DOCTORAL PROGRAMME

Information Management

Specialization in Information and Decision Systems

Diffusion perspective of Geographic Information Technology across Mozambican institutions

Nelson Adamo Cabá Amade

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor in Information Management

June 2018

NOVA Information Management School
Universidade Nova de Lisboa

NOVA IMS Information Management School

Doctorate Program in Information Management

Professor Doutor Marco Octávio Trindade Painho, Supervisor

Professor Doutor Tiago André Gonçalves Félix de Oliveira, Supervisor

Doctorate Program in Information Management

Abstract

Over the last century, the human race has witness the technology revolution. This revolution is creating a new order in world, the era where information is one of the precious assets for nations and governments. In the coming decades, more is going to change in the technology field than the past century. Natural hazards, floods, tectonic activities, within others that in past many nations have fallen, today it can be predicted, monitored and controlled. Among the most extraordinary types of technologies, geographic information technologies (GIT) is gaining attention over decision makers and top managers of many sectors. These technologies can be described as all sort of computer systems used in processing georeferenced information. Over the years these systems were kept in shadow and ignored by organizations.

Mozambique introduced these technologies after independence. Over the years these technologies have mature and expand to a wide range of sectors of activities. In our days, these systems are present in all most every Mozambican institution.

The overall goal of this study we intend to contribute to a better understanding of the determinants behind the adoption of geographic information technologies in Mozambican institutions (public, private, NGO's). To be able to cover the main goal, three studies have been developed. We started in chapter two with geographic information technologies literature and narrow to a specific case study (Mozambican context). In chapter three we analyze the determinants behind geographic information technologies at two stages of adoption (intention and adoption) applied for Mozambican institutions and a research model have been developed. In the third chapter, we propose a research model to understand the determinants behind the geographic information technologies at Post-adoption stage.

The combination of innovative theories and frameworks that operates at organization level provides a solid foundation of our study. Two research models have been developed and proposed. The first research model is characterized with seven variables seeking to explain the drivers behind the adoption of geographic information technologies at intention and adoption stages. The variables declared were technology competence, security, financial concerns, competitive pressure, government policies, donor pressure, and intention to adopt. The variables donor pressure and government policies played a key role in motivating organizations to adopt new technologies. In the second research model we declared 10 variables seeking to understand what takes organizations to keep using and increase the level of use of geographic information technologies at post-adoption stage. The variables were relative advantage, compatibility, complexity, organization size, geographic scope, expansion opportunities, coercive pressure, normative pressure, mimetic pressure and GIT use.

This work provides several contributions for research, practice, advancement of knowledge, for experts in the field of these technologies, society and institutions. In first paper, the results showed that the main drivers of GIT use by organizations are compatibility, competitive pressure, complexity, donor pressure, government policy, intention to adopt, innovation, relative advantage, security, and technology competence, with compatibility and technology competence being the mains ones. In second paper, technology competence, security, competitive pressure, are important drivers to explain the intention to adopt GIT. Financial concerns, government policies, donor pressure, and intention to adopt are important drivers to explain adoption of GIT. The donor pressure is the only driver that is statistically significant in both intention and adoption of GIT. In the third paper, the variables compatibility, geographical scope, expansion opportunities, and normative pressure contribute to explain the GIT use. The relative advantage, complexity, coercive pressure and mimetic pressure contribute to explain the intention to increase the GIT level of use. The model explains 59.2% of variation in GIT use and 57.0% of variation in intention to increase the GIT level, revealing substantial power of explanation for the GIT post-adoption.

Keywords: GIT, intention, adoption, post-adoption, institutions, Mozambique.

Resumo

No último século, o homem testemunhou a revolução tecnológica. Essa revolução está criando uma nova ordem no mundo, a era em que a informação é um dos ativos preciosos para nações e governos. Nas próximas décadas, muita coisa vai mudar no campo da tecnologia do que no século passado. Perigos naturais, inundações, atividades tectônicas, dentro de outros que no passado levaram muitas nações a caírem hoje podem ser previstos, monitorados e controlados. Entre os tipos mais extraordinários de tecnologias, as tecnologias de informações geográficas (TIG) estão ganhando atenção sobre os decisores e os administradores de topo em vários setores. Essas tecnologias podem ser descritas como todo tipo de sistemas informáticos usados no processamento de informações georreferenciadas. Ao longo dos anos, esses sistemas foram mantidos à sombra e ignorados pelas organizações.

