to assess the effects of development" (Mäkelä, 2012). Maturity is depicted as quality of a process, growth in some factor or an improvement in a capability (Mettler 2011). Maturity models in information systems attempt to describe the maturity of an object (quality of a process, technology, data, or management activities) through a sequence of stages (levels of maturity states from low to high) determined over a set of dimensions defined over some benchmark variables. Maturity models are built on the assumption that "a higher level of maturity will result in higher performance" (Boughzala and de Vreede, 2012), thus incremental development is the goal. Maturity models were developed in academia and then utilized by practitioners and consultancy firms due to their ability to simplify complex reality, making them helpful for diagnosing an organization's maturity. Maturity models have been applied to various domains such as e-business, e-government, business process, software engineering, knowledge management, information security, supply chain management, ERP, business intelligence and social media networks. Recent literature reports that there is an increase in the development of new maturity models (Poeppelbuss et al, 2011; Wendler, 2012), and there is still a need for this concept as "these models help managers to balance divergent objectives with regard to obtaining and retaining competitive advantage, assembling new products and services, reducing costs and time to market and enhancing quality" (Mettler et al., 2010). In fact, the success of Indian companies in outsourcing projects has been linked to their ability in certifying themselves as level five on the CMM model (Vom Brocke and Rosemann, 2010).

Maturity models began with Nolan's stages of growth (1973, 1979), Galliers and Sutherland (1991) revision of Nolan's model, then proliferated as a result of Carnegie Mellon's Capability Maturity Model (CMM) in 1995. Nolan's theory is that the expenditure on electronic data processing (DP) and growth of IT follows an S curve with three identifiable change points and progresses from the stage of initiation, contagion, control, to finally the stage of maturity. In addition to IT spending, Nolan postulated that growth can be assessed by examining the scope of the application portfolio, focus of the DP unit, DP planning and control and user awareness

(Nolan, 1973). Nolan later added two more stages, namely data administration and integration (Figure 7). Nolan assumes that organizations pass through a number of predetermined stages in using and managing IT (Galliers and Sutherland, 1991).

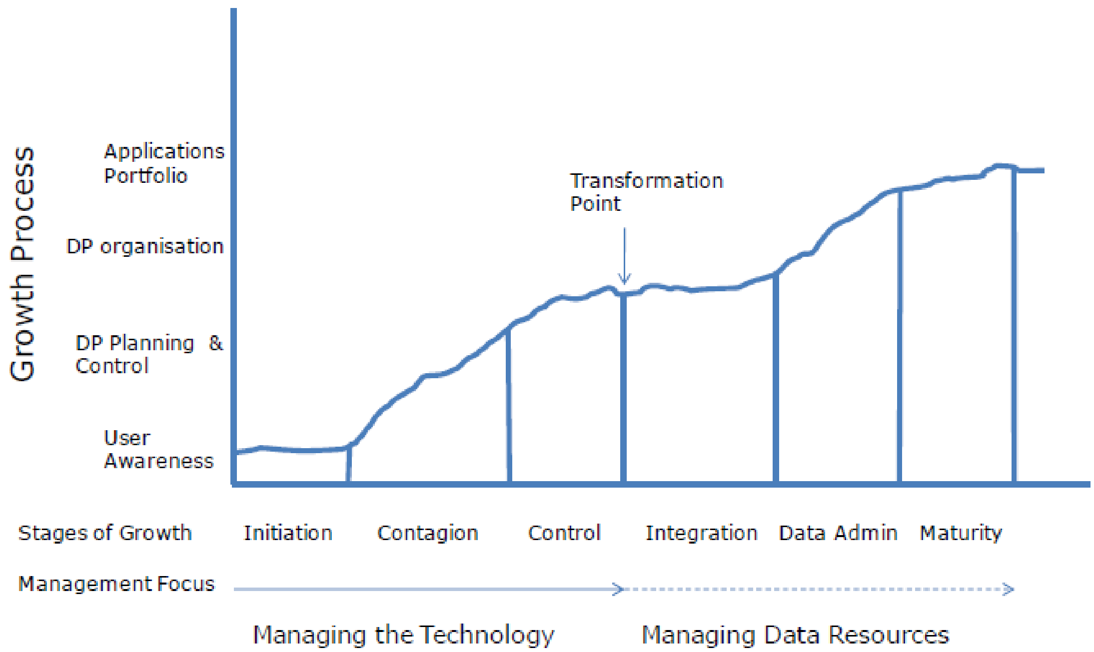


Figure 7. Nolan's stages of growth (adopted from O'Neill, 2013)

By far the most influential maturity model in the field is the 'Capability Maturity Model (CMM) and Capability Maturity Model Integration (CMMI) proposed by the Software Engineering Institute in 1993 to evaluate the quality of the software design process (Paulk et al., 1993). The CMM focuses on optimizing the software development process through documentation, performance measurement and control. The CMM provides "a conceptual structure for improving the management and development of software products in a disciplined and consistent way" (Paulk et al., 1993). CMM allows an organization to assess their software process maturity and plan for development. CMM outlines five stages of maturity namely initial, repeatable, defined, managed and optimizing (Paulk et al., 1993). For each level of maturity, CMM supplies key process areas, common features and key practices. CMM relies heavily on formality, bureaucracy, consistency and standards for the success of the process rather than depending on the heroics of individuals.

Maturity models in general face a core problem with “maturation, that is, the process of becoming more mature has been understood rather vaguely as a term that is associated with organizational development toward the better” because the theoretical foundation is weak (Poeppelbuss et al., 2011). Between the years of 2009-2010, sixty-two articles were published that discussed or introduced a new maturity model (Wendler, 2012). Despite that validation and evaluation of these models remain a concern due to the overreliance on qualitative case study methods (Wendler 2012, Solli-Sæther and Gottschalk, 2010). Despite their popularity, maturity models have received many criticisms including:

1. Oversimplifying reality as step-step recipes (de Bruin et al., 2005)
2. Proliferation of new and similar models in the same domain that don’t use an existing body of knowledge (Becker et al., 2009)
3. Hard to justify CMM use for smaller companies (Mettler and Rohner, 2009)
4. Overreliance on conceptual models with no empirical validation (de Bruin et al., 2005)
5. Too generic and too comprehensive (Patas et al., 2013)
6. No documentation for the development process of creating the model (de Bruin et al., 2005; Mettler, 2009)

In face of these criticisms, many maturity model design methodologies and guidelines have been developed over recent years and gained support from the community of interest. These methods will be discussed later in Chapter 4. The research will show how the chosen methodology mitigates these criticisms and problems.

Although there have been about 128 new maturity models developed over the past years (Wendler, 2012), this research was able to identify only one paper in the IT maturity literature that discussed usage maturity (Holland and Light, 2001) which is shown in Figure 8.

Constructs	Stage 1	Stage 2	Stage 3
Strategic Use of IT	- Retention of responsible people - no CIO (anymore) - IS does not support strategic decision-making	- ES is on a low level used for strategic decision-making - IT strategy is regularly reviewed - ES Importance is high	- Strong vision - IT strategy through whole organization - CIO in the senior management team
Organizational Sophistication	- no process orientation - very little thought about information flows - no culture change	- significant organizational change - improved transactional efficiency	- process oriented organization - top level support and strong understanding of ERP-implications
Penetration of the ERP System	- the system is used by less than 50% of the organization - cost-based issues prohibit the number of users - few formalized training - staff retention	- most business groups / departments are supported - high usage by employees	- truly integrated organization - users find the system easy to use
Drivers & Lessons	Key drivers: - priority with management information - costs Lessons: - mistakes are hard to correct - high learning curve	Key drivers: - reduction in costs - replacement of legacy systems - integrating all business processes - improved access of management information	Key drivers: - single supply chain - replacement of legacy systems
Vision	- no clear vision - simple transaction processing	- performance oriented culture - internal and external benchmarking	- higher level uses are identified - other IT systems can be connected

Figure 8. ERP usage maturity model (adopted from Steghuis, 2005)

Holland and Light proposed a usage maturity model for ERP use where they examined the consequences of maturity (result) instead of examining the antecedents of maturity (quality of process, capability or infrastructure). Holland and Light (2001) proposed five dimensions for ERP usage maturity (strategic use of IT, organizational sophistication, penetration of the ERP System, drivers and lessons and vision) over three stages. This research utilizes this model as a foundation for building a GIS usage maturity models. This research envisions GIS ultimately as an enterprise system and thus the Holland and Light model serves as a relevant model. The research intends to keep the same number of stages but provide dimensions from GIS and local government domains as the Holland and Light model has a private sector concentration.

2.4.1 GIS Maturity Models

GIS has its share of maturity models. This research was able to locate twelve different maturity models between the years 1996-2014. These models were developed by academics, experts, institutions and consultancy firms. Not surprisingly, most of the models were developed and applied to local government due to its long historical use of GIS, and thus many variations of maturity would be expected. Although the context is similar for these models (local government), they measure GIS maturity from different perspectives (Karalopoulos and Kavouras, 2015). Table 1 summarizes the available GIS maturity models.

Marr and Benwell (1996) developed a four-stage model for GIS use and integration based on Nolan's four stages of development. They have attempted to quantify GIS maturity in a computational formula (rather than dimensions of stages) using six variables, namely the degree of acceptance of GIS in the organization; the department responsible for GIS; the number of departments in the organization using GIS; the number of the uses which GIS is assisting; the population base of the local government organization; and the age in years of the GIS implementation. They have found that "the number of uses of GIS, the number departments using GIS and the age of the GIS, can be used in combination to form an approximate measure of GIS maturity in New Zealand local government" (Marr and Benwell, 1996). Although the Marr and Benwell (1996) model is closely related to the nature of this research, it doesn't provide a complete maturity model with description of the stages and dimensions covering the stages. However, their work provides unique variables for measuring GIS maturity from a usage perspective. Grimshaw discusses the evolution of GIS management strategies over five stages (based on Galliers and Sutherland, 1991 model) using seven elements (strategy, structure, systems, staff, style, skills and shared values) to describe each stage of which strategy, structure, staff, style, and skills are used as it relates to organizational usage of GIS (Grimshaw, 1996). Based on a longitudinal study, researchers have attempted to discover patterns in the long-term development of corporate GIS (Chan and Williamson, 2000). They presented a three-stage model. In stage 1, GIS demonstrates value through projects directly related with core services or products. As funding and top management commitment is acquired, a centralized and robust GIS is developed on stage 2. In stage 3, focus shifts to building GIS capabilities (Chan and Williamson, 2000).

Linda Tomaselli proposed her own five stages of GIS maturity (GIS interest and awareness, GIS development begins, GIS acknowledgment, GIS support expands and enterprise GIS) by focusing on an individual's aspect (champions, enthusiastic implementers and users) of maturity.

She outlines the importance of having a GIS champion, using consultants, hiring qualified GIS staff, and breaking the barriers preventing departments from sharing spatial data (Tomaselli, 2004). Other researchers have developed another GIS maturity model (based on Nolan's 4-stage model) composed of four stages (early implementation, growth, control and stability) by focusing also on the human aspect of GIS (O'Flaherty et al., 2005) and highlighting the interplay between GIS implementation and SDI implementation. Van Loenen and Van Rij analyzed the evolution of GIS at the state and regional level, referred to as Spatial Data Infrastructure (SDI); they proposed a four-stage model (initiation, standardization, intermediary and network) building on Nolan's four-stage model with an organizational perspective (non-technical factors), encompassing six organizational factors, namely vision, leadership, communication, self-organizing ability, awareness and financial sustainability (Van Loenen and Van Rij, 2008). In the context of GIS usage at the local governmental level, vision of GIS and GIS awareness are important organizational factors and thus will be part of the maturity model.

Even Keel Strategies, a consulting firm, developed a 5-stage GIS maturity model (enthusiasts, departmental, centralized, integrated and enterprise) over five dimensions (alignment, data management, accessibility, integration and sustainability) to guide the way towards enterprise GIS (Mangan, 2008). The model uses 16 variables to assess maturity and relies on the integrations between GIS and the enterprise priorities (Mangan, 2008). Jaana Mäkelä offered a more comprehensive GIS maturity model made of six stages (decided case-specifically, separately governed, concentratedly coordinated, comprehensively managed, strategically optimized and innovative) depending on architecture, services, processes and capabilities as key areas (Mäkelä, 2012). Mäkelä's model assesses how mature an organization is in utilizing spatial data using 15 variables related to technical, organizational and social aspects.

URISA's GIS capability maturity model focused on optimizing the GIS operation (quality of GIS processes, enabling capability, and execution capability) and based their model on CMM under the assumption that a capability maturity model evaluates an "organization's ability to accomplish a defined task or set of tasks" (Babinsky, 2013). URISA's model contains 5 stages (ad-hoc, repeatable, defined, managed and optimized) specified by dimensions covering technology and infrastructure, data, process, staff and organizational structure. The model basically evaluates the GIS infrastructure and resources (called enabling capabilities) using a 7-point scale and the GIS processes (called execution ability) using a 5 level scale through a total of 45 questions (Babinsky, 2013). Exprodat, a GIS consulting firm in the petroleum industry, proposed a five stage (initial, recognizing, defining, managing and optimizing) GIS maturity model based on CMM specified over six dimensions namely business awareness and governance, spatial data management and integration, technology, training, support and use of GIS (Exprodat, 2013). Giff and Jackson (2013) take a comprehensive approach to the governance of GIS and propose six levels of geospatial data maturity over five dimensions of organizational structure, information management, technology, process and customer service. Kurwakumire evaluated GIS maturity in terms of benefits gained in a model of four stages (grass-root, intermediate, mature and integrated) in terms of information communication, improved availability of data and improved access to data (Kurwakunire, 2014).

Although all of these models aim at describing maturity of GIS, it was not always clear what was “maturing.” Is it the technology, infrastructure, process, management of GIS, or service provided by GIS? Although some of these models aim at describing maturity in using GIS, their benchmark variables (process area, critical success factors, competency, capability or best practices) don’t correspond tightly with GIS usage. Some of those models cover such a wide range of perspectives that it’s questionable to label it as a maturity model when in fact they are more of an IT/GIS management framework. The purpose of maturity models is to develop a simple yet comprehensive method of diagnosing an organization’s maturity (Wendler, 2012), but except for URISA, none of the other models disclose the measurement tool.

Table 1 provides some of the limitations in existing GIS maturity models. Models in Table 1 assess the capability to use GIS but not actual usage. Some of these models are not empirically tested beyond the cases that formed the model. Another issue is that the measurement tool is missing, which limits its practical use. Except for Exprodat’s model, use of GIS is not considered part of maturity. Even Exprodat’s model does not provide details about how to measure GIS usage. Another important issue is that some of these models assess the state or countrywide maturity of GIS (SDI) while in this research the scope is the individual city or municipality using GIS. These models emphasize to a great extent the infrastructure, technology, data, management activities, and policies associated with GIS yet they place little emphasis on evaluating the actual usage and application of GIS. The organizational usage of GIS and the environment surrounding it has not been sufficiently studied and no measurement tool exists to date to measure organizational usage of GIS. The view of this research is that having a state-of-the-art quality operational GIS alone is not sufficient to indicate maturity. This research asserts that the actual use of GIS resources by the organization is a more accurate indicator of GIS maturity and thus it attempts to develop such a model.

There seems to be an agreement of the various GIS maturity models, that the ultimate and finale stage of GIS is the enterprise stage. The majority of the models also utilize stages of growth theory as opposed to the CMM. Although the unit of analysis for these models is the organization (Karalopoulos and Kavouras, 2015), current GIS maturity models haven't given organizational GIS usage sufficient focus. Current GIS maturity models have not examined usage broadly or in depth, lack empirical validation, and measurement tools to diagnose maturity are not readily available. The majority of the models focus on the qualitative nature of measuring maturity and less on the quantitative side (Karalopoulos and Kavouras, 2015). Although GIS maturity models do exist, they focus on the design (infrastructure, architecture, technology or data), process or the organizational aspect of managing GIS. Moreover, the value created as a result of GIS use hasn't yet been considered a part of the GIS maturity cycle. Most of the models introduced are conceptually formed. Even if empirically validated, measurement is lacking. Current GIS maturity models don't have a clear definition of GIS maturity.

2.5 GIS Studies in Local Government

Studies in this category explored empirically the use of GIS in local government. The research looked at published articles that were accessible. These studies examined different phases of GIS deployment from diffusion, implementation, success, barriers, data sharing and use.

French and Wiggins (1990) studied the introduction of GIS and CAD in California planning agencies (a total of 35 both counties and cities). They report low usage of GIS in advanced applications such as land suitability analysis (used in only 8.6%). They find a significant correlation between the time GIS was introduced and the number of GIS applications. They also find a correlation between adopting GIS and the size of organization (in terms of land, population and budget), in that bigger cities are more likely to adopt GIS than smaller cities. They also find more applications and data sharing for those using GIS compared to their counterparts using CAD.

Croswell (1991) performed a literature review of the obstacles to GIS implementation's success. He grouped the reported factors in 11 categories named as fear of change, funding, management support, coordination and conflicts, training, staffing, software issues, network issues, data management problems, standards and other. At that time standards problems were most significant compared to low importance of technical problems. He also supplied a set of maxims to confront these obstacles in two directions; internally, inside the organization to manage GIS projects and externally, to the societal community of GIS to raise awareness and knowledge.

Calkins and Obermeyer (1991) created a taxonomy to survey the use and value of GIS in the decision making process. They begin nicely with a framework to understand the role of GIS in decision making which starts from the object's spatial characteristics, data preparation, GIS processing, manipulation of GIS data to information, analysis and modeling, predictions and projections that translates finally to products of decision making in decision rules. They lay out 24 questions loosely grouped under six categories. The questions revolve around the characteristics of successful uses of GIS, benefits of GIS, effectiveness of GIS use, measurement of benefits, characteristics of GIS data and spatial analysis and organizational factors. The questions that pertain to GIS usage at the organizational level in local government are: those focusing on the purpose of using GIS (inventory, analysis, or decision support); the GIS capabilities required (display of geographic data, query, direct measurement, map overlay, network algorithms, and spatial models); users of geographic data or information (analyst, middle management, upper management, general public, or public opinion groups); and management level of user (operations, management, or policy) as described in Calkins and Obermeyer (1991).

Nedovic-Budic (1993) studied the adoption and use of GIS in local governments of Florida, Georgia, North and South Carolina. She found that the use wasn't widespread and GIS is actually underutilized however adoption was intensive. She reports that smaller populations were slower to implement GIS than bigger cities. GIS was used primarily for mapping and that GIS usage depends on how comprehensive the GIS database was. Obstacles to GIS use were lack of funding and lack of professional expertise with GIS. She found that in 50% of the surveyed governments, GIS was used in only a single department. An interesting finding of the study was that the average number of departments using GIS was four when a GIS department was present. However, the average number of departments using GIS when there was no GIS department decreased to 1.5 and the difference was statistically significant.

Onsrud and Pinto (1993) examined the factors of GIS adoption success using a survey of local governments from their GIS vendors. They examined interpersonal, organizational and institutional variables that affect the decision to acquire, implement and use GIS. They conceptualized GIS success as use (measured by a user satisfaction as a proxy) and perceived value. They found that ease of use, cost, utility (visibility of GIS impact) and past technology failures are predictors of GIS use. They found that the existence of a GIS champion is important to acquire GIS only and not on usage. They also found that GIS consultants play an important role in the success of GIS.

Ventura (1995) used his experience with GIS implementation in Wisconsin's local governments and related literature to talk about GIS use in local governments. He observes that complex GIS analysis and ad-hoc decision making rarely happens, and that use is mainly limited for mapping. He supports Croswell's argument that organizational (people problems) and institutional (e.g. funding) constraints are more profound than technical obstacles. He calls for customizing GIS for the needs of each local government.

Brown (1996) surveyed 88 of URISA's local government members on the constraints of GIS success. She found that 53% of the hurdles were organizational (staffing, leadership, commitment, planning, change management and conflicts), funding constraints and lastly technical problems accounted for only 7% of the constraints. She also found that decision-making coordination using GIS was difficult to achieve.

Nedovic-Budic and Godschalk (1996) investigated the human factors in GIS diffusion in four case studies of local governments. By using the individual user as the unit of analysis, they found that willingness to use GIS was associated with perceived relative advantage, computer efficacy and networking. They report that organizational conflict and instability control the decision to use GIS. Other factors that influence individual GIS use include state mandate, funding, management support and commitment, size of the organization, training and including users in system design.

Sieber (2000) observed GIS implementation models in grassroots organizations in California over a period of five years in four cases. She observed differences between grassroots and local government's implementation of GIS mainly in funding, structure and top management commitment. She outlines 4 models of GIS implementation, namely an organization that wants complete GIS in house, information only, shared GIS with a consortium and GIS for an individual user only. She observes poor system use in all cases.

Borges and Sahay (2000) report on an exemplar case of GIS implementation in a city in Brazil. They attribute success in the case to long-term plan of GIS, the existence of a GIS department with unique team skills (programming, analysis, geography and design), the existence of a champion from top management, a holistic and integrated database, user interaction and relationship building.

Kohsaka (2000) shared the experience of GIS use in local governments of Japan. He reports that some governments that have invested largely in GIS hardly used them and in fact over the years 26% of governments withdrew from using GIS mainly due to cost, difficulty with software in updating spatial data and standardization of scales. GIS is used more in big cities and only moderate results have been obtained so far. More successful uses have been reported in routine process compared to ad-hoc and the author interprets that to utility, as ad-hoc use loses its value once the situation is resolved where routine process continues to payoff. The author points to a need for GIS specialists.

Turner and Higgs (2003) surveyed 74 of UK's local governments to evaluate "joined up governments" initiative and identify trends in using GIS for e-government purposes. They report that GIS use has moved beyond single departments as compared with previous studies in the UK. They also report that 32% of surveyed governments provide citizens with some of the GIS data.

Higgs et al. (2005) focused on healthcare use of GIS in the UK. They explored through survey behavioral, cultural and organizational factors in GIS diffusion. Overall, consistent with previous research, GIS use is mainly for map production. Few organizations have a GIS strategy. Barriers identified in GIS use include time constraints, funding and staffing.

Baban and Ramlal (2006) examined GIS use in 33 local governments of the UK and Trinidad and Tobago. Their main claim is that GIS success (conceived as usage) depends on the GIS implementation approach (technology led, business led, top down or bottom up). They were among the first in the field to propose a measure of GIS usage that included number of departments using GIS, number of tasks where GIS is used, human commitment, number of GIS users and awareness of GIS potential. Overall, again consistent with the literature, low usage of GIS is observed.

Esnard (2007) studied the organizational and institutional barriers to the use of GIS in community-based organizations for environmental protection in Northern California. Reported barriers from the survey and interviews include lack of GIS mission, GIS skills shortage, no apparent need for GIS, GIS awareness and staffing issues.

Weir and Bangs (2007) explored the use of GIS by crime analysts in the UK. They report that GIS is used more for descriptive analysis (to pin crimes on a map) and less for problem solving (patterns of crimes, intervention evaluation, proactive rather than reactive analysis). Reported barriers to GIS use include training and quality of data.

Convery and Ives-Dewey (2008) surveyed 67 local governments in Pennsylvania about their use of GIS. GIS use was measured by frequency of use (daily, weekly, monthly etc.), purpose of use, type of users and GIS staff. They found that the existence of a GIS champion and securing enough funding are predictors of successful GIS implementation and perceived effectiveness of GIS. Again they report that GIS isn't being used to its full potential.

Hussain and Johar (2010) detail the experience of GIS use through a case study of a planning department in Malaysia. They use a socio-technical framework for their analysis, which includes the organizational context, people, change and instability, centralization and decentralization and the state of computer based development. They found that the decision to use GIS is predicted by skills, knowledge and training. Again, consistent with previous work, despite the widespread availability of GIS, the potential isn't being exploited fully although decent use of GIS in tactical decision-making is reported. Hurdles include language barrier, data updating and lack of GIS skills.

Göçmen and Ventura (2010) surveyed 265 planning departments in Wisconsin about barriers to GIS use. They examined technological, organizational and institutional barriers. Most mentioned barriers were training, funding and data problems. Fear of change and top management support are no longer a barrier. When examining advanced use of GIS in particular, training, funding, accurate data, awareness of GIS and length of time with GIS stand out as predictors. They report low usage for spatial analysis, alternative scenario valuation and modeling. Still, basic use of GIS is more common.

Olafsson and Skov-Petersen (2014) surveyed 89 local governments in Denmark about GIS use for recreational trail planning. They measured use by the extent of daily use by participant, purpose of use, the presence of a dedicated GIS department and the planner's use of GIS. They found that 86% have a dedicated GIS department. Reported usage is fairly high, barriers are less severe than reported in the literature (only 20% exhibited significant barriers in GIS skills, ease of use and awareness about the potential of GIS) and data problems are minimal.

Alrwais and Hilton (2014) paint a vivid picture of GIS usage from a case study of a city in California. The case provides an exemplar integration of GIS in the city's operations both tactically and strategically. High usage is attributed to unique GIS department structure, GIS staff skills, relationship building between GIS and other departments, championship and support from consecutive city managers, extended time period since GIS was introduced and a good relationship with the GIS vendor.

Ye et al. (2014) reexamined the barriers to GIS use through a survey of 22 individuals experienced with GIS and interviews. Reported barriers are organizational (training, awareness and funding) and technical (ease of use, data problems and terminology difficulty). Again low usage of advanced GIS capabilities is reported. The presence of a dedicated GIS department is claimed to improve GIS use.

Eldrandaly et al. (2015) provided a model for measuring GIS success post-implementation utilizing Delone and Mclean's model with some modifications. They surveyed 252 users of GIS in Egypt and abroad. The unit of analysis is the individual user. They measured GIS use by extent of use, possibility of doing work without GIS and the level of importance of decisions based on GIS information. They found GIS use to have significant effect on the individual and social benefits, however no effect was found on organizational benefits.

The majority of the studies in this stream of research were concerned with the factors facilitating or hindering adoption/diffusion and use of GIS (Brown, 1996; Göçmen and Ventura, 2010; Ventura, 1995). Case studies are used to present the experience of one organization using GIS (Alrwais and Hilton, 2014; Hussain and Johar, 2010) or surveys are used to provide a report on the extent of use (Higgs, Smith, and Gould, 2005; Olafsson and Skov-Petersen, 2014). The majority of these studies are "subjective accounts describing the benefits of GIS from a single-user perspective" (Brown, 1996); few have looked at the organizational level. Portions of the surveys are old and conducted outside the United States, which calls into question their current validity. More importantly, this research did not find any attempt to consolidate the findings of these studies into classifying GIS usage. In these studies, GIS use was rarely measured objectively from the organizational perspective. Each study emphasized only one part or dimension of GIS use while neglecting other dimensions of use. Still, this literature serves to provide some empirical GIS usage variables as well as identifying the environment surrounding GIS in local government settings.

2.6 GIS Value

A common method to evaluate the economic outcome of a business investment (project, program or policy) is through CBA analysis (Worrall, 1994). This analysis considers the ratio of benefits to costs and regards the investment a success if the ratio is greater than one (Nedovic-Budic, 1999). This type of analysis has been applied to evaluate GIS projects. But researchers have disputed the employment of cost/benefit analysis to evaluate GIS projects (Dickinson and

Calkins, 1988; Nedovic-Budic, 1999; Wilcox, 1990) mainly due to the difficulty of quantifying intangible benefits. Additionally, CBA and similar tools focus on the investment decision and business case for the private sector and as such, falls short of a comprehensive evaluation of a system in the public sector that isn't necessarily profit driven. In this research, hundreds of organizations will be surveyed and it is almost impossible to perform a CBA for each case. Moreover, this research aims at examining the intangible and societal impact of GIS, which CBA isn't adequate for.

Clapp et al. (1989) developed a framework for evaluating multipurpose land information systems (similar to a GIS) based on the Jordan and Sutherland (1979) program evaluation model. Clapp et al. (1989) developed four categories of benefits in a means-end hierarchy where each benefit is an input to the second level of benefits. The first level is the "operational efficiency", which measures the performance of the system (e.g. response time). The second is the "operational effectiveness", which measures the impact of information in satisfying the needs of users. The third level "program effectiveness" examines the employment of information in decision making and conflict resolution. The fourth category "well-being," explores the effect of the system on the society and citizens. Calkins and Obermeyer (1991) had developed another taxonomy of GIS value which incorporates questions as to whether GIS had an impact on time savings, increased productivity, avoidance of costs, reduction of risk and the development of new applications not possible without GIS.

Worrall (1994) focused on listing different costs and benefits associated with GIS. Efficiency benefits are listed as cost saving and avoidance, productivity gains, better services and increased income. Effectiveness benefits include better information quality, better analysis and resource allocation. Intangible benefits identified include reduced risk, data improvement, better access to data and overall improved service to customers. Listed costs associated with GIS include hardware, software, contracts, consultants, customization, training, networks, cost of reengineering processes, data costs and project management costs.

Brown (1996) labeled GIS value as GIS goals and listed them as improved interdepartmental coordination, enhanced productivity and performance, facilitated sharing of information, better long range planning, better service to the public, improved project management and facilitated decision making. Brown asked respondents to rate the importance of each goal on a scale from 1-5. The respondents of the survey rated data sharing goals as the most important.

Nedovic-Budic (1999) reviewed the literature on GIS impact from 1990-1998 and noted the mixed results of GIS effects and emphasized the importance of examining societal impact as a distinct dimension of GIS success. The Delone and Mclean (1992) model was used as a framework to review GIS impact literature. Nedovic-Budic (1999) examined organizational effects of GIS in terms of efficiency gains and a system's effectiveness.

Tulloch and Epstein (2002) consider three categories for examining the benefits of multipurpose land information systems. Benefits coincide with the development stage. In the record keeping stage, efficiency gains (in terms of time, cost and productivity) are most prevalent. In the analysis stage of development, effectiveness (quality of information, process and decision) benefits occur. Once an organization reaches the democratization stage then equity (empowerment, public access, social justice and quality of life) benefits start to occur. Danziger and Anderson (2002) assessed the overall effect of IT in government by differentiating the effects on the individual level and the collective level over four categories of capabilities, interactions, orientations and value distribution.

Joffe (2003) takes a practical approach to outlining GIS benefits. Revenue for GIS is generated through accurate taxation on properties and land, extra revenue from accurate land information, funding from grants where GIS is the main actor, subscriptions from usage fees, selling GIS capabilities externally, cost savings as a result of fraud detection and reduced insurance and selling GIS capabilities internally to requesting departments. The theme is that GIS generates value once it is distributed then used.

Pick and Shin (2008) focus on measuring GIS value at the process level for private business using sense-making theory. Maguire et al. (2008) details the steps of preparing a return on investment (ROI) document to justify the business case for GIS on project selection decisions.

Kurwakumire (2014) developed an evaluation model for measuring the success of GIS based on field data from local governments of Uganda. Three categories of benefits develop over four stages. Information communication starts with basic mapping, planning, inclusion in reports, then ultimately in policy presentation. Improved availability of data goes from framework data, sector data, and application data to geospatial products and services. Next, improved access of data transitions from paper and CD-ROM format, online services, data accessibility online and finally to geospatial portals.

Eldrandley et al. (2015) divided GIS value on three levels, namely individual, organizational and societal. Individual benefits are time saving, accurate and quicker decision-making and increased awareness and understanding of the problem. Organizational benefits in terms of efficiency and effectiveness include cost savings and avoidance, productivity increase, increased revenues, better quality of services, better information and a more satisfied work force. Societal benefits are framed as equal access to information, public participation in decision making, improved standards of health and safety, economic prosperity and better services to citizens.

Akingbade et al. (2009) reviewed the literature on GIS impact from 1998-2008, which yielded 38 articles. They claim that a CBA analysis would be inadequate to measure GIS value as it captures only tangible benefits of GIS and thus they draw upon the related work of Clap et al. (1989), Danziger and Anderson (2002) and Tulloch and Epstein (2002) to propose a taxonomy of GIS impact. Akingbade et al. (2009) categorized GIS value into gains in efficiency, effectiveness and societal well-being (Figure 9). It was found that 56% of the literature examined efficiency impact of GIS (45% positive impact, 18% negative, 32% mixed), 39% examined effectiveness benefits (26% positive, 18% negative, 18% mixed) and only 5% of the literature paid attention to social impact of GIS (3% positive, 5% negative, 3% mixed). Akingbade et al. (2009) corroborated the work of Nedovic-Budic (1999) in that the results of the societal impact of GIS are inconclusive and required more investigation.

Taxonomic designation	Definition	Impact issue
Contribution to efficiency	The degree to which GIS operates with minimum waste, duplication, and expenditure of resources (Stone, 2002).	1. Availability and accessibility to products and services 2. Cost (monetary and nonmonetary costs associated with utilizing a service or buying a product) 3. Coverage and completeness 4. Data acquisition capability 5. Data storage capability 6. Time-saving
Contribution to effectiveness	The extent to which GIS has contributed to the satisfaction of information needs, in adequate quantity and quality of data and decision-making process.	1. Adequacy of service relative to need 2. Improved planning, coordination and cooperation 3. Improved products and services 4. Job satisfaction 5. Potentials for conflict resolution 6. Support for quicker, more explicit articulation of decisions (improved decision support) 7. User satisfaction
Contribution to societal well-being	The degree to which GIS helps in the realization of collective goals of a society or impact of GIS on broad societal objectives such as "individual integrity, social justice, distribution of wealth and fulfillment of human aspirations" (Clapp et al., 1989; p42).	1. Citizen-public sector interactions (participation) 2. Economic benefits 3. Enhancement of principles of a democratic society, for example, freedom from constraints such as corruption 4. Improved standard of health and safety 5. Protection of legal rights, such as privacy (surveillance and confidentiality) 6. Social justice: fair treatment and a just share of benefits, for example equal availability of information to citizens when needed and equal ease of access

Figure 9. GIS value taxonomy taken from Akingbade et al. (2009)

Akingbade et al. (2009) defined efficiency as a "'ratio of outputs to inputs … expressed as cost savings, cost avoidance or productivity gains' (Nedovic-Budic, 1999), effectiveness as 'improvement in the performance of an organization's fundamental duties' (Tulloch and Epstein, 2002), and societal well- being as 'how GIS technology has transformed society and its way of dealing with human problems'" (Akingbade et al., 2009). Akingbade's et al. (2009) most recent work makes use of the related literature and measures GIS value objectively over the organizational level, and thus will be used in this research as a framework for measuring GIS value.

2.7 Summary

This chapter clarified relevant work to this research identifying the current body of knowledge and highlighting research gaps. Although these research streams are diverse, there was an overarching theme connecting them together with regards to the impact of technology. The research started broadly by looking at the research on the business value of IT, especially in the last four years. With continued investments and interest in new technologies and applications, it is still relevant to ask about the impact of IT. There is a consensus in recent research that IT does create value at some level under certain conditions and configurations. For GIS in particular, researchers were able to demonstrate that GIS does improve individual decision making in terms of decreasing the decision time and increasing the quality of decisions (accuracy). Research about individual decision making under GIS supports the link between GIS use and GIS value. However, it is limited to the decision making process and only applies at the individual level. Going broadly again to the research concerned with system use, we find different definitions and measures of system use and conflicting results on the individual level. Recently researchers have attempted to provide a consistent and comprehensive measure of system use. This research employs Burton-Jones and Straub's (2006) re-conceptualization of system use on the individual level and applies it at the organizational level. The systems theory is also used to guide the measurement of system use especially in defining the environment that a system operates within. This chapter has outlined the scarcity of research on organizational system use particularly for the public sector. IT maturity models evaluate the organization comprehensively as one unit to assess its maturity. This approach aligns perfectly with the objective of this research in assessing organizational use of GIS. The research found only one maturity model on "usage maturity" and uses it as a foundation for constructing a new maturity model. Existing GIS maturity models are explored and deficiencies have been identified. Studies on local government use of GIS are dated; rely on single case studies, for the most part; and are more concerned with barriers to use than in measuring usage holistically. Studies on GIS value classification have been examined and Akingbade et al. (2009) taxonomy was chosen for its recent nature, comprehensively incorporating related literature and recognizing the societal side of GIS.

In the next chapter, the research will show how these research streams will come together in forming a new GIS usage maturity model.

CHAPTER 3 – RESEARCH FRAMEWORK

This chapter describes the new GIS usage maturity model. The chapter begins with a justification for choosing three stages to differentiate the range of GIS uses. Description of each stage is then provided. Next the overall structure of the model is explained. The rationale connecting the five dimensions of the model is discussed and related theories and research is referenced. Then each dimension is defined and described. Indicators for each dimension are explained and relevant literature is referenced. Measurement for each indicator is outlined. After that a GIS value taxonomy is presented. The chapter concludes with the propositions and assumptions of the research.

3.1 Model Stages

Mayr (1995) defines GIS maturity as “the degree to which systems are actually used” while Giff and Jackson (2013) base their maturity model on geospatial information usage. Others propose that maturity is “linked to the level that GIS has been integrated and utilized on an organization wide basis in day-to-day activities” (Marr and Benwell, 1996). This research builds on the previous definitions of GIS maturity and defines GIS maturity as the “extent of usage and absorption of GIS resources and applications within an organization” and uses this definition as a foundation for the proposed model. Stages of the model will reflect on this definition for their formation.