Moçambique introduziu estas tecnologias após a independência. Com o passar dos anos, essas tecnologias amadureceram e expandiram-se pelos setores de atividades. Nos nossos dias, estes sistemas estão presentes em quase todas as instituições moçambicanas.

O estudo tem por objectivo melhorar a compreensão dos factores determinantes para a adopção de tecnologias de informação geográfica nas instituições moçambicanas (públicas, privadas, ONGs). Para poder cobrir com o objetivo principal, três estudos foram desenvolvidos. O capítulo dois foi caracterizado com uma revisão de literatura sobre tecnologias de informação geográfica que em seguida foi aplicada a um contexto (contexto moçambicano). No capítulo três, analisamos os determinantes por detrás das tecnologias de informação geográfica em dois estágios de adoção (intenção e adoção) aplicados a instituições moçambicanas e um modelo de pesquisa foi desenvolvido. No terceiro capítulo, propomos um modelo de pesquisa para entender os determinantes por detrás das tecnologias de informação geográfica na fase de pós-adoção.

A combinação de teorias e estruturas inovadoras que operam no nível da organização fornece uma base sólida ao estudo. Dois modelos de pesquisa foram desenvolvidos e propostos. O primeiro modelo de pesquisa é caracterizado por sete variáveis que buscam explicar os impulsionadores da adoção de tecnologias de informação geográfica nas etapas de intenção e adoção. As variáveis declaradas foram competência tecnológica, segurança, preocupações financeiras, pressão competitiva, políticas governamentais, pressão dos doadores e intenção de adotar. As variáveis pressão dos doadores e políticas governamentais desempenharam um papel fundamental na motivação das organizações para adotar novas tecnologias. No segundo modelo de pesquisa, declaramos 10 variáveis buscando entender o que leva as organizações a continuar usando e aumentar o nível de uso das tecnologias de informação geográfica na fase de pós-adoção. As variáveis foram vantagem relativa, compatibilidade, complexidade, tamanho da organização, abrangência geográfica, oportunidades de expansão, pressão coercitiva, pressão normativa, pressão mimética e uso do TIG.

Este trabalho fornece várias contribuições para pesquisa, prática, e avanço no conhecimento, para especialistas no campo dessas tecnologias, sociedade e instituições. No primeiro artigo, os resultados mostram que os principais impulsionadores do uso das TIG nas organizações são compatibilidade, pressão competitiva, complexidade, pressão dos doadores, política do governo, intenção de adotar, inovação, vantagem relativa, segurança e competência tecnológica, sendo identificadas como principais compatibilidade e competência tecnológica. No segundo artigo, a competência tecnológica, a segurança, a pressão competitiva são fatores importantes para explicar a intenção de adotar as TIG. Preocupações financeiras, políticas governamentais, pressão dos doadores e intenção de adotar são fatores importantes para explicar a adoção de TIG. A pressão do doador é o único driver que é estatisticamente significativo tanto na intenção quanto na adoção. No terceiro artigo, as variáveis compatibilidade, abrangência geográfica, oportunidades de expansão e pressão normativa contribuem para explicar o uso das TIG. A vantagem relativa, a complexidade, a pressão coercitiva e a pressão mimética contribuem para explicar a intenção de aumentar o nível de uso das TIG. O modelo explica 59,2% da variação no uso do TIG e 57,0% da variação na intenção de aumentar o nível do TIG, revelando poder substancial de explicação para a pós-adoção do GIT.

Palavras - chave: TIG, intenção, adoção, pós-adoção, instituições, Moçambique.

Publications

List of publications resulting from this thesis:

Papers (published or accepted)

Amade, Nelson; Painho, Marco; Oliveira, Tiago (2018). Geographic Information Technology use in Developing Countries – A Case Study in Mozambique. *Geo-spatial Information Science.*

Nelson Amade, Marco Painho and Tiago Oliveira, 2017. Determinants of Geographic Information Technologies Intention and Adoption and Mozambique Institutions' Perspectives. *Research Journal of Information Technology, 9: 64-73.*

Papers (submitted or under review)

Nelson Amade, Marco Painho and Tiago Oliveira, 2018. Understanding the determinants of GIT Post-adoption: Mozambique institutions perspectives.

Other publications (under PhD program)

Cabral, Pedro; Augusto, Gabriela; Akande, Adeoluwa; Costa, Anjos; Amade, Nelson; Niquisse, Sérgio; Atumane, Ali; Cuna, António; Kazemi, Kiana; Mlucasse, Ramires; Santha, Rubini (2017) "Assessing Mozambique's exposure to coastal climate hazards and erosion" International Journal of Disaster Risk Reduction.

Acknowledgments

Firstly, I would like to thank God to give me the strength to reach this day. My greatest debt of gratitude goes to my wife, children's and parents, without their love and support I would not have been able to complete my thesis. For my supervisors Prof. Marco Painho and Prof. Tiago Oliveira I owe invaluable debt of gratitude. Their energy and encouragement always motivates me to keep moving as a researcher and realize that I would reach my final thesis. I would like to thank the CAT committee members for their helpful comments. Finally, to Agostinho Macane, Frans Haanstra, and my PhD colleagues for their friendship and support.

Table of Contents

List of figures

List of tables

Chapter 1 – Introduction

1.1.Introduction

Advances in technological area in the last century is revolutionary the way organizations conduct their business in the market arena. The delivery of technology services has experienced major changes during the last decades of technology cycle. The ever-production and spread of technologies deluge the markets with different approaches and types, encouraging the organizations to start a new era. From an information system perspective, geographic information technologies (GIT) is one of the major technological innovation that enables organizations to accomplish their goals and fulfill their commitments. Developed during the years 1960's and 70s, has matured in the last decades and has gained attention across many sectors of society. GIT can be understood as all types of computer systems (hardware and software) and tools used in processing georeferenced information. This set of systems and tools includes remote sensing systems (Horler & Barber 1981), Global Position Systems (GPS) (Kaplan & Hegarty 2005), Geographic Information Systems (GIS) (Christian 2002), and all systems and sub-systems that deal with geographic information processing (Harrison et al. 2007; Jankowski & Nyerges 2001). Although some authors refers to these technologies as decision support systems that can be integrated as backbones for the organizational information systems (Harrison et al. 2007; Hendriks 2000). Adopting these technologies in organizations is an important concern because it improving efficiency, flexibility, growth possibilities, reduces operational costs, providing for the organizations clients a more convenient mean to meet their needs in an accepted time frame. For these reasons, it is extremely important to understand the adoption of GIT in Mozambican institutions. The main motivational factors to do this study are presented as follow:

- Mozambique introduced these technologies after independence, 4 decades after, these technologies have been spread over the country. Unfortunately, there is no much information on adoption of these technologies. Therefore running a research that will contribute to enhance the comprehension about the adoption of these technologies applied to a specific context (Mozambique) will be a contribution to advancement of knowledge.

- Even though literature has covered certain drivers of geographic information technology, the adoption stages are still more underused than expected, the literature suggests that new constructs should be identified and explored depending on context, contributing to advancement in knowledge.
- Existing research on geographic information technologies are more focus on use than adoption. Assuming that the other part still important, they should be studied in combination with some theoretical models and theories.
- Studies on adoption that lead to understand the factors behind are few, leaving open an area of research special when we focus to understand the determinants/factors behind the adoption of these technologies applied to a specific context.
- Geographic information technologies is a relative new area of research, under explored when compared to other areas of research. Therefore need be more explored.

Mozambique started to adopt these technologies after independence (years 1980s) through the help of external donors. With the time pass, these technologies gained attention over the years and the need have growing exponential and spread all over the country (public institutions, private organizations and Non-Government-Organizations (NGOs)). 40 years passed and there still lack of available information on the country about the degree of adoption and their actual stage.

Motivated by these factors, the study seeks to understand the drivers/factors behind the adoption of these technologies, areas of adoption, and stages of adoption in Mozambique.