The number of stages in a maturity model varies from roughly three stages of maturity in some models to six stages in other models. In describing the design process for developing maturity models, De Burin et al. (2005) argue that “the number of stages may vary from model to model, but what is important is that the final stages are distinct and well defined, and that there is a logical progression through stages.” In Chapter 2 it was mentioned that the Holland and Light (2001) model would be used as a foundation for constructing the new model and their model describes the usage maturity of ERP systems over three stages. Other researchers employ three stages (record keeping, analysis and democratization) to describe the use of a multipurpose land information system (MPLIS) post implementation (Tulloch and Epstein, 2002). Brodzik (2004) outlined three stages (infancy, intermediate and mature) to describe the evolution of enterprise

GIS. Roger Tomlinson, a pioneer in GIS, also uses three levels to define the scope of GIS in organizations as a single purpose project, department level application, or an enterprise system (Tomlison, 2007). John O'Looney, a specialist in GIS projects for local government, employs three phases (beginning, intermediate, and advanced) to describe GIS administration (O'Looney, 2000). Rebecca Somers, a GIS consultant, again uses the notion of three levels (business tool, data and service resource, or an enterprise) to describe the different organizational models of GIS depending on the role and scope that GIS plays (Somers, 1998). Chan and Williamson (2000) propose three stages of development to explain the patterns of a corporate GIS. Given the support for the notion of three levels to describe GIS components (Brodzik 2004; Chan and Williamson, 2000; O'Looney, 2000; Somers, 1998; Tomlison, 2007; Tulloch and Epstein, 2002), this research postulates that three stages named exploration, exploitation, and enterprise would be appropriate to describe the maturity in using GIS. Although there could be a stage before exploration, where a decision to purchase GIS is taking place and a use case is being considered, this stage is outside the scope of this work since GIS usage hasn't taken place yet. The notion of three stages is adopted to distinguish between heavy users (enterprise stage), light users (exploration stage) and moderate users (exploitation stage) of GIS. The model is based on the assumption that progression from stage to stage is cumulative and stages build on each other. In the following paragraphs each stage is described.

Exploration: In this stage the organization is investigating the benefits of GIS to its activities and the services it offers. GIS is used primarily to comply with regulations and to produce maps occasionally. Beyond that, development of GIS is led by individual enthusiasts eager to learn the technology and adapt it to their work. A more coordinated development occurs in the form of projects when new needs arise or as a reaction to an event. Recognition of GIS is very low outside the circle of planners and engineers and thus skills in using GIS are scarce. The use is not coordinated as departments work in silos with GIS and very little sharing of spatial data occurs. GIS specialists are distributed throughout departments (those who perform mapping in the planning, fire, or public works department). In some instances, the GIS could be maintained by an outside contractor (outsourced). Only the basic functionalities of GIS have been explored. The focus is on digitizing, data collection, and building base maps (framework data). GIS is used more as a data resource for record keeping. On other occasions GIS is used to replace manually produced paper maps and perform limited measurements (distance, directions, proximity, and buffering). As a result of duplicate data and distribution of GIS professionals throughout departments, spatial data reporting is rarely real-time.

Exploitation: The organization has recognized the importance of GIS in improving the performance of specific departments and processes (well-established processes where the need for GIS is evident). GIS is heavily used within these departments and has become a routine. Other departments (where geography is not a crucial part of their work) are beginning to exploit the functionalities of GIS. Duplication of effort still occurs as coordination remains low. A GIS coordinator or manager may exist but is usually controlled by a specific department (due to the hierarchy, as the GIS team might be positioned under the IT department for example), which limits the role that GIS can play in organizational development. However, GIS usage by operational management and field workers is widespread and is integrated with a fair number of processes. GIS in this stage acts as a "Service Bureau" meeting the needs and demands of other departments. Often this results in duplication of effort, and a staff that cannot possibly meet all of the demands of other departments. Slowly applications are modified to take advantage of GIS. Not all applicable processes are spatially enabled.

Enterprise: The organization has recognized GIS as a strategic asset (mission critical) that provides competitive advantage and is essential to the success of the organization in fulfilling its mandates. GIS is integrated with strategic planning. GIS is used extensively across the organization. Critical mass has been reached and the organization sees the benefit of a multi-purpose enterprise system beneficial to the whole organization. GIS is the glue that connects departments and processes together. Spatial information is used by senior management to make decisions and form policies. There exists a GIS department responsible for managing the spatial data for all the departments (central database and data model) to use and for providing the required services (solutions, applications, changes, and training). Processes are continuously reengineered to take advantage of GIS. Usage and sharing of spatial data is not limited to inside the organization. External usage (individuals and agencies) of GIS exists. Organizational changes are widespread to obtain the strategic value of GIS.

3.2 Model Dimensions

As illustrated earlier, Burton-Jones and Straub (2006) outlined the importance of using a rich measure for system usage that includes the system, task, and user at the individual level. This research takes this conceptualization of system usage and applies it to GIS usage but at the organizational level. Research on GIS has touched to some extent on these three dimensions (system, task and user). Calkins and Obermeyer (1991) suggest asking questions about GIS functions used (system) to evaluate the usage of GIS. Göçmen and Ventura (2010) also examine GIS functions to measure GIS usage. Others stress the need to examine the nature of tasks (processes, workflow, jobs, applications or procedures) where GIS is used (Baban and Ramlal, 2006; Calkins and Obermeyer, 1991; French and Winggins, 1990; Giff and Jackson, 2013; Mäkelä, 2012; Marr and Benwell, 1996; Nedovic-Budic, 1993). Researchers have also shown interest in asking questions about the type of users and departments using GIS (Baban and Ramlal, 2006; Calkins and Obermeyer, 1991; Convery and Ives-Dewey, 2008; Marr and Benwell, 1996). These three dimensions (system, task and user) are essential for measuring GIS usage, however they are not enough, as they are quantitative metrics, to measure extent of use but other qualitative measures are needed (How and why is GIS used? and how GIS is supported?). Burton-Jones and Straub's (2006) three dimensions of system usage were developed for measuring individual (single user) system usage, but this research deals with organizational system usage, which is more complex and requires additional dimensions.

To get to the other part of GIS usage, this research followed the logic of the systems approach (Churchman, 1979) in forming the model that in order to understand a system you have to inspect the elements that make up the system and the environment within which this system operates and the linkages between them. An important element of the environment surrounding GIS is the organizational configuration (strategy, vision, training, awareness and cooperation). Many researchers have acknowledged the importance of organizational factors in influencing GIS use (Brown, 1996; Calkins and Obermeyer, 1991; Croswell, 1991; Esnard, 2007; Göçmen and

Ventura, 2010; Higgs et al., 2005; Hussain and Johar, 2010; Onsrud and Pinto, 1993; Ventura, 1995; Ye et al., 2014). GIS maturity models have also considered the implication of organizational variables (Babinsky, 2013; Exprodat, 2013; Giff and Jackson, 2013; Grimshaw, 1996; O'Flaherty et al., 2005; van Loenen and van Rij, 2008). Given the support from the aforementioned research, this research considers the organizational configurations as an independent dimension of maturity. Several GIS studies indicated that having a dedicated GIS department influences the development of GIS within an organization (Alrwais and Hilton, 2014; Borges and Sahay, 2000; Budic, 1993; Croswell, 1991; Olafsson and Skov-Petersen, 2014). Therefore, this research also considers the GIS department responsible for managing GIS as an additional dimension to the maturity model. In summary, this work adds two additional dimensions to system usage: the organization dimension and the GIS department dimension. The five dimensions are summarized in Table 5.

System	Functions of the GIS software used, spatial products utilized and the degree of customization applied to the system
Tasks	Extent of integration between GIS and business process and impact on workflow
Users	Extent to which GIS is used organization wide (internal users, external users, departments and management)
Organization	Managerial environment surrounding GIS
GIS Department	Specification of the department responsible for managing GIS activities

Table 5. Dimensions definitions

Given the dimensions outlined, this research mapped these dimensions over the three stages of maturity. Based on the related work discussed earlier, this study extracted relevant benchmark variables to assess and evaluate each dimension. This study integrated the components of GIS usage that were previously dispersed, fragmented, and studied in isolation. The values for each stage over the dimensions were guided by what was described and assessed in the literature and refined by expert opinions. The model is presented in Table 6 and follows a simple logic of evolution from basic and few to advanced and abundant. The model is based on the assumption that the stages build on each other and that the optimal goal of GIS is to be used as an enterprise system to inform decision-making.

Dimensions	Stage 1: Exploration	Stage 2: Exploitation	Stage 3: Enterprise
System **1) GIS functions used** **2) GIS products utilized** **3) GIS customization**	1) Mapping (overlay, visualization), basic measurement and spatial database	1) + Spatial and statistical analysis 2) + Online GIS 3) Minimal	1) + 3D, decision modeling, forecasting and monitoring 2) + Mobile GIS

	2) Desktop GIS 3) Vendor driven		3) Extensive and ongoing
Tasks **1) Core process** **2) Support process** **3) Complexity of the task** **4) Workflow reengineering after GIS**	1) Only in certain established process 2) Minimal 3) Simple (location, structured) 4) Digitize manual process	1) ≈ 40% of core process supported by GIS 2) ≈ 40% of support process supported by GIS 3) Moderate (trends, semi-structured) 4) Moderate changes to take advantage of GIS	1) ≈ 60% of core process supported by GIS 2) ≈ 60% of support process supported by GIS 3) Complex (what if modeling, unstructured) 4) Radical changes as GIS enables new and existing workflows
Users **1) Percentage of internal users over all employees** **2) Percentage of departments using GIS over all departments** **3) Extent to which GIS is used at the operational, tactical and strategic level of management** **4) Number of GIS connections (usage agreements) with outside agencies**	1) <20% 2) <20% 3) Operational: Moderate Tactical: Minimal Strategic: None 4) None	1) 20-40% 2) 20-40% 3) Operational: Moderate Tactical: Moderate Strategic: Minimal 4) <3	1) 41% or more 2) 41% or more 3) Operational: High Tactical: High Strategic: Moderate 4) 3 or more
Organization **1) GIS vision** **2) GIS strategic plan** **3) Purpose of use** **4) Pattern of use** **5) GIS awareness** **6) Training** **7) Cooperation/ coordination between departments as a result of GIS**	1) To manage spatial data 2) Doesn't exist 3) Inventory 4) Specialized 5) Low 6) For designated employees only 7) Rare	1) To improve efficiency 2) Researching GIS strategic plans 3) + Analysis 4) Routine (embedded in business process) 5) Moderate 6) During implementation mostly 7) Moderate	1) To enhance decision making 2) Formal document exists 3) + Policy making 4) Innovative 5) High (GIS day exists) 6) Ongoing in house and outside 7) High (team work spirit)
GIS Department **1) Structure** **2) Role** **3) Number of staff** **4) Skill set** **5) Management style** **6) Use of consultants**	1) Doesn't exist 2) Not clear 3) <3 4) Cartography and engineering 5) Traditional (order taking help desk approach) 6) To justify initial investments	1) A team within a department 2) Provide basic GIS functionalities 3) 3-7 4) + Web programming 5) Service oriented 6) During implementation	1) Stand alone department 2) Support organization 3) 7 or more 4) + Mobile programming + Business knowledge 5) Customer oriented (on demand solutions) 6) Ongoing and considered important

Table 6. GIS Usage Maturity Model

3.3 System Dimension

The system dimension refers to the "object being used" and more precisely the "artifact that provides representation of one or more task domain" in terms of features provided (Burton-Jones and Straub, 2006). Beyond this definition, Burton-Jones and Straub (2006) don't provide any practical guidelines for measuring the system dimension. Jasperson et al. (2005) emphasized the need to measure system use in terms of features of the system provided and used. This research links the "system dimension" with an important factor in the IS success literature, the system quality. System quality entails many indicators, some of which are perceptual (e.g. ease of use, ease of learning) and some are more objective. This research focuses on the objective measures of "system quality," which are features or functions and level of customization as indicated in Gable et al. (2008). Moreover, the way in which GIS is provided (traditional desktop/server, online or mobile architecture) and GIS products utilized are an additional component to the system dimension. Thus, this research considers three indicators of system dimension; GIS functions, GIS products (infrastructure) and GIS customization.

3.3.1 GIS Functions

GIS functions refer to the capabilities provided by the system and what it can do in generic terms. Calkins and Obermeyer (1991) catalog GIS capabilities as display of geographic data, query, counting and direct measurement, map overlay, network algorithms and spatial modeling. Mennecke and Crossland (1996) classify GIS functions as spatial visualization (map production, display of spatial data, layering of data), spatial database management (query), decision modeling (what if analysis, spatial analysis) and design and planning. Tomlinson (2005) defines GIS functions as data acquisition and preprocessing (digitization, editing, projection and transformation), database management (store, update, delete and query), spatial measurement and analysis (buffering, overlay) and graphic output and visualization (statistical maps, scale transformation). Keenan (2005) from the SDSS aspect, views GIS as either a spatial data manipulation tool (measurement, buffer and overlay analysis), an automation tool, a reporting tool, a database management tool, or a decision support system. Eldrandaly (2007) references Goodchild et al. (2005) and others to list GIS functions as geographic data management, tabular data management, GIS data import/export, map design, basic query and analysis, network analysis, terrain and 3D data processing and analysis and raster image processing. Jarupathirun and Zahedi (2007) distinguish between simple and standard GIS (map representation, spatial DB, zoom in/out, pan, measurement, proximity, buffer and overlay) and advanced analytical GIS (spatial analysis, 3D presentation, statistical modeling, network analysis and shortest path). Göçmen and Ventura (2010) follow the same logic as Jarupathirun and Zahedi (2007) and identify advanced GIS as the one utilizing three of the following functions general data analysis: site selection, land suitability analysis, impact assessment, and visualization or public participation. Lastly, Exprodat (2013) divided GIS functions into data organization, visualization, query, data editing, spatial analysis (distance, area, patterns, network analysis), geo-processing (overlay analysis, proximity analysis, surface analysis, raster processing and data modeling) and prediction (site selection and data mining).

Using previously cited work and information available on GIS vendor websites and documents, this research presents a synthesized classification of 24 GIS functions as shown in Figure 10. The bottom of the triangle "spatial data management" represents standard functions for capturing, storing, editing, converting and querying spatial and non-spatial data. The second tier "visualization" includes functions necessary for producing and presenting maps. The "basic processing" class of functions represents traditional processing of spatial data in GIS in terms of measurement, buffering and reporting. Advanced processing includes more sophisticated and complex analysis that is difficult to perform without a GIS, such as spatial analysis (e.g. heat maps), asset monitoring and tracking, design and planning. The last category represents spatial decision support functions including site selection (e.g. where to build or buy a branch), evaluation of policies (impact assessment) and predictions (e.g. how condensed city roads will be if a new college is to be built).

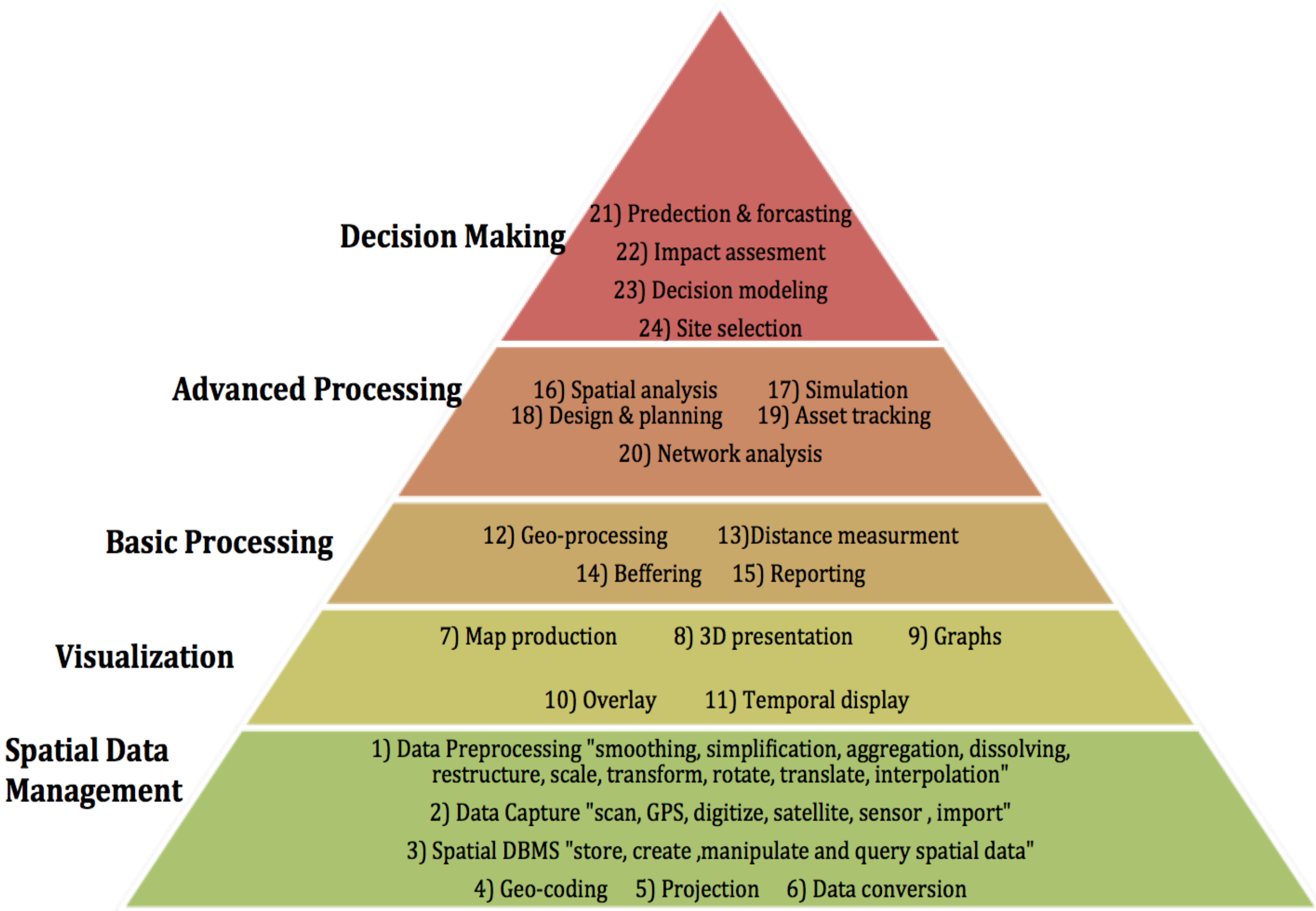


Figure 10. A generic classification of GIS functions

The next step was to divide these 24 functions over the three stages of the model. The exploration stage received what has been called "basic GIS" in the literature. Thus, 10 functions were listed under exploration stage, which includes the spatial data management category (data preprocessing, data capture, spatial DM, geo-coding, projection, data conversion), map production, overlay, distance measurement and buffering. This stage represents limited GIS capabilities. The exploitation stage was given functions that reflected routine use of GIS. Thus, 7 functions fit this description which includes reporting, graphs, geo-processing, spatial analysis, network analysis, design and planning and asset tracking. The enterprise stage reflected the notion of "advanced GIS" in the literature. Thus, seven functions were added to this stage, including the decision-making category (prediction and forecasting, impact assessment, decision modeling, site selection), 3D presentation temporal display and simulation.

In order to identify the stage of GIS functions that an organization belongs to a formula was used. To be in exploration stage, at least 4 out of the 10 functions should be used. For the exploitation stage, in addition to satisfying the exploration stage condition, at least three out of the seven functions of the exploitation stage should be used. For the enterprise stage, in addition to the two previous conditions, three out of the seven functions of the enterprise stage should be used. Exceptions were granted depending on the overall number of functions used (out of 24) and other functions mentioned. In the survey, there was an opportunity for the respondent to mention other GIS functions used not listed here.

3.3.2 GIS Products

This indicator represents the GIS software solutions (systems, platforms, programs, applications, add-ons, extensions, plugins and services) consumed by the organization. It gives an indication of the infrastructure (hardware and software) supporting GIS. Mäkelä (2012) lay out GIS technologies over 6 stages of GIS maturity beginning from desktop GIS, mobile and internet GIS, integrated architecture of desktop, internet and mobile GIS, flexible GIS, software oriented architecture (SOA) and cloud based GIS and finally an architecture of GIS where new technologies of GIS can be integrated quickly. Taking into consideration Mäkelä's (2012) work and by examining the breadth of products available from ESRI (at http://www.esri.com/products) a major GIS vendor, this research presents a grouping of 32 GIS products shown in Figure 11. The central circle contains core GIS products (1-11) and extensions. The right most circle covers GIS products (12-18) designed for mobile devices. The lower circle has services (19-23) specifically designed for local governments. The left most circle includes online products (24-27) and services. The top most circle encompasses newer products (28-32) dealing with sophisticated products or real time reporting and monitoring applications.

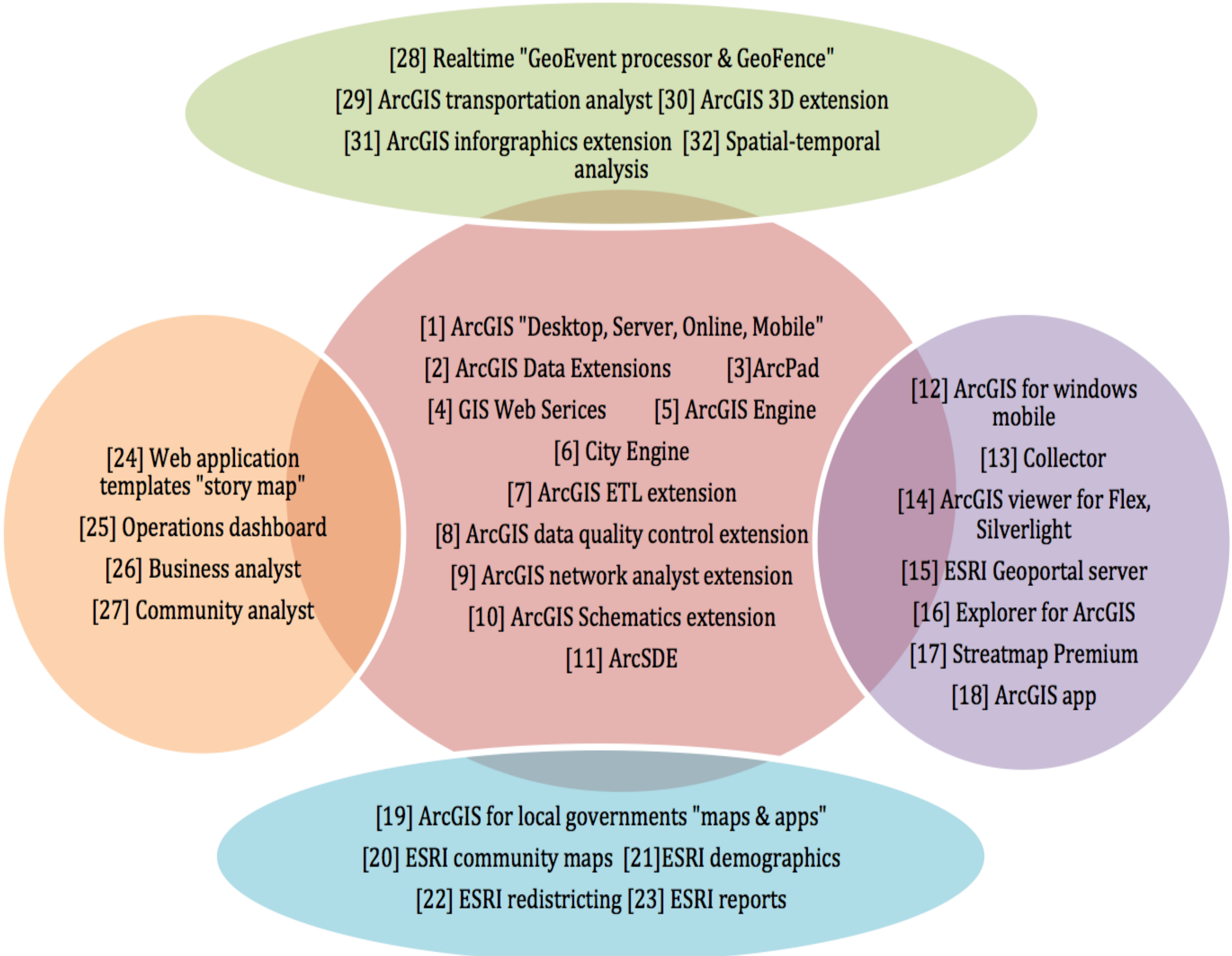


Figure 11. Grouping of GIS products

These GIS products were divided into the three stages according to how closely they are related to the desktop, online or mobile architecture of GIS. The exploration stage represented traditional desktop GIS where the functionalities lay on the client/server machine. Products for exploration stage include ArcGIS desktop; ArcSDE; ArcGIS ETL; ArcGIS data quality; ArcGIS Schematic; Explorer, Streatmap Premium; transportation analyst; network analyst; and ArcGIS data extensions. The exploitation stage is best represented by online GIS which include ArcGIS online; GIS web services; ArcGIS viewer; ESRI geo-portal; ArcGIS for local government; ESRI demographics; ESRI reports; web applications template; business; and community analyst. The enterprise stage includes the earlier products in addition to the mobile GIS package. The enterprise stage products contain the products of ArcGIS mobile; ArcPad; ArcGIS engine; city engine; ArcGIS for Windows mobile; collector; operations dashboard; real-time monitoring; ArcGIS 3D extension; and spatial-temporal analysis.

3.3.3 GIS Customization

Although heavy use of GIS functions and products is a good indicator of system use, there seems to be a missing element. The degree to which these general functions and products of GIS are customized to suit the needs of a specific organization would indicate further use of the system. Gable et al. (2008) in their review of IS success studies included the level of customization as an element of system quality. Birks et al. (2003) cited the inability of GIS staff to customize applications to the individual needs of users as a factor for GIS failure in UK retailing industry. Mangan (2008) views "user-based customization and personalization" as an indication of reaching enterprise stage of GIS in their maturity model. This research considers the degree of GIS customization as a third indicator of the system dimension. In the exploration stage, hardly any customization will be performed and if needed the GIS vendor would be responsible for making the changes. But in the exploitation stage and due to fair usage of GIS products, needs and events will require some customization from city staff (mainly the GIS staff). In the enterprise stage cross department process and new opportunities where GIS can add competitive advantage will constantly require ongoing customization and changes by the GIS department.

3.4 Tasks Dimension

The tasks dimension refers to the "goal-directed activity performed by a user" (Burton-Jones and Straub, 2006) on a system that produces an output. Tasks dimension incorporates the wide range of applications that GIS enables and the degree of complexity of those applications. Investigating the type of tasks that GIS assists with (difficulty in terms of simple and complex, or low, medium and high difficulty spatial tasks), and the impact on decision performance has been a core construct in GIS decision support studies (Dennis and Carte, 1998; Jarupathirun and Zahedi, 2001; Mennecke el al., 2000; Smelcer and Carmel, 1997; Swink and Speier, 1999). GIS maturity models have also focused on examining the integration between GIS and business tasks. Giff and

Jackson (2013) devote a component of their maturity model to assessing GIS use in operational process in terms of business work use and extent of integration with workflow. Mangan (2008) also measured the integration between GIS and enterprise workflow in their maturity model. The URISA (Babinsky, 2013) and Exprodat (2013) maturity model similarly pays attention to processes where GIS is used. Mäkelä (2012 in his maturity model likewise examines GIS use in internal core processes as well as support processes and services. Asking about GIS applications has been a central question of focus in most GIS studies at local government level (Calkins and Obermeyer, 1991; French and Wiggins, 1990; Nedovic-Budic, 1993; Weir and Bangs, 2007; Ye et al., 2014). Holland and Light (2001) in their ERP usage maturity model have two dimensions closely related to tasks, including organizational sophistication and the penetration of the ERP system. Holland and Light (2001) considered issues of information flow, organizational changes and percentage of use of ERP on business process in those two dimensions. Massetti and Zmud's (1996) conceptualization of organizational system usage is relevant to this dimension when applied and similar to the work of Jonas and Bjorn (2011) and Picoto et al. (2014) where both studies operationalized a segment of system usage as percentage of primary and secondary process that are supported by a system.

By taking the previous studies into consideration, this research provides four indicators of the tasks dimension as an application of GIS in the organization's core business process, support process, complexity of the tasks and the degree of business process reengineering as a direct result of GIS.

3.4.1 Core and Support Process

A central piece in Porter's value chain is the demarcation between primary (core) activities and support activities that a firm engages in to manufacture a product and the role of IT in providing a competitive advantage (Porter and Millar, 1985). Primary activities include tasks directly involved with making and distributing a product (logistics, operations, marketing, sales and services) while support activities include secondary activities that support day-to-day operations which includes infrastructure, human resource management, technology development and procurement (Porter and Millar, 1985). Mäkelä (2012) followed this logic and considers the use of GIS at local government both in the core and support process. This research adopts this line of thinking, and divides local government tasks into core and support process in generic terms to be applicable to most local governments.

This research relied mainly on inspecting a handful of local government's websites and public documents to form a list of core and support process. This list was checked and refined in the pilot study. Furthermore, in the survey there was an "other" option for respondents to add any core or support process that they use which GIS plays a role, and none of them added any other process which further supports the comprehensiveness of this list. Core process in this research is shown in Table 7. Twenty-eight processes are listed in Table 7, which cover fundamental and primary duties of a local government in the context of the United States.

Budget preparation
Business licensing
Cadastral/parcel
City hall meetings (open or private)
City Annual plans
Community assessment
Customer services (complaints, orders and requests)
Development review and approval (subdivision, building permits)
Economic development
Elections
Emergency management (Police, Fire)
Employment
Engineering
Environmental monitoring
Infrastructure management
Land use planning
Landscape management
Park's maintenance
Permitting and inspections
Procurement and contract management
Public health
Public safety
Revenue management
School management
Taxation (property assessment)
Transportation management
Utility management (sanitary, water, trash, recycling and sewer)
Zoning and districting

Table 7. Core process

Support processes used in this research are shown in Table 8. Twenty-four processes are listed in Table 8, which includes secondary processes that support and complement the core processes of a local government in the context of the United States.

Aged and disabled services
Human resources
Children's services
Performance monitoring
Library services
Citation management
Fleet monitoring
Resource allocation
Platting
Historical and tourism planning
Records management
Parking management
Event scheduling
Street closure permitting
Documentation
Housing
Information technology
Information dissemination
Reporting
Data collection (for regulations, state or federal)
Code enforcement
Owner notification
Address verification
Mapping

Table 8. Support process

The next step was to lay out these processes over the three stages of the model. The exploration stage represents specialized use of GIS (planner and engineers) thus cadastral/parcel, emergency management (police and fire), engineering, infrastructure management, land use planning, utility management (sanitary, water, trash, recycling and sewer), zoning and districting were included under this stage. The exploitation stage was linked with transportation management, community assessment, environmental monitoring, park maintenance, landscape management, permitting and inspections, economic development, development review and approval (subdivision, building permits) processes. The enterprise stage represents more cross-department and strategic use of GIS, and thus budget preparation, taxation (property assessment), school management, public health, employment, public safety, business licensing, procurement and contract management, revenue management, city hall meetings (open or private), city yearly plans, customer services (complaints, orders and requests) and election processes were labeled under this stage. The same logic was used for support processes. Thus, support processes for the exploration stage included platting, records management, documentation, data collection (for regulations, state or federal), owner notification, address verification and mapping. The exploitation stage included the processes of information dissemination, library services, parking management, event scheduling, citation management, housing, street closure permitting, code enforcement, aged and disabled services. Consequently, the enterprise stage had resource allocation, reporting, performance monitoring, historical and tourism planning, information technology, human resources, children's services and fleet monitoring processes.

To assign core and support process a stage of maturity in using GIS for an organization, this research used percentages for each stage. In addition to identifying the processes used from the list, each organization was asked a question about the percentage of core and support processes that have been enabled by GIS. An organization was assigned to the exploration stage if the core or support process were less the 40% enabled by GIS. If the percentage were between 40-59% the organization would belong to the exploitation stage. If the percentage were 60% or more the organization would be classified into the enterprise stage.

3.4.2 Complexity of the Task

Herbert Simon, a prominent social scholar of the twentieth century, proposed three categories of decision tasks. The first he called "programmed" where there is a clear routine for the task under a stable situation such a hiring a new employee in an established department. The second type of tasks Simon called the "un-programmed" where the process is unclear and the situation is dynamic and new to the organization, and there is no clear way for solving the problem and coming up with a solution. The third is the "semi-programmed" where there is some structure for part of the process but not all of it (Simon, 1960). Gorry and Scoot Morton used the same idea of the structuration of tasks along with the levels of management and proposed their classical framework of management support systems (Gorry and Morton, 1989). Ariav and Ginzberg (1985) in their study of DSS, devoted a section of their model to study the structure of tasks where DSS is used, and they divide the tasks into structured, unstructured and semi-structured. This framing of tasks has been applied to GIS also, and John O'Looney, an academic and consultant in many local and state GIS projects, has observed that GIS tasks tend to fall on a scale from "simple questions" to "complex questions" (O'Looney, 1997). Thus, this research postulates that in the exploration stage, the majority of the tasks where GIS is used will be for simple and structured tasks (e.g. find the location of a property). The exploitation stage will be more associated with semi-structured medium difficulty tasks (e.g. find the best route to a location). Tasks in the enterprise stage tend to be more complex and unstructured (e.g. site selection). This indicator will be measured using a question that asks respondent to think about the most accurate statement regarding the complexity of the tasks GIS is used in most of the time and if the answer options would be simple, moderate or complex tasks.

3.4.3 Process Reengineering

If GIS has been used to some extent, then changes (in workflow, time, required data, steps, number of employees needed or required documents) to existing processes should have taken place. Integration between GIS and workflow has been indicated as a measure of maturity (Giff and Jackson, 2013; Mangan, 2008). For the exploration stage, this research claims that GIS had only minimal changes to existing processes in terms of digitizing some procedures and forms. In the exploitation stage, GIS serves more as an automation tool with moderate changes to existing workflows. In the enterprise stage, more radical and innovative changes should have taken place as GIS fosters new ways of doing business. This indicator will be measured by asking respondents to examine how GIS impacted existing workflows. The answer options will indicate if GIS either replaced manual and paper forms and maps (digitization), or prompted moderate changes (changed order, steps or time) or radical changes (reengineered processes).

3.5 Users Dimension

Burton-Jones and Straub (2006) define a user initially as the "subject using the information system" and later as "an individual person who employs an IS in a task," and they limit this definition to the actual users of a system. In this research, the scope of users is extended to include consumers of the information of GIS, not necessary using GIS directly, but through other means such as reading a GIS report or discussing a spatial analysis produced by GIS. Burton-Jones and Straub (2006) didn't provide guidelines about how to measure this dimension at the organizational level. Calkins and Obermeyer (1991) emphasize the need to ask questions regarding who uses GIS data and information. Calkins and Obermeyer (1991) classify users into professional analyst, middle management, upper management (decision maker), general public, and non-profit organizations. Calkins and Obermeyer (1991) also considered the level of decision making of the user if it is operations, management or policy. Marr and Benwell (1996) found that the number of departments using GIS to be a significant indicator of GIS usage maturity. Most of the empirical GIS studies in local government have investigated the number and type of users and departments using GIS (Baban and Ramlal, 2006; Brown, 1996; Convery and Ives-Dewey, 2008; French and Winggins, 1990; Turner and Higgs, 2003; Nedovic-Budic, 1993; O'Looney, 1997, Witkowski et al., 2008). The previous studies focused on internal users of GIS and overlooked external users (citizens, agencies, business, academics and non-profit organizations). Usage agreements signed between the organization and outside agencies to use and share their system, data, or analysis have been considered a measure of success and popularity of the GIS (French and Winggins, 1990; Witkowski et al., 2008). By considering the full spectrum of the users dimension, this research utilizes the number of internal users and departments using GIS, the level of management use of GIS, and number of usage agreements as indicators of the users dimension.

3.5.1 Percentage of Internal GIS Users

Who uses GIS? GIS has the ability to serve most employees and workers in local government. An increase in the number and type of GIS users signifies increase in usage. Witkowski et al. (2008) considers the number of GIS users as a metric of success for enterprise GIS. Rather than quantifying the number of GIS users, Calkins and Obermeyer (1991), and Convery and Ives-Dewey (2008) consider the type (job title) of GIS users. Researchers who investigated organizational system usage, used the percentage of current ERP users/potential ERP users (Jonas and Bjorn, 2011) and daily number of ERP users (Ruivo et al., 2012) as measures of system users. This research presents in Table 9, a listing of GIS user types in local government.

Analysts
Attorneys
City manager
City manager’s deputy
Clerks
Council members
Department heads
Engineers
Field workers
Firefighters
General public
IT staff
Local business
Mayor
Planners
Police officers

Table 9. Types of GIS users in local government

In the exploration stage, engineers and planners are expected to be the users of GIS. In the exploitation stage, the reach of GIS expands to field workers, clerks, police officers, firefighters and analysts. In the enterprise stage, GIS connects with higher levels of management including department heads, city manager, mayor, council members and the general public. Because local governments vary in terms of the number of employees or workers, this research adopts a percentage of GIS users over all employees (GIS users + non-GIS users) as a measure of GIS users. This research asked respondents to indicate the percentage of employees who use GIS (directly via the system or indirectly via the GIS information or its reports) of all employees. If the percentage of GIS users was less than 20%, then the response would belong to the exploration stage (low use). If the percentage was between 20-40%, then the response would belong to the exploitation stage (indicating moderate use). If the percentage was 41% or more, then the response would belong to the enterprise stage as it indicates high number of GIS users.

3.5.2 Percentage of Departments Using GIS

The planning department has been the main user of GIS as they employ the technology in designing maps for the city, zoning, land use planning and facility management. However, other departments use GIS but to a lesser extent. Marr and Benwell (1996) found that the number of departments using GIS to be a significant indicator of GIS usage maturity. Studies that investigated GIS usage have looked and compared the different departments using GIS (Baban and Ramlal, 2006; Convery and Ives-Dewey, 2008; French and Winggins, 1990; Nedovic-Budic, 1993). In Table 10, a listing of city departments is provided.