1.2. Adoption Models

There is consensus that in recent decades, much research has been addressed in the field of information system to explain the adoption process of technologies in organizations. These efforts include the combination of theories and models that operates at institutional level, such as, Diffusion On Innovation theory (DOI) (Rogers 1995), Technology Organization and Environment framework (TOE) (Tornatzky & Fleischer 1990) and institutional theory (Dimaggio & Powell 1991). Other popular theories such as the theory of planned behavior (TPB) (Hill et al. 1977; Ajzen & Fishbein 2005;

Fishbein & Ajzen 1975; Ajzen 1985), technology acceptance model (TAM) (Davis 1985; Venkatesh & Davis 2000), unified theory of acceptance and use of technology (UTAUT and UTAUT2) (Venkatesh et al. 2003; Venkatesh et al. 2012) are not considered in this study because these theories are not applied to the individual level.

1.3. Research Focus

Mozambique is a country divided into 11 provinces and is located in southeastern Africa, bathed by the Indian Ocean to the east and is bordered by Tanzania to the north, Malawi and Zambia to the northwest, Zimbabwe to the west and Swaziland and South Africa to the southwest. It is considered a third world country where much of the population lives in small-scale farming, fishing and livestock (Torres & Garmendia 2011).

Understanding the determinants/drivers that taking Mozambican institutions to adopt geographical information technologies, as well as the post adoption, are the main work focus of interest, as presented in Figure 1.1. The study is only focused at institution level, no individual level will be studied or analyzed.

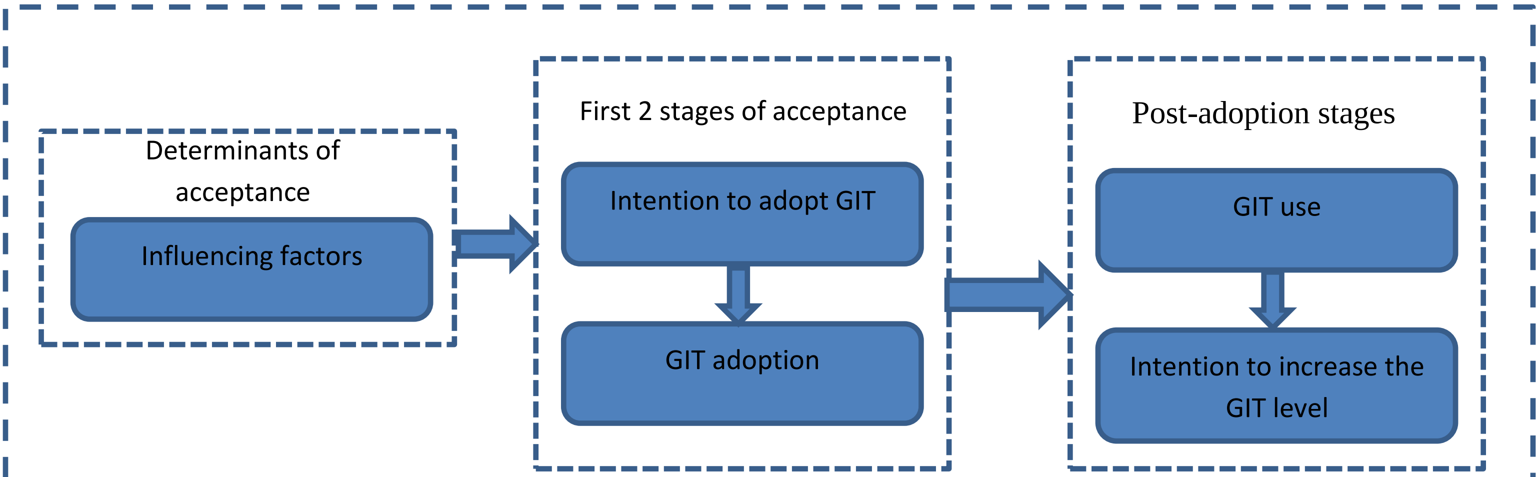


Figure 1.1: Research Focus

1.4. Objectives of the study

Trying to better target and understand the determinants that taking Mozambican institutions to adopt geographical information technologies, as well as their continuity, we divided our research in different studies, each of them presented in a separated chapter:

The study starts with a meta-analysis about geographical information technologies, and is presented in second chapter, where the authors tried to synthesize the findings from existing research, put in evidence the relevant studies, their relationship, promoting an updated view of what have been done, where possible and target to a Mozambican context.

In the third chapter, the authors analyzed the determinants of geographic information technologies at two stages (intention and adoption) for a specific Mozambican context. Acceptance studies in this region are scarce, leaving the research an almost unexplored area.

In the fourth chapter, having in consideration that in some contexts it's hard to guarantee the continuity of use of one technology, we analyses the determinants of GIT Post-adoption.

As an ending, the fifth chapter, a summary of the main conclusion identified is presented, aiming to present the most important aspects in the conclusion based on the studies presented in the previous chapters.

In summary, the study seeks to understand/comprehend the determinants/drivers/factors that took Mozambican institutions to have the intention to adopt, use and continue use of GIT. In a specific way, the study:

- Seeks to understand the factors behind GIT adoption and use in Mozambique.
- The study seeks to investigate the drivers behind the adoption of GIT at two stages (intention and adoption) applied to Mozambican context.
- Identify the determinants behind the post-adoption use and intention to increase the level of use in Mozambican institutions.

1.5. Methods

To study the adoption of geographical information technologies in Mozambican institutions we developed a survey and target to public institutions, private organizations and NGO's. Supported by a number of survey instruments, the data were analyzed and compiled. The purpose of this study was to understand the real factors/determinants/drivers that motivates Mozambican institutions to adopt geographical information technologies and their continuity of use.

1.5.1. Theoretical Framework

The diffusion of innovation (DOI) theory, technology organization and environment (TOE) framework and police context is used in the study presented in chapter 3. The study presented in chapter 3 seeks to investigate the drivers behind the adoption of GIT at two stages (intention and adoption) applied to a Mozambique context.

In chapter 4 the diffusion of innovation (DOI) theory, technology organization and environment (TOE) framework are combined with institutional theory. The study presented in chapter 4 seeks to understand and comprehend the determinants of GIT post-adoption in Mozambican institutions.

1.5.2. Quantitative Research Methods

The chapters 3 and 4 use information collected from an on-line questionnaire. The questionnaire was designed to assess the information related to the stage of adoption of geographic information technologies in Mozambique. The data collection was conducted in Mozambique, targeting public institutions, private organizations and non-government-organizations. A total of 110 valid answers had been collected. Non-response was attributed to diverse issues, including invalid email addresses, inbox full, lack of updated emails, and lack of appropriate persons to respond to the questionnaire, among others. The model was tested using structural equation modelling (SEM), specifically partial least square (PLS).

1.6. Path of research

The study is a collection of separated researches of interrelated subjects, reported separated in different chapters, some of them already published in international journals with blinded review process, others are in different stages; in development, under review, or submitted. The current stage of each study is presented in Table 1.1.

Chapter	**Title**	**Current stage**
2	Geographic Information Technology use in Developing Countries – A Case Study in Mozambique.	Accepted for publication in Geo-spatial information science journal
3	Determinants of Geographic Information Technologies Intention and Adoption and Mozambique Institutions' Perspectives	Published in Research Journal of Information Technology
4	Understanding the determinants of GIT Post-adoption: Mozambique institutions perspectives	Under review
	Assessing Mozambique's exposure to coastal climate hazards and erosion	Published in International Journal of Disaster Risk Reduction

Table 1.1: Status of the studies

Chapter 2 – Geographic Information Technology Use in Developing Countries – A Case Study in Mozambique

2.1.Introduction

Technology has come to pervade many types of organizations in recent decades as they take advantage of the opportunities that technology offers for improving efficiency, flexibility, and growth possibilities. Geographic Information Technologies (GIT), developed during the 1960's and 70s, has matured in the last three decades and has gained attention across many sectors of society. The ability of these technologies to support decision making is seen as one of the main reasons for organizations to select this type of technology (Harrison et al. 2007). GIT include all types of computer systems (hardware and software) and tools used in processing georeferenced information. This set of systems and tools includes remote sensing systems (Horler & Barber 1981), Global Position Systems (GPS) (Kaplan & Hegarty 2005), Geographic Information Systems (GIS) (Christian 2002), and all systems and sub-systems that deal with geographic information processing (Harrison et al. 2007; Jankowski & Nyerges 2001). These technologies have been studied in several ways, including their use as decision support systems and as integrating backbones for the organizational information systems (Hendriks 2000).