Administration	Employment services	Planning
Airports	Engineering	Police
Animal control	Environmental services	Public works
Building and safety	Finance	Purchasing and contracting
City attorney office	Fire	Records and archive
City auditor office	General services	Redevelopment
City clerk office	Harbor/ports	Risk management
City manager office	Health and human services	Sanitation and recycling
Code enforcement	Housing and real estate	Transportation and parking
Community development	Human resources	Treasurer's office
Community services	Information Technology	Utilities
Convention center	Landscape and Public infrastructure	Volunteer services
Cultural affairs	Library services	Water and power
Disability and aging	Mayor's office	Zoo services
Economic development	Oil and gas	
Emergency management	Parks and recreation	

Table 10. City departments

For the exploration stage, GIS is most used in the departments of planning, public works, engineering, water, sanitation, records and utilities, which deal with spatial data on day-to-day basis. The exploitation stage includes additional departments not initially familiar with GIS, which are police, fire, animal services, housing, building and safety, code enforcement and economic development. In the enterprise stage, GIS reaches further departments including employment, health and human services, finance, human resources, purchasing and risk management. Each city could have more or less of the departments listed in Table 10. The question about name of departments using GIS was supplemented with another question. That other question asked the respondents to indicate the percentage of city departments that use GIS (directly via the system or indirectly via the GIS information or its reports) of all city departments. If the percentage of departments using GIS was less than 20%, then the response would belong to the exploration stage (low use). If the percentage was between 20-40%, then the response would belong to the exploitation stage (indicating moderate use). If the percentage was 41% or more, then the response would belong to the enterprise stage as it indicates wide penetration of GIS into city departments.

3.5.3 Level of Management Using GIS

Decisions take place in organizations at different levels. Decision makers at different hierarchy (level) of the organization require a different type and quantity of data (Manglik, 2006). Operational managers make daily decisions concerning the process they manage, and thus they require tailored real time data about their own process and a view of other processes related to them. Knowledge workers require more aggregated and integrated data that crosses departments. Middle managers require even more aggregated and seasonal data to take tactical decisions about the department or region they manage. Executive managers require totally different data as they take strategic decisions, and thus need to see the big picture concerning how the organization operates as a whole. Gorry and Morton (1989) differentiate between information systems depending on their focus on operational control, management control or strategic planning. Ariav and Ginzberg (1985) also follow the same notion in studying DSS by examining the management support at the operational, managerial and strategic level. Researchers that have studied ERP use (Jonas and Bjorn, 2011) have examined the level of management supported by the system. Research on GIS has also considered the use of the technology over different levels of management (Calkins and Obermeyer, 1991; O'Looney, 1997; Somers, 1998). This research follows the logic of previous research and applies it to the three stages. For extent of use, a scale ranging from none, minimal, moderate and high will be used to measure use at each level of management. In the exploration stage, majority of the use will be in the operational level (low level managers, supervisors and field workers). Thus, it is expected that for the exploration stage GIS will be used moderately at the operational level, minimally at the tactical level and almost never at the strategic level. For the exploitation stage, middle level of management (city manager, deputies and department heads) will have increased use of GIS. Thus for exploitation stage, moderate use of GIS on the operational and tactical level and minimal use at the strategic level would be expected.. As for the enterprise stage, as GIS reaches new ground there will be more use of GIS at the strategic level (mayor, commissions, boards and city council members). Thus, high use of the GIS will be evident in the operational and tactical level and moderate use on the strategic level.

3.5.4 External Users of GIS

The previous indicators (users, departments and level of management) of the users dimension are concerned with the internal users. GIS could be used outside the city/municipality by county/state agencies, special districts, citizens, visitors of the city and local business. If GIS is used outside the boundary of the agency, then that signifies maturity of the technology. Witkowski et al. (2008) considers the number of GIS data usage agreements signed and in place as a metric of success for enterprise GIS. French and Winggins (1990) in their survey of California planning agencies report that the average number of outside agencies having access to GIS was 3.2 agencies and the number is expected to have increased since that time. This research doesn't consider sharing GIS between departments (for example public works having access to GIS at the planning department) as a usage agreement and considers only outside users. Thus, for the exploration stage no sharing of GIS is expected as GIS is hardly used inside. For the exploitation stage, this research postulates that one or two usage agreements will be in place. For the enterprise stage, three or more usage agreements should be signed and in use.

3.6 Organization Dimension

Previous dimensions focused on measuring GIS usage directly. The system, task and user dimensions are essential for measuring GIS usage, however they are not enough as they are only quantitative metrics that measure extent of use but other qualitative measures are needed (how and why is GIS used? What is the ramification of GIS on the structure of the organization? What are the managerial activities related to GIS? And how is GIS supported?). In this dimension, the focus is on outside factors affecting usage. There is a need to look at the environment surrounding GIS use. This environment could encourage or hinder GIS usage. In a quest to understand the boundaries of the environment that a system operates in, this research followed the logic of the systems approach (Churchman, 1979) in that in order to understand a system you have to inspect the elements that make up the system and the environment within which this system operates with the linkages between them. Ariav and Ginzberg (1985) utilized this theory to understand the characteristics of the environment that a DSS operates within. According to Ariav and Ginzberg (1985), the surrounding environment is made up of two dimensions, task characteristics and access pattern. Access pattern involves usage pattern, number of users, experience with computers, experience in the problem area, role in the decision process and level of integration with other systems (Ariav and Ginzberg 1985). This research adopts this line of thinking but adds factors relevant to GIS. An important element of the environment surrounding GIS is the organizational configuration (strategy, vision, training, awareness and cooperation) associated with the use of GIS. Many researchers have acknowledged the importance of organizational factors in influencing GIS use (Brown, 1996; Calkins and Obermeyer, 1991; Croswell, 1991; Esnard, 2007; Göçmen and Ventura, 2010; Higgs et al., 2005; Hussain and Johar, 2010; Onsrud and Pinto, 1993; Ventura, 1995; Ye et al., 2014). GIS maturity models have also considered the implication of organizational variables (Babinsky, 2013; Exprodat, 2013; Giff and Jackson, 2013; Grimshaw, 1996; O'Flaherty et al., 2005; van Loenen and van Rij, 2008). In fact, many GIS researchers report that the organizational and institutional factors play a more significant role on GIS use and adoption than the technical factors (Croswell, 1991; Göçmen and Ventura, 2010; Onsrud and Pinto, 1993; Ventura, 1995; Wellar, 1993). This research selected GIS vision, GIS strategic plans (GIS strategy), GIS awareness (top management support), GIS training, cooperation (coordination or collaboration), purpose of GIS use and GIS usage pattern as the organizational factors related to GIS use. Supporting research for the chosen factors is listed in Table 11.

Indicator	Related studies
Vision	Chan et al., 2000; Grimshaw, 1996; Somers, 1998; Witkowski et al., 2008; MacKenzie, 2003; Colijn et al., 2000; Holland et al., 2001; Van Loenen et al., 2008; Davis, 1999
Strategic plans	Giff et al., 2013; Grimshaw, 1996; Somers, 1998; Exprodat, 2013; Gudes et al., 2015; Hendriks, 1998; Higgs et al., 2005.
Purpose	Calkins et al., 1991; O'Looney, 2000; Somers, 1998; Tulloch, 1999
Usage pattern	Ariav et al., 1985
Awareness	Chan et al., 2000; Somers, 1998; Van Loenen et al., 2008; Exprodat, 2013; Higgs et al., 2005; Campbell et al., 1995; Tulloch, 1999; Croswell, 1991; Onsrud et al., 1993; Budić,1994; Alwaraqi et al., 2012; Sieber, 2000; Hussain et al., 2010; Gallaher, 1999; Eldrandley et al., 2015; Tomaselli, 2004; Baban et al., 2006
Training	Tulloch, 1999; Nasirin et al., 1998; Alwaraqi et al., 2012; Somers, 1998; Sieber, 2000; Croswell, 1991; Hussain et al., 2010; Higgs et al., 2005; Davis, 1999; Exprodat, 2013; Mangan, 2008; Giff et al., 2013; Gudes et al., 2015; Colijn et al., 2000; Göçmen et al., 2010;

	MacKenzie, 2003; Witkowski et al., 2008; Brodzik, 2004; Ye et al., 2014; Brown, 1996
Cooperation	Mäkelä 2012; Olafsson et al. 2014; Ye et al., 2014; Brodzik, 2004; Van Loenen et al., 2008; Tomaselli, 2004; Mangan, 2008; Sieber, 2000; Alwaraqi et al., 2012; Brown, 1996; Somers, 1998

Table 11. Supporting literature for the organizational factors

This research omitted other factors recently mentioned in the literature such as funding or GIS budget as it might have an effect on the initial implementation of the technology, but its effect fades away with time. Also funding manifests itself in other variables such as training. The city budget was included in the survey question but used as a control variable in the analysis.

3.6.1 GIS Vision

The GIS vision if it exists, dictates the potential role that GIS could have on the organization. GIS vision sets the target to be reached (Davis, 1999) and needs to be communicated. GIS vision requires an understanding of the benefits that can be realized (Davis, 1999). Many researchers have investigated this factor as can be seen from Table 11. This research assessed GIS vision by asking respondents to choose the most accurate statement regarding the vision behind GIS in their city. In the exploration stage, GIS vision is expected to be centered on managing spatial data. The exploitation stage will have a GIS vision related to improving the efficiencies of city processes. In the enterprise stage, GIS takes a strategic role and the vision there is more towards enhancing the decision making of the city.

3.6.2 GIS Strategic Plan

The GIS strategy, or strategic plans for GIS, is the means by which the GIS vision is to be achieved. Strategic plans are yearly plans included with the general city plan that includes the strength and weaknesses of GIS, and new changes in the technology that could add value and scheduled projects. Many researchers have investigated this factor as can be seen from Table 11. This research assessed GIS strategic plans by asking respondents to choose the most accurate description regarding the strategic plans in the future for GIS in their city. In the exploration stage, no plan for GIS is expected to exist, rather ad hoc and uncoordinated projects are implemented from time to time. Strategic plans for GIS will begin to be developed in the exploitation stage. In the enterprise stage, these plans will be completed and a formal documented plan will exist outlining the opportunities for growth.

3.6.3 Purpose of GIS

Calkins and Obermeyer (1991) in their taxonomy of GIS use, designate a question for the purpose of using geographical data and provide as answer options inventory, monitoring, query a database, simple analysis, advanced analysis or spatial decision support. Tulloch (1999) considers the purpose of using GIS as inventory, analysis or management. O'Looney (2000) views the purpose of GIS as inventory, analysis or policy and planning. This research assessed the purpose of GIS use by asking respondents to choose the most accurate description regarding the purpose of using GIS in their city. In the exploration stage, the use is for inventory purposes (e.g., locating property information and condition). The purpose of GIS in exploitation stage is for analysis (e.g., to understand the relationship between a spatial location, sidewalks condition and the demographics of residents). GIS has a greater purpose in the enterprise stage, that of policymaking (e.g., to inform, revise and justify polices and decisions).

3.6.4 GIS Usage Patterns

Ariav and Ginzberg (1985) consider usage patterns for DSS as either through subscription, terminal, clerk or intermediary basis. Ariav and Ginzberg's (1985) focus was on the method of access. But in this research the focus is on the mode of access. This research postulates three patterns in the use of GIS. In the exploration stage, GIS is seen as a proprietary technology and the pattern is to use GIS on ad-hoc basis by specialists (few experts use GIS as part of their job). On the exploitation stage, GIS has become part of the routine (GIS has become embedded in some business processes) and serves a predictable need. In the enterprise stage, GIS is unpredictable, always changing, and new and innovative ways of using GIS are constantly rolled out and tested.

3.6.5 GIS Awareness

This factor is concerned with the education about GIS in the organization and top management support and commitment towards GIS. Awareness about GIS role and potential and top management support has been often cited as a condition for GIS success, as can be seen from the share of studies in Table 11. To measure GIS awareness, this research asked participants to name the GIS champion if he or she existed. In addition, participants were asked to indicate the level of GIS awareness in the city's departments and offices. GIS awareness is expected to be low in the exploration stage, moderate in the exploitation stage and high in the enterprise stage (where such events as a "GIS day" take place).

3.6.6 GIS Training

GIS is a complex technology with terminology and methods new to most employees, thus training is required. Technology in general changes rapidly and training provides an avenue to keep up with changes and understand how to apply technology to current issues. The frequency of training in the organization signifies renewed commitment from management. Many researchers have commented about the importance of GIS training as can be seen in studies listed in Table 11. Respondents were asked to indicate the state of GIS training in their city. It is expected that training will be infrequent and for a handful of employees only at the exploration stage, occasional and mostly in the implementation phase at the exploitation stage, and frequent at the enterprise stage.

3.6.7 Cooperation Between Departments After GIS

Cooperation, coordination and collaboration between departments is expected to some degree as GIS facilitates a platform for sharing and visualizing data. Many researchers citied in Table 11 have envisioned cooperation after implementing GIS. Respondents were asked to indicate the level of cooperation between departments as a result of GIS in their cities. It is expected that since GIS use is low in the exploration stage, that cooperation would be rare. In the exploitation stage, cooperation would be moderate in terms of sharing data for the most part. Cooperation would be high in the enterprise stage, made evident by an organization that performs as one team due to GIS functioning as a glue connecting departments together.

3.7 GIS Department Dimension

This dimension prescribes the characteristics of the department, unit, team or division responsible for managing and supporting GIS in an organization. The assumption is that the way in which the GIS department operates has a direct effect on GIS use. GIS can do more than just create pretty maps, and this potential hinges in part on the way that the GIS department is set up and the relationship between it and other departments in the organization. Case studies that have documented exemplary GIS operations within an organization have attributed part of this success to the GIS department's organizational structure, purpose, role and staff skills (Alrwais and Hilton, 2014; Borgesa and Sahayb, 2000). Other studies have also stressed the importance of the GIS department in GIS development (Olafsson and Skov-Petersen, 2014; Brodzik, 2004; McGill, 2005; Alwaraqi and Zahary, 2012; Gallaher, 1999; Tomlinson, 2005; Ford and Conry, 2001; Joffe, 2003). The importance of having a special purpose department for GIS is evident in Budic (1993) when she demonstrated that having such a department significantly increases the number of departments using GIS to four compared to 1.5 without a GIS department. Anecdotal GIS management success practices encourage establishing a dedicated GIS department (Croswell 1991; Somers 1998). Marr and Benwell (1996) in their computational model for GIS usage maturity, include "the department responsible for GIS" as a maturity variable. The GIS department is specified according to its organizational structure, role in the organization, number of staff in the department, skills of staff in the department, style of management and relationship with other departments and the degree of use of GIS consultants.

3.7.1 Organizational Structure

This indicator is concerned with how the GIS department is positioned within the organization hierarchy. Solomon Nimako, senior GIS analyst for the city of Rancho Cucamonga, responded to a question about why the GIS department isn't positioned under IT by saying: "that question is the reason why most cities don't have a developed GIS as we do." He adds that because GIS in Rancho Cucamonga isn't buried under any other department, "and that means [when GIS belongs under another department] they're 90% focused that the division they are working for gets their things done. And they don't look at the overall picture. That is the difference between Rancho's GIS and anywhere else." When no GIS department exists and GIS specialists are scattered over the departments, GIS is approached in a "'piece meal style" that delivers duplicate solutions and limited capabilities. Many GIS studies have examined the change in the structure of the GIS department as GIS reach expands (Alrwais and Hilton, 2014; Brodzik, 2004; McGill, 2005). The organizational structure of the GIS department was assessed by asking respondents to "indicate how the GIS unit/department/division/team is positioned within the city's hierarchy."' The answer options were: "we don't currently have a GIS unit; dedicated GIS unit; under Information Technology department; under planning department; under engineering department; under community development; under public works or other structure." In the exploration stage, it is expected that no formal GIS department exists, rather a few employees operate GIS in their own departments. For the exploitation stage, a form of structure for GIS begins to emerge, however the GIS team is subordinate to another department (mostly IT, planning, or public works). In the enterprise stage, a dedicated and independent GIS department exists.

3.7.2 Role

The attention here is on the role, responsibilities and objectives of the GIS department. The question asked is "what purpose does the GIS department serve?" Somers (1998) talks about the role of GIS in general and argues that "GIS could play a prominent role that draws attention to GIS, or it could play a more subtle role." Gallaher (1999) and Ayodeji (2008) view the optimal role of GIS to support the organization in fulfilling its mandate. This research follows this line of thinking and applies it down to the GIS department level. The role of the GIS department is measured by asking respondents what role (objective) the GIS unit performs. The first option is "not clear" as the GIS department doesn't exist and this applies to the exploration stage. The second option for respondents to choose is 'provide basic GIS functionalities" which comes in the form of creating maps and managing spatial data and this applies to the exploitation stage. The third option available is "support the organization (departments, citizens and businesses)" where the GIS department also serves external entities and that applies to the enterprise stage.

3.7.3 Number of Staff

This indicator measures the number of staff or employees currently working under the GIS department. The number gives an indication about the size, budget and importance of the department. One hurdle to GIS success often citied is inadequate GIS staff to serve the needs of the organization (Croswell, 1991; Brown, 1996; Sieber, 2000; Ye at al., 2014). This indicator was measured by asking respondents about the number of employees working full time in the GIS department. Since the GIS department doesn't exist in the exploration stage, number of employees is expected to be less than three. In the Exploitation stage, the number is expected to be between 4-6 employees. In the enterprise stage, the number is expected to be 7 employees or more.

3.7.4 Staff Skills

Skills that the GIS staff poses vary depending on the hiring criteria of the department, education that each staff member obtained and training provided by the department. Staff skills determine the type of applications they can develop and problems they can assist with. Somers (1994) talks about the importance of GIS staff's skills in the success of GIS projects. Tomlinson (2005) also emphasized the importance of having qualified GIS staff with various technical and interpersonal skills as necessary for the success of GIS. Göçmen and Ventura (2010) again emphasized the need to improve the skills of GIS staff in order to use the more advanced functions of GIS. This indicator was measured by asking a direct question to the respondents about the different skills of the employees working in the GIS department. In the exploration stage, since those who could perform GIS support are mainly planners and engineers, the expected staff skills of GIS includes cartography, geography and engineering. For the exploitation stage, skills expand to include web application development and design. In enterprise stage, GIS staff is expected to develop mobile applications, and thus their skills should include mobile programming and business knowledge to be able to simplify business processes and provide useful spatial applications.

3.7.5 Management Style

This indicator assesses the relationship approach between the GIS and other departments. A theme emerges from successful GIS departments shaped by strong relationship building between the GIS department and other departments, allowing the GIS department to understand their process, problems and opportunities for productive change (Alrwais and Hilton, 2014; McGill, 2005). This indicator was measured by asking respondents about the management style of the GIS unit when dealing with other city departments. The first option is "traditional" (order taking similar to a help desk style) where GIS support is reactive, and this applies to the exploration stage. The second option given was "service-oriented" (provides standard services that can be shared) and that applies more to the exploitation stage, as the effort there is to reduce redundancy and improve quality. The third option is "customer-oriented" (tailored on demand solutions) where the GIS department takes a proactive approach proposing solutions even before the customers ask, and this aligns with the enterprise stage.

3.7.6 Use of GIS Consultants

This indicator covers GIS support from outside the GIS department that takes the form of third party GIS consultants or consultants from GIS vendors. Nedovic-Budic and Godschalk (1996), Brail (2008), Geertman and Stillwell (2009), Olafsson and Skov-Petersen (2014) argue for the importance of involving consultants in GIS development. This indicator was measured by asking respondents how GIS consultants are used in their city. The response options were: we don't use consultants, in the initial phases to justify investments in GIS, during implementation to manage the project or ongoing and considered important for the development of the city. In the exploration stage, if consultants are used then their role is limited to building the business case of where GIS could add value to the organization. The role of GIS consultants in the exploitation stage extends to managing GIS project implementation. The relationship with GIS consultants continues after implementation in the enterprise stage as the technology changes rapidly and the organization needs to adapt accordingly. The supporting studies for each indictor of all five dimensions are listed in Table 12.

Indicator	Related studies
GIS functions used	Calkins et al., 1991; Eldrandaly, 2007;Keenan, 2005; Mennecke et al., 1996; Tomlinson, 2005; Jarupathirun et al., 2007; Göçmen et al., 2010; Exprodat, 2013
GIS products utilized	Mäkelä, 2012; ESRI, 2015
GIS Customization	Birks et al., 2003; Gable et al., 2008; Mangan, 2008;
Core process	Porter et al., 1985; Mäkelä, 2012
Support process	Porter et al., 1985; Mäkelä, 2012
Task complexity	Simon, 1960; O'Looney, 1997; Ariav et al., 1985; Gorry et al., 1989; Dennis et al., 1998; Jarupathirun et al., 2001; Mennecke el al., 2000; Smelcer et al., 1997; Swink et al., 1999

Workflow reengineering	Giff et al., 2013; Mangan, 2008
Percentage of internal users	Calkins et al., 1991; Convery et al., 2008; Witkowski et al., 2008; Jonas et al., 2011
Percentage of departments	Baban et al., 2006; Convery et al., 2008; French et al., 1990; Nedovic-Budic, 1993; Marr et al., 1996
Extent of management use	Ariav et al., 1985; Jonas et al., 2011; Calkins et al., 1991; O'Looney, 1997; Somers, 1998
Number of GIS connections	Witkowski et al., 2008; French et al., 1990
Vision	Chan et al., 2000; Grimshaw, 1996; Somers, 1998; Witkowski et al., 2008; MacKenzie, 2003; Colijn et al., 2000; Holland et al., 2001; Van Loenen et al., 2008; Davis, 1999
Strategic plans	Giff et al., 2013; Grimshaw, 1996; Somers, 1998; Exprodat, 2013; Gudes et al., 2015; Hendriks, 1998; Higgs et al., 2005.
Purpose	Calkins et al., 1991; O'Looney, 2000; Somers, 1998; Tulloch, 1999
Usage pattern	Ariav et al., 1985
Awareness	Chan et al., 2000; Somers, 1998; Van Loenen et al., 2008; Exprodat, 2013; Higgs et al., 2005; Campbell et al., 1995; Tulloch, 1999; Croswell, 1991; Onsrud et al., 1993; Budić,1994; Alwaraqi et al., 2012; Sieber, 2000; Hussain et al., 2010; Gallaher, 1999; Eldrandley et al., 2015; Tomaselli, 2004; Baban et al., 2006
Training	Tulloch, 1999; Nasirin et al., 1998; Alwaraqi et al., 2012; Somers, 1998; Sieber, 2000; Croswell, 1991; Hussain et al., 2010; Higgs et al., 2005; Davis, 1999; Exprodat, 2013; Mangan, 2008; Giff et al., 2013; Gudes et al., 2015; Colijn et al., 2000; Göçmen et al., 2010; MacKenzie, 2003; Witkowski et al., 2008; Brodzik, 2004; Ye et al., 2014; Brown, 1996
Cooperation	Mäkelä 2012; Olafsson et al. 2014; Ye et al., 2014; Brodzik, 2004; Van Loenen et al., 2008; Tomaselli, 2004; Mangan, 2008; Sieber, 2000; Alwaraqi et al., 2012; Brown, 1996; Somers, 1998
Structure	Alrwais et al., 2014; Brodzik, 2004; McGill, 2005
Role	Somers, 1998; Gallaher, 1999; Ayodeji, 2008
Number of staff	Croswell, 1991; Brown, 1996; Sieber, 2000; Ye at al., 2014
Skill set	Somers, 1994; Tomlinson, 2005; Göçmen et al., 2010
Management style	Alrwais et al., 2014; McGill, 2005
Use of consultants	Nedovic-Budic et al., 1996), Brail, 2008), Geertman et al., 2009, Olafsson et al., 2014

Table 12. Supporting studies for each usage indicator

3.8 GIS Value

As discussed in Chapter 2, this research utilized Akingbade et al. (2009) taxonomy of GIS value (Table 13).

Category	Definition	Indicators
Efficiency	The degree to which GIS operates with minimum (waste, duplication and expenditure of resources) or with the same level of inputs but provides greater output (productivity).	1. Better allocation of resources (labor, space, material and capital) 2. Cost (savings or avoidance) 3. Increased productivity (automation and simplicity which translates into grater output with less or the same resources) 4. Better spatial data management capability (acquisition, storage, retrieval, coverage, completeness, accuracy, availability, access and dissemination) 5. Time-saving
Effectiveness	The extent to which GIS has contributed to the satisfaction of information needs, in adequate quantity and quality of data and decision-making process. GIS enhances performance as well as enabling many business processes that are not possible without GIS.	1.Adequacy of service relative to the need (satisfies information needs with expected quality) 2.Improved planning, coordination and cooperation 3.Improved products and services 4.Increased job satisfaction (internal users satisfied with the technology and decisions made based on it) 5.Better conflict resolution (as a result of information) 6.Support for more explicit articulation of decisions (improved decision making, better decisions than without GIS) 7. More responsive to the needs of citizens
Societal well-being	The degree to which GIS helps in the realization of collective goals of a society or impact of GIS on broad societal objectives such as "individual integrity, social justice, distribution of wealth and fulfillment of human aspirations."	1.Citizen-public sector interactions (Public participation and citizen empowerment) 2.Economic benefits (increased revenue for example accurate taxation or fraud detection) 3.Enhancement of principles of a democratic society, for example, freedom from constraints such as corruption (better transparency) 4.Improved standard of health and safety 5.Protection of legal rights, such as privacy (surveillance and confidentiality) 6.Social justice: fair treatment and a just share of benefits, for example equal availability of information to citizens when needed and equal ease of access (equity)

Table 13. Taxonomy of GIS impact (Akingbade et al., 2009)

As for the efficiency impact of GIS, this research elaborated more on the definition to include productivity gains which other researchers place under the category of efficiency (Tulloch and Epstein, 2002; Worrall, 1994; Nedovic-Budic, 1999). Thus, the original indicators of efficiency gains were changed slightly. Increased productivity was added as a new indicator. In addition, data related indicators (coverage, acquisition and storage) were collapsed into one indicator entitled "better spatial data management capability" that encompassed all data related gains. The original indicator named "availability and accessibility to products and services" seemed vague and too generic and was changed to "better allocation of resources" (labor, space, material and capital) as used in Rich (1995) and Stachowicz (2004). Thus, the indicators of efficiency impact were reduced from six to five. The definition of effectiveness was also changed to include enhancing performance as well as enabling many business processes that are not possible without GIS, and this addition was derived from Calkins and Obermeyer (1991). Indicators of effectiveness were kept the same but more description was provided, and the indicator named "user satisfaction" applies more to the individual level. This research is interested in organizational gains and thus it was changed to "more responsive to the needs of citizens" as described in Craglia and Signoretta (2000). As for societal well-being, the definition and indicators were kept the same with more description in some instances.

Efficiency	GIS has provided us with better spatial data management (capture, store, retrieve, share and display)
	We have gained cost savings as a result of using GIS
	We have gained cost avoidance as a result of using GIS
	GIS has increased our productivity
	GIS gave us better allocation of resources (labor, assets, material, space or capital)
	We have gained time savings as a result of using GIS
Effectiveness	GIS provided us with higher information quality relative to our needs
	GIS improved interdepartmental coordination
	GIS improved interdepartmental cooperation
	GIS has improved our city planning
	We are able to provide better service (better quality) to the public after using GIS
	Our employees are more satisfied with their jobs after using GIS (for example GIS has simplified their jobs)
	GIS helps us in conflict resolution (as a result of information sharing)
	GIS has improved our decision making process
	With GIS we have become more responsive to the needs of citizens, businesses and customers

Societal well being	GIS has increased the public's engagement and interaction with the city
	We have gained economic value as a result of using GIS (for example more revenues through accurate taxation)
	GIS has contributed to enhancing democracy in our city (via more transparency, less corruption)
	GIS has contributed to the improvement of standard of health and safety in the city
	GIS has helped in insuring the protection of legal rights (surveillance, security and privacy)
	In our city we see evidence that GIS has contributions to social justice (equity)

Table 14. GIS value measurement

Respondents were asked to indicate whether they agree or disagree with each value indicator (if the benefits had been realized in their city as a result of using GIS) and that assessed GIS value. A four-point Likert scale was used (strongly disagree, disagree, agree, strongly agree) which had no middle point (neutral). This strategy was chosen to force respondents to think deeply if the indicator under question had been achieved or not. A single item was used to measure each indicator except cost and cooperation, which were split into two questions. Value measurement is shown in Table 14. Total value of GIS was calculated by assigning +2 for strongly agree, +1for agree, -1 for disagree and -2 for strongly disagree then adding up all the scores.

3.9 Research Propositions

The main objective of this research is to develop a usage based maturity model for GIS from the organizational level. The model consists of stages, dimensions, indicators for each dimension and values for each indicator. The research model is depicted in Figure 12.

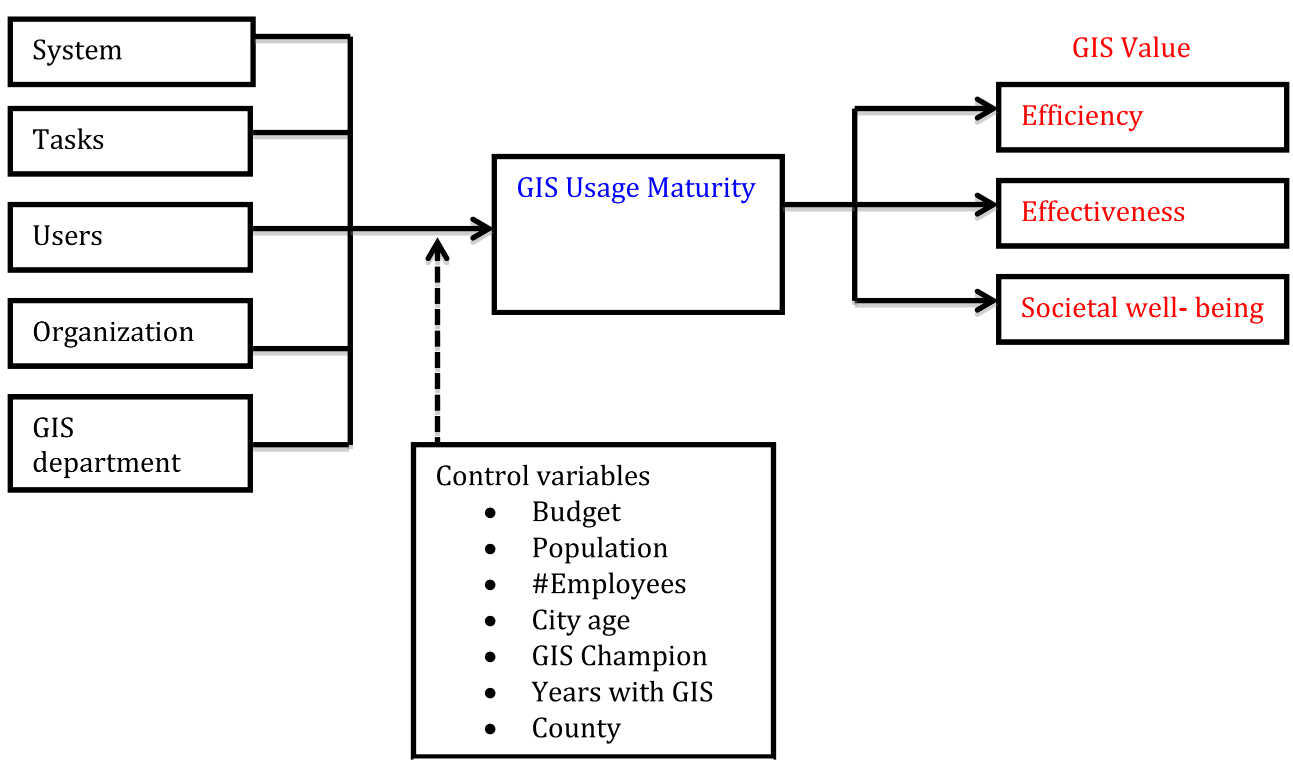


Figure 12. Research model

The structure of the proposed model was based on Holland and Light's (2001) model in terms of the conceptualization of maturity (defined as usage), number of stages (3) and number of dimensions (5). Usage dimensions were formed by adopting Burton-Jones and Straub's (2006) conceptualization of system usage (system, task and user) in addition to "organization" and "GIS department" as new dimensions to system usage following the systems theory referenced in the work of Ariav and Ginzberg (1985). The organization dimension was added to include non-quantitative organizational variables associated with GIS usage as supported by the work of (Grimshaw 1996; O'Flaherty et al. 2005; van Loenen and van Rij, 2008; Croswell, 1991; Göçmen and Ventura, 2010; Onsrud and Pinto, 1993; Ventura, 1995) and others previously citied. The GIS department dimension was added to include the competence of GIS support provided, which is considered to have a significant impact on GIS development as supported by case studies (Alrwais and Hilton, 2014; Borgesa and Sahayb, 2000) and empirical work (Alwaraqi and Zahary, 2012; Budic, 1993; Marr and Benwell, 1996). Thus:

P1.1 GIS usage maturity is a function of system, tasks, users, organization and GIS department dimensions.

P1.2 The three stages of exploration, exploitation and enterprise are sufficient to represent GIS usage maturity levels.

The proposed model has been outlined in Table 6 with indicators of each dimension and supporting studies listed in Table 12. In total, 24 indicators are used to measure the five dimensions. The second set of propositions are:

P2.1 Functions, products and level of customization are valid and reliable indicators of the system dimension.

P2.2 Core and support process, complexity of the task and workflow reengineering are valid and reliable indicators of the tasks dimension.

P2.3 Percentage of internal users and departments using GIS, extent of management use and number of GIS connections are valid and reliable indicators of the users' dimension.

P2.4 GIS vision, GIS strategic plan, purpose, pattern, GIS awareness, training and cooperation/coordination between departments are valid and reliable indicators of the organization dimension.

P2.5 Structure, role, number of staff, skill set, management style and use of consultants are valid and reliable indicators of the GIS department dimension.

Many studies have documented the positive relationship between system usage and some aspect of business value (Devaraj and Kohli, 2003; Hadaya and Cassivi, 2012; Kumar, 2004; Picoto et al., 2014; Ruivo et al., 2012; Zhu et al., 2005). In the GIS domain, the relationship between GIS usage and GIS impact has also been documented (Calkins and Obermeyer, 1991; Eldrandaly et al., 2015; Jarupathirun and Zahedi, 2007; Joffe, 2003; Mennecke el al., 2000; Reiach, 1999). Thus:

P3.1 Higher levels of GIS usage maturity will be associated with higher levels of GIS value.

P3.2 Exploration stage is positively related to efficiency gains but not related to effectiveness or societal well-being.

P3.3 Exploitation stage is positively related to efficiency and effectiveness gains but not related to societal well-being.

P3.4 Enterprise stage is positively related to efficiency, effectiveness and societal well-being gains.

Some GIS studies have found a positive relationship between characteristics of a city (size, budget, years of experience with GIS) and the state of GIS development (Colijn and Huyckburg, 2000; Convery and Ives-Dewey, 2008; French and Wiggins, 1990; Johnson, 2013; Kun, 2014; Nedovic-Budic, 1993; Olafsson and Skov-Petersen, 2014) in that larger organizations are more likely to have a well-developed and functioning GIS. Other studies have stressed the importance of a 'GIS champion' in GIS development and success (Borges and Sahay, 2000; Convery and Ives-Dewey, 2008; Onsrud and Pinto, 1993; Nasirin and Birks, 1998). Thus,

P4.1 There is a significant difference in GIS maturity between cities with different characteristics (budget, population, number of employees, city age, GIS champion and years with GIS).

P4.2 There is a significant difference in GIS maturity between counties.

CHAPTER 4 – RESEARCH DESIGN

This chapter outlines the research design undertaken to build and validate the proposed GIS usage maturity model described in Chapter 3. The chapter starts with a discussion about design methodologies for maturity models, which leads to the introduction of De Bruin et al. (2005) method. The method of De Bruin et al. (2005) is described in detail and linkage is made between the steps of this research and De Bruin's method. The chapter then goes to describe the phases of this research including the sample selection, data collection procedure, IRB process, questionnaire administration and timeline. The last section of the chapter describes the structure of the questionnaire, expert opinion about the proposed model, pilot study and statistician's feedback about the questionnaire.

4.1 Research Methodologies for Maturity Models

Despite the proliferation, relevance and use of maturity models in recent years, they have been subject to many criticisms. In Chapter 2, some of these problems were discussed. Earlier maturity models were developed haphazardly without a consistent process. Fundamental problems in maturity models include: neglecting existing maturity models within the same domain (Becker et al., 2009); anecdotal description based on limited case studies without an empirical foundation for most cases (De Bruin et al., 2005; Junttila, 2014; McCormack et al., 2009; Solli-Sæther and Gottschalk, 2010); and lack of documentation for the development process (Becker et al., 2009; De Bruin et al., 2005; Mettler, 2009). To mitigate these problems and aid researchers in developing more rigorous maturity models based on a consistent process, a handful of design methodologies have been suggested and gained support in academia (listed in Figure 13).

De Bruin, Freeze, Kaulkarni, and Rosemann (2005) propose six phases to be followed for designing a maturity model that is "theoretically sound, rigorously tested and widely accepted." The first phase called "scope" involves setting boundary decisions for the model (domain focus or general) and specifying stakeholders to participate in model development. The second phase called "design" is impacted by decisions taken in the first phase and deals with the architecture of the model, which consists of choosing the audience, method of application, driver of application, respondent and application. In the third phase "populate," the content of the model (components, sub-components and measurement tool) is specified. Phase 4 "test" is for insuring validity, reliability and generalizability of the model and its instrument. Phase 5 "deploy" concerns the deployment of the model to entities independent of the model development cycle. The last phase, "maintain" is for the long-term management of the model (revisions, training and certifications).

Becker et al. (2009)	de Bruin et al. (2005)	Gottschalk & Solli-Sæther (2009)	Maier et al. (2012)	Mettler & Rohner (2009)	van Steenbergen et al. (2010)
1. Problem definition	1. Scope	1. Suggested stage model	1. Planning	1. Problem identification and motivation	1. Problem identification and motivation
2. Comparison of existing maturity models	2. Design	2. Conceptual stage model	2. Development	2. Objectives of the solution	2. Define the objectives for a solution
3. Determination of development strategy	3. Populate	3. Theoretical stage model	3. Evaluation	3. Design and Development	3. Design and development
4. Iterative maturity model development	4. Test	4. Empirical stage model	4. Maintenance		4. Demonstration
5. Conception of transfer and evaluation	5. Deploy	5. Revised stage model			5. Evaluation
6. Implementation of transfer media	6. Maintain				6. Communication
7. Evaluation					
(8. Rejection of maturity model)					

Figure 13. Maturity model development phases (adopted from Junttila, 2014)

Becker, Knackstedt and Pöppelbuß (2009) adopted a design science research (Hevner et al., 2004) approach to propose a generic method for designing and evaluating maturity models in the IT management domain. By adopting the seven guidelines of design science, Becker et al. (2009) proposed equivalent guidelines of maturity model design. The first requirement speaks to the need for examining existing maturity models, and the second requirement emphasizes the necessity to define the problem (domain). After that, the strategy of development (new model or build on existing one) should be chosen. Model design should be iterative once an initial draft of the model is available. Based on refinements and feedback, subsequent drafts should be developed. Evaluation is the next requirement, which deals with testing the model for quality, usefulness and utility. The last set of requirements deal with publishing the results, documenting model development and transferring acquired knowledge.

Gottschalk and Solli-Sæther (2009) theorize about growth models in management research. They interpret maturity models as a theory. Their proposed procedure begins with what they call a "suggested stage model," where a maturity model is developed from previous research and inputs from practitioners. The following phase, "conceptual" is where the number of stages and content is outlined. The third phase, "theoretical" links relevant theories to extract benchmark variables and their associated values and are discussed in focus groups. The model is tested in the fourth stage, "empirical" via a survey. Lastly, the "revised stage model" reflects the results from the empirical test.

Mettler and Rohner (2009) again utilized a DSR approach to suggest three guidelines for developing maturity models. The first step, "problem identification and motivation," is designated for presenting the problem and the need for the model through discussion with stakeholders. The second step, "objectives of the solution," outlines the benefits of the model to the stakeholder. The last step called "design and development," is where the actual development begins from defining dimensions, stages, approach of design, measurement selection, populating the model with content and values, pilot study, expert opinion then finally empirical testing.

Steenbergen et al. (2010) builds on Mettler and Rohner's (2009) method and adds three more steps for developing maturity models. The first additional step called "demonstration" involves applying the model in the field. The second step called "evaluation" assesses the correspondence between the research process and DSR guidelines. The last step named "communication" deals with publishing the results for the scientific community to comment.

Maier et al. (2012) present four phases for the development of maturity grids inspired by DSR. The first phase named "planning" involves identifying the audience, aim, scope and success criteria of the model. The second phase titled "development" contains decisions regarding process area, maturity levels and administration mechanism. The third phase labeled "evaluation" concerns empirically validating and verifying the utility of the model. Lastly, the "maintenance" phase involves documenting model development and communicating the results to the community of interest.

These six methods of design share some aspects of commonality but exhibit some differences also. The dominant research method is the design science approach in four of the six methods, which forces the use of DSR if one wants to adopt these approaches for maturity model design. In Becker et al. (2009) there is a loose coupling with the DSR approach and it seems that the alignment is almost forced. The sequence of requirements isn't well thought out. Although Gottschalk and Solli-Sæther (2009) don't use DSR, they limit research methods to case study in phase two and survey for step four. Mettler and Rohner's (2009) method lacks detail, is narrowly designed for a specific case and neglects important phases such as wide scale deployment and testing. Steenbergen et al. (2010) and Maier et al. (2012) are similar to the other methods and don't provide anything new. Becker's et al. (2009) method is geared towards IT management, Gottschalk and Solli-Sæther (2009) applies more to industrial management, Mettler and Rohner's (2009) is for organizational engineering, Steenbergen et al. (2010) focuses more on area maturity models while Maier's et al. (2012) method is more applicable for maturity grids.

De Bruin et al. (2005) were the first to propose a development method that has a clear logic and sequence between the phases, is not limited to a specific research method, and has been used widely. De Bruin et al. (2005) provided specific deliverables in each phase, which makes following their approach possible. Further, their approach addresses measurement of the model, which is lacking from other methods. De Bruin's et al. (2005) method is generic enough to be applied to any domain. For these reasons, this research followed the De Bruin method in designing the GIS usage maturity model, except the last phase as it relates to the long-term management of the model, which is outside the scope of this work.

4.1.1 De Bruin's Methodology

De Bruin et al. (2005) argues that more than 150 new maturity models have been developed over the years across different domains in IS, which is a high number of maturity models that are broad in application. However, little documentation exists on how to develop a maturity mode that is "theoretically sound, rigorously tested and widely accepted." They propose a generic framework that encompasses six phases to develop a maturity model regardless of the target domain. They make the distinction between descriptive models (assess only the as is state of maturity), prescriptive (link maturity with business value and provide best practices to improve maturity from stage to stage) and comparative maturity models (can be applied to organizations in diverse industries and regions). The order of phases is important as decisions taken in earlier phases impact choices available at later phases (for example, scoping decisions impact test alternatives).

The first phase called "scope" deals with setting the boundary for application and use, focus (general or domain specific) and target of the maturity model. This step is followed by an examination of the literature in the domain, related domains and comparisons with existing maturity models. Literature review will reveal gaps and domain issues in the form of inability to address domain challenges, complexities not considered or weak testing. Then the purpose of the new maturity model can be better articulated (complement existing maturity models, be applied to a new domain, etc.). Once these steps are completed, stakeholders (academics, industry experts, government or nonprofit organizations) are identified and involved to assist in designing the new maturity model and clarifying its purpose (De Bruin et al., 2005).

For this research, the proposed model has a specific domain that of GIS maturity at local government. In Chapter two, relevant literature from the GIS domain, related domains (system usage) and maturity models were reviewed. Gaps identified included lack of a comprehensive measure for organizational GIS usage, inadequate testing of GIS maturity models and complexity of the system usage construct. The purpose of this model is to diagnose the maturity of an organization in using GIS "as-is" and enable comparison with GIS value obtained. Stakeholders to be involved in the development of this model include local government (cities and municipalities), academics, GIS consultants, and experts within the GIS industry. Later on in this chapter, initial stakeholder's feedback about the proposed model will be discussed.

The second phase labeled "design" is concerned with the approach for operationalizing the maturity model and organizing its structure based on why the model is needed, who will be involved, how the model will be assessed and what benefits will be achieved by the organization if the model is used. There should be a balance between meeting these requirements in a complex reality and model simplicity. This phase includes the approach of design either top-down (define the stages first then the dimensions and sub-dimension) or bottom up (start from the sub-dimensions all the way to the stages), assessment method (self-reported or third party), choosing the number of stages, naming the stages, defining each stage and calculation method (average or stage-gate) (De Bruin et al., 2005).

The audiences of the proposed model are local government officials interested in evaluating their current use of GIS to examine if the potential is met (how GIS currently serves the organization and where GIS could be used.) The method of application will be self-assessment through a questionnaire. Respondents will be GIS managers or staff aware of GIS use in the organization. This research took a top-down approach where the number, name and description of each stage was determined first then the components of the model followed accordingly. Average maturity was chosen as the calculation method used by similar models in GIS. Stage names and definitions for the proposed model have been supplied in the first section of Chapter 3.

The third phase named "populate" focuses on generating the content of the model, what will be measured and how will it be measured. The first step to generating the content is to specify the domain components (success factor or barriers) by performing a literature review. Once an initial list of components and sub-components are generated, then exploratory research methods (delphi, nominal groups, case study or focus group) can be used to validate these a priori constructs depending on stakeholders involved and available resources. The last step is to generate the measurement instrument (questions and scale) based on instruments from the literature if possible. A quantitative method in the form of a survey available electronically is recommended to validate the model (De Bruin et al., 2005).

The content and measurement of the model has been discussed thoroughly in Chapter 3. This research relied mainly on the literature and a case study (Alrwais and Hilton, 2014) to develop the initial draft of the model. Later on in this chapter expert opinions and comments about the model will be discussed.

The fourth phase marked “test” intends to insure the relevance and rigor of the design by examining construct validity (face and content) and instrument validity, reliability, and generalizability (De Bruin et al., 2005). Face validity can be assessed through interviews and focus groups. Content validity can be assured by the extent of literature review, breadth of the domain covered, and pilot testing. Instrument validity and reliability is assessed through the quality of measures borrowed from the literature, expert opinions and results from a pilot test. In a survey, a pilot test allows respondents to comment about the structure of the survey, ease of completion, time required to complete and clarity of questions. Factor analysis can be used once the survey is administered to assess convergent and divergent validity (De Bruin et al., 2005).

Construct validity for the model has been insured by careful and thorough examination of the literature covered in Chapters 2 and 3 and expert opinions. Instrument validity and reliability can be satisfied by the breadth of literature covered and instruments borrowed from the literature outlined in Chapter 3. A discussion about the instrument with a statistician (Dr. June Hilton) and results from a small-scale pilot study will be discussed later. Validity and reliability tests will be discussed in detail in Chapter 5.

Phase five is named “deploy” and is devoted to the application of the model in a large scale to test its generalizability. The authors of the study argue that unless the model is tested on entities independent of development and testing (collaborators and involved stakeholders), then generalizability will be an issue (De Bruin et al., 2005). For this research the model has been tested on a large scale in the local government of Southern California; the results will be analyzed in Chapter 5.

The last phase termed “maintain” concerns the long-term management for the growth and use of the model. The authors of the study call for establishing a repository to track the model’s evolution and development (De Bruin et al., 2005). The model could be presented online in a website or through an application, which needs to be changed if the model is updated and this depends on the available resources. Issues of certification and training are also addressed in this phase. For this research, the objective is to develop a new model. The issues of long-term management of the model are outside the scope and resources of this work. However, future research can extend this work to cover the "maintain" phase by developing an application based on the survey that can calculate GIS usage maturity and identify areas requiring attention and focus for potential development automatically.

4.2 Experts' Opinions

The scope, design and populate phases have been addressed in Chapters 1, 2 and 3. In the remaining part of this chapter, the steps taken in the "test" phase are described. The initial draft of the maturity model was developed based on the literature and a case study (Alrwais and Hilton, 2014), which was subjective, therefore experts were contacted to validate the structure of the models (usage and value) and suggest revisions to insure content validity. Experts contacted included academics, GIS consultants, practitioners and local government employees. In total, 18 individuals were contacted by email in the period between Nov 2014 and March 2015. These 18 individuals were chosen because of their interest in the subject as evident from their publications and work. Their emails were obtained from publications, LinkedIn, personal websites and Internet search. An email was sent to them explaining the purpose of the research and asking them to comment about the models and suggest changes. Each expert obtained a copy of the maturity model, GIS value taxonomy and stage description.

Experts contacted were Rebecca Somers; Zorica Nedovic-Budic; Jaana Mäkelä; Nancy Obermeyer; Linda Tomaselli; Marc Witkowski; Bruce Joffe; Stephen Ventura; Harlan Onsrud; Jeffrey Pinto; Brian Mennecke; John O'Looney; Abbas Rajabijfard; Mohamed Hamouda; Valrie Grant; Dianne Haley; Greg Babinski; and David DiBiase. No response to the email was received from Jaana Mäkelä; Marc Witkowski; Bruce Joffe; Harlan Onsrud; Brian Mennecke; Abbas Rajabijfard; Mohamed Hamouda; and Valrie Grant. Zorica Nedovic-Budic indicated that she doesn't work in the area currently and declined to participate. Jeffrey Pinto also replied that he doesn't perform research in this area currently and suggested two other names to contact that were already on the list of experts. Dianne Haley replied on March 2015 and offered to send her opinion by May 2015, which was too late, as the questionnaire had already been administered by that time. Rebecca Somers expressed interest in the topic and promised to send feedback by February of 2015, but unfortunately, nothing was received by that time. David DiBiase forwarded the email to Greg Babinski.

In total, five valid replies about the model were received from Nancy Obermeyer; Linda Tomaselli; Stephen Ventura; John O’Looney; and Greg Babinski. Nancy Obermeyer acknowledged the need to find out where and how GIS is being used by local government and expressed interest in another researcher in the same area. Linda Tomaselli supported the maturity model structure in general and suggested minor expression changes to stage and model descriptions. Linda Tomaselli shared her experience that the impact of GIS depends mostly on the preferences of the decision maker (data oriented or not) and his/her own agenda. She expressed doubt that the societal values of GIS will ever be achieved. Stephen Ventura raised a concern that the values (indicator score for each stage) of the maturity model were too narrowly defined, suggested some word changing to stage description, and questioned the inclusion of the GIS department as a dimension related to usage. John O’Looney’s response was mostly supportive of the maturity model. He suggested some minor changes including relaxing the values for the number of usage agreements required for each stage and suggested adding knowledge management as a dimension to the model. Greg Babinski communicated interest in the topic. He had concerns that the values of the maturity model were too subjective and strict, especially in the number of usage agreements and staff in the GIS department. He suggested some linguistic and wording changes. He had questions about the type of maturity that this model tries to assess: who will perform the evaluation, how the evaluation will be carried out, and how this maturity model complements other GIS maturity models. The detailed responses are shown in Appendix 1.

Overall, the majority of the responses acknowledged the importance of evaluating local government’s use of GIS and supported the overall structure of the model. Comments included suggestions for the definition of stages, notes about wording, relaxing the values of variables for some stages, suggesting the possibility of needing more stages, the need for clarifying variable description, questions about how the model will be measured and by whom, and proposing extra dimensions (data and knowledge management). These comments were taken into consideration and the model was revised accordingly.

4.3 Questionnaire

Following the feedback and validation by experts, the next step was to build the measurement tool (a questionnaire). The literature again provided some initial questions and items, however, for the remainder of the model new questions needed to be developed. These questions contain straightforward statements reflecting each indicator of the model and seek the facts regarding actual overall usage, not behavior, opinion, intentions, or individual beliefs. Measurement for each indicator was discussed in Chapter 3. For some questions, a text field titled "other" was added for participants to supply their own answer if the choices given didn't apply to their current condition. Where applicable some questions had the "check all that applies" option to choose more than one answer. The final question in the questionnaire was an open-ended question for respondents to write anything they thought mattered regarding GIS use or benefits. In total there were 51 questions. Before filling out the questionnaire, respondents had to read the consent form and agree to participate in the questionnaire. Also they had to declare that they were knowledgeable about the role of GIS in their city, otherwise they weren't able to fill the rest of the questionnaire.

The questionnaire is composed of five parts. The first part deals with demographics regarding the participant (age, gender, education, years of employment with the city and years of experience with GIS). The main question in this section was the job title. The targeted group from the questionnaire was either GIS personnel (analysts or manager) or employees trained on GIS (city planner or engineer); thus the job title question was important to guarantee that the questionnaire was completed by a qualified respondent. Part two contains questions regarding the characteristics of the city/municipality (age of the city, governance, population, budget and number of employees). This part provided the control variables for the study. Part three focuses on the history of GIS in the city (age of GIS in the city, form of GIS, existence of a GIS champion, vendor of GIS). This part also provided some control variables and descriptive information to set the scene of how GIS was implemented. Part four contains the questions directly related to the maturity model (GIS usage), while part five deals with the value gained from GIS to the city. The questionnaire can be seen in Appendix 2.

4.4 Pilot Study

After constructing the questionnaire and before handing it out to the respondents, the measurement (items and scale) had to be tested for validity, clarity, ease of completion and time required to complete. First, June Hilton, a statistician, was consulted to assess the soundness of the instrument, statistical tests possible based on the current structure of the questionnaire, and objectives of the research. June Hilton suggested adding an extra question for perceived GIS value, adopting a four point scale for GIS value statements to encourage respondents to take a stance (either positive or negative) instead of leaning towards the middle to play it safe, rearranging some of the descriptive questions, changing the intervals for some questions and rephrasing other questions. These suggestions were very valuable and taken into consideration and the questionnaire was modified accordingly.

Additionally, three individuals, James Troyer, the Director of Community Development for the City of Fontana; John Tangenberg, a GIS analyst for the Council for Watershed Health; and Mike Tschudi, a programmer at ESRI and involved with local government, were approached to try out the questionnaire and provide their insights. Two accepted interview requests. At the interview they were presented with the questionnaire, objectives of the research, and were asked to provide feedback. Feedback that was obtained from this small pilot study included modification to the phrasing of some questions and items, order of listing, addition/deletion of some answer choices, concern about the length of the questionnaire, reordering the flow of some questions, and revisions to the stage description. The questionnaire was adjusted based on these responses. Other than those suggestions, they supported the structure of the questionnaire and the goal behind it.

4.5 IRB Procedure

Since this research involves the participation of public officials and random monetary rewards would be offered, the office of Institutional Review Board (IRB) at Claremont Graduate University (CGU) had to be notified. A formal document containing the IRB form, consent form, a copy of the questionnaire and invitation email was submitted to the IRB office. On March 2015, the IRB office responded and decided to consider this research exempt from IRB oversight (exemption letter shown in Appendix 3).

4.6 Population

The proposed maturity model in this research is designed to apply specifically to local government. Government has been an early adopter of GIS and hence, it is expected that there will be variations in the use of GIS in government. Local governments in specific have long-used GIS for planning land use, zoning, taxation, infrastructure management and emergency planning, and thus constitute a suitable study sample. In an effort to control for the variations that exist within local governments (such as policies and regulations, population, size, geography and terrain, weather, availability of GIS vendors in the region and tourism), the study focused on cities within the Southern California region of the United States. Southern California is divided into ten counties and includes 235 cities (map shown in Appendix 6). The websites of each of these cities were accessed to obtain email addresses of employees thought to be involved with GIS (GIS manager, GIS analyst, IT staff, planner or engineer). Thanks to Javier Aguilar, this research also obtained the email addresses from a secondary source via the Southern California Association of Governments (SCAG).

4.7 Data Collection Process

The fifth element of De Bruin's method is the "deploy" phase. After getting some support for the maturity model and its instruments, it was time to deploy the survey on a large scale to test the validity and utility of the proposed model. Sending, filling and receiving the response electronically is cost effective, more convenient to the respondent (can be done from anywhere, can stop and resume at any time, doesn't require any physical mailing, and can be easily forwarded to another person), faster, easier to track progress and send reminders, and thus a higher response rate is expected compared to paper mailing. In an effort to encourage participation, five Amazon gift cards each worth $40 were offered randomly for completed responses.

Qualtrics is a very popular online survey software that enables users to perform a multitude of functions in addition to designing, administering, and receiving responses to an online survey. Users can incorporate logic into the survey (certain questions displayed based on previous answers); implement validations to answers before submission; configure questions as mandatory or voluntary; manage mailing lists and reminders; run reports; and export data into many formats. Qualtrics is a comprehensive software that was available through Claremont Graduate University and was used in this research.

An invitation letter (depicted in Appendix 4) was sent to each of the 235 cities in Southern California with a link to the survey. The invitation letter explained the purpose of the research, benefits of completing the survey to the organization, assurance of confidentiality and a request for their participation. Qualtrics enabled generating a unique URL for each city. Respondents used the URL to fill out the survey and their responses were received electronically as soon as they answered all the required questions. If there were multiple emails for a given city, then the email was sent to the person most likely knowledgeable about GIS (e.g. GIS manager). In the invitation letter, respondents were encouraged to pass the survey to another person in the city if they thought he or she would be in a better position to fill it out. In a third layer of insuring that the right person filled out the questionnaire, some questions asked respondents about their job title and experience with GIS. After sending the first invitation email, Qualtrics enabled sending automatic weekly reminders. After a few weeks, new invitation emails for different individuals were sent to those cities that didn't reply (didn't open the email or click the URL.) The duration of data collection was from March 16, 2015 until June 1, 2015. Qualtrics also enabled generating automatic thank you letters for completed responses.

CHAPTER 5 – DATA ANALYSIS

This chapter describes the data analysis of the study and the interpretation of the results. First the response rate of the study is reported followed by descriptive statistics of the respondents, responding cities and research variables. Second reliability and validity tests are discussed. Then correlations between research variables are reported. After that, the maturity score of each participating organization is reported and analyzed against this research's propositions. Also data concerning GIS value is reported and discussed. Next statistical tests are performed to analyze the relationship between GIS maturity and GIS value. Qualitative Analysis of the open-ended questions in the questionnaire is also included. The chapter concludes with general discussion about the research propositions and the results of the study.

5.1 Response Rate

The questionnaire was sent to 7 cities in San Luis Obispo County; 11 in Kern County; 8 in Santa Barbara County; 10 in Ventura County; 88 in Los Angeles County; 24 in San Bernardino County; 34 in Orange County; 28 in Riverside County; 18 in San Diego County; and 7 in Imperial County. In total, 235 cities were asked to participate. Not all of the cities were likely to participate given that some of them still do not have GIS, either because of geography (small area to govern), funding, staff shortage, or unique features of the city (e.g. private gated community, newly incorporated).

Sixty-one cities did not open the questionnaire URL (either they did not open the email, email went into junk email folder, or they decided not to participate after reading the invitation letter clarifying the research objectives). This yielded 26% with no response. One hundred and seventy four cities (74%) received the emails and clicked on the URL for the questionnaire. Of those 174, 138 answered the first question (decision to participate or not in the questionnaire). Of that number, 122 indicated that they would like to participate, and 16 declined to participate. Additionally, 19 cities declined to participate (they sent a rejection email) without answering the first question of the questionnaire. In total, 35 cities (14.9%) formally declined to take part in the questionnaire. Those cities that declined gave the following reasons: not using or having a working GIS, stopped using GIS after the GIS technician left the city, respondent not qualified to answer GIS related questions, minimal use due to lack of financial resources and work load commitments preventing them from having time to complete the questionnaire. These reasons feed into the validity of the study since only cities with working and usable GIS participated.

There were 23 partial responses, which were included in the descriptive statistics only. There were 99 full responses with two redundant responses (two persons from the same city filling different questionnaires) yielding a total response rate of 41.3%. There were 4 responses from San Luis Obispo County; 4 from Kern; 5 from Santa Barbara; 6 from Ventura; 32 from Los Angeles; 14 from San Bernardino; 13 from Orange; 8 from Riverside; 9 from San Diego; and 2 from Imperial County.

5.2 Descriptive Statistics

After agreeing to participate in the questionnaire, respondents were asked if they were familiar with the role of GIS in their city. All respondents (100%) answered yes to this question, which provides a first step assurance that only qualified persons participated. The vast majority of the respondents were males (81%) compared to 19% females, as men dominate planners, engineers, IT and GIS staff positions (Schuurman, 2002).

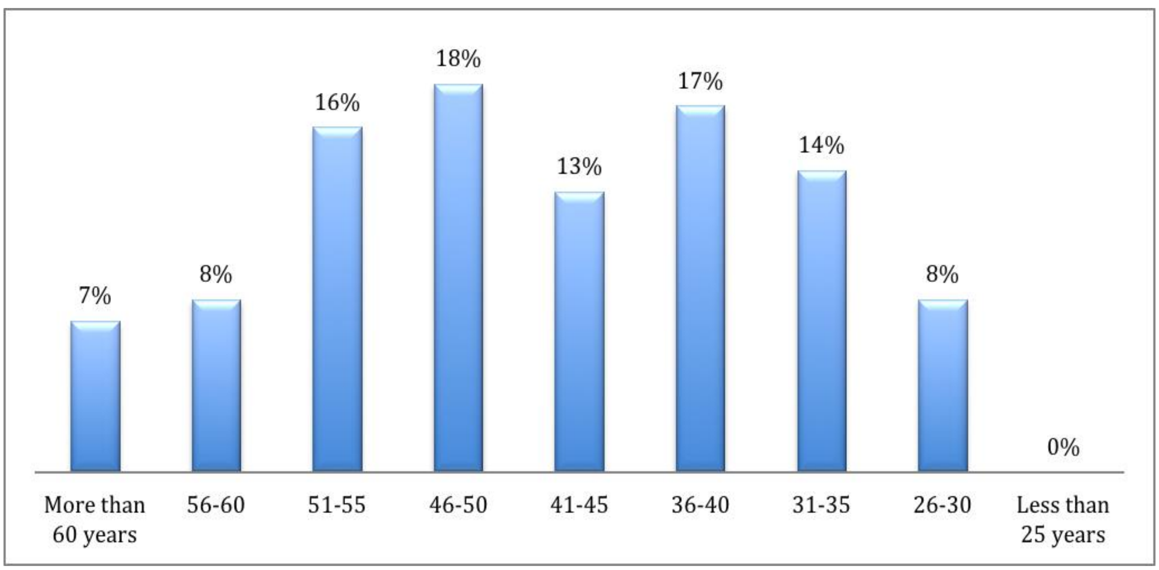


Figure 14. Age groups of respondents (N=119)

The age of respondents was between the mid-thirties to the mid-fifties, with a few respondents older than 60, as can be seen from Figure 14. The majority of respondents held Bachelor’s degrees

(51%), followed by Master's degrees at 37%, and just a diploma at 8%; only 2% of respondents had a Ph.D. degree. More importantly, in terms of respondents experience with GIS, 71% had more than six years of experience, 23% between 1-6 years and 7% had less than one year of experience. This is the second layer of protection that proves that for the most part, experienced individuals with GIS filled out the questionnaire. Respondents were also asked about their current job title as shown in Figure 15.

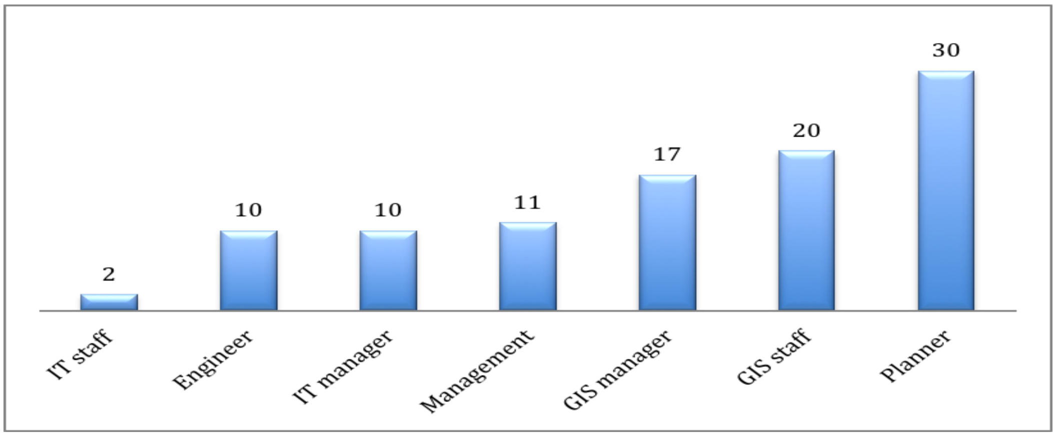


Figure 15. Job title of respondents (N=119)

Thirty-seven percent worked in GIS related jobs, 30% were planners, 12% from IT, 11% were department heads or held management positions and 10% were engineers. This was the population that this research attempted to target: those who are in a good position to evaluate GIS use and GIS value in their organizations. Additionally, respondents were asked about the period of time they have been with their current employer. Forty-five percent had been with their city for more than 9 years, 19% between 7-9, 11% between 4-6, 22% between 1-3 years, and only 3% of respondents were employed within the last year. Respondent's demographics and work qualifications provide assurance that they were suitable individuals, able to provide accurate information about GIS usage and GIS benefits in the city where they worked. The second set of questions concerned the characteristics of cities in the sample. Table 15 shows the descriptive statistics for the number of years since the city was incorporated. It can be seen that there exists great diversity between cities in the sample with some new cities and some very old cities. On average, cities in the sample were well-established with about 60 years of history.

Min	Max	Average	STD	Mode	Median
14	234	78	43	59	61

Table 15. Years since the city was incorporated

Concerning the form of government, 98% followed a city council (or mayor) and city manager form of government. Population of these cities varied: from less than 49,000 in 42% of the sample; 27% were between 50,000-99,999 people; 13% were between 100,000-149,999 people; 8% were between 150,000-199,999 people; and 11% had more than 200,000 people. This indicates a mixture between big metropolitan cities, medium sized cities and small towns. The diversity is also apparent in the annual city budget, which was less than 50 million for 55% of the sample, between 50-100 million for 17% and over 100 million for 28% of the sample. The number of workers in these cities also varied as 51% of the sample had less than 200 workers, 20% had between 200-400 workers and 29% employed more than 400 workers. It is evident that the cities in the sample are diverse (in terms of size, budget, population and age) and comprise a suitable assortment in which GIS and different city characteristics can be tested. The third set of questions was about GIS history in the city. Table 16 shows the descriptive statistics for number of years since the city has been using GIS. On average, cities in the sample have been using GIS for at least 13 years. This period is sufficient to examine GIS usage and look for GIS value.

Min	Max	Average	STD	Mode	Median
0	40	13	8	15	13

Table 16. Years of experience with GIS

When asked about how the GIS functionality is provided to the city, 71% of respondents have it in house; 17% through a consultant or contractor firm; 6% through the county; 4% mixed (in house and outside); 1% through an NGO; and 1% shared among a league of neighboring cities. The champion for GIS in these cities came from different departments, with the largest number in the planning department (18%); IT was at 16%; city management 15%;public works and engineering at 14%; GIS 13%; community development 8%; and outside influencers in only 2% of the sample. When asked about the GIS vendor, 72% have ESRI; 12% Autodesk; 7% Digital map products; 3% Microstation; 2% XY MAPS; and 1% for Bentley, Intergraph, Smallworld, and open source GIS

(QGIS, SAGA, GRASS). These numbers indicate that there is reasonable variety among the cities in how they handle and manage GIS, and thus indicate that it is a suitable sample for studying GIS use.

The fourth section of the questionnaire contained questions concerning the GIS usage maturity model. Participating cities were asked to select the GIS functions that they currently use. Table 17 illustrates the responses to GIS functions utilized ordered from most to less used. Basic GIS functions (map creation, spatial data management, basic measurement) are heavily used. On the other hand, decision related functions and advanced functionality of GIS are used less than 25% by the surveyed organizations.

GIS Function	Frequency (N=103)	Percentage
Map production	98	95%
Distance Measurement	87	84%
Buffering	81	79%
Overlay	67	65%
Data Capture (digitize, scan, GPS, sensors, satellite spatial data)	65	63%
Reporting	64	62%
Geo-coding	63	61%
Design and Planning	61	59%
Data Preprocessing (transformation, scaling and smoothing of spatial data)	57	55%
Spatial Database	56	54%
Spatial Analysis	56	54%
Asset Tracking	55	53%
Geo-processing	53	51%
Data Conversion	52	50%
Projection	40	39%
Site Selection	40	39%
Graphs	39	38%
Network Analysis	32	31%
Impact Assessment	25	24%
Decision Modeling	25	24%
Temporal Display	20	19%
Prediction and Forecasting	18	17%
Simulation	15	15%
3D Presentation	14	14%

Table 17. GIS functions used

Another question asked about the GIS products and packages used. Table 18 lists the responses to this question. ArcGIS Desktop software is by far the most used at 86% of the sample.

GIS Product	% (N=103)	GIS Product	%	GIS Product	%
ArcGIS Desktop	86% (89)	Explorer for ArcGIS	9% (9)	Trimble Pathfinder Office	1% (1)
ArcGIS Server	52% (54)	ArcGIS Data Extensions	8% (8)	Avenza MaPublisher	1% (1)
ArcGIS Online	48% (49)	Business Analyst	7% (7)	Cityworks for AML	1% (1)
ArcSDE	35% (36)	ESRI demographics	7% (7)	Pictometry	1% (1)
GIS Web services	28% (29)	ArcGIS for windows mobile	5% (5)	XY Maps	1% (1)
ArcGIS Flex or Silverlight	26% (27)	City Engine	5% (5)	Photomapper	1% (1)
ArcPad	26% (27)	Spatial-temporal analysis	4% (4)	PostgreSQL/PostGIS	1% (1)
Web applications templates	23% (24)	Operations dashboard	4% (4)	Esri Production Mapping	1% (1)
ArcGIS Mobile	20% (21)	Community Analyst	3% (3)	Bentley	1% (1)
ArcGIS network analyst	19% (20)	ESRI Reports	3% (3)	GeoServer	1% (1)
ESRI community maps	17% (17)	ArcGIS Schematics	2% (2)	OpenLayers	1% (1)
ArcGIS Engine	16% (16)	Real-time monitoring	2% (2)	Leaflet	1% (1)
Collector	16% (16)	ESRI Geoportal	2% (2)	SAGA	1% (1)
ArcGIS for local government	14% (14)	ArcGIS ETL	2% (2)	GRASS	1% (1)
ArcGIS 3D extension	12% (12)	Digital Maps Products	2% (2)	Whitebox GAT	1% (1)
ArcGIS app	11% (11)	ArcGIS Spatial Analyst	2% (2)	Orfeo Toolbox	1% (1)
		Autodesk	2% (2)	TRAKiT	1% (1)
		Google Earth	2% (2)	ArcGIS Transportation Analyst	1% (1)
		Nobel	2% (2)	Streatmap Premium	1% (1)
		Geocortex	2% (2)	ArcGIS data quality	1% (1)
		QGIS	2% (2)	AutoCAD	1% (1)
				ArcInfo	1% (1)
				ArcView	1% (1)

Table 18. GIS products used

Besides the standard format of ArcGIS desktop, server, online or mobile, other GIS products were rarely used at less than 20% of the sample. Respondents were also asked about the applications of GIS. Table 19 lists the core and support processes enabled by GIS in the sample. Clearly planning and engineering processes utilize GIS more than administration or financial processes. In 53% of the sample, GIS enables less than a third of all city processes, which is an indication of underutilization of GIS capabilities.

Core Process	Frequency (N=101)	%	Support Process	Frequency (N=101)	%
Zoning and districting	92	91%	Mapping	91	90%
Land use planning	89	88%	Address verification	62	61%
Engineering	60	59%	Owner notification	57	56%
Infrastructure management	60	59%	Code enforcement	55	54%
Utility management	55	54%	Data collection	37	37%
Emergency management (Police,	51	50%	Reporting	35	35%

Fire)					
Economic development	48	48%	Information dissemination	34	34%
Cadastral/parcel	46	46%	IT	29	29%
Permitting and inspections	45	45%	Housing	23	23%
Public safety	43	43%	Documentation	22	22%
Development review and approval	38	38%	Street closure permitting	22	22%
Transportation management	38	38%	Event scheduling	18	18%
Landscape management	36	36%	Parking management	18	18%
Parks maintenance	34	34%	Records management	14	14%
Community assessment	32	32%	Historical and tourism planning	13	13%
Environmental monitoring	29	29%	Platting	12	12%
City hall meetings (open or private)	29	29%	Resource allocation	8	8%
Customer services (requests)	26	26%	Fleet monitoring	7	7%
Business licensing	24	24%	Citations management	4	4%
Elections	20	20%	Library services	4	4%
City Yearly plans	19	19%	Performance monitoring	3	3%
Budget Preparation	15	15%	Human resources	1	1%
Taxation (property assessment)	11	11%	Children's services	1	1%
Public health	7	7%			
Revenue management	4	4%			
Employment	3	3%			
School management	2	2%			
Procurement and contract management	1	1%			

Table 19. Core and support processes supported by GIS

In terms of the complexity of the tasks GIS is used in, 68% of respondents use it for simple tasks, 34% for moderate tasks and only 20% use GIS for complex tasks. When looking at how GIS has reengineered workflows and processes, 71% of respondents say GIS has only digitized manual processes; 50% experienced moderate changes; and only 20% have seen radical changes as a result of GIS. Table 20 lists the users of GIS in the each organization in the sample. Planners and engineers use GIS the most, followed by field workers and emergency response officers and then city executives. It is surprising to see that the general public is considered a user of GIS in 44% of the sample when compared to the city manager's deputy seen as a user in only 28% of the sample. In about 69% of the sample GIS is used by less than half of all city employees.

User Type	Frequency (N=99)	%
Planners	96	97%
Engineers	80	81%
Department heads	62	63%
Field workers	50	51%
Analysts	45	45%
Clerks	44	44%
General public	44	44%
IT staff	42	42%
Police officers	42	42%
City manager	41	41%
Firefighters	38	38%
City manager's deputy	28	28%
Council members	28	28%
Mayor	25	25%
Attorneys	20	20%
Local business	20	20%

Table 20. Users of GIS

Departments using GIS are presented in Table 21. Planning, public works and engineering heavily use GIS followed by community and development departments then minimal use by health and city service departments. Overall, there is high usage of GIS from city departments. In 65% of the sample, GIS is used by more than half of all city departments. Respondents were also asked about the level of management that uses GIS and the responses are displayed in Figure 16. There is high use of GIS by operational management, some use at middle management, but very low use at top management.