Natural resource management infrastructure development, and other social and economic development activities, can in general benefit from the use of GIT as they contain a major spatial component. We illustrate the importance of GIT for organizations in the developing world by using Mozambique as a case study.

As in other countries the introduction of GIT and ICT (Dong-Ju 2013) in Mozambique has increased in the recent years. However, there is no clear understanding of how GIT use has evolved exactly, how it is being used and in which sectors. This paper, therefore, seeks to understand the factors behind GIT adoption and use in Mozambique. The goal of the work presented here is to understand the main drivers and uses of GIT in organizations and to give an overview of the GIT situation in Mozambique by analyzing the results of a survey responded to by 123 Mozambican organizations that are current GIT users. This chapter is organized as follows. In the next part a methodology is presented. The work continues with an overview of the theoretical background, introducing an analyses of GIT use in organizations and society and their drivers through a literature review. Discussion and preliminary results of GIT use in the Mozambican context is presented, and the last part is reserved for conclusions and future research.

2.2. Methodology

Literature to support the process of GIT adoption in organizations is rare or unpublished to the best of our knowledge and information regarding GIT adoption in Africa and specifically in Mozambique is non-existent.

The review approach includes articles identified in peer-reviewed journals or conference proceedings from 1990 to 2015, using the Web of Science, Google Scholar, Science Direct, information system journals, and conference proceedings as information sources. The review was compiled based on the following list of keywords: GIT/GPS adoption/use in/in organizations, GPS/GIS adoption/use, GIS diffusion, GIS implementation, GIT/GIS integration, remote sensing adoption, and use of remote sensing in organizations. The literature review systematically isolated, for each source, domain application areas, drivers, uses, and countries where the technology has been used through a qualitative assessment of its content analysis. Domain application areas, uses and countries were directly extracted from the text by the authors. We used the drivers normally used in the technology adoption literature (Oliveira & Martins 2011; Zhu & Kraemer 2005; Zhu, Kraemer, et al. 2006; Cooper & Zmud 1990; Nkhoma & Dang 2013; Zhu et al. 2016; Low et al. 2011; Ghobakhloo et al. 2011; Moore & Benbasat 1991; Rogers 2003).

In order to get an insight of GIT use in developing countries we develop a case study for the case of Mozambique. Mozambique has a favored and strategic geographic location in Southern Africa. With an area of approximately 800,000 km^2, its economy has grown at an average of 7.7% annually between 1996 and 2011 (Foster & Dominguez 2011) and above 7% between 2011 and 2014 (World Bank 2016). In the late 2000s the country spent an annual average of 664 million USD (equivalent to 10% of its GDP) on infrastructure including Information and Communication Technology

(ICT) (Foster & Dominguez 2011). In its master plan the Mozambican government establishes the use of technology and regulates the availability of ways that enable organizations to introduce new technology approaches (Moçambique 2010).

A survey on GIT adoption was conducted during mid-2014, and was targeted at governmental, private, and non-profit organizations. There is no known organized database or list of institutions using GIT in Mozambique. As a result, we tried to contact all government levels, private sector and non-profit organizations, and specialists in the field of GIT and gathered as many contacts as possible. The part of the survey used in this paper[1] includes eight questions that involve a characterization of the organization pertaining to the use of GIT: sector, institution size (number of employees), type of GIT used, and maturity. The questionnaire was conducted online using the Survey Monkey engine and the link was addressed and shared through emails to organizations.

The data collected provide a good overview on how organizations are using GIT in Mozambique. It also enables the development of a conceptual adoption model in the future. From the 2043 surveys sent, 123 were returned and validated, of which 61 were from governmental institutions and 62 from the private and non-profit sectors. Considering that the 2043 individuals that received the survey were distributed by approximately 380 organizations, the return rate at the institutional level, was 32%. The study only considers institutions that are using GIT.

The resultant data is analyzed in terms of the main sectors (also found in the literature) as well as globally in terms of the country as whole.

2.3. An overview of GIT applications and reasons for use

In the 21st century there are many sensitive issues (including biodiversity, natural hazards, sustainable agriculture, transportation, crime, climate change, migration and urbanization, health care), that all of these share a common trait: they exhibit a geographical component and thus can benefit from the use of GIT.