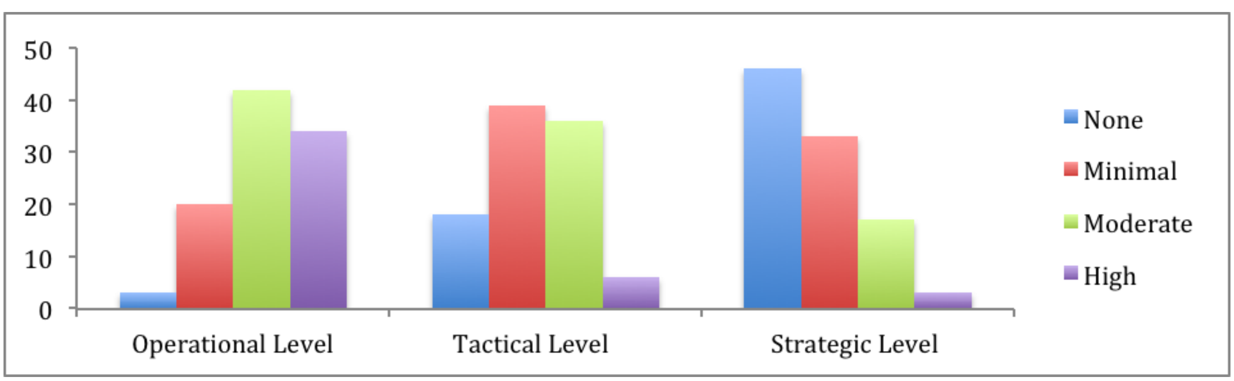


Figure 16. Management use of GIS

Department	% (N=99)	Department	%	Department	%
Planning	96% (95)	Redevelopment	39% (39)	Library services	10% (10)
Public works	87% (86)	Water and power	39% (39)	Treasurer office	10% (10)
Engineering	73% (72)	Community services	38% (38)	Cultural affairs	9% (9)
Community development	68% (67)	Finance	34% (34)	Human resources	7% (7)
Code enforcement	67% (66)	Sanitation and recycling	33% (33)	Volunteer services	6% (6)
Parks and recreation	55% (54)	City clerk office	33% (33)	Harbor/ports	6% (6)
Building and safety	52% (51)	Environmental services	27% (27)	Purchasing and contracting	5% (5)
Police	51% (50)	Mayor's office	25% (25)	City auditor office	4% (4)
Utilities	51% (50)	City attorney office	24% (24)	Health and human services	3% (3)
Economic development	49% (49)	Housing and real estate	22% (22)	Zoo services	3% (3)
Administration	49% (49)	General services	20% (20)	Convention center	3% (3)
Information Technology	44% (44)	Records and archive	16% (16)	Disability and aging	3% (3)
City manager office	44% (44)	Risk management	15% (15)	Oil and gas	2% (2)
Emergency management	42% (42)	Airports	13% (13)	Employment services	1% (1)
Transportation and parking	42% (42)	Animal control	13% (13)		
Landscape and Public infrastructure	42% (42)				
Fire	41% (41)				

Table 21. Departments using GIS

Respondents were asked a series of questions regarding the GIS department if it existed. They were asked about the structure of the GIS department/team in the organizational chart. The responses are shown in Figure 17. The most common place for the GIS department in the sample was under the IT department. It is surprising to see that although the average city experience with GIS is 13 years, 28% do not have a GIS department and only 6% have a dedicated GIS department independent from any other departmental responsibilities. Mostly the GIS unit is positioned within the department that uses them the most (IT, planning, public works or engineering). Fifty-two percent of the sample states that the purpose of GIS is to enhance policymaking, yet that hasn't been translated into practical steps, such as establishing an independent GIS team to support the whole organization.

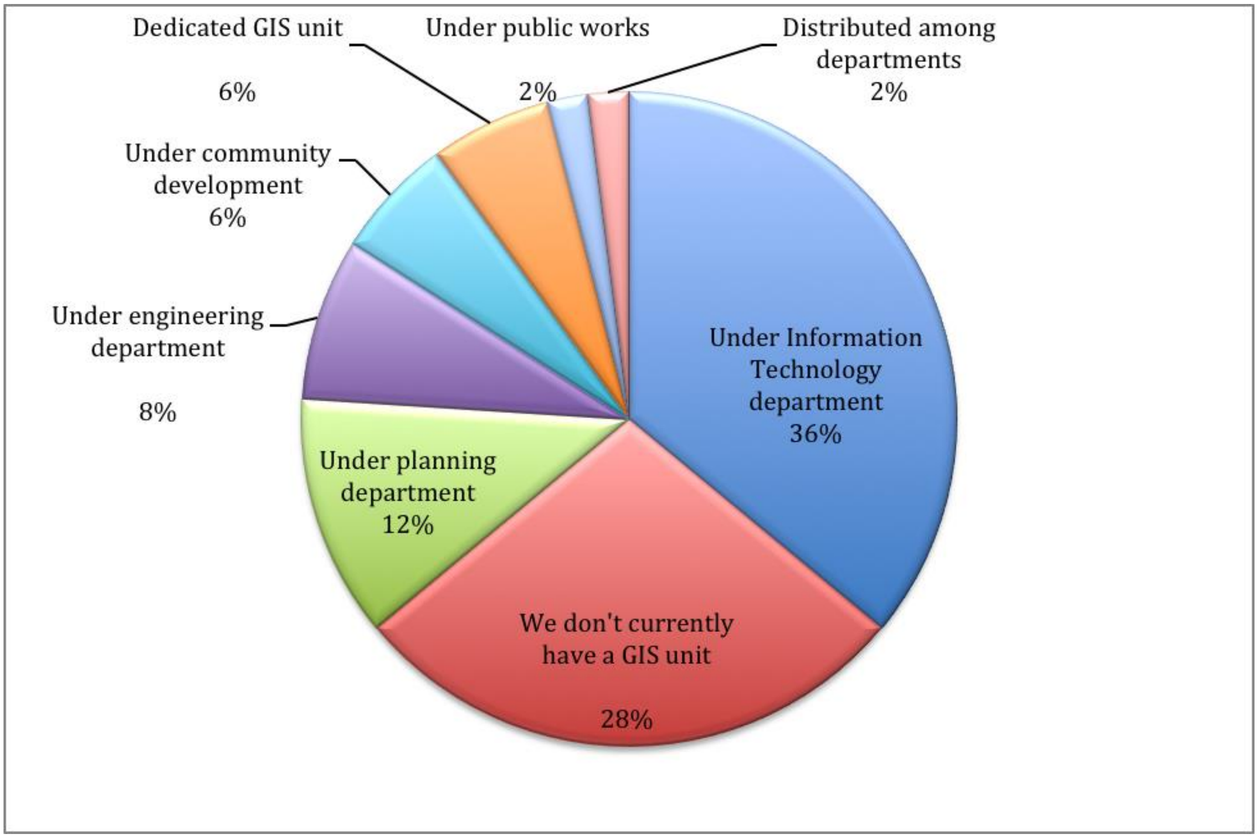


Figure 17. Location of the GIS unit in the organizational chart

For those cities with a GIS department, 72% have three or less employees working in the GIS department and only 28% have more than three employees. If a department is to serve at least 100 city employees and at the same time keep up with the changing nature of technology, three employees are not sufficient to bring radical and innovative changes to the city. Respondents were also asked about the extent of using an outside GIS consultant in their projects: 40% do not use GIS consultants compared to only 29% that use GIS consultants on a regular basis.

The last section of the questionnaire was to elicit responses regarding the impact of GIS realized by responding organizations. Respondents were asked to comment on 21 statements about the benefits that the city has realized from using GIS. Responses are shown in Figure 18. The most agreed upon benefits of GIS were better spatial data management, higher information quality, time saving, productivity and better service quality. The least realized GIS benefits were social justice, protection of legal rights, improving health and safety and economic gain. There is agreement about efficiency and effectiveness gains but societal benefits of GIS are rarely realized. It is interesting that there is no consensus about GIS impact on improving health, safety and bringing economic value although GIS vendors promise significant changes in those areas.

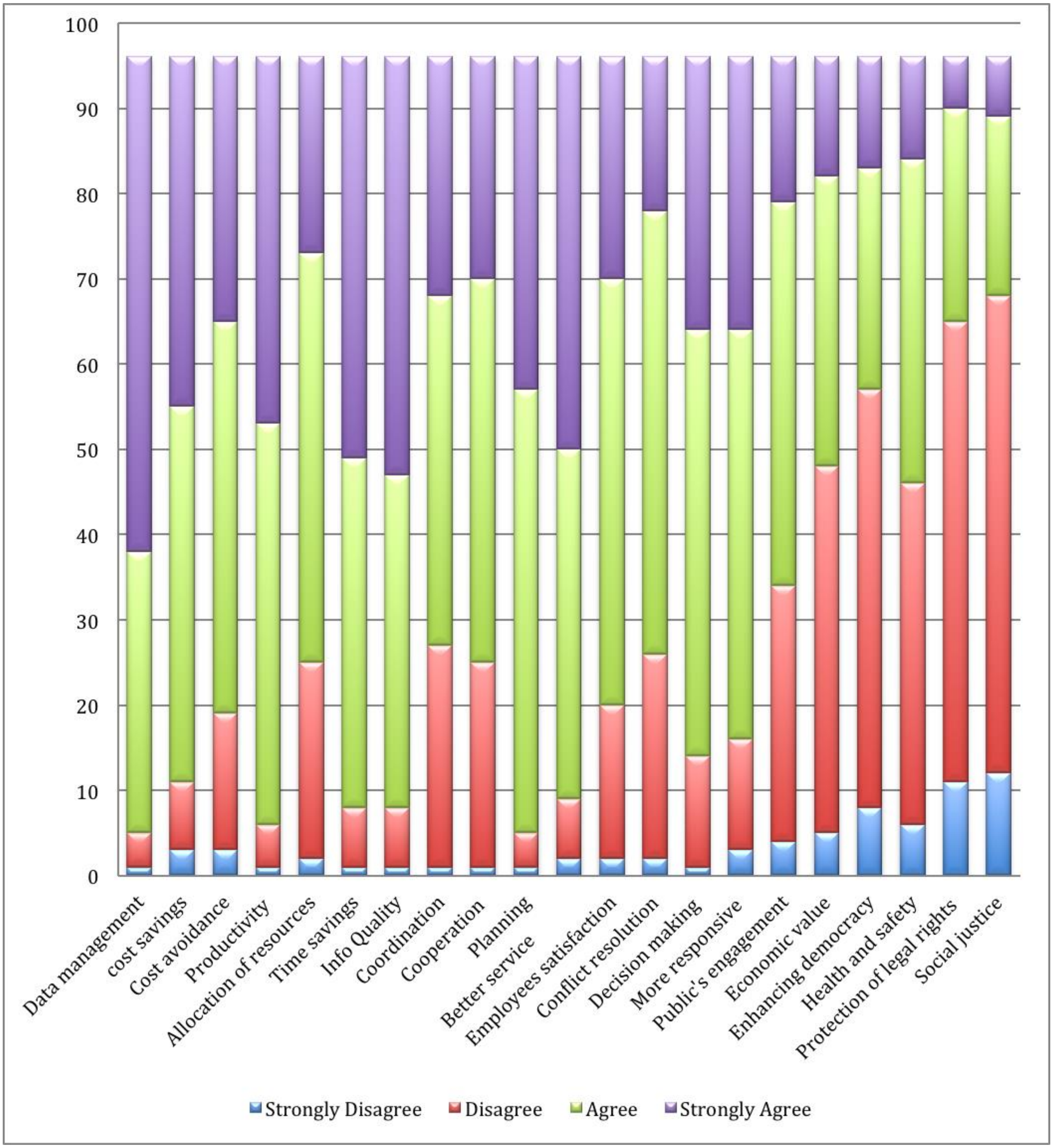


Figure 18. The realized impact of GIS

5.3 Normality Assumption

The data concerning the maturity model are categorical, and for the GIS value the data comes from a four point Likert scale that is ordinal. The data is not continuous thus normal distribution cannot be assumed. Normality tests will be performed to see if the data is normally distributed. The variable concerning GIS functions will be used as an example. When plotting the histograms for this variable and the normal distribution curve (Figure 19) it can be observed that the distribution does not follow the normal distribution curve and there are actually three peaks.

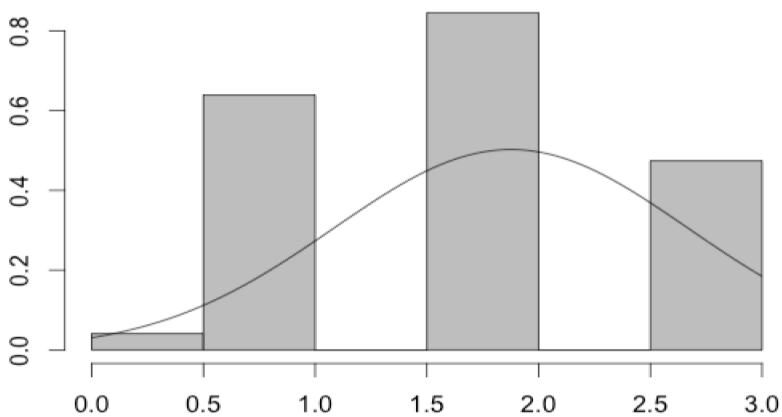


Figure 19. Histogram of GIS functions variable

When looking at the QQ plot in Figure 20, the points do not lie on the straight diagonal line thus it indicates deviations from normal distribution. The variable has a skewness value of -0.03, which indicates negative skewness to the left. The kurtosis value is 2.2 indicating it is a platykurtic distribution with a low peak and highly dispersed data that is far from a normal distribution.

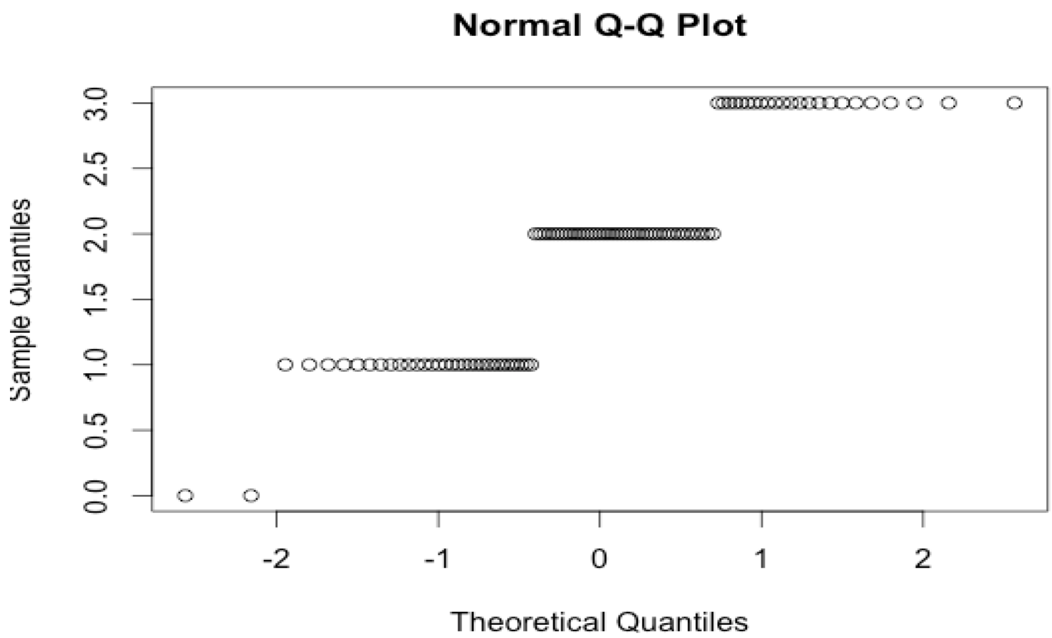


Figure 20. QQ plot for GIS functions variable

The p value for the Shapiro-Wilk normality test was < .001, which means that the null hypothesis (that the sample came from a normal distribution) can be rejected. The same results apply to all the variables of this research thus for the rest of this chapter non-parametric tests will be used as normal distribution is not visible. Even when GIS value is regressed on GIS maturity the residuals aren't perfectly normally distributed and homoscedasticity assumption is violated, as the variance isn't constant (see Appendix 5).

5.4 Reliability and Validity

Reliability and validity are two key characteristics used to evaluate the quality of a measure. Reliability is concerned with the consistency of the measure and refers to the "ability of the measure to produce the same results under the same conditions" (Field, 2009). A common method to assess the internal consistency of scales (reliability) is through Cronbach's alpha (Cortina, 1993), which does not require normal distribution. Despite some disagreements, the minimum acceptable value for a reliable measure is .70 (George and Mallery, 2003). The users and GIS department dimensions had a Cronbach's alpha less than 0.7. After further investigation of these two dimensions, it was found that the number of usage agreements and use of consultants had the least correlations with other indicators in each dimension (less than 0.26 for the correlation coefficient at a very low significance level). These two indicators were removed from the model. Table 22 shows the Cronbach's alpha after deletion for each dimension and for all the indicators together. The values are all above 0.7 thus the measurement can be deemed reliable.

Element	Cronbach's alpha	Composite reliability
System dimension	0.74	.735
Tasks dimension	0.85	.852
Users dimension	0.77	.778
Organization dimension	0.81	.817
GIS department dimension	0.71	.749
Reliability of all GIS usage indicators	0.94	
Efficiency measure	0.92	.917
Effectiveness measure	0.94	.942
Societal well-being measure	0.91	.912
Reliability of all GIS value indicators	0.96	

Table 22. Reliability test for GIS usage and GIS value

Validity can be defined as "whether an instrument actually measures what it sets out to measure" (Field, 2009). Measurement validity is a multifaceted concept often discussed in terms of content, face and construct validity. Face and content validity have been discussed in Chapter 4 through the use of expert opinion, pilot study interviews and literature review. Construct validity refers to the "degree to which an operational measure correlates with the theoretical concept" (Alshehri et al., 2013). A popular method to insure construct validity in survey research is through confirmatory factor analysis (CFA). CFA is a multivariate statistical test used "for testing hypotheses on the number of dimensions or factors of a complex construct" (Fritz et al., 2001), and it will be used here for testing the proposed dimensions of GIS usage maturity and GIS value. Two important assumptions about CFA are normal distribution and a sample size of at least 200 (Arrindell and Van der Ende, 1985) or 10-15 observations for each variable. While the current data violates these two assumptions, the main objective here is to examine the factor loadings and insure that the indicators align with each factor (dimension) thus the violation shouldn't prevent from using the procedure. Table 23 shows the fit of the model and item loadings for GIS usage maturity construct.

Estimator= maximum likelihood, Chi-square= 314, degrees of freedom= 204, CFI= .90, TLI= .88, RMSEA= .075, SRMR= .07			
Construct	**Item**	**Standardized item loading**	**Standard error**
System	Functions	.82	.046
	Products	.67	.063
AVE: .50	Customization	.58	.074
Tasks	Core process	.78	.046
	Support process	.76	.048
AVE: .59	Complexity	.76	.048
	Workflow	.77	.048
Users	Employees	.73	.056
	Departments	.86	.039
AVE: .56	Management	.60	.071
Organization	Vision	.51	.080
	Strategic plans	.55	.076
AVE: .40	Purpose	.56	.075
	Pattern	.63	.076
	Training	.56	.075
	Cooperation	.79	.045
	Awareness	.75	.050
GIS department	Structure	.72	.057
	Role	.90	.036
AVE: .40	Number of employees	.38	.093
	Employee's skills	.64	.065
	Management style	.35	.095
GIS usage maturity	System	.96	.039
	Tasks	.95	.028
	Users	.93	.037
	Organization	.97	.027
	GIS department	.83	.048

Table 23. CFA for GIS usage construct

The fit measures indicate acceptable fit of the model. A rule of thumb for good fit is when chi-square/degrees of freedom is less than three (Knijnenburg, 2016), and in this case (314/204= 1.5) is less than 2 indicating good fit; however the p-value for the chi-square is less than .05 indicating no significant change between the proposed model and the baseline model. On the other hand, other fit indices signal an acceptable fit of the model. The Comparative Fit Index (CFI) was 0.90 (≥90 indicates fair fit and ≥.95 indicates good fit (Hu and Bentler, 1999)), the Tucker-Lewis index was .88 (>.90 indicates good fit) and Root Mean Square Error of Approximation (RMSEA) was 0.075 (≤.08 indicates fair fit and ≤.05 indicates better fit (Hu and Bentler, 1999)). All the indicators loaded on the factors higher than 0.50 (commonly accepted cutoff value) except for number of employees in the GIS department (0.38) and management style of the GIS department

(0.35), which indicate that these two variables should be removed from the GIS department dimension. Table 24 shows the fit measurement and item loadings for GIS value construct.

Estimator= maximum likelihood, Chi-square= 480, degrees of freedom= 186, CFI= .84, TLI= .82, RMSEA= .128, SRMR= .08		
Construct	**Item**	**Standardized item loading**
Efficiency **AVE: .66**	Data management	.78
	Cost savings	.89
	Cost avoidance	.81
	Productivity	.72
	Allocation of resources	.81
	Time saving	.82
Effectiveness **AVE: .66**	Information quality	.72
	Coordination	.91
	Cooperation	.91
	Planning	.72
	Better service	.72
	Employee satisfaction	.82
	Conflict resolution	.82
	Better decision making	.82
	More responsiveness	.77
Societal well-being **AVE: .63**	Public participation	.75
	Economic value	.79
	Enhancing democracy	.83
	Health and safety	.82
	Protection of legal rights	.79
	Social justice	.79
GIS Value	Efficiency	.91
	Effectiveness	.97
	Societal well-being	.79

Table 24. CFA for GIS value construct

The fit indices for the proposed factors of GIS value are below the thresholds. However, the average variances extracted (AVE) for the three factors of GIS value are above .60, meaning that more than 60% of observed variance in the factors is explained by the indicators. Also, all the items loaded on the factors higher than .70 indicating high association between variables and factors.

5.5 Correlations Between the Research Variables

In this section, correlations between research variables will be explored. The intent is to see if there are variables that are perfectly correlated (autocorrelation) so that one of them is only used for analysis. Since the data isn't normally distributed, Spearman correlation (a non-parametric correlation that uses ranks instead of actual value and doesn't assume change at a constant rate) will be used. Table 25 represents the correlations coefficient between GIS usage variables. All the variables are positively and significantly correlated (at the .05 level and below) with each other except vision with strategic plans and GIS pattern of use with the structure of the GIS department. The average correlation between the variables is .44 indicating moderate relationship. The high level of correlations between the variables supports the notion that they represent ultimately one thing, which is GIS usage maturity.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Functions	-																			
2. Products	.53	-																		
3. Customization	.50	.44	-																	
4. Core process	.66	.54	.37	-																
5. Support process	.63	.44	.34	.69	-															
6. Complexity	.60	.44	.32	.63	.53	-														
7. Workflow	.59	.53	.42	.53	.52	.70	-													
8. Users	.52	.40	.34	.46	.51	.39	.41	-												
9. Departments	.65	.48	.47	.58	.55	.64	.62	.65	-											
10. Management	.44	.26	.35	.44	.44	.43	.44	.46	.49	-										
11. Vision	.47	.35	.23	.33	.30	.37	.42	.27	.36	.25	-									
12. Strategic plans	.44	.36	.36	.44	.39	.42	.32	.39	.43	.31	**.19**	-								
13. Purpose	.53	.31	.28	.38	.39	.46	.42	.34	.38	.44	.53	.30	-							
14. Pattern	.40	.32	.35	.44	.52	.39	.44	.53	.57	.37	.29	.40	.32	-						
15. Awareness	.46	.40	.42	.47	.59	.51	.58	.61	.66	.50	.31	.30	.33	.56	-					
16. Training	.45	.51	.29	.43	.52	.43	.37	.26	.32	.27	.22	.45	.34	.36	.34	-				
17. Cooperation	.53	.42	.45	.57	.56	.52	.58	.52	.70	.52	.41	.37	.42	.53	.65	.41	-			
18. GIS unit structure	.50	.46	.36	.49	.36	.35	.40	.31	.39	.24	.27	.29	.28	**.17**	.41	.34	.34	-		
19. Role	.61	.54	.51	.56	.48	.49	.57	.46	.60	.50	.48	.38	.42	.46	.59	.42	.58	.68	-	
20. Skills	.48	.50	.41	.37	.35	.41	.48	.37	.43	.28	.30	.36	.22	.33	.49	.33	.35	.55	.54	-

Table 25. Correlations between usage variables (all significant at .05 except red)

Correlations between indicators of GIS value are even stronger. The highest correlations coefficient was between coordination and cooperation (.93) and cost avoidance and savings (.80), suggesting that they basically represent the same entity. The fewest correlations were for social justice and protection of legal rights.

5.6 Maturity Matrix

As discussed in Chapter 4, average maturity was chosen as the calculation method for maturity. This method is often used to calculate IT maturity and has been used before to calculate GIS maturity (see for example Giff and Jackson, 2013). The maturity calculation follows the traditional method in the literature by taking the average indicator for each dimension then taking the average of all dimensions (Giff and Jackson, 2013). The formula used to calculate the final maturity score is

$$\text{GIS Maturity} = \frac{\sum(\text{System})/3 + \sum(\text{Tasks})/4 + \sum(\text{Users})/3 + \sum(\text{Organization})/7 + \sum(\text{GIS department})/3}{5}$$

Table 26 details the maturity score for each participating city using the aforementioned formula. Values in each column range from 0 to 3. Table 26 is ordered from low mature organizations to high maturity organizations based on their overall usage of GIS. The average maturity score for the sample is 1.82, meaning that on average, surveyed cities were closer to the exploitation stage of the model. The lowest maturity on the sample was 1 while the highest scored 2.9 out of 3. After rounding the values for the computed maturity, 30 organizations are in the exploration stage; 57 are in the exploitation stage; and 10 are in the enterprise stage. These scores indicate that the majority of surveyed organizations have moved beyond basic GIS yet few have reached enterprise GIS. When examining the variables independently, training had the highest scores in stage 1 and least in stage 3, indicating that cities still have to do a lot more training on GIS than they currently do, especially for non-experts. The percentage of departments using GIS had the highest scores in stage 3 indicating GIS had reached a wide range of departments. The organizational structure of the GIS unit had very low scores in stage 3 as cities have yet to recognize the need to establish a dedicated GIS department with enough funding and staffing to serve the whole city.

City	Func	Product	Custom	Core	Supp	Task	Flow	Emp	Dep	Level	Vision	Plans	Purpose	Pattern	Aware	Train	Coop	Unit	Role	Skills	GIS Mat'y
City1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
City2	0	1	1	1	0	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	**1**
City3	1	1	2	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	**1**
City4	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	0	**1.05**
City5	1	0	1	1	1	1	1	1	1	0	3	1	3	1	1	1	1	1	1	0	**1.05**
City6	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1.05**
City7	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1.05**
City8	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	0	**1.05**
City9	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	0	**1.1**
City10	0	1	2	1	1	1	1	1	1	1	2	1	1	2	1	1	2	1	1	1	**1.15**
City11	1	2	2	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1	0	**1.15**
City12	2	1	1	1	1	1	1	2	2	1	1	1	1	2	1	1	2	1	1	0	**1.2**
City13	1	1	1	1	1	1	1	1	1	1	1	1	3	1	2	1	1	2	2	0	**1.2**
City14	1	1	2	1	1	1	2	1	1	1	2	1	2	1	1	1	1	1	1	1	**1.2**
City15	1	1	2	1	1	1	1	1	1	1	1	1	3	1	1	1	1	2	2	1	**1.25**
City16	1	1	2	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1	1	0	**1.25**
City17	2	1	1	1	1	1	1	1	1	1	2	1	3	1	1	1	1	2	2	0	**1.25**
City18	1	2	2	1	1	1	1	1	2	1	2	1	2	1	1	1	1	1	1	1	**1.25**
City19	1	1	2	1	1	1	2	1	2	1	1	2	1	1	2	1	2	1	1	0	**1.25**
City20	2	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	**1.25**
City21	1	1	2	1	1	1	1	1	1	1	1	2	3	2	1	1	1	1	1	2	**1.3**
City22	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	1	1	2	3	1	**1.3**
City23	1	1	1	1	1	1	1	2	3	1	2	1	2	2	2	1	2	1	1	0	**1.35**
City24	1	1	2	1	1	1	1	1	2	1	1	1	1	2	2	1	2	2	2	1	**1.35**
City25	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	**1.35**
City26	1	1	2	1	1	1	1	3	3	1	1	1	1	2	2	1	2	1	1	0	**1.35**
City27	2	1	2	1	2	1	1	2	3	1	1	2	2	1	1	1	2	1	1	0	**1.4**
City28	2	1	2	2	2	2	1	1	1	0	3	1	3	1	1	1	1	2	1	1	**1.45**
City29	1	2	2	1	1	1	1	1	2	1	2	1	1	1	2	1	1	2	3	2	**1.45**
City30	2	1	2	1	1	1	1	2	1	1	2	2	3	1	1	2	1	2	1	1	**1.45**

City31	1	1	2	1	1	1	1	3	3	2	1	2	1	2	2	1	2	1	1	1	**1.5**
City32	1	1	2	2	2	2	1	2	2	1	1	2	2	2	2	1	2	1	1	0	**1.5**
City33	1	1	1	1	1	1	1	3	2	1	2	1	2	2	2	1	2	2	2	1	**1.5**
City34	1	3	2	2	1	1	2	1	2	1	2	1	2	1	2	1	2	2	1	0	**1.5**
City35	1	1	1	1	1	2	2	2	2	1	2	2	2	2	1	1	1	2	1	3	**1.55**
City36	1	1	1	2	1	2	2	2	2	2	1	1	1	1	2	1	2	2	2	2	**1.55**
City37	2	2	1	1	2	1	1	2	2	1	2	1	1	1	2	1	1	2	3	2	**1.55**
City38	1	3	2	2	2	1	1	1	1	1	1	2	2	3	1	2	1	2	2	1	**1.6**
City39	1	2	1	1	2	1	2	3	3	1	2	1	1	2	3	1	1	1	1	2	**1.6**
City40	2	0	2	1	1	1	1	1	2	3	2	2	2	2	2	1	2	1	3	1	**1.6**
City41	2	2	2	1	1	1	2	2	3	1	1	2	3	1	1	1	2	2	2	1	**1.65**
City42	1	2	2	2	2	1	2	2	2	1	2	1	1	1	1	1	3	2	3	1	**1.65**
City43	2	1	3	2	1	2	2	1	3	1	1	1	1	1	2	1	1	3	3	1	**1.65**
City44	2	2	2	1	1	1	2	2	2	1	3	1	2	2	2	1	1	2	3	1	**1.7**
City45	2	2	1	2	2	1	1	1	2	2	2	2	2	1	1	2	2	3	2	2	**1.75**
City46	2	1	2	2	1	3	2	2	3	1	1	3	2	2	1	1	1	2	2	1	**1.75**
City47	3	1	1	3	3	2	2	2	2	1	2	1	3	2	2	1	2	1	1	0	**1.75**
City48	3	1	2	2	2	2	2	2	3	2	2	1	3	2	1	1	2	1	1	0	**1.75**
City49	2	1	1	2	2	2	2	3	3	1	1	1	1	2	3	1	2	2	2	1	**1.75**
City50	1	1	1	2	2	2	1	2	3	2	2	1	3	2	2	2	2	2	3	0	**1.8**
City51	2	2	3	2	2	2	2	1	3	1	1	2	1	1	2	1	2	3	2	1	**1.8**
City52	2	3	2	1	1	2	2	1	3	1	3	1	3	1	2	1	2	2	3	1	**1.85**
City53	2	2	2	2	1	1	1	2	2	2	3	2	3	2	2	1	2	2	3	1	**1.9**
City54	2	1	1	2	2	2	2	1	3	1	3	1	3	2	2	1	3	2	3	1	**1.9**
City55	2	3	2	2	2	1	1	3	2	1	2	2	2	1	2	1	1	3	2	3	**1.9**
City56	3	3	3	2	1	1	1	3	3	1	2	2	2	2	1	1	2	2	3	1	**1.95**
City57	2	2	2	2	1	3	1	3	3	1	2	2	3	1	2	1	2	2	2	3	**2**
City58	2	2	3	2	2	2	2	1	3	1	2	2	1	2	3	1	2	2	3	3	**2.05**
City59	2	1	3	1	1	1	3	2	2	2	2	1	3	1	3	1	3	3	3	3	**2.05**
City60	2	1	3	2	2	1	1	3	3	3	2	1	3	2	2	1	2	2	3	2	**2.05**
City61	2	2	3	1	3	1	2	3	2	1	2	2	3	3	2	2	2	2	3	1	**2.1**
City62	3	1	3	2	2	1	2	2	3	3	2	2	3	2	2	1	2	2	3	2	**2.15**

City63	3	3	2	2	2	1	2	3	3	1	2	1	3	2	3	1	2	2	2	3	**2.15**
City64	3	3	2	2	1	3	3	1	3	1	3	1	3	1	1	2	2	2	3	3	**2.15**
City65	2	1	3	2	2	1	1	3	3	1	2	3	3	2	3	2	3	2	3	2	**2.2**
City66	2	2	3	2	2	2	2	1	3	2	3	2	3	2	2	2	2	2	3	2	**2.2**
City67	2	2	2	2	1	2	2	3	3	2	3	2	3	2	2	1	3	2	3	2	**2.2**
City68	2	3	3	3	2	1	2	3	3	2	2	1	3	3	2	1	2	2	3	1	**2.2**
City69	2	2	3	2	1	2	2	2	3	2	3	1	3	3	3	1	3	2	3	2	**2.25**
City70	2	1	2	3	3	2	2	2	3	1	3	2	2	3	3	1	3	2	3	2	**2.25**
City71	2	1	2	1	3	3	3	3	3	3	2	1	3	2	3	1	2	2	3	2	**2.25**
City72	2	3	3	2	2	2	2	3	3	2	1	1	2	2	3	2	3	2	3	2	**2.25**
City73	2	3	3	2	1	2	3	3	3	1	3	2	3	2	2	1	2	2	3	2	**2.25**
City74	2	2	3	1	1	2	2	3	3	2	2	3	3	2	3	1	2	2	3	3	**2.25**
City75	2	3	2	2	2	2	3	1	3	1	2	3	3	3	2	3	3	2	3	2	**2.35**
City76	2	2	2	2	2	2	3	3	3	2	3	2	3	2	3	2	3	2	3	1	**2.35**
City77	2	3	2	3	2	3	2	3	3	2	1	3	3	2	3	2	2	2	3	1	**2.35**
City78	3	2	2	2	2	3	2	3	3	3	3	3	3	2	2	1	2	2	3	1	**2.35**
City79	3	1	3	2	2	3	3	3	3	2	3	2	3	2	3	2	2	2	3	1	**2.4**
City80	2	2	3	2	2	2	3	3	3	2	2	2	3	2	3	1	3	2	3	3	**2.4**
City81	2	3	2	2	2	3	3	2	3	2	1	2	3	3	3	2	2	2	3	3	**2.4**
City82	3	3	3	3	2	2	2	3	3	1	2	3	2	2	2	2	2	2	3	3	**2.4**
City83	3	2	3	2	3	1	2	3	3	1	2	2	2	3	3	2	2	3	3	3	**2.4**
City84	3	2	2	3	3	2	3	3	3	2	2	3	3	2	2	1	2	2	3	2	**2.4**
City85	3	3	3	2	2	3	3	3	3	2	3	1	3	2	2	1	2	2	3	2	**2.4**
City86	3	3	3	2	2	3	3	2	3	1	2	2	2	3	2	2	2	2	3	3	**2.4**
City87	3	2	3	2	3	3	2	2	3	2	2	2	3	2	3	2	3	2	2	3	**2.45**
City88	3	3	2	2	2	3	3	2	3	1	3	3	3	2	2	3	3	2	3	2	**2.5**
City89	3	3	3	3	3	3	2	3	3	3	2	2	3	1	2	2	3	2	3	1	**2.5**
City90	2	3	3	2	3	3	3	3	3	2	2	2	3	3	3	2	3	2	3	1	**2.55**
City91	3	3	3	2	2	3	2	3	3	1	3	2	3	2	3	2	3	2	3	3	**2.55**
City92	3	3	3	3	3	2	3	3	3	3	2	1	3	2	3	2	3	2	3	2	**2.6**
City93	3	3	1	3	3	3	3	3	3	3	2	2	3	2	3	2	2	2	3	3	**2.6**
City94	3	3	2	3	3	2	2	3	3	2	3	3	3	2	3	3	3	2	3	2	**2.65**

City95	3	3	3	3	3	3	3	2	3	3	2	2	3	2	3	1	3	2	3	3	**2.65**
City96	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2	3	2	3	1	**2.75**
City97	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2	3	3	**2.9**

Table 26. Maturity breakdown for each city

To better understand the results, the study analyzes each dimension according to the stages in table 27.

	System	Tasks	Users	Organization	GIS Unit
Exploration	33%	38%	28%	31%	31%
Exploitation	46%	42%	48%	60%	55%
Enterprise	21%	20%	24%	9%	14%
Total	100%	100%	100%	100%	100%

Table 27. Percentages of stages for dimensions

It can be observed that the organizational and GIS unit dimensions have the least percentages in the enterprise stage. The user dimension scored higher in the enterprise stage than all other dimensions. The dimension that still struggles with GIS maturity is the tasks dimension (38% of the sample in the exploration stage in terms of tasks dimension), meaning that a lot of cities still use GIS mostly for simple tasks. It can also be observed that the majority falls under the exploitation stage in all the dimensions of GIS usage.

5.6.1 Comparsion Between the Stages

After rounding the total maturity score of each organization in the sample, only ten have reached the Enterprise Stage, which accounts for only 10.3% of the sample. It would be valuable to study those ten organizations in more depth and search for unique factors (assuming that they exist) that distinguish them from the other ninety percent. To accomplish this, the Exploration and Exploitation Stage have been combined together and analyzed against the Enterprise Stage as shown in Table 28. Despite having variations in some indicators, organizations in the Enterprise Stage all reached the highest score in the following four indicators: diverse GIS products utilized; at least 17 different departments use GIS; GIS is used for the purpose of policy making and the role of the GIS department is to support the whole organization. It can be observed from Table 28 that organizations in the Enterprise Stage were higher than organizations in the Exploration Stage and Exploitation Stage in all the indicators of maturity. The difference was always at least double or more. This was expected as it follows the description of the enterprise stage outlined in Table 6. However, the biggest differences between the stages outlined in Table 28 were: training, teamwork, complexity of the GIS task, radical changes to process after using GIS, strategic plans for GIS, degree of GIS awareness then lastly diversity of GIS products utilized. Also, it can be

	Exploration & Exploitation Stage (N=87)	Enterprise Stage (N=10)
Average number of GIS functions used	10.4	20.5
Average number of GIS products utilized	4.5	12.8
High customization percentage	25%	70%
Average number of core process enabled by GIS	8.4	18.7
Average number of support process enabled by GIS	4.9	12.5
Complex task percentage	13%	80%
Radical changes percentage	14%	70%
Average number for the type of GIS usrs	6.4	13.5
Average number for the type of departments using GIS	12.5	28.3
Top management use of GIS percentage	48%	90%
Vision for enhancing decision making	18%	50%
Strategic plans for GIS documented	9%	40%
Using GIS to make policies	46%	100%
Innovative use of GIS	10%	20%
High GIS awareness	21%	80%
Frequent GIS training	1%	20%
High teamwork due to GIS	14%	90%
Percentage of cities where a GIS unit exists	70%	100%
GIS role is to support the whole organization	46%	100%
Percentage of cities with advanced GIS skill sets	16%	40%
Average maturity of the system dimension	1.8	2.8
Average maturity of the tasks dimension	1.6	2.8
Average maturity of the users dimension	1.8	2.7
Average maturity of the organization dimension	1.7	2.5
Average maturity of the GIS department dimension	1.8	2.4
Average overall maturity	1.7	2.6

Table 28. Enterprise stage against the two other stages

seen from Table 28 that the biggest difference between the stages with regards to the dimensions of maturity was in the tasks dimension. This means that in order for a city to reach the Enterprise Stage, it has first to integrate GIS with more than half of it core and support business process. Which would as a consequence, guarantee that GIS would be used for some complex tasks (unstructured decision making) and would result to a fair degree of reengineering to some of their business process. Also low maturity cities need to focus on the organizational factors of GIS. This research reveals the need to establish a clear strategy defining the growth path for GIS, raising awareness about GIS, increasing the frequency and type of GIS training offered and thinking about innovative ways to get city departments to cooperate and collaborate through the platform of GIS data and analysis. To conclude, low maturity cities need to focus on the organization and task dimension at the same time expand the pool of GIS products that they use in order for them to transition into the Enterprise Stage.

5.7 Validating the Research Propositions

The first set of propositions for this research was geared towards the structure of the proposed maturity model. Proposition 1.1 states, "GIS usage maturity is a function of system, tasks, users, organization and GIS department dimensions." In the previous chapters, literature review and expert opinions have been discussed to support the notion of using five dimensions to represent GIS usage maturity. Here empirical validation is presented. The first empirical support is the reliability score of these dimensions together. From Table 22, the composite reliability of the dimensions together is 0.94, which gives proof that these dimensions change together to represent GIS usage maturity. The second empirical validation is the results of the confirmatory factor analysis in Table 23. Some of the fit indices reported (CFI, RMSEA and chi-square/df <2) support the validity of model despite the limitations on sample size and violation of normality condition. More importantly, the factor loading for the dimensions on the GIS usage maturity factor (system=.96, tasks=.95, users=.93, organization=.97 and GIS department =.83) is very high and strongly suggests that they belong to this factor. Proposition 1.2 states "The three stages of exploration, exploitation and enterprise are sufficient to represent GIS usage maturity levels." To test proposition 1.2, this research considers the correlation between computed maturity and perceived maturity (should be high) and the differences between the means (there should be no significant difference). The Spearman correlation coefficient between the actual and perceived maturity was .75 (significant at the < .001 level), which is high and indicates strong relationship. Furthermore, the mean for perceived maturity is 1.98 and the mean for the calculated maturity is 1.82. When comparing the means using a Wilcoxon rank sum test, the differences weren't significant (p= .550) indicating that the population distribution is similar.

The second set of propositions concerned the reliability and validity of the 24 indicators of the five dimensions of GIS usage maturity. From Table 22, Cronbach's alpha for the three indicators of the system dimension is 0.74 and the composite reliability is .735, both higher than the .7 thresholds, which indicates high reliability of the system indicators. From Table 23, the indicators load consecutively on .82, .67 and .58 all higher than the .50 thresholds. Also the average variance extracted (AVE) was .50, which equals the limit of .5 or higher that indicates strong validity (convergent validity) of the system indicators. For the indicators of the tasks dimension, the Cronbach's alpha is 0.85 and the composite reliability is .852, indicating high reliability. The indicators of tasks dimension loaded consecutively on .78, .76, .76 and .77 (all higher than .7). Also, the average variance extracted was .59 (higher than .5), which means strong support for the validity of the indicators. The indicators of the tasks dimension are the most reliable and valid measures from all the other dimensions. The users dimension initially had four indicators and the Cronbach's alpha was .67, which was too low. After examining the correlations, it was found that the number of usage agreements had the lowest correlation with the other indicators so it was deleted. After deletion, the Cronbach's alpha became 0.77 and the composite reliability rose to .778, which now indicates reliable indicators. The factor loading for the indicators of the user dimension are consecutively .73, .86 and .60 (>.50), and the AVE is .56 denoting that the indicators are valid measures of the users dimension. For the organization dimension, the Cronbach's alpha is 0.81 and the composite reliability is .817 both acceptable. The factor loadings for the indicators of the organization dimension are consecutively .51, .55, .56, .63, .56, .79 and .75 (all >.50) indicating moderate validity, however the AVE was .40. The initial reliability of the GIS department dimension was .63 and after deleting GIS consultants the Cronbach's alpha rose to 0.71 and the composite reliability to .749. For validity of the GIS department dimension, the AVE is .40, which raises questions about the validity of the dimension. The number of employees in the GIS department and management style loaded very poorly on the factor (.38 and .35 < .50), thus they shouldn't be included as indicators (when deleted, AVE rose to .58). To summarize, data analyses suggest that 20 of the 24 (except number of usage agreements, GIS consultants, number of employees in the GIS department and management style of the GIS department were dropped) initial indicators are valid and reliable measures.

The third set of propositions explored the relationship between GIS usage maturity and GIS value. Proposition 3.1 states "Higher levels of GIS usage maturity will be associated with higher levels of GIS value." To investigate this, the correlation between the maturity score and total GIS value is computed. The Spearman correlation coefficient between these two variables is .72 (significant at the < .001 level), which indicates strong relationship. Figure 21 shows a plot of

GIS maturity and value fitted by a local polynomial curved regression line that shows increased value relative to an increase in GIS usage. The scatter plot showing GIS maturity stage and GIS value in Appendix 5 also supports the proposition.

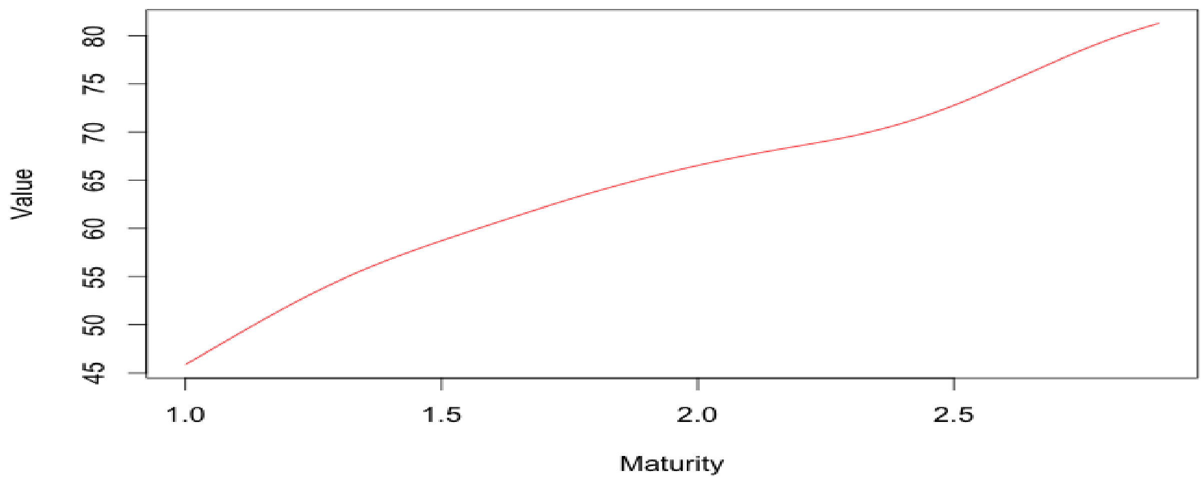


Figure 21. Local polynomial regression of GIS value predicted by GIS usage

To examine the propositions concerning the stages of GIS usage and categories of GIS value, the answer for the value questions has been aggregated to either agree or disagree. There were 29 organizations in the exploration stage; of those 7 have attained efficiency gains (against 22 who didn't achieve all efficiency gains), 6 also obtained effectiveness gains (against 23), and two have claimed that they reached the societal well-being gains (against 27). These results suggest that proposition 3.2 isn't supported (because only few obtained efficiency value and more have effectiveness value which contradicts the proposition.) There were 57 organizations in the exploitation stage; of which 45 reported efficiency gains (against 12), 39 reported effectiveness gains (against 18) and 11 reached societal well-being gains (against 46). The results suggest that proposition 3.3 is partially supported (because some reached societal gains, which is not in line with the proposition.) There were 10 organizations that reached the enterprise stage, all of whom reported efficiency and effectiveness gains and 7 reported societal well-being gains. The results suggest that proposition 3.4 is supported.

The last set of propositions involves investigating the relationship between city characteristics and GIS maturity. To determine this the difference between the means is examined to see if there is a significant difference using Kruskal Wallis for the overall difference, and Wilcoxon rank sum test for the pairwise comparisons with bonferroni adjustment for the p value.

For the budget, the overall difference is significant ($p < .001$), and there is a significant difference in GIS maturity between cities with a budget over 100 million compared to those with less than 25 million, between 25-49 million, or a budget between 50-74 million. There is strong evidence to conclude that the city budget has a profound influence on the maturity of GIS usage. Cities with a higher budget are more likely to have a more mature GIS.

When comparing the populations of the cities and GIS maturity, the overall difference is significant ($p < .001$), and there is a significant difference in GIS maturity between cities with a population less than 49,000 people compared to cities with a population between 100,000-149,000 and cities with more than 200,000 people. Also there was a significant difference in GIS maturity between cities with a population between 50,000-99,000 and cities with more than 200,000 people. There is strong evidence to conclude that the number of people living in a city has a profound influence on the maturity of GIS usage. Cities with more people are more likely to have a mature GIS.

As for the number of employees that work in a city, the overall difference is also significant ($p < .001$), and there is a significant difference in GIS maturity between cities with more than 400 workers and those with less than 100, and those with 100-100 workers. Moreover, there was a significant difference of GIS maturity between cities with less than 100 workers compared to cities with 300-399 workers. The more workers in a city, the more likely the GIS will be more mature.

To examine the effect of city age on GIS maturity, the correlation between the two variables is computed. Spearman correlation coefficient between the city age and GIS maturity was .25, indicating a very weak relationship between the two variables. The same type of test was conducted between the age of GIS (number of years since the city has been using GIS) and GIS maturity. Spearman correlation coefficient was .59 indicating moderate relationship between experience with GIS and GIS maturity.

Concerning the GIS champion, contrary to previous research there was no effect on GIS maturity between cities that reported that there was a GIS champion compared to cities where there was no GIS champion. The average GIS maturity for cities with a GIS champion was 1.83 and 1.77 for cities without a GIS champion; however this difference wasn't significant (p= .600)

The last proposition of this research stated that "there is a significant difference in GIS maturity between the counties." To test that, a Kruskal Wallis test was conducted which yielded no significant difference (p= .416). Thus, proposition 4.2 isn't supported, and it can be concluded that the county doesn't play a significant role in advancing the GIS of a city. Rather, it is the city itself which has a salient role in maturing GIS usage.

5.8 Content Analysis

At the end of the questionnaire, respondents were asked to add any additional comments regarding GIS usage or GIS benefits in their cities. An interesting theme that emerged from their responses was the obstacles or barriers to GIS usage in small cities. Respondents cited shortage of staff and lack of time (time to grow GIS by adding data and performing analysis) as important hurdles to GIS growth. The reality is that users of GIS come from different fields and often need to be retrained to use GIS along with their other daily duties. Without having a dedicated GIS department in the city where GIS staff can focus only on growing the GIS capabilities, GIS becomes peripheral and in a "no growth" mode. Another obstacle cited numerously was lack of funding (to invest in the technology, hire GIS staff or GIS consultants) and resources for GIS projects. Without expanding the user base of GIS, it is difficult to convince top management to accept the cost of GIS. Cities still suffer from budget constraints and economic downturns that makes more investments in technology challenging. However, respondents reported they had devised alternative methods to fund GIS. Some cities rely on the county GIS for most of their needs (although some counties have reduced their GIS staff and have also decided that tools like Google Earth were sufficient for all their GIS tasks). Others partner with local non-profit agencies (associations, universities, students and research centers), some utilize cloud-based GIS subscriptions, and some have been trying free and open source software GIS and remote sensing platforms. Some cities seem optimistic about GIS and have plans for growth (in terms of data, applications and users), while others have given up due to cost issues. It also seems that a portion of the cities are still building their GIS (digitizing, geocoding and automating paper records). Some cities still rely on the heroic work of only one individual to maintain the entire GIS system.

Other respondents focused on the positive side of GIS and shared their success stories. Respondents emphasized the role of GIS information (especially when accurate and up to date) in supporting decision-making. Respondents also mentioned the value of providing GIS to non-IT personnel who are able to conduct their own analyses. Benefits even extend to the public in the form of online GIS portals offering various city maps, GIS data and mapped events (e.g., police calls, property information, local business and demographic information). Other cities shared their accomplishments and reported that GIS has improved the quality of life in their cities by supporting the city's goals of better management through more accurate information.

5.9 Summary

This chapter was devoted to testing the proposed maturity model and validating the research propositions. Data analysis covered the study's response rate, descriptive analysis of research variables and questionnaire questions, reliability and validity tests along with discussion about the distribution of the data, correlations between research variables have been reported; the maturity scoring has been explained and discussed, and quantitative and qualitative analysis have been performed to test the research propositions. Table 29 summarizes the results of testing the research propositions.

Proposition	**Result**
1.1 (GIS maturity is composed of system, users, tasks, organization and GIS department dimensions)	Supported
1.2 (Exploration, exploitation and enterprise stages are sufficient to represent GIS usage maturity)	Supported
2.1 (Indicators of system dimension are reliable and valid)	Supported
2.2 (Indicators of tasks dimension are reliable and valid)	Supported
2.3 (Indicators of users dimension are reliable and valid)	Partially supported (except usage agreements)
2.4 (Indicators of organization dimension are reliable and valid)	Supported
2.5 (Indicators of GIS department dimension are reliable and valid)	Partially supported (except GIS

	consultants, number of employees and management style)
3.1 (Relationship between GIS maturity and GIS value)	Supported
3.2 (Relationship between exploration stage and efficiency gains)	Not supported
3.3 (Relationship between exploitation stage and efficiency and effectiveness gains)	Partially supported
3.4 (Relationship between enterprise stage and efficiency, effectiveness and societal well being gains)	Supported
4.1 (City characteristics influence GIS maturity)	Partially supported (except city age and GIS champion)
4.2 (County characteristics influence GIS maturity)	Not supported

Table 29. Results summary of the research propositions

Overall, 20 of the 24 variables of GIS usage maturity have been empirically validated. The maturity model was able to differentiate between low and high maturity organizations. The structure of the proposed maturity model has empirical support however, the measures of the organization and GIS department need further refinement and perhaps new insights. There seems to be a positive relationship between GIS maturity and GIS value, however the details, order and temporal occurrences of a specific GIS value associated with a certain increase in GIS maturity need further investigation and research. In terms of evaluating GIS usage in Southern California local governments, cities have reached the exploitation stage and moved beyond justifying the business case. What needs to be done is to expand the pool of GIS functions used by trying more GIS products (some of which could be free open source) that would create a platform in which additional applications could be developed that cater more to the non-specialist (non-IT or GIS experts) users, some of which will be top management and stakeholders. To accomplish this, cities need to expand their GIS training and establish independent GIS departments able to support the city's departments, citizens and local business.

CHAPTER 6 – CONCLUSION

This chapter provides a summary of the dissertation and an outlook for the future. First the work performed in the study is restated. Following that, major findings are presented and discussed along with a revisit to the research questions. Then the contribution of this dissertation is discussed both in terms of research and practice. Finally, limitations of this dissertation are outlined and future research opportunities are discussed.

6.1 Research Summary

Cities all over the world are facing enormous challenges. An increase in urban population means more pressure on existing infrastructure (roads, sidewalks, parking spaces, sewers, housing, safety and food) and more pollution. What further complicates the situation is that cities still exhibit budget constraints, political gridlock, green infrastructure demands from the younger generation, vision towards smarter cities, mandates for more transparency (e.g. body cameras for police officers), public participation and the birth of a new economy (the "sharing economy"). Consequently cities have to adapt to accommodate these dynamic changes and do more with less. Since much of local government data is spatially linked and most of these challenges are of a geographical nature, GIS has a central role to play in fulfilling or guiding the transition into solutions to these challenges. However, is local government's GIS ready to tackle these challenges? Do we know or have a tool that measures organizational usage of GIS? Without reaching certain levels or stages of GIS maturity, combating these challenges and achieving bold goals doesn't seem realistic. The purpose of this dissertation was to construct this needed maturity model for GIS usage on the scale of local government and examine the relationship between GIS maturity and GIS value in Southern California.

In order to construct the proposed maturity model and relate it to GIS value, this dissertation has looked at a broad range of diverse but related research streams. First, recent empirical studies on the business value of IT were examined which revealed that majority of the studies have found positive impact of IT investments, detailed focus on a specific technology and its process level value and voices to include system use in the IT value cycle. Moving on to specifically GIS impact, researchers have limited GIS impact to the decision making process at the individual scale, which has been found to be helpful (use of GIS leads to better quality of decisions in shorter time compared to paper or tabular data.) Next, the research turned to the "system use" literature to understand how system usage has been studied and what dimensions are relevant for studying this construct. The review outlined the complexities with measuring the system usage construct (different definitions and measures) and near absence of research on organizational system usage in the public sector domain. The review outlined the importance of Burton-Jones and Straub's (2006) conceptualization of system usage and extended it to incorporate additional dimensions related to GIS usage on the organizational level by referring to the systems theory (West, 1968) and its interpretation in the DSS domain by Ariav and Ginzberg (1985). GIS studies of local government have focused for the most part on one dimension of system use and no attempt was found to consolidate the findings of these studies into classifying GIS usage. Next, IT maturity models were reviewed because the unit of analysis is mostly the organization, and the system usage literature has failed to provide a comprehensive measure of organizational system usage. IT maturity models have neglected "usage maturity" except for Holland and Light (2001), who proposed an ERP usage maturity model which this dissertation is built on. Finally, GIS maturity models were examined. Identified limitations of current GIS maturity models included lack of a measurement tool, assessment of capacity to use GIS not actual use, weak empirical validation, no clear definition for GIS maturity, have not examined usage broadly or in-depth, and are focused more on the qualitative nature of measuring maturity and less on the quantitative side.

The proposed GIS usage maturity model consists of three stages (exploration, exploitation and enterprise) and five dimensions (system, tasks, users, organization and GIS department). GIS in the exploration stage is mostly used to produce maps, organized around projects, led by enthusiasts, used by planners and engineers, data focused and only basic functions of GIS are utilized. In the exploitation stage, more processes and tasks are GIS enabled, recognition of GIS ability to improve performance is noticed, users expand to field workers and middle management, and the analytical capability of GIS is utilized. Ultimately, in the enterprise stage, GIS is considered a strategic asset, used in most departments for many processes by an expanded range of users that includes top management; a GIS department responsible for supporting GIS exists, and GIS informs decision-making because advanced functionalities are utilized and subsequent reports are pushed all the way to the decision maker. The system dimension covers the extent of using the system; tasks dimension measures the extent of using GIS in business process and applications; users dimension looks for the type of GIS users internally and externally; organization dimension evaluates the managerial environment surrounding GIS; and, lastly, the GIS department dimension looks at the specification of the department responsible for managing and supporting GIS activities. Based on the related work, 24 benchmark variables were extracted to assess and evaluate each dimension. The model follows a simple logic of evolution from basic and few to advanced and abundant and is based on the assumption that the stages build on each other.

De Bruin et al. (2005) methodology guided the research design of the maturity model. In the scope phase, decisions were made about the focus, target, domain and purpose of the maturity model. In the design phase, the structure of the model, approach, number, label and definition of each of stage was clarified. For the populate phase, the content of model was specified and the measurement tool was designed based on literature review and a case study. The test phase, which insures rigor and relevance of the model, was satisfied by thorough examination of the literature, five expert opinions, a pilot study on two organizations and a consultation with a statistician. The deploy phase involved validating the model in Southern California local governments to test the generalizability of the model.

Out of 235 cities contacted, there were 99 valid responses to the questionnaire (two were redundant for the same city by different individuals.) Reliability and validity tests rendered 20 out of the 24 indicators of GIS usage maturity as valid and reliable. Confirmatory factor analysis showed that all the indicators loaded on their dimension higher than .5 suggesting strong connection to the dimension. Results show that usage variables were highly correlated to each other indicating that they form ultimately one construct “GIS usage” and changes in one variable is associated with the change in the other reflecting the maturity stages to a fair extent. The association between GIS usage and GIS value has been found to be positively significant. About

50% of the variability in GIS value can be attributed to GIS usage. However, the specific GIS value that was thought to be associated with each GIS maturity stage wasn't empirically supported. Ad hoc analysis revealed that big cities (defined in terms of budget, population and number of city workers) are more mature in GIS than smaller cities. Ad hoc analysis showed also that there is no significant difference in GIS maturity between Southern California counties. Thus the difference comes from the city itself and how much it uses and employs GIS in its daily operations. Content analysis revealed funding, shortage of skilled GIS staff and time constraints as barriers to GIS usage in small cities.

6.2 Research Findings

The first set of findings pertains to GIS usage. The average number of functions used by a city was 11.4 (out of 24 listed GIS functions) of which 6.5 are basic GIS functions (map production in 95% of the sample and spatial databases in 54%). Decision related GIS functions are used in less than 25% of the sample (GIS for prediction and forecasting is used in only 17% of the respondent cities while decision modeling is at 24%). The same pattern persists and is even clearer when examining the GIS products utilized (86% for basic GIS but only 4% for advanced spatial analytics.) The average number of GIS products/solutions used by a city was 5.32 (out of 35 listed GIS products.) The typical pool of GIS products in place is to have ArcGIS desktop, online or mobile, its supporting solutions (server, SDE, engine) and one or two specific purpose GIS solutions (network analyst or ArcGIS Flex or Silverlight). These products are hard to use and make sense of by non-GIS experts. In terms of the penetration of GIS to existing tasks and process, the average number of applications supported by GIS is 15.3 out of 54 listed applications (core and support). The average number of GIS users is 32% (out of all city workers) and about 56% of city departments use GIS based on the sample. At least for the cities that participated, GIS has made it to a good number of departments, but the problem is that experts (engineers or planners) only use them in the departments making GIS a support tool to accomplish only part of a process. This is reflected by the fact that only 20% of surveyed cities use GIS for complex and unstructured tasks and only 20% realized radical reengineering of processes as a result of using GIS.

For the most part, the use of GIS is not apparent to city management (few specialists use it as part of their job), thus they didn't feel a need push its use any further. This pattern can be determined from the results: only 22% of the sample have a vision for GIS to be used for enhancing decision-making; 12% have a formal strategy for the growth of GIS in their city; 12% continue to see new and innovative uses of GIS being rolled out and tried; and only 4% hold frequent GIS training sessions. The maturity of the GIS department is low. Only 6% have a dedicated GIS department; 19% have four or more GIS staff; 21% have GIS staff with an ability to develop mobile GIS applications; and 40% don't use GIS consultants. As a result of having low few mature GIS departments, cities outsource their complex GIS needs (e.g. development sketching, policy change assessment, environmental constraints on existing projects, sustainability plans, land use patterns, visualizing complex spatial and attribute data) to private companies.

Results indicate the presence of GIS underutilization particularly in the areas of breadth of GIS solutions used, type of task, top management use (type of user), vision and strategy, GIS training and the GIS department resources (structure, number of employees, skill set and use of GIS consultants.) Progress can be reported in the area of departments using GIS, number of users, degree of customization and GIS awareness (understanding the role and purpose of GIS.) When we aggregate those variables/indicators to the dimension level, results show high maturity for the system and users dimension and very low maturity for the tasks dimension. For the organization dimension, progress has been made yet cities need to do more (in the training and strategies for growth) to reach the enterprise stage in this dimension. The GIS department dimension still lags behind in maturity due to organizational hierarchy. (GIS staff need to be independent of any departmental responsibilities and focused only on GIS work.) It is surprising to see that although the average city experience with GIS is 13 years, and 52% of the sample states that the purpose of GIS is to enhance policymaking, that hasn't been translated into practical steps yet, such as establishing an independent GIS team with adequate staffing and funding to support the whole organization.

In terms of the maturity model, no city was mature on all dimensions, nor was a city less mature on all dimensions, which is expected as organizations might have strength in some areas but struggle in other areas. Organizations in the sample did not always follow the characteristics of each stage; but rather fluctuated between the dimensions being more mature in one dimension than the other. This is expected as the model is conceptually conceived and describes the ideal arrangement for each stage. However, the model was able to differentiate between more mature organizations and less mature ones as can be seen from the variability of scores and high correlation with perceived maturity. Also there was no significant difference between the counties in GIS maturity, which supports this work that usage is contingent upon the city itself and the decision to leverage GIS capabilities for the benefit of the city and its citizens.

An important city characteristic that was confirmed to influence GIS maturity was the size of the city. This research demonstrated that big cities (defined in terms of city budget, number of workers and population) are more likely to have a mature GIS when compared to small cities. This conclusion was similar to what other studies in the field have found (Colijn and Huyckburg, 2000; Convery and Ives-Dewey, 2008; French and Wiggins, 1990; Johnson, 2013; Kun, 2014; Nedovic-Budic, 1993; Olafsson and Skov-Petersen, 2014). This does not mean that large cities will automatically be at the enterprise stage. In fact, many large cities in the sample did not reach the enterprise stage of the maturity model. Contrary to other studies (Borges and Sahay, 2000; Convery and Ives-Dewey, 2008; Onsrud and Pinto, 1993; Nasirin and Birks, 1998) this research didn't find a relationship between the existence of a GIS champion and GIS maturity. This research found more GIS applications being used than what older studies (French and Wiggins, 1990; Nedovic-Budic, 1993) have reported. Similar to other studies (Göçmen et al., 2010; Gudes et al., 2015; Hussain et al., 2010; Ye et al., 2014), this research found that the frequency of GIS training being offered is low and impedes GIS maturity.

The majority of surveyed local governments in Southern California are within the exploitation stage. In order for them to reach the enterprise stage, they need to increase their GIS training, pool of users (by introducing GIS to processes that top management cares about and monitors) and separate the GIS team from the IT, planning or public works departments into an independent new department. For local governments in the exploration stage, results reveal major problems in GIS skill set and type of tasks where GIS is used. From the open-ended question, cities in the exploration stage have complained about lack of resources and time to grow the GIS and spatial data while others were optimistic about the future and planned to expand GIS usage. Some cities in Southern California dealt with the funding obstacle by adopting free open source GIS platforms, leveraging the community (students and interns) and county resources and using cloud based solutions (instead of the costly desktop version.) French and Wiggins (1990) found a significant correlation between the time GIS was introduced and the number of GIS applications in California planning agencies. This dissertation found similar results in that the number of applications supported by GIS was almost double (19 compared to 10) when comparing cities with experience in GIS for more than 15 years. When comparing the computed maturity stage with the perceived maturity stage, 57 cities got it right, 29 overestimated their level (thought they were more mature than they actually were) and 11 underestimated their maturity (their maturity was higher than what they thought it was.) These results speak to the difficulty of objectively evaluating organizational GIS usage with its multiple dimensions and indicate the need for the proposed maturity model.

The second set of findings were directed towards GIS value. On a very high level, most organizations surveyed expressed positive sentiments regarding the impact of GIS (on average, 73% agreed that the questioned GIS value has been realized in their city.) The most agreed upon impact of GIS was GIS ability to improve city planning, better spatial data management, increased productivity, time savings, higher information quality and better service to the public. These payoffs are internal to the organization. On the other hand, the least realized value of GIS was its contribution to social justice, protection of legal rights, enhancing democracy, economic value, improving standards of health and safety and increasing public engagement. This other set of impacts are external to city management. Since GIS use is mostly internal, the value of GIS is more visible internally. There is a dichotomous understanding regarding the impact of GIS in increasing the economic value and revenue of the city (50% agree, 50% disagree) despite almost the consensus on GIS ability to save costs (89% agree.) This can be explained by the fact that GIS is used to improve existing workflows and ways of doing business, yet it is not used to innovate and create ways to bring new revenues or radically improve existing processes. Cities aren't aware, or educated about, exemplar success stories of GIS use. In terms of GIS ability to improve the decision making process, 85% agree but the remaining 15% is worrying, and deserves attention as to why GIS is failing to accomplish its fundamental duties here (for example it could be that decision makers don't trust GIS analysis and rely on their experience.)

When aggregating these GIS value indicators to the category level, this research found that 65% seized all efficiency gains, 57% realized all effectiveness gains, while only 21% reached all societal well-being gains. It can be also observed that GIS value is cumulative, meaning that effectiveness gains occur after efficiency (in 48 of the 55 cases of the sample), and societal well-being occurs after effectiveness gains (in all 20 cases of the sample). When comparing this (actual value) with perceived GIS value, 26% limited the observed GIS value to efficiency gains, 63% reported effectiveness gains, and only 11% stated that GIS made contributions to societal well-being. Consistent with previous research (Pickles, 1995), this dissertation found that using GIS to achieve societal well-being or equitable benefits and goals, is rare and difficult (only 21% of the sample from the measurement tool and 11% from perceived value.) One explanation for this is that GIS for the most part, isn't used to solve the big problems that face society but rather is limited to narrowly defined problems.

The last segment of the findings concerns the relationship between GIS usage and GIS value. Consistent with other research in ERP (Ruivo et al., 2012), DSS (Kohli et al., 2003) and e-business (Zhu and Kraemer, 2005), this research found that there is a positive relationship between actual organizational GIS usage and organizational GIS value. About 50% of the variability in GIS value can be accounted for by GIS usage (but when comparing perceived maturity with perceived value, the relationship is much weaker and accounts for only 19% of the variability in perceived GIS value.) The more an organization expands it usage of GIS, the more value they get out of it. However, the value attained for each GIS maturity stage isn't consistent. For example, of two cities in the enterprise stage, one received a total of 42 points for GIS value (highest possible score) while the other got only 17 points for GIS value. The overall relationship is positive, but it seems valid to assume that there are other variables that moderate this relationship. These variables could be environmental (political stability, community pressure, crime rate, household income) or organizational (perceived relative advantage of GIS, organizational complexity, business process agility, decision maker's mind set and preferences, organizational fit) and deserve further investigation.

Regarding the research questions, this dissertation has demonstrated that the system, tasks, users, organization, and GIS department are necessary dimensions in studying GIS usage at the organizational level of local government. Concerning the measurement to these dimensions, 20 of the 24 proposed indicators are reliable and valid and the measurement tool has been constructed and provided with this dissertation. However, convergent validity (derived from AVE) is low for the organization and GIS department dimension, and requires additional indicators, new items to measure the proposed indicators for the two dimensions, or a rethinking about excluding them from the maturity model and adding other dimensions such as a data dimension (number of datasets, number of layers, accuracy of data, number of updates to existing data.) The scoring method used to compute maturity was an average score for the dimension, an average of all dimensions then rounding the resulting score. The relationship between GIS maturity and GIS value has been found to be positively correlated. However, other variables that moderate, mediate, or control this relationship should be further investigated. Southern California local governments on average are in the exploitation stage. Big strides have been observed in terms of introducing GIS to different departments and users. More has to be done in terms of increasing GIS training, expanding the pool of GIS products used, diversifying the type of tasks GIS could assist in, and recognizing the need to have an independent GIS department with adequate staffing, funding and support. Southern California local governments have gained value from using GIS in terms of efficiency and effectiveness, however societal well-being benefits are still difficult to obtain.

6.3 Contribution

6.3.1 Research Contribution

The nature of this dissertation is theoretical, and there are a couple of knowledge contributions in this area. This research was motivated by the scarcity of research in organizational system usage, diverse definitions, contradicting results and weakness in empirically validated measures. The major contribution of this dissertation is the introduction of a comprehensive measure of organizational system usage in the GIS domain that integrates previous research and draws from multiple research streams. This measure constituted the assessment tool of a new GIS maturity model that has been developed through adopting a rigorous methodology and has been field-tested on a large scale. The new maturity model overcomes many of the shortcomings of previous GIS maturity models and provides the measurement tool and the scoring method. The new maturity model provides a new way to think about maturity in IT by conceptualizing it as usage maturity instead of indirectly tapping into it through capacity to use. This dissertation also provided the operationalization of Akingbade et al. (2009) categories of GIS value, which considers the societal implications of GIS that have often been ignored. This work has also corroborated the link between actual system use and system value that is critical to understanding the business value of IT. Lastly, this research provides an update to the rich literature on GIS at local government based on a large sample.

6.3.2 Practical Contribution

This work has also provided some practical contributions and discussed possible implications. This work has delivered a simple tool for local governments (with similar structure to Southern California local governments) to use for evaluating their current practices and maturity in using GIS and the associated value. The maturity model could be used as a road map to identify particular gaps and plan for development. Other organizations (county, state or federal government, private business or NGOs) could benefit from the maturity model with some modifications, and relate to some of the findings of this research. In this dissertation an analysis of Southern California local government's use of GIS was conducted, and their maturity was discussed both in terms of positive and the negative progress. Barriers to GIS use, especially in small municipalities, were outlined and possible solutions were discussed. Lastly, this dissertation has emphasized the importance of establishing a GIS department/team with adequate structure, role and resources for any organization requiring GIS and aiming to reap the benefits of GIS.

6.4 Limitations and Future Opportunities

The work conducted in this research suffers from a few limitations that should be stated. First, the sample is based on the southern region of the state of California, which could limit the generalizability of the findings to other regions. Local governments in Southern California enjoy the benefit of physical proximity to ESRI headquarters, which could have positive ramifications (awareness about GIS, conferences, customer support, pool of talent, interest in GIS from local universities and colleges) not available to other US local governments. Also the proposed maturity model is based on the assumption of "stages of maturity," which has received criticisms by academics on different occasions. Most importantly, the indicators of usage maturity are measured by single items and are newly developed. More research is needed to explore the depth of each indicator and test if additional items are needed.

Looking forward, there are different directions where this research could be extended. The data collected in this study could serve as a basis for refining the values of each stage of the model (especially the numeric and quantitative values.) There is also a need for case studies on high and low maturity organizations to understand the differences and environmental and institutional factors (not covered in this model) that play into obtaining GIS value. Longitudinal studies are needed to record how organizations go through maturity and produce best practices for transitioning from one stage to another.

It is also valid to ask whether organizations in the sample that were classified into Exploration and Exploitation Stages "chose to be in that stage of maturity?" "Did that stage satisfy their basic needs (spatial data management and efficiency gains)?" Meaning that the strategic value of GIS was not apparent thus they did not push the use of the technology beyond the circle of planners and engineers. This raises another question, "is more maturity always a good thing?" A deeper question one would ask, "do GIS vendors have a problem with their software and platform (which Google solved with their maps through simplicity and rich content)?" Or is it inherent in GIS that it is not perceived as a strategic level of information (compared to business intelligence for example)? This study found that three out of the ten cities in the Enterprise Stage did not attain the societal benefits of GIS. Researchers should ask if there is an extended value to be at the Enterprise Stage but that organizations have not perceived it and thus do not direct resources it has to leverage the benefits of that stage. Moreover, one has to raise the obvious question, is there a tipping point where the value of GIS does not outweigh the cost? What would be the characteristics of that point? Would that point be generic to the industry or varies according to the specificity of each organization?

Statistical tests rendered only 3 out of the 6 indicators of the GIS department dimension as valid and reliable. Future work could look more closely at the GIS department and consider new ways to measure this dimension and suggest practical strategies for establishing a GIS team and the associated challenges. The vast majority of organizations belonging to the exploitation stage in the sample could suggest that this stage ought to be broken down into two stages. An investigation could also be performed to examine why societal impacts of GIS are rare and propose strategies to increase the benefits. Lastly, GIS and decision making in local governments (or businesses) is an important topic that needs to be studied individually to understand and trace how, when, and why GIS is being used to support decision makers. For this research, the objective was to develop a new model. The issues of long-term management of the model are outside the scope and resources of this work. However, future research can extend this work to cover the "maintain" phase (in De Bruin et al., 2005 methodology) by developing an application based on the survey, and which can calculate GIS usage maturity and identify areas requiring attention and focus for potential development automatically.

References

Akingbade, A., Navarra, D. D., and Georgiadou, Y. (2009). A 10 years review and classification of the geographic information systems impact literature (1998-2008). *Nordic Journal of Surveying and Real Estate Research*, *4*, 84-116.

Alrwais, O. A., and Hilton, B. N. (2014). Spatial analytics for Rancho Cucamonga: a city on a map. *Journal of Cases on Information Technology (JCIT)*, *16*(1), 40-49.

Alshehri, M., Drew, S., and AlGhamdi, R. (2013). Analysis of citizens' acceptance for e-government services: applying the UTAUT model. *IADIS International Conferences Theory and Practice in Modern Computing and Internet Applications and Research*, 69-76

Alwaraqi, G. and Zahary, A. (2012). Critical factors of GIS projects failure in Yemeni governmental agencies. *Proceedings of the 13th International Arab Conference on Information Technology*, 53-65. Jordan.

Anand, A., Wamba, S., and Sharma, R. (2013). "The effects of firm IT capabilities on firm performance: the mediating effects of process improvement", In *24th Australasian Conference on Information Systems (ACIS)*. (pp. 1-10). RMIT University.

Antenucci, J. C., Brown, K., Croswell, P. L., Kevany, M. J., and Archer, H. (1991). *Geographic Information Systems: a guide to the technology*. New York: Van Nostrand Reinhold

Ariav, G., and Ginzberg, M. J. (1985). DSS design: a systemic view of decision support. *Communications of the ACM*, *28*(10), 1045-1052.

Arrindell, W. A., and Van der Ende, J. (1985). An empirical test of the utility of the observations-to-variables ratio in factor and components analysis. *Applied Psychological Measurement*, *9*(2), 165-178.

Ayodeji, O.O., (2008). *How Does Geo-Information System Affect Organization Structure?* MSc thesis. ITC Enschede, Enschede, The Netherlands.

Azmi, A. M. (2000). *The extent of utilization of geographic information systems in California water utilities for task and decision-making support.* (Doctoral dissertation). University of La Verne, La Verne, California.

Baban, S. M., and Ramlal, B. (2006). An examination of GIS success within local government departments in the UK and in Trinidad and Tobago. *Surveying and Land Information Science, 66*(4), 269-277.

Babinski, G., Fumia, D., Reynolds, T., Singh, P., Scott, T., and Zerbe, R. (2012). *An analysis of benefits from use of geographic information systems by King County*. Washington. Seattle: Richard Zerbe and Associates.

Babinski, G. (2013). *GIS Capability Maturity Model*. Des Plains, IL: Urban and Regional Information Systems Association (URISA).

Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99-120.

Becker, J., Knackstedt, R., and Pöppelbuß, D. W. I. J. (2009). Developing maturity models for IT management. *Business and Information Systems Engineering, 1*(3), 213-222.

Benbasat, I., and Zmud, R. W. (2003). The identity crisis within the IS discipline: defining and communicating the discipline's core properties. *MIS Quarterly,27*(2) 183-194.

Birks, D. F., Nasirin, S., and Zailani, S. H. M. (2003). Factors influencing GIS project implementation failure in the UK retailing industry. *International Journal of Information Management, 23*(1), 73-82.

Bokhari, R. H. (2005). The relationship between system usage and user satisfaction: a meta-analysis. *Journal of Enterprise Information Management, 18*(2), 211-234.

Borgesa, K. A. D. V., and Sahayb, S. (2000). GIS for the public sector: experiences from the city of Belo Horizonte, Brazil. *Information Infrastructure and Policy 6*, 139-155.

Boughzala, I., and de Vreede, G. J. (2012). A collaboration maturity model: development and exploratory application. *Proceedings of the 45th Hawaii International Conference on System Sciences*. (pp. 306-315). Maui, Hawaii.

Brail, R. K. (2008). *Planning support systems for cities and regions*. Cambridge: Lincoln Institute of Land Policy.

Brodzik, Z. (2004). Development and integration of enterprise GIS. *Proceedings of ESRI User Conference*. San Diego, CA.

Brown, M. M. (1996). An empirical assessment of the hurdles to geographic information system success in local government. *State and Local Government Review 28* (3) 193–204.

Brynjolfsson, E. (1993). The productivity paradox of information technology. *Communications of the ACM, 36*(12), 67–77.

Budić, I. Z. D. (1994). Effectiveness of geographic information systems in local planning. *Journal of the American Planning Association, 60*(2), 244-263.

Budic, Z. D. (1993). GIS use among southeastern local governments. *Journal of the Urban and Regional Information Systems Association, 5*(1), 4-17.

Budic, Z. D. (1998). The impact of GIS technology. *Environment and Planning B, 25*, 681-692.

Burton-Jones, A., and Gallivan, M. J. (2007). Toward a deeper understanding of system usage in organizations: a multilevel perspective. *MIS Quarterly, 31*(4) 657-679.

Burton-Jones, A., and Straub Jr, D.W. (2006). Reconceptualizing system usage: An approach and empirical test. *Information systems research 17*(3) 228-246.

Calkins, H. W., and Obermeyer, N. J. (1991). Taxonomy for surveying the use and value of geographical information!. *International Journal of Geographical Information System, 5*(3), 341-351.

Campbell, H., and Masser, I. (1995). *GIS in organizations: how effective are GIS in practice?* London: CRC Press.

Carr, N.G. (2003). IT doesn’t matter. *Harvard Business Review 81*(5), 41–49.

Chae, H., Koh, C. and Prybutok, V. (2014). Information technology capability and firm performance: contradictory findings and their possible causes. *MIS Quarterly, 38*(1), 305-326.

Chan, T.O., and Williamson, I.P. (2000). Long term management of a corporate GIS. *International Journal of Geographical Information Science 14*(3), 283-303.

Chang, K. C., Lie, T., and Fan, M. L. (2010). The impact of organizational intervention on system usage extent. *Industrial Management and Data Systems, 110*(4), 532-549.

Chen, Y., Wang, Y., Nevo, S., Jin, J., Wang, L., and Chow, W. S. (2014). IT capability and organizational performance: the roles of business process agility and environmental factors. *European Journal of Information Systems, 23*(3), 326-342.

Churchman, C.W. (1979). *The systems approach and its enemies* (p. 11). New York: Basic Books.

Clapp, J. L., McLaughlin, J. D., Sullivan, J. G., and Vonderohe, A. P. (1989). Toward a method for the evaluation of multipurpose land information systems. *Journal of the Urban and Regional Information Systems Association, 1*(1), 39-45.

Colijn, R., and Huyckburg, F. (2000). *The diffusion of GIS at municipalities in the Netherlands*. (Doctoral dissertation, MSc thesis). UNIGIS Vrije Universiteit ,Amsterdam.

Convery, M., and Ives-Dewey, D. (2008). Champions of GIS: municipal implementation and organizational diffusion of GIS in Pennsylvania governments. *Middle States Geographer, 41*, 9-18.

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of applied psychology, 78*(1), 98-104.

Craglia, M., and Signoretta, P. (2000). From global to local: the development of local geographic information strategies in the United Kingdom. *Environment and Planning B, 27*(5), 777-788.

Croswell, P. L. (1991). Obstacles to GIS implementation and guidelines to increase the opportunities for success. *Journal of the Urban and Regional Information Systems Association, 3*(1), 43-56.

Danziger, J.N. and K.V. Andersen (2002). The impacts of information technology on public administration: an analysis of empirical research from the 'golden age' of transformation. *International Journal of Public Administration, 25*, 591-627

Daulatkar, S., and Sangle, P. S. (2015). Causality in information technology business value: a review. *Business Process Management Journal*, *21*(3), 482-516.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly 13*(3), 319-340.

Davis, J. (1999). Six keys to gaining Executive commitment to GIS. *Proceedings of the URISA Conference*, 566-570, Chicago.

Davis, J. M., Mora-Monge, C., Quesada, G., and Gonzalez, M. (2014). Cross-cultural influences on e-value creation in supply chains. *Supply Chain Management: An International Journal, 19*(2), 187-199.

De Bruin, T., Freeze, R., Kulkarni, U., and Rosemann, M. (2005). Understanding the main phases of developing a maturity assessment model. *ACIS 2005 Proceedings*, 109-119. Sydney, Australia.

DeLone, W. H., and McLean, E. R. (1992). Information systems success: the quest for the dependent variable. *Information systems research, 3*(1), 60-95.

Delone, W.H. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems 19*(4) 9-30.

Dennis, A. R., and Carte, T. A. (1998). Using geographical information systems for decision making: extending cognitive fit theory to map-based presentations. *Information Systems Research, 9*(2), 194-203.

Devaraj, S., and Kohli, R. (2003). Performance impacts of information technology: is actual usage the missing link? *Management Science 49*(3) 273-289.

Dickinson, H. J., and Calkins, H. W. (1988). The economic evaluation of implementing a GIS. *International Journal of Geographical Information System, 2*(4), 307-327.

Doll, W. J., and Torkzadeh, G. (1998). Developing a multidimensional measure of system-use in an organizational context. *Information and Management, 33*(4), 171-185.

Drucker, P. F., and Maciariello, J. A. (2008). *Management* (Revised ed.). New York: HarperCollins.

Eldrandaly, K. (2007). GIS software selection: a multicriteria decision making approach. *Applied GIS, 3*(5), 1-17.

Eldrandaly, K. A., Naguib, S. M., and Hassan, M. M. (2015). A model for measuring geographic information systems success. *Journal of Geographic Information System, 7*(04), 328.

Erskine, M. A., and Gregg, D. G. (2013). Impact of geospatial reasoning ability and perceived task-technology fit on decision-performance: the moderating role of task characteristics. *Proceedings of the Nineteenth Americas Conference on Information Systems*, Chicago, Illinois, August 15-17, 2013.

Esnard, A. (2007). Institutional and organizational barriers to effective use of GIS by community-based organizations. *URISA Journal, 19*(2), 13.

Exprodat (2013). *Exprodat Consulting GIS Strategy Review*. Exprodat Consulting Ltd.

FELIX, T. T. C. (2010). Conceptualising use for information systems (IS) success (Doctoral dissertation), Queensland University of Technology.

Field, A. (2009). Discovering statistics using SPSS. London: SAGE Publications.

Ford, B. and Conry, T., (2001). Fairfax County GIS: from reactive to directive. *URISA Annual Conference*, 112-121, Long Beach.

Foresman, T.W. (1998). The history of geographic information systems: perspectives from the pioneers. Upper Saddle River, NJ: Prentice Hall.

French, S. P., and Wiggins, L. L. (1990). California planning agency experiences with automated mapping and geographic information systems. *Environment and Planning B*, *17*(4), 441-450.

Fritz, W., Mollenberg, A., and Chen, G. M. (2001). Measuring intercultural aensitivity in different cultural context. *Biannual Meeting of the International Association for Intercultural Communication Studies*. Hong Kong.

Gable, G. G., Sedera, D., and Chan, T. (2008) Re-conceptualizing information system success: The IS-impact measurement model. *Journal of the association for information systems, 9*(7), 377-408.

Gallaher, D. (1999). Three leading killers of GIS. *Proceedings of the URISA Conference*, 585-586, Chicago.

Galliers, R.D. and A.R. Sutherland (1991). Information systems management and strategy formulation: the stages of growth model revisited. *Information Systems Journal 1*(2), 89–114.

Geertman, S., and Stillwell, J. (2009). *Planning support systems. Best practice and new methods. The Geojournal Library*. Netherlands: Springer.

George, D., and Mallery, P., (2003). *SPSS for Windows step by step: a simple guide and reference*. 4th ed. Boston: Allyn and Bacon.

Gibson, C. F., and Nolan, R. L. (1974). Managing the four stages of EDP growth. *Harvard Business Review*, 76-87.

Giff, G., and Jackson, J. (2013). Towards An online self-assessment methodology for SDIs. In H. Onsrud and A. Rajabifard (Eds.), *Spatial enablement in support of economic development and poverty reduction: research, development and education perspectives* (99-119). Needham, MA: GSDI Association Press

Göçmen, Z. A., and Ventura, S. J. (2010). Barriers to GIS use in planning. *Journal of the American Planning Association, 76*(2), 172-183.

Goodchild, M. F., Longley, P. A., Maguire, D. J., and Rhind, D. W. (2005). Geographic information systems and science. (Vol. 2). Chichester: John Wiley and Sons.

Goodhue, D.L., and Thompson, R.L. (1995). *Task-technology fit and individual performance*. *MIS Quarterly, 19*(2), 213-236.

Gorry, G. A., and Morton, M. S. (1989). A framework for management information systems. *Sloan Management Review, 30*(3), 49-61.

Gottschalk, P., and Solli-Sæther, H. (2009). Towards a stage theory for industrial management research. *Industrial Management and Data Systems*, *109*(9), 1264-1273.

Government Accountability Office (GAO) (2015). Progress needed on identifying expenditures, building and utilizing a data infrastructure, and reducing duplicative efforts. Retrieved 10 September 2015from http://www.gao.gov/assets/670/668494.pdf.

Grimshaw, D.J. (1994). *Bringing geographical information systems into business*. Harlow, UK: Longman Scientific and Technical.

Grimshaw, D.J. (1996). Towards a taxonomy of geographical information systems. *The Proceedings of the Twenty-Ninth HICSS* (Vol. 3), 547-556. Wailea, Hawaii.

Gu, L., and Wang, J. (2009). A study of exploring the "big five" and task technology fit in web-based decision support systems. *Issues in information systems, 10*(2), 210-217.

Gudes, O., Mullan, N., and Weeramanthri, T. (2015). *Spatial maturity in a health agency: a pilot study*. Published by the Australia and New Zealand Cooperative Research Centre for Spatial Information.

Habjan, A., Andriopoulos, C., and Gotsi, M. (2014). The role of GPS-enabled information in transforming operational decision making: an exploratory study. *European Journal of Information Systems, 23*(4), 481-502.

Hadaya, P., and Cassivi, L. (2012). Joint collaborative planning as a governance mechanism to strengthen the chain of IT value co-creation. *The Journal of Strategic Information Systems, 21*(3), 182-200.

Harris, S. E., and Katz, J. L. (1991). Organizational performance and information technology investment intensity in the insurance industry. *Organization Science*, 8(2 and 3), 263-295.

Hendriks, P. H. (1998.)"Information strategies for geographical information systems. *International Journal of Geographical Information Science, 12*(6), 621-639.

Hevner, A. R., March, S. T., Park, J., and Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75-105.

Higgs, G., Smith, D. P., and Gould, M. I. (2005). Findings from a survey on GIS use in the UK National Health Service: organisational challenges and opportunities. *Health Policy, 72*(1), 105-117.

Hitt, L.M. and Brynjolfsson, E. (1996). Productivity, business profitability, and consumer surplus: three different measures of information technology value. *MIS Quarterly, 20*(2), 121-142.

Holland, C. P., and Light, B. (2001). A stage maturity model for enterprise resource planning systems use. *ACM SIGMIS Database, 32*(2), 34-45.

Hu, L.T., and Bentler, P.M., (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1) 1-55.

Hussain, M., Ramzi, M., and Johar, F. (2010). The socio-technical factors in the use of GIS at the Planning Departments of the Kuala Lumpur City Hall. *Journal of the Malaysian Institute of Planners, 8*, 69-103.

IBM. (2013)"What Is Big Data?" Retireved 10 September 2015 from http://www-01.ibm.com/software/data/bigdata/what-is-big-data.html.

Jarupathirun, S., and Zahedi, F. (2001). A theoretical framework for GIS-based spatial decision support systems: utilization and performance evaluation. *AMCIS 2001 Proceedings, 49*, 245-248.

Jarupathirun, S., and Zahedi, F. M. (2007). Exploring the influence of perceptual factors in the success of web-based spatial DSS. *Decision Support Systems, 43*(3), 933-951.

Jasperson, J. S., Carter, P. E., and Zmud, R. W. (2005). A comprehensive conceptualization of post-adoptive behaviors associated with information technology enabled work systems. *MIS Quarterly, 29*(3), 525-557.

Joffe, B. (2003). *10 ways to support your GIS without selling data*. Oakland, CA.

Johnson, C.A. (2013). *The diffusion of geospatial technologies among Louisiana assessors* (Doctoral dissertation). University of New Orleans, New Orleans, Louisiana.

Jonas, H., and Björn, J., (2001). Measuring utilization of ERP systems usage in SMEs. In M.M. Cruz-Cunha and J. Varajao (Eds), *Enterprise information systems design, implementation and management: organizational applications* (287-299). Hershey, NY: Business Science Reference.

Jordan, J. M., and Sutherland, S. L. (1979). Assessing the results of public expenditure: program evaluation in the Canadian federal government. *Canadian Public Administration, 22*(4), 581-609.

Junttila, J. (2014). *A business continuity management maturity model: the search for an ISO 22301 compliant BCM maturity model* (Master's thesis), University of Turku, Finland.

Karalopoulos, A., and Kavouras, M. (2015). Survey on maturity models for the geospatial domain. *AGILE 2015*, Lisbon, Portugal.

Keenan, P. (2005). Concepts and theories of GIS in business. In J. Pick (Ed.), *Geographic information systems in business* (1-19). Hershey, NY: Idea Group Publishing.

Keenan, P. B. (2006). Spatial decision support systems: a coming of age. *Control and Cybernetics, 35*(1), 9.

King, W.R., and Teo, T.S. (1997). Integration between business planning and information systems planning: validating a stage hypothesis. *Decision Sciences, 28*(2), 279-308.

Knijnenburg, B. (n.d.). Part 2: Measurement. Quantitative Research Methods Seminar. Retrieved 2016 January 12 from http://www.usabart.nl/QRMS/QRMS2.pdf.

Kohli, R., and Grover, V. (2008). Business value of IT: an essay on expanding research directions to keep up with the times. *Journal of the association for information systems, 9*(1), 28-39.

Kohli, R., Devaraj, S., and Ow, T. T. (2012). Does information technology investment influence a firm's market value? A case of non-publicly traded healthcare firms. *MIS Quarterly, 36*(4), 1145-1163.

Kohsaka, H. (2000). Applications of GIS to urban planning and management: problems facing Japanese local governments. *GeoJournal, 52*(3), 271-280.

Komarkova, J., Hub, M., Neumannova, J., and Visek, O. (2010). Information system supporting spatial decision-making and its quality. *International Journal of Computers and Communications 2*(4), 31-38.

Kraemer, K., and Dedrick, J. (2001). The productivity paradox: is it resolved? Is there a new one? What does it all mean for managers? *Center for Research on Information Technology and organizations*, University of California, Irvine.

Kumar, R. L. (2004). A framework for assessing the business value of information technology infrastructures. *Journal of Management Information Systems, 21*(2), 11-32.

Kun, U. (2014). *The use of geographic information systems (GIS) by law enforcement agencies and its impact on police performance in the US* (Doctoral dissertation). Commonwealth University, Virginia.

Kurwakumire, E. (2014). Towards a public-sector GIS evaluation methodology. *South African Journal of Geomatics, 39*(6) 53-55.

Lavoie, D., and Culbert, S.A. (1978). Stages of organization and development. *Human Relations 31*(5), 417-438.

Liu, H., Ke, W., We, W. and Hua, Z. (2013). The impact of IT capabilities on firm performance: the mediating roles of absorptive capacity and supply chain agility. *Decision Support Systems, 54*(3), 1452-1462.

Longley, P.A, Goodchild, M., Maguire, D.J., and Rhind, D.W. (2010). *Geographic information systems and science* (3rd ed.). Chichester: John Wiley and Sons.

MacDonald, M. L., and Radcliffe, P. T. (1997). *Benchmarking public sector efficiency and productivity gains from geographic information systems*. Palo Alto, CA: Electric Power Research Institute.

MacKenzie, L. (2003). The challenges of implementing Enterprise GIS at the City of Fort Worth. *ESRI International User Conference*. ESRI.

Maguire, D. J., Smith, R., and Kouyoumjian, V. (2008). The business benefits of GIS: an ROI approach. Redlands,CA: ESRI, Inc.

Maier, A. M., Moultrie, J., and Clarkson, P. J. (2012). Assessing organizational capabilities: reviewing and guiding the development of maturity grids.*IEEE Transactions on Engineering Management, 59*(1), 138-159.

Mäkelä, J. (2012). Model for assessing GIS maturity of an organization. In A. Rajabifard and D. Coleman (Eds.), *Spatially Enabling Government, Industry and Citizens* (143-165).

Mangan, M. (2008). *Introducing a maturity model For Enterprise GIS*. Even Keel Strategies, Inc.

Manglik, A. (2006). Increasing BI adoption: an enterprise approach. *Business Intelligence Journal, 11*(2), 44.

Markus, M. L. (2004). Technochange management: using IT to drive organizational change. *Journal of Information Technology, 19*(1) 4-20.

Marr, A., and Benwell, G.L. (1996). GIS maturity and integration. *GeoComputation'96 Special Issue 96/25*, 1-18.

Massetti, B., and Zmud, R.W., (1996). Measuring the extent of EDI usage in complex organizations: strategies and illustrative examples. *MIS Quarterly, 20*(3), 331-345.

Mayr, W. (1995). Levels of GIS maturity in Malaysia. *The Australasian Geographic Information Systems Applications Journal*, *12*, 30-31.

McCormack, K., Willems, J., Van den Bergh, J., Deschoolmeester, D., Willaert, P., Indihar Štemberger, M., Škrinjar, R., Trkman, P., Ladeira, M., Oliveira, M., de, Vuksic, V and Vlahovic, N. (2009). A global investigation of key turning points in business process maturity. *Business Process Management Journal, 15*(5), 792-815.

McGill, W. J. (2005). Moving local government GIS from the tactical to the practical. *The GIS Guide for Local Government Officials*, 9-28.

Mclean, E. R., Sedera, D., and Tan, F. T. C. (2011). Reconceptualizing system use for contemporary information systems. *PACIS 2011 Proceedings*. Paper 130.

Melville, N., Kraemer, K. and Gurbaxani, V. (2004). Review information technology and organizational performance an integrative model of IT business value. *MIS Quarterly, 28*(2), 283-322.

Mennecke, B. E., and Crossland, M. D. (1996). Geographic information systems: Applications and research opportunities for information systems researchers. *Proceedings of the Twenty-Ninth Hawaii International Conference on Information Science*, (Vol. 3), 537-546.

Mettler, T. (2009). A design science research perspective on maturity models in information systems. *St. Gallen: Institute of Information Management. University of St. Gallen, Switzerland*.

Mettler, T. (2011). Maturity assessment models: a design science research approach. *International Journal of Society Systems Science*, *3*(1) 81-98.

Mettler, T., and Rohner, P. (2009). Situational maturity models as instrumental artifacts for organizational design. In *DESRIST '09 Proceedings of the 4th International Conference on Design Science*, Philadelphia, USA.

Mettler, T., Rohner, P., and Winter, R. (2010). Towards a classification of maturity models in information systems. In *Management of the interconnected world* (333-340). Heidelberg: Physica-Verlag.

Mishra, A. N., Konana, P., and Barua, A. (2007). Antecedents and consequences of internet use in procurement: an empirical investigation of US manufacturing firms. *Information Systems Research*, *18*(1), 103-120.

Mithas, S., Tafti, A. R., Bardhan, I., and Goh, J. M. (2012). Information technology and firm profitability: mechanisms and empirical evidence. *MIS Quarterly, 36*(1), 205-224.

Nasirin, S. and Birks, D. (1998). Geographical information systems (GIS) success factors amongst UK food retailers: comparisons between market leaders and followers. *Proceedings of the 10th Annual Colloquium of the Spatial Information Research Center*, 235-242, Dunedin.

Nedovic-Budic, Z. (1999). Evaluating the effects of GIS technology: review of methods. *Journal of Planning Literature, 13*, 284-295

Nedovic-Budic, Z., and Godschalk, D. (1996). Human factors in adoption of geographic information systems: a local government case study. *Public Administration Review, 56*(6), 554–567.

Neufeld, D. J., and Griffith, S. (2000). Isobord's geographic information system (GIS) solution. *Journal of Cases on Information Technology (JCIT), 2*(1), 91-108.

Nolan, R. (1973). Managing the computer resource: a stage hypothesis. *Communications of the ACM, 16*(7), 399-405.

Nolan, R. (1979). Managing the crises in data processing. *Harvard Business Review, 57*(2), 115–126.

O'Flaherty, B., Bartlett, D., Lyons, G., Keanko, W., Ending, M., and Schulz, J., (2005). Towards a stage model for GIS and SDI deployment in local government. *PACIS 2005 Proceedings*. Paper 60.

O'Looney, J. (1997). *Beyond maps: GIS and decision making in local government*. ESRI, Inc.

O'Looney, J. (2000). *Beyond maps. GIS and Decision making in local government*. Redlands, CA: ESRI.

O'Neill, D. (2013). *The potential role of Maturity Models in an assessment of Hospital IT capability in Ireland* (Doctoral dissertation). University of Dublin.

Olafsson, A. S., and Skov-Petersen, H. (2014). The use of GIS-based support of recreational trail planning by local governments. *Applied Spatial Analysis and Policy, 7*(2), 149-168.

Onsrud, H. J., and Pinto, J. K. (1993). Evaluating correlates of GIS adoption success and the decision process of GIS acquisition. *URISA Journal, 5*(1), 18-39.

Oxera Consulting, Ltd. (2013). What is the economic impact of geo services? Retrieved 10 September 2015 from http://www.oxera.com/Oxera/media/Oxera/downloads/reports/What-is-the-economic-impact-of-Geo- services_1.pdf.

Ozimec, A. M., Natter, M., and Reutterer, T. (2010). Geographical information systems-based marketing decisions: effects of alternative visualizations on decision quality. *Journal of Marketing, 74*(6), 94-110.

Patas, J., Pöppelbuß, J., and Goeken, M. (2013). Cherry picking with meta-models: a systematic approach for the organization-specific configuration of maturity models. In *Design science at the intersection of physical and virtual design* (353-368). Berlin: Springer.

Paulk, M. C., Curtis, B., Chrissis, M. B., and Weber, C. V. (1993). Capability maturity model, version 1.1. *IEEE Software, 10*(4), 18-27.

Pearson, J. M., and Shim, J. P. (1995). An empirical investigation into DSS structures and environments. *Decision Support Systems, 13*(2), 141-158.

Piccoli, G., and Lui, T. W. (2014). The competitive impact of information technology: can commodity IT contribute to competitive performance? *European Journal of Information Systems, 23*(6), 616-628.

Pick, J., and Shin, N. (2008). Assessing the business value of geographic information systems: a process-oriented approach. *Academic Proceedings of the 2008 ESRI Business GIS Summit*. Redlands, CA, University of Redlands, 11-26.

Pickles, J. (Ed.). (1995). *Ground truth: the social implications of geographic information systems*. New York: Guilford Press.

Picoto, W.N., Bélanger, F., and Palma-dos-Reis, A. (2014). An organizational perspective on m-business: usage factors and value determination. *European Journal of Information Systems, 23*(5) 571-592.

Poeppelbuss, J., Niehaves, B., Simons, A., and Becker, J. (2011). Maturity models in information systems research: literature search and analysis. *Communications of the Association for Information Systems, 29*(27) 505-532.

Porter, M. E., and Millar, V. E. (1985). How information gives you competitive advantage. *Harvard Business Review, 63*(4), 149-158.

Quaadgras, A., Weill, P., and Ross, J. W. (2014). Management commitments that maximize business impact from IT. *Journal of Information Technology, 29*(2), 114-127.

Reiach, L. (1999). GIS value demonstrated during storm of the century. *Public works, 130*(4), 47-49.

Rich, T. (1995). *The use of computerized mapping in crime control and prevention programs. NIJ Research in Action Series*. Washington: National Institute of Justice.

Ruivo, P., Oliveira, T., and Neto, M. (2012). ERP use and value: Portuguese and Spanish SMEs. *Industrial Management and Data Systems, 112*(7), 1008-1025.

Schryen, G. (2013). Revisiting IS business value research: what we already know, what we still need to know, and how we can get there. *European Journal of Information Systems, 22*(2), 139-169.

Schuurman, N. (2002). Women and technology in geography: a cyborg manifesto for GIS. *The Canadian Geographer/Le Géographe canadien, 46*(3), 258-265.

Setia, P., Venkatesh, V., and Joglekar, S. (2013). Leveraging digital technologies: how information quality leads to localized capabilities and customer service performance. *MIS Quarterly, 37*(2), 565-590.

Sieber, R. E. (2000). GIS implementation in the grassroots. *URISA journal, 12*(1), 15-29.

Simon, H. A. (1960). *The new science of management decision*. New York: Harper & Brothers.

Smelcer, J. B., and Carmel, E. (1997). The effectiveness of different representations for managerial problem solving: comparing tables and maps. *Decision Sciences*, *28*(2), 391-420.

Smith, D.A. and Tomlinson, R.F. (1992). Assessing cost and benefits of geographic information systems: methodological and implementation issues. *International Journal of Geographical Information Systems, 6*, 247-256.

Solli-Sæther, H. and Gottschalk, P. (2010). The modeling process for stage models. *Journal of Organizational Computing and Electronic Commerce, 20*(3), 279-293.

Someh, I. A., and Shanks, G. (2015). How business analytics systems provide benefits and contribute to firm performance?, In *23rd European Conference on Information Systems (ECIS 2015)*.

Somers, R. (1994). GIS organization and staffing. *Urban and Regional Information Systems Association Annual Conference Proceedings, 1*, 41-52.

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

Stachowicz, S. (2004). Geographical data sharing–advantages of web based technology to local government. In *10th EC GI and GIS Workshop Proceedings, ESDI State of the Art* (pp. 23-25). Warsaw, Poland

Steghuis, C., Daneva, M., and van Eck, P. (2005). Correlating architecture maturity and enterprise systems usage maturity to improve business/IT alignment. *Proceedings of REBNITA 2005*, 64-73. Paris, France.

Sun, H., and Zhang, P. (2005). A research agenda toward a better conceptualization of IT use. *AMCIS 2005 Proceedings*, Paper 224.

Swink, M., and Speier, C. (1999). Presenting geographic information: effects of data aggregation, dispersion, and users' spatial orientation. *Decision sciences, 30*(1), 169-195.

Teece, D., Pisano, G. and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*, 509–533.

Tomaselli, L. (2004). The enterprise model of GIS, and the implications for people and organizations. *Annual GIS Symposium at Troy State University*.

Tomlinson, R. (2005). *Thinking about GIS: Revised and updated edition*. Redlands, CA: ESRI Press.

Trapp, N., Schneider, U. A., McCallum, I., Fritz, S., Schill, C., Borzacchiello, M. T., Huemesser,C., and Craglia, M. (2015). A meta-analysis on the return on investment of geospatial data and systems: a multi-country perspective. *Transactions in GIS, 19*(2), 169-187.

Tu, Q. (2001). Measuring organizational level IS usage and its impact on manufacturing performance. *AMCIS 2001 Proceedings*, Paper 418.

Tulloch, D. L. (1999). Theoretical model of multipurpose land information systems development. *Transactions in GIS, 3*(3), 259-283.

Tulloch, D. L., and Epstein, E. (2002). Benefits of community MPLIS: efficiency, effectiveness, and equity. *Transactions in GIS, 6*(2), 195-211.

Turel, O., and Bart, C. (2014). Board-level IT governance and organizational performance. *European Journal of Information Systems, 23*(2), 223-239.

Turner, P., and Higgs, G. (2003). The use and management of geographic information in local e-government in the UK. *Information Polity, 8*(3), 151-165.

Van Loenen, B., and van Rij, E. (2008). Assessment of spatial data infrastructures from an organisational perspective. In J. Crompvoets, A. Rajabifard, B. van Loenen, T. Delgado Fernandez (Eds.), *A multi-view framework to assess spatial data infrastructures* (173-192). Melbourne: University of Melbourne.

Van Steenbergen, M., Bos, R., Brinkkemper, S., van de Weerd, I., and Bekkers, W. (2010). The design of focus area maturity models. In *Global perspectives on design science research* (317-332). Berlin: Springer.

Ventura, S. J. (1995). The use of geographic information systems in local government. *Public Administration Review, 55*(5), 461-467.

Vessey, I. (1991). Cognitive fit: A theory-based analysis of the graphs versus tables literature. *Decision Sciences, 22*(2), 219-240.

Vom Brocke, J., and Rosemann, M. (Eds.). (2010). *Handbook on business process management 1*. Berlin: Springer-Verlag.

Wang, S., and Cavusoglu, H. (2015). Small and medium sized manufacturer performance on third party B2B electronic marketplaces: the role of enabling and IT capabilities. *Decision Support Systems, 79*, 84–194

Weir, R., and Bangs, M. (2007). *The use of geographic information systems by crime analysts in England and Wales*. London: Home Office.

Wellar, B. (1993). Key institutional and organizational factors affecting GIS/LIS strategies and applications. *Computers, environment and urban systems, 17*(3), 201-212.

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and software technology, 54*(12), 1317-1339.

Wilcox, D. L. (1990). Concerning the economic evaluation of implementing a GIS. *International Journal of Geographical Information System, 4*(2), 203-210.

Witkowski, M. S., Rich, P. M., and Keating, G. N. (2008). Metrics of success for enterprise geographic information systems (EGIS). *Journal of Map and Geography Libraries, 4*(1), 59-82.

Worral, L. (1991). *Spatial analysis and spatial policy using geographic information systems*. London: Belhaven Press.

Worrall, L. (1994). Justifying investment in GIS: a local government perspective. *International Journal of Geographical Information Systems, 8*(6), 545-565.

Worrall, L., and Bond, D. (1997). Geographical information systems, spatial analysis and public policy: the British experience. *International statistical review, 65*(3), 365-379.

Xu, W., Ou, P., and Fan, W. (2015). Antecedents of ERP assimilation and its impact on ERP value: a TOE-based model and empirical test. *Information Systems Frontiers*, 1-18.

Xue, L., Ray, G., and Sambamurthy, V. (2012). Efficiency or innovation: how do industry environments moderate the effects of firms' IT asset portfolios? *MIS Quarterly, 36*(2), 509-528.

Ye, H., Brown, M., and Harding, J. (2014). GIS for all: exploring the barriers and opportunities for underexploited GIS applications. *OSGeo Journal, 13*(1), 19-28.

Yeow, A., and Goh, K. H. (2012). Healthcare processes and IT: exploring productivity gains through improved allocative efficiency. *Proceedings of the 32nd International Conference on Information Systems (ICIS)*, Orlando, FL, USA.

Zhang, L., Huang, J., and Xu, X. (2012). Impact of ERP investment on company performance: evidence from manufacturing firms in China. *Tsinghua Science and Technology, 17*(3), 232-240.

Zhao, J., and Jiang, Y. (2013). From e-supply chain capability generation to information technology value co-creation: a perspective of e-business process. In *2013 International Conference on* e-*Business (ICE-B)*, 1-7. Reykjavik, Iceland.

Zhu, K., and Kraemer, K. (2005). Post-adoption variations in usage and value of e-business by organizations: cross-country evidence from the retail industry. *Information Systems Research, 16*(1) 61–84.

Appendix 1. Expert Opinion

Dear Olmer:

Thanks for the reminder. I just saw your email the other day, and wondered if you still wanted my comments. Sorry to take so long.

<u>GIS Usage Maturity Model:</u>

First off, to be able to understand your model you need to provide some definitions. For example, what does "Core process" mean? "Support process"?

Secondly, I am not sure I agree with GIS Department in "enterprise" as "stand alone". This implies (to me, anyway) a central keeper, "controller" and custodian of all data.

I don't think that is what you mean.

Your description states it better:

"GIS is used extensively across the organization" and "GIS department responsible for managing the spatial data for all the departments (central database and data model) to use and for providing the required services (solutions, applications, changes and training)."

The departments are not just "users" of GIS, but they are the ones who "own", input and analyze their pieces of the overall database.

Therefore, I would call the GIS Department as the manager, but not the owner, gatekeeper or controller of the database.

Regarding <u>GIS-Value</u>

This looks very good.

I do have some of my own comments.

<u>Effectiveness:</u>

"4. Increased job satisfaction (internal users satisfied with the technology and decisions taken" ((I suggest "made" instead of taken)) "based on it)"

Furthermore, the users are satisfied because they are able to do their work not only more efficiently, but also more effectively and accurately, which makes them feel that what they are doing is more valuable to their organization and even to "society".

<u>Societal Well-being:</u>

Forgive me for being more pessimistic here. All of your statements are good, and are what we desire to be the outcome of GIS. I am not criticizing any of them.

So now I must get up on my soap box and vent my frustrations.

In reality, the results or "Impacts" are so very much dependent on the quality of the local (elected and managerial) decision makers.

First of all, they may just not be data people, so they ignore hard facts. Or there are data people, but they are over-ruled.

Secondly, they may have their own agendas, such as development in certain areas, even though the "facts" may contradict.

As far as "Citizen-public sector interactions" or "Social justice", GIS data may be available, but the citizenry may lack the time, knowledge or other resources to make effective use of it.

I am working on a project right now, where the city extended sewer and water about 4 miles out into undeveloped land in 2007. They spent over $12 million. There are only about 250 homes developed in the area so far. Maybe it was at the time when the housing boom was still on, so no one questioned it. It costs the city about $800,000 annually in extra police and road maintenance costs, plus about $750,000 annually in bond principal and interest. These costs have gone on for 6 years (my analysis date is 2013).

Looking at a map of the city, a planner and most citizens can easily spot this as "sprawl". However, as their fiscal impact consultant, it has been difficult for me to pull together all the information that quantifies the negative impact. If I were just a citizen questioning this development, the data would not be readily available, and it would take a lot of time an expertise to put it all together. For example, the city engineer had to dig into his archives to find the cost figures, and the finance officer could only show me the interest, because the principal is buried somewhere else into their accounting and reporting system.

I guess what I am saying is that maybe there is a stage beyond "Enterprise". I do not know what to call it ("exter-prise"?) I do not know if it is even achievable, unless there is something like a city "ombudsman" that can study the issues independently from the city staff and decision-makers. This would certainly create controversy, which is why I say it may be unachievable. As a consultant, I feel like an ombudsman, but the city leadership must authorize hiring someone like me. Actually, I was hired by the county. I am not sure how the city will react to the final report. Furthermore, my approach, using GIS, is still unique to me. Other fiscal impact consultants do not use GIS. I hope to expand the use of GIS for this, but it takes more work and better, more detailed data

So, now you have my initial comments on your model.

I think you have captured the essence of what it should be, perhaps with my minor tweaks. I hope this is helpful. Please do not hesitate to contact me if you have any questions.

Sincerely,

Dr. Linda Tomaselli

****

Omer --

I'm afraid you've hit a very busy time of year, so I won't be able to give this much more than a quick glance.

I think the 3 general stages you describe are useful points along a continuum that could be divided in any number of ways. I did find your descriptions of the stages somewhat narrowly cast and perhaps specific to some of the organizations that you've observed. You should also be cautious about implying motivations (for example "The organization isn't serious about using GIS"). If you're going to use a stage-based model, it should be based on what can be ascertained about technology, data, and usage. The beliefs and intentions of an organization are a different dimension that should be considered separately.

Re dimensions. I would also be cautious about using specific numeric thresholds for your categories, as these are just markers along a continuum. In fact, I'm sure that you'll find that an organization may be in the "exploration" stage for one dimension and the "exploitation" or even "enterprise" stage for others. Also, I also doubt that "GIS department" will be a useful way to distinguish stage. I think it is possible for GIS to be implemented in many ways that don't fall neatly within your categories.

Re your classification of value gained -- this is very much the scheme that has been in use for quite some time, only referred to as the 3E's : efficiency, effectiveness, and equity (instead of "societal well-being"). I think this was first published in URISA Proceedings around 1990.

Hope this helps,

Steve V.

+-+
Stephen J. Ventura
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Interesting proposal. You've done quite a bit of solid research on this, so you're off to a good start. One issue that I have with where you are at this point is that it isn't clear to me if you are looking at the rate of implementation of GIS by local governments or if you are interested to see if these local governments have invested time in developing a "capability maturity model" for their GIS implementations. I may be confused, but I see these as two different things. Governments implement GIS because they can use it to fulfill their organizational duties. I see the CCM as something different, something more like an evaluation of their GIS. And yet, it isn't quite the same as a cost-benefit analysis or an ROI (return on investment) analysis.
As I understand it, your research will be based on a survey of local governments in Southern California to find out to what extent they are using GIS. Will you be asking them if they are using a CCM to assess their use of GIS? Or will you use the survey to see to what extent they are using GIS and then place it within a CCM that you will define?
I ask this because I've worked in state government in Illinois in the past and I'm currently a board member of the Bloomington, Indiana Public Transit agency. Based on my personal/professional experience outside of academia, when you're working in a public organization, you focus on your organizational tasks and duties first and foremost. So I'm wondering if CCMs for their GIS will even be within the realm of consciousness of most local government agencies. I do know, however, that there probably is a need to find out where and how GIS is being used by governments in the U.S., based on my recent conversations with Lisa Warnecke.

Which government? Be specific. I'm not so sure I agree with this point. There are many different units of government and each unit of government adopted GIS at different times. You might try to find "Geographic Information Technology in Cities and Counties: a Nationwide Assessment" by Lisa Warnecke et al. It was published by URISA in 1998

(http://search.library.wisc.edu/catalog/ocm39886903). Lisa contacted me recently about the need to do research on the use of GIS by governments in the U.S. You might also find it useful to check with NSGIC to see what information they have on GIS in governments around the U.S. (www.nsgic.org)
If I can be of any further help, please let me know.

Sincerely,
Nancy Obermeyer

****

Dear Omer....

Sorry for the delay in responding to you. Shortly after your first request I completed the purchase of a new house and then moved during the year-end holidays.

Here are some general comments and then I will respond to your specific questions.

First, I think that your work needs to clarify the aspects of GIS maturity that you intend your model to address. It seems to focus on developmental utilization within the organization and the perceived value that an organization receives from GIS use. This is different than looking at maturity from a capability standpoint or from a process maturity standpoint, which the URISA GIS Capability Maturity Model addresses. This is not a bad thing, but you might consider clarifying how you are thinking about maturity from the top down, and how your approach compliments other maturity model approaches.

Second, your model relies heavily upon very subjective evaluations. You might address how an organization could validate their application of your model to their operation. The URISA GISCMM relies on validation by a knowledgeable person within the organization, separate from the person origination the evaluation. Within King County where I work, we are accomplishing this by performing our evaluation by our entire GIS management team, along with our IT Service delivery manager. Have you thought of what an online survey or a paper questionnaire would look like, designed for an agency to assess its maturity against your model?

Third, your model does not clarify who would use it and how it would be used. What would the results look like? How might an organization use it to effect change?

Fourth - this is just house-keeping, but you might have someone proofread your two documents. There are many spelling and grammatical errors. It should also have some headings with title, your authorship, and versions/dates. Also, you cite one source in the text, but you do not list the publication from which the citation comes.

On to some specifics:
□□□□□□□□□□Stage 1 (Exploration) text: The first sentence (The organization isn't serious….) I think is not appropriate for what you describe as stage 1 elsewhere. With >30% of employees using GIS (as your matrix implies) that is quite serious investment, staff time commitment, and cost to the agency. Maybe the first sentence suggests that you need an earlier stage (Stage 0?) called something like 'Initial Awareness' in which 'The organization is aware of GIS but not yet committed to its use'?
□□□□□□□□□□Stage 2 (Exploitation) text: Your reference to 'low coordination' at this level is problematic. I think it is possible to have a very strong enterprise GIS operation, with strong coordination and low duplication, but with exploitation even lower than 30% of all employees.
□□□□□□□□□□Stage 3 (Enterprise) text: Not clear what you mean by '…and GIS is integrated with strategic planning'? Not sure what 'Critical mass' means at this stage. Not sure that the statement 'GIS is the glue that….' can be substantiated. Perhaps 'GIS helps connects departments and processes together'? Also, I do not think a mature organization would want 'Processes [to be]

continuously reengineered to take advantage of GIS' – they might want them to be reengineered if there are process improvement opportunities, but not continuously.

On your Dimensions Matrix, here are some comments:
□□□□□□□□□□□You have a total of 24 characteristics within five dimensions of maturity. But I know of many organizations in which their utilization of GIS for the dimensions and categories might be in multiple stages. How does a user of the model make sense of where they are overall? KCGIS for the 'Systems' dimension w/b Stage 3, but for users, we are at about 30% (4,600 of 13,000 employees) – Stage 1.
□□□□□□□□□□□For 'Tasks' – I think you need to define 'Core' and 'Support' processes. For these processes, why stop at 90% to define Stage 3. If an organization is 100%, what stage is that?
□□□□□□□□□□□For 'Users' – I think it is many many years in the future before 60-90% of employees in most organizations are using GIS. The relevance of 4) GIS Connections is not clear. These would vary by size and nature of an organization, as well as other political, organizational, and business case aspects. I think it is also possible for GIS to begin in many organizations (Stage 1) from a top-down Strategic focus.
□□□□□□□□□□□For 'Organization' 1) Vision – I think maybe you mean how is GIS used. An organization could be very immature (Stage 1) but have a Stage 3 vision – indeed without vision there is little likelihood of progress.
□□□□□□□□□□□For 'GIS Department' 1) structure and 2) Role – I think these could exist in a well-defined manner at Stage 1 and 2. 3) Number of staff assumes some nominal overall size of the organization. I know of some very well-functioning Enterprise GIS operations for small jurisdictions with <100 overall employees and only one of two GIS staff.

For your 'Value' document:
□□□□□□□□□□□This is a very good summation of value from GIS (or what should be the value from any government support service).
□□□□□□□□□□□For Efficiency, you might emphasize business-process productivity. Maybe take a look at the King County GIS ROI study for some ideas here (http://www.urisa.org/clientuploads/directory/Documents/Journal/Under%20Review/KCGISROIZERBE-URISAJOURNAL(20140603).pdf).
□□□□□□□□□□□For effectiveness, an often overlooked value is that GIS enables many government business process that are impossible without GIS.
□□□□□□□□□□□The societal benefits are also often overlooked, but this is an excellent summery.

You might consider presenting your model at the 2015 GIS-Pro Conference (http://www.urisa.org/education-events/gis-pro-annual-conference/) in October. I know that there would be considerable interest in this topic and you could meet with many others who are addressing it.

Omer…thank you for the opportunity to review your work. I hope that these suggestions and comments help you craft a maturity model that is clear and concise and that provides clear benefit to those who use, operate, manage, invest in, pay for, and benefit from GIS.

Feel free to follow-up with me.

Best of luck….

greg babinski,MA, GISP
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****

Omer,
It looks pretty good to me.   A couple of minor observations:

1. You use <90% a few times when I think you mean > 90%
2. I am not sure that it would always be necessary to have 6+ agreements with outside agencies. You would only need as many as you need to meet your strategic goals.
3. You might want to incorporate the concept of ‘knowledge management’ somewhere in your model

Good luck with your research.
Best regards,
John

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Appendix 2. Questionnaire

Consent

Informed Consent Form

STUDY LEADERSHIP: You are being asked to participate in a research project conducted by Mr. Omer Alrwais, a PhD student at the School of Information Systems and Technology, Claremont Graduate University (CGU). The research is supervised by Dr. Thomas Horan, Dr. Brian Hilton and Dr. Tamir Bechor.

PURPOSE: The purpose of this study is to examine the factors that relate to an organization's maturity in using GIS. In addition, the study assess the organizational value gained from using GIS

ELIGIBILITY: To take part in this study, you must be a city employee with knowledge about how GIS is being used in the city that you work with.

PARTICIPATION: During the study, you will take an online questionnaire asking about your education and work experience, and demographic questions such as your approximate age and gender. The questionnaire contains questions about the city, GIS history in the city, questions about the detailed usage of GIS citywide and questions about the impact of GIS over the city. Completing this questionnaire will take about 30 minutes.

RISKS OF PARTICIPATION: The potential risks you run by taking part in this study are minimal as you will be reporting objectively about the usage and value of GIS in the city.

BENEFITS OF PARTICIPATION: This study might benefit you be exposing you to the range of applications that GIS might be applied to and the potential value of GIS in your place of work. This study might benefit your city by providing an excellent opportunity for the city to reflect on its usage of GIS, evaluate the value gained as a result of investing in GIS and contemplate the opportunities for advancing GIS in the city. The results and findings of this study will be communicated to you which is expected to benefit you personally and the city. .This study will benefit me by validating a maturity model I have proposed as part of my PhD progress. This study is also intended to benefit the field of Information Systems by providing a new maturity model and emphasizing the importance of measuring the organizational usage of systems.

COMPENSATION: For taking part in this study, you will be given a chance to enter a lottery to win one of five $40 gift cards for Amazon.com, to be chosen at random for those who complete the questionnaire. You will have roughly a 5/233 chance of winning a gift card, depending on the final number of participants in the questionnaire. If your city regulations don't prevent you from taking such a prize, please choose the option of participating in the lottery at the end of the questionnaire. If you win, you will be contacted by the email you supplied in the questionnaire to claim your prize.

VOLUNTARY PARTICIPATION: Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time, or refuse to answer any particular question for any reason without it being held against you.

CONFIDENTIALITY: This online study is being conducted through the website of Claremont University using the Qualtrics software. You may find out more about this the questionnaire's software, if you wish, at http://www.qualtrics.com. The only identifiable information taken from you is your email address in case you win a prize and that piece of information will be kept secured and will not be shared with any one . All individual answers will be presented in an anonymized and aggregated form in any papers, books, talks, posts, or stories resulting from this study. All electronic data will be encrypted and secured with a password.

FURTHER INFORMATION: If you have any questions or would like additional information about this study, please contact Omer Alrwais at omer.alrwais@cgu.edu or (909)223-6661. You may also contact my faculty advisor at Brian.Hilton@cgu.edu. You may print and keep a copy of this consent form.

CONSENT: Clicking the "Yes" entry below means that you understand the information on this form, that any questions you may have about this study have been answered, and that you are eligible and voluntarily agree to participate. This link will direct you to the questionnaire. Clicking the "No" entry will close this page and exit the questionnaire.

- Yes, I would like to participate
- No, I do not want to participate

GIS Knowledge

Are you familiar with the role of GIS in your city?

(If no please stop filling this survey and kindly pass it to someone in your city knowledgeable about GIS use)

- Yes
- No

Part One: Demographics

Part One: Demographics

If you can kindly provide the following information

How many years of experience do you have with GIS ?

- Less than 1 year
- 1-3 years
- 4-6 years
- More than 6 years

Email (Only to contact you if you win a gift card)

Age

- Less than 25 years
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- 51-55
- 56-60
- More than 60 years

Gender

- Male
- Female

Please indicate the highest degree/s you earned

- Diploma
- Bachelor
- Master
- PhD
- Other

What is your current job title ?

- GIS manager
- GIS staff
- IT manager
- IT staff
- Planner
- Engineer
- Other

How many years have you been with the city ?

- Less than 1 year
- 1-3
- 4-6
- 7-9
- More than 9 years

Part Two: The City

Part Two: The City

What is the name of the city you're working in ?

What year was the city incorporated ?

What form of government does the city follow ?

- Council-Manager
- Commission
- Council-Mayor
- Town Meeting
- Other

What is the approximate number of people living in your city ?

- Less than 49,000 people
- 50,000 – 99,999
- 100,000 – 149,999
- 150,000-199,999
- More than 200,000

What was the city's annual budget last year ?

- Less than 25 Million
- 25-49 Million
- 50-74 Million
- 75-99 Million
- More than 100 Million

What is the total number of employees currently working for the city (full time + part time) ?

- Less than 100
- 100-199

- 200-299
- 300-399
- More than 400

Part Three: GIS history in the city

Part Three: GIS history in the city

How many years has the city been using GIS?

How is the GIS functionality provided?

- Through the city (in house)
- Through the county
- Through a contractor or consultant firm
- 3d party (university or non for profit organization)
- Shared with neighboring cities
- Other

(a champion is a high level administrator who sees how GIS can benefit one or more tasks that the organization has to do)

Who was/were the champion/s for GIS ? Please provide their job title

Who is the vendor/s of GIS that your city works with? (Check all that apply)

- ESRI
- Bentley
- MapInfo
- Autodesk
- Intergraph
- Smallworld
- MicroStation

☐ Other

Part Four: GIS Usage

Part Four: GIS Usage

Please choose from the following, the maturity stage that best describes the current usage of GIS in your city

○ **Exploration:** The organization is investigating the benefits of GIS to its activities and the services it offers. It's used primarily to comply with regulations and to produce maps occasionally. Beyond that, development of GIS is led by individual enthusiasts eager to learn the technology and adopt it to their work. A more coordinated development occurs in the form of projects when new needs arise or as a reaction to an event. Recognition of GIS is very low outside the circle of planners and engineers thus skills in using GIS are scarce. The use isn't coordinated as departments work in silos with GIS and very few sharing of spatial data occurs. GIS specialists are distributed around the departments (those who perform mapping in the planning, fire or public works department). In some instances, the GIS could be maintained by an outside contractor all together (outsourced). Only basic functionalities of GIS have been explored. The focus is on digitizing, data collection and building base maps (framework data). GIS is used more as a data resource for record keeping. On other occasions, GIS is used to replace manually produced paper maps and perform limited measurements (distance, directions, proximity and buffering). As a result of duplicate data and distribution of GIS professionals over the departments, spatial data reporting is rarely real time.

○ **Exploitation:** The organization has recognized the importance of GIS in improving the performance of obvious departments and process (well-established process where the need for GIS evident). GIS is heavily used within these departments and has been routinized. Other departments (where geography isn't a crucial part of their work) are beginning to exploit the functionalities of GIS. Duplication of effort still occurs, as coordination remains low. A GIS coordinator or manager may exist but is usually influenced by a specific department (due to the hierarchy, as the GIS team might be positioned under the IT department for example), which limits the role that GIS can play in organizational development. However, GIS usage by operational management and field workers is widespread and is integrated with a fair number of processes. GIS in this stage acts as a 'Service Bureau' meeting the needs and demands of other departments. But often this results in duplication of effort, and a staff that cannot possibly meet all of the demands of other departments. Slowly, applications are modified to take advantage of GIS. Not all applicable processes are spatially enabled.

○ **Enterprise:** The organization has recognized GIS as a strategic asset (mission critical) that provides competitive advantage and is essential to the success of the organization in fulfilling its mandates. GIS is integrated with strategic planning. GIS is used extensively across the organization. Critical mass has been reached and the organization sees the benefit of a multi-purpose enterprise system beneficial to the whole organization. GIS is the glue that connects departments and process together. Geo-spatial information is used by senior management to take decisions and form policies. There exists a GIS department responsible for managing the spatial data for all the departments (central database and data model) to use and for providing the required services (solutions, applications, changes and training). Processes are continuously reengineered to take advantage of GIS. Usage and sharing of spatial data isn't limited to inside the organization; External usage (individuals and agencies) of GIS exists. Organizational changes are widespread to obtain strategic value of GIS.

System Usage

Please identify from the following list, the GIS functions that your city currently uses (Check all that apply)

- ☐ Data Preprocessing (transformation, scaling and smoothing of spatial data)
- ☐ Data Capture (digitize, scan, GPS, sensors, satellite spatial data)
- ☐ Spatial Database
- ☐ Geo-coding
- ☐ Projection
- ☐ Data Conversion
- ☐ Map production
- ☐ Geo-processing
- ☐ Distance Measurement
- ☐ Buffering
- ☐ Spatial Analysis
- ☐ Simulation
- ☐ Design & Planning
- ☐ Network Analysis

- [ ] 3D Presentation
- [ ] Graphs
- [ ] Reporting
- [ ] Overlay
- [ ] Temporal Display
- [ ] Asset Tracking
- [ ] Prediction & Forecasting
- [ ] Impact Assessment
- [ ] Decision Modeling
- [ ] Site Selection
- [ ] If you use other functions of GIS not listed here, kindly please list all of them

Please identify from the following list, the GIS products that your city currently utilizes (Check all that apply)

- [ ] ArcGIS Desktop
- [ ] ArcGIS Server
- [ ] ArcGIS Online
- [ ] ArcGIS Mobile
- [ ] ArcSDE
- [ ] ArcPad
- [ ] ArcGIS Engine
- [ ] GIS Web services
- [ ] City Engine
- [ ] ArcGIS ETL
- [ ] ArcGIS data quality
- [ ] ArcGIS network analyst
- [ ] ArcGIS Schematics
- [ ] ArcGIS for windows mobile
- [ ] Collector
- [ ] ArcGIS Flex or Silverlight
- [ ] ESRI Geoportal
- [ ] Explorer for ArcGIS
- [ ] Streatmap Premium
- [ ] ArcGIS app
- [ ] ArcGIS for local government
- [ ] ESRI community maps
- [ ] ESRI demographics
- [ ] ESRI Redistricting
- [ ] ESRI Reports
- [ ] Web applications templates (e.g. story map)
- [ ] Operations dashboard
- [ ] Business Analyst
- [ ] Community Analyst
- [ ] Real-time monitoring (e.g. Geo-Event processor or Geo-Fence)
- [ ] ArcGIS Transportation Analyst
- [ ] ArcGIS 3D extension
- [ ] ArcGIS infographics extension
- [ ] Spatial-temporal analysis
- [ ] ArcGIS Data Extensions
- [ ] Other (If you use other ESRI GIS products not listed here or use GIS products from other vendors, kindly please list all of them)

What would be the most accurate statement regarding the city's efforts in customizing the GIS products it acquires ?

- ○ Vendor (contractor) responsible for changes
- ○ Minimal changes by city staff
- ○ Extensive & ongoing changes by city staff

City Processes Usage of GIS

Which of the following core city processes (primary and fundamental) have been enabled by GIS ?
(Check all that apply)

- [ ] Budget Preparation
- [ ] Taxation (property assessment)
- [ ] Economic development
- [ ] Community assessment
- [ ] Landscape management
- [ ] Permitting & inspections

- [ ] Cadastral/parcel
- [ ] Emergency management (Police, Fire)
- [ ] Engineering
- [ ] City Yearly plans
- [ ] Utility management (sanitary, water, trash, recycling and sewer)
- [ ] Public safety
- [ ] city hall meetings (open or private)
- [ ] Land use planning
- [ ] Business licensing
- [ ] Elections
- [ ] Environmental monitoring
- [ ] Development review and approval (subdivision, building permits)
- [ ] Transportation management
- [ ] Zoning & districting
- [ ] Procurement and contract management
- [ ] Infrastructure management
- [ ] Employment
- [ ] Revenue management
- [ ] School management
- [ ] Park's maintenance
- [ ] Customer services (complaints, orders and requests)
- [ ] Public health
- [ ] Other

Approximately, what is the percentage of core processes that have been enabled by GIS ?

Which of the following support city processes (secondary processes that support day-day activities) have been enabled by GIS ? (Check all that apply)

- [ ] Resource allocation
- [ ] Parking management
- [ ] Street closure permitting
- [ ] Fleet monitoring
- [ ] Event scheduling
- [ ] Code enforcement
- [ ] IT
- [ ] Human resources
- [ ] Address verification
- [ ] Documentation
- [ ] Citation's management
- [ ] Owner notification
- [ ] Reporting
- [ ] Children services
- [ ] Platting
- [ ] Mapping
- [ ] Aged and disabled services
- [ ] Performance monitoring
- [ ] Information dissemination
- [ ] Records management
- [ ] Historical and tourism planning
- [ ] Library services
- [ ] Housing
- [ ] Data collection (for regulations, state or federal)
- [ ] Other

Approximately, what is the percentage of support processes that have been enabled by GIS ?

What would be the most accurate statement regarding the complexity of the tasks GIS is used in most of the times ? (Check all that apply)

- [ ] Simple (Structured decisions, simple queries, for example to find the location of a resource in the city)

- ☐ Moderate (Semi-structured decisions, for example to find the best route to a location)
- ☐ Complex (Unstructured decisions, for example to find the best site for the new fire station)

How has GIS impacted existing work-flows ? (Check all that apply)

- ☐ Replaced manual & paper forms and maps (digitization)
- ☐ Moderate changes (changed order, steps or time)
- ☐ Radical changes (reengineered processes)

Users of GIS

Could you please indicate who uses GIS (directly via the system or indirectly via the GIS information or its reports) ?

(Check all that apply)

☐ Field workers	☐ Department heads	☐ Local business
☐ Engineers	☐ City manager	☐ General public
☐ Planners	☐ City manager's deputy	☐ Attorneys
☐ Clerks	☐ Council members	☐ Analysts
☐ Police officers	☐ Mayor	☐ IT staff
☐ Firefighters	☐ Other ______	

Would you please indicate which of the following departments, offices or divisions
use GIS (directly via the system or indirectly via GIS information or reports) ? (Check all that apply)

☐ Administration	☐ Utilities	☐ Finance
☐ Public works	☐ Volunteer services	☐ General services
☐ Planning	☐ Disability & aging	☐ Human resources
☐ Information Technology	☐ Airports	☐ Water & power
☐ Fire	☐ Harbor/ports	☐ Zoo services
☐ Police	☐ City manager office	☐ City auditor office
☐ Animal control	☐ City clerk office	☐ Oil & gas
☐ Employment services	☐ City attorney office	☐ Purchasing & contracting
☐ Environmental services	☐ Mayor's office	☐ Risk management
☐ Health and human services	☐ Treasurer office	☐ Engineering
☐ Housing & real estate	☐ Building & safety	☐ Community development
☐ Records & archive	☐ Convention center	☐ Code enforcement
☐ Parks & recreation	☐ Cultural affairs	☐ Redevelopment

☐ Sanitation & recycling
☐ Library services
☐ Community services
☐ Landscape & Public infrastructure
☐ Emergency management
☐ Economic development
☐ Transportation & parking
☐ Other

Approximately, what is the percentage of employees who use GIS (directly via the system or indirectly via the GIS information or its reports) of all city employees ?

Approximately what is the percentage of city departments that use GIS (directly via the system or indirectly via the GIS information or its reports) of all city departments ?

Please specify the extent to which GIS is used at the following levels of management in your city

	None	Minimal	Moderate	High
Operational Level (e.g. Low level managers, supervisors and field workers)	○	○	○	○
Tactical Level (e.g. City manager and department heads)	○	○	○	○
Strategic Level (e.g. Mayor, commissions, boards and city council members)	○	○	○	○

What is the number of usage agreements that your city has signed with other agencies to use your GIS data or system ?

○ None
○ 1-3
○ More than 3

Organizational Issues of GIS

What would be the most accurate statement regarding the vision behind GIS in your city ?

○ To manage spatial data
○ To improve efficiencies of city processes
○ To enhance decision making

What would be the most accurate description regarding the strategic plans in the future for GIS in your city ?

- ◯ We don't have such a plan
- ◯ We are in the process of researching the strategic plan for GIS
- ◯ A formal documented plan exists outlining the opportunities for growth

What would be the most accurate description regarding the purpose for using GIS in your city ? (Check all that applies)

- ☐ For inventory purposes (e.g. locating property information and condition)
- ☐ For analysis (e.g. to understand the relationship between geography and the environment)
- ☐ For policy making (e.g. to inform, revise and justify polices and decisions)

What would be the most accurate description regarding the pattern (form) in which GIS is used in your city ?

- ◯ Specialized (few experts use GIS as part of their job)
- ◯ Routine (GIS has become embedded in some business processes)
- ◯ Innovative (new uses of GIS are constantly rolled out)

What is the level of GIS awareness in the city's departments and offices ?

- ◯ Low
- ◯ Moderate
- ◯ High

What is the state of GIS training in the city ?

- ◯ Infrequent
- ◯ Occasional
- ◯ Frequent

What is the level of cooperation between departments as a result of GIS ?

- ◯ Low
- ◯ Moderate (sharing data mostly)
- ◯ High (teamwork)

GIS Unit

Could you please indicate how the GIS unit/department/division/team is positioned within the city's hierarchy ?

- ◯ We don't currently have a GIS unit
- ◯ Dedicated GIS unit
- ◯ Under Information Technology department
- ◯ Under planning department
- ◯ Under engineering department
- ◯ Under community development
- ◯ Under public works
- ◯ Other

What role (objective) does the GIS unit perform ?

- ◯ We don't currently have a GIS unit
- ◯ Provide basic GIS functionalities
- ◯ Support the organization (departments, citizens and businesses)

What is the number of employees in the GIS unit ?

- ◯ None
- ◯ 1-3
- ◯ 4-6
- ◯ 7-9
- ◯ More than 9

What are the different skills of the employees in the GIS department ? (Check all that applies)

- ☐ Cartography
- ☐ Engineering
- ☐ Computer programming
- ☐ Web programming
- ☐ Mobile programming
- ☐ Communications
- ☐ Business knowledge (understanding of different processes of the city)
- ☐ Other

What is the management style of the GIS unit when dealing with other city departments ?

- ◯ Traditional (order taking similar to a help desk style)
- ◯ Service-oriented (provides standard services that can be shared)
- ◯ Customer-oriented (tailored on demand solutions)

How are GIS consultants used in your city ? (Check all that apply)

- ☐ In the initial phases to justify investments in GIS
- ☐ During implementation to manage the project
- ☐ Ongoing and considered important for the development of the city
- ☐ We don't use consultants

Part Five: GIS Value

Part Five: GIS Value

Please indicate whether you agree or disagree with the following statements regarding the benefits that the city has realized from using GIS

	Strongly Disagree	Disagree	Agree	Strongly Agree
GIS has provided us with better spatial data management (capture, store, retrieve, share and display)	○	○	○	○
We have gained cost savings as a result of using GIS	○	○	○	○
We have gained cost avoidance as a result of using GIS	○	○	○	○
GIS has increased our productivity	○	○	○	○
GIS gave us better allocation of resources (labor, assets, material, space or capital)	○	○	○	○
We have gained time savings as a result of using GIS	○	○	○	○
GIS provided us with higher information quality relative to our needs	○	○	○	○
GIS improved interdepartmental coordination	○	○	○	○
GIS improved interdepartmental cooperation	○	○	○	○
GIS has improved our city planning	○	○	○	○
We are able to provide better service (better quality) to the public after using GIS	○	○	○	○
Our employees are more satisfied with their jobs after using GIS (for example GIS has simplified their jobs)	○	○	○	○
GIS helps us in conflict resolution (as a result of information sharing)	○	○	○	○
GIS has improved our decision making process	○	○	○	○
With GIS, we have become more responsive to the needs of citizens, businesses and customers	○	○	○	○
GIS has increased the public's engagement and interaction with the city	○	○	○	○
We have gained economic value as a result of using GIS (for example more revenues through accurate taxation)	○	○	○	○
GIS has contributed to enhancing democracy in our city (via more transparency, less corruption)	○	○	○	○
GIS has contributed to the improvement of standard of health and safety in the city	○	○	○	○
GIS has helped in insuring the protection of legal rights (surveillance, security and privacy)	○	○	○	○
In our city, we see evidence that GIS has contributions to social justice (equity)	○	○	○	○

Overall, what would be the most accurate description regarding the value gained from using GIS in your city ? (Check all that apply)

- ☐ **Efficiency:** The degree to which GIS operates with minimum (waste, duplication and expenditure of resources) or with the same level of inputs but provides greater output (productivity).
- ☐ **Effectiveness:** The degree to which GIS has contributed to the satisfaction of information needs, in adequate quantity and quality of data and decision-making process. GIS enhances performance as well as enabling many business processes that are challenging without GIS.
- ☐ **Societal well-being:** The degree to which GIS helps in the realization of collective goals of a society or impact of GIS on broad societal objectives such as individual integrity, social justice, distribution of wealth and fulfillment of human aspirations.

Would you like to add anything about how GIS is used or about GIS benefits?

Appendix 3. IRB Response

Claremont

GRADUATE UNIVERSITY

Institutional Review Board

March 4, 2015

IRB #: 2434
Title of study: Towards a New GIS Maturity Model: a Usage Perspective
Determination: EXEMPT

Dear Omer Alrwais,

Thank you for submitting your research protocol to the IRB at Claremont Graduate University for review. Based on the information you have submitted, we consider your study *exempt from IRB supervision* under CGU policy and federal regulations.

Please note that a series of suggestions may also be attached to this email. These are suggestions to develop or improve your research protocol. These suggestions are highly recommended but not required. You do not need to send anything back to the IRB.

Exempt status means that so long as the study does not vary significantly from the description you have given us, further review in the form of filing annual Renewal or project Closure forms is not necessary. You may specify in relevant study documents that CGU human subjects protection staff members have reviewed the study and determined it to be exempt from IRB supervision. The IRB does not "*approve*" (or disapprove) studies that are exempt, so kindly avoid use of this verb.

Please note carefully that maintaining exempt status requires that (a) the risks of the study *remain minimal*, that is, as described in the application; (b) that *anonymity or confidentiality* of participants, *or protection* of participants against any higher level of risk due to the internal knowledge or disclosure of identity by the researcher, is maintained as described in the application; (c) that *no deception* is introduced, such as reducing the accuracy or specificity of information about the research protocol that is given to prospective participants; (d) the research *purpose*, *sponsor*, and recruited *study population* remain as described; and (e) the principal investigator (PI) continues and is not replaced.

If changes are contemplated in *any such features* of the study as described, this may affect one or more of the conditions of exemption, and that would very likely warrant a reclassification of the research protocol from exempt status and require additional IRB review. If any such changes are contemplated, please notify the IRB as soon as possible and before the study is begun or changes are implemented. If any events occur during the course of research, such as unexpected adverse consequences to participants, that call into question the features that permitted a determination of exempt status, you must notify the IRB as soon as possible.

If Applicable: most listservs and websites have policies regulating the types of advertisements or solicitations that can be posted, including from whom prior approval must be obtained before posting a recruitment notice for research. Similarly, most institutions, and even classroom instructors, have policies regarding who can solicit potential research participants from among their students, employees, etc., what information must be included in solicitations, and how recruitment notices are distributed or posted. You should familiarize yourself with the policies and approval procedures required of you to conduct your study by listservs, websites, institutions, and/or instructors. CGU IRB approval or exemption does *not* substitute for these approvals or release you from the responsibility to insure that you have gained appropriate approvals *before* advertising your study or conducting your research.

The IRB may be reached at (909) 607-9406 or via email to irb@cgu.edu. The IRB wishes you well in the conduct of your research project.

APPROVED
MAR 04 2015
CLAREMONT GRADUATE
UNIVERSITY IRB

135 East Twelfth Street • Claremont, California 91711-6160
Tel: 909.607.9406 • Fax: 909.607.9655

Appendix 4. Invitation Letter

Dear Sir/Madam,

My name is Omer Alrwais and I am a Phd student at the Center For Information Systems and Technology (CISAT) at Claremont Graduate University (CGU), California USA. I am working on a dissertation titled “Towards a New GIS Maturity Model: a Usage Perspective” under the supervision of my faculty committee. My research examines the factors that relate to an organization’s maturity in using GIS. In addition, I would like to assess the organizational value gained from using GIS. For that matter, I have designed a questionnaire to understand this issue. My focus is on local governments and especially cities and municipalities.

I have obtained your email form the city website. I ask for your participation in this questionnaire. Your participation is voluntary. The information you provide about the city’s use of GIS will be kept confidential and the reported results will not identify your city specifically. Rather, general findings will be reported.

Answering the questionnaire will be an excellent opportunity for the city to reflect on its usage of GIS, evaluate the value gained as a result of investing in GIS and contemplate the opportunities for advancing GIS in the city.

If you think that another person in your city is more involved with GIS and would better answer this questionnaire, kindly please forward this email to him/her.

There will be a random drawing of 5 amazon gift cards each worth $40 for those that complete the questionnaire and their city regulations allows them to take such a prize. The questionnaire will take approximately 20-30 minutes of your time.

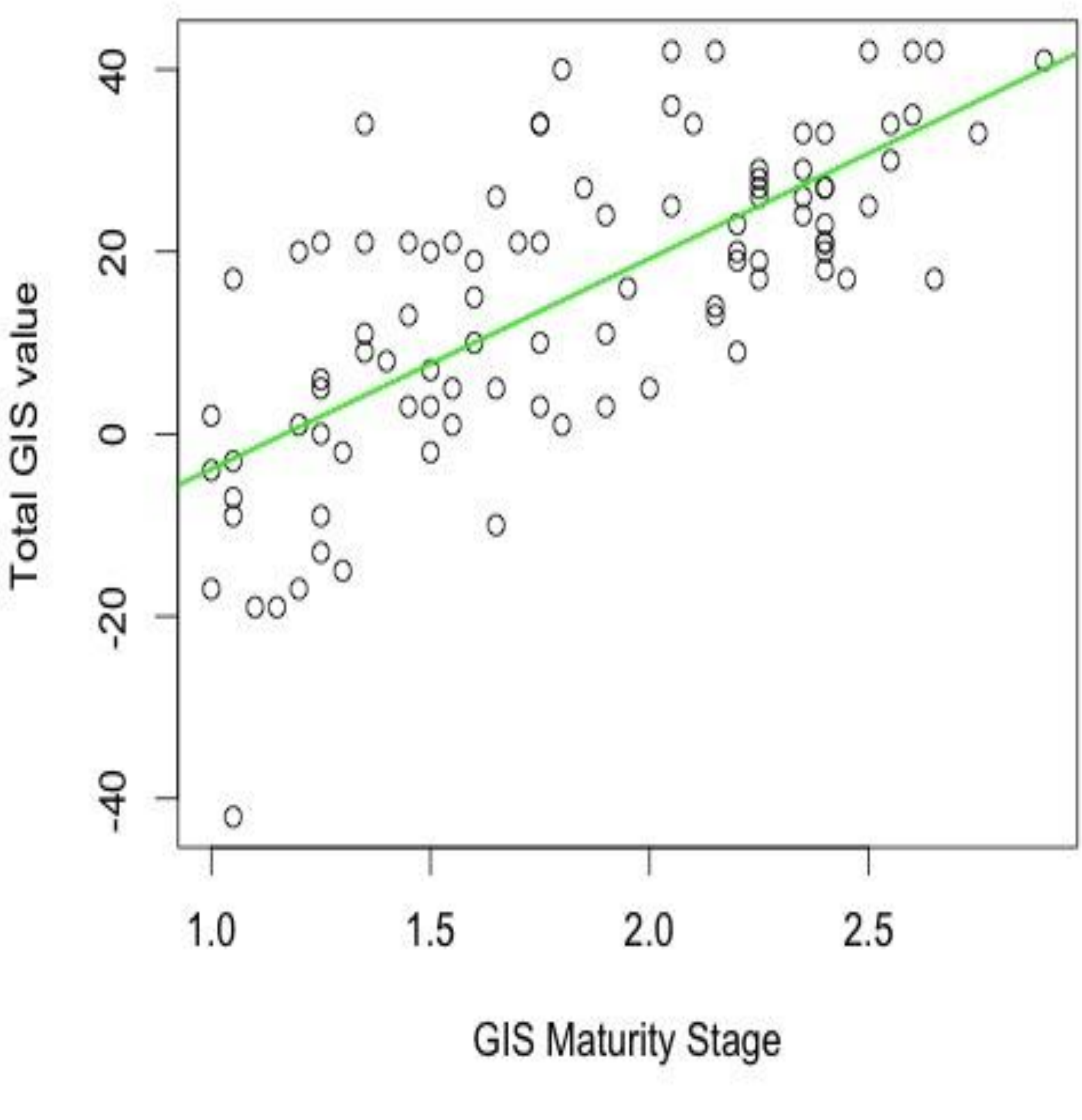
If you decide to participate, please click the link below to answer the questionnaire and sign the consent form.

I appreciate your candid feedback in advance and I am very thankful for your help and assistance.

If you have in concerns or questions regarding the questionnaire, please don’t hesitate to call me at or email me at

Sincerely,
Omer Alrwais

Appendix 5. Scatter Plot of GIS Maturity and Value



Appendix 6. Study Area Map