[1] The complete survey is composed of 33 questions. The remaining questions are related to adoption constructs and will be used in developing the adoption model. For a list of the questions used in this article (Appendix (chapter 2)).

This section reviews GIT applications with a focus whenever on developing countries, covering the past 25 years (1990-2015) and a wide range of application domains and sectors. There seemed very few, if any, articles whose core objective was to study the factors behind adoption of GIT, and the reasons for taking up GIT in organizations are deduced from the qualitative assessments in the text. Tables 2.1, 2.2, and 2.3 summarize the most frequently mentioned domains, drivers, and uses that explain the reasons why, in the articles reviewed, organizations are using GIT as a working tool, as well as the authors and country where the application took place. These tables are further summarized and analyzed in Figures 2.1 and 2.2 in section 2.3.4. We assume that the applications described in the reviewed articles take place within an organization. From the analysis of the text we infer the type of organization, the application domain and the main drivers and uses for each case.

Cases of reported GIT use are very diverse, and numerous. There are many GIT applications in the literature, and it is difficult to construct a complete overview of all possible uses and motivations. The review below offers relevant examples found in the scholarly literature to illustrate the importance and widespread use of GIT in society.

2.3.1. Agriculture and natural resources

Table 2.1 presents the GIT drivers and uses for organizations in agriculture and natural resources. In the agricultural sector the issue of crop suitability analysis is leading many organizations that deal with land to adopt GIT. The need of this sector to improve the understanding and comprehension of land and productivity related variables is crucial.

Domain	**Drivers**	***Uses***	**Author (s)**	**Country**
Agriculture	RA | TC	*DS | MO | PR | RE*	(VoPham et al. 2015)	United States
	TC	*DS | PR | SU*	(Zolekar & Bhagat 2015)	India
	CX | TC	*DS | MO |PR |RE | SU*	(Chen et al. 2010)	Australia
	CO | TC	*DS | MO | PR | RE*	(Zhu et al. 2009)	China
	CX	*DS | PR | RE | SI | SU*	(Bandyopadhyay et al. 2009)	India
	CX | TC	*DS | MO | PR | SI*	(Mati et al. 2000)	Kenya
Environment and natural resources	TC	*DS | MO | PR |RE |SI*	(Mohammed et al. 2015)	Malaysia
	RA | TC	*RG | SU*	(Mkiramwinyi et al. 2009)	Tanzania
	DP | TC	*CM | DS | MO | RM*	(Pactwa et al. 2015)	Poland
	CO |DP |TC	*DS | MO | PR | RM*	(Van Westen 2013)	unknown
	GP | TC	*DS | MO | PR | RM*	(Tasoulas et al. 2013)	Greece
	GP	*CM |DS |MO |RM |SI*	(Millock et al. 2012)	United States
	ST | TC	*DS | SI*	(Haule et al. 2009)	Tanzania
	TC	*DS | ED |PR |ST |RM*	(Javadian et al. 2011)	Iran
	CO | TC	*DS | MO | PR | RM*	(Zook et al. 2010)	Haiti
	CO | TC	*DS | SI | SU*	(Javaheri et al. 2006)	Iran
	GP	*DS | PR | RM SU*	(Karikari et al. 2005)	Ghana
	GP	*DS | MO | RG | SU*	(Puri & Sahay 2003)	India
	GP	*DS | MO | RG | SU*	(Michael Barrett, Sundeep Sahay 2001)	India
Marine Resources	GP	*DS | MO | PR | RG*	(Levine & Feinholz 2015)	United States
	CO | TC	*DS | MO | PR | RM*	(Mahboubi et al. 2015)	Canada
	TC | IA	*DS | MO | RG | SI*	(Claus et al. 2014)	Belgium
	TC	*DS | MO | PR | RM*	(Nunes & Almeida 2011)	Brazil
	CO | TC	*DS | MO | RE | SI*	(Kulawiak et al. 2010)	Greece
	TC	*DS|MO|PR|R RM|SI*	(Wright & Heyman 2008)	Arctic & Canada
	DP | TC	*DS | MO | RG | SI*	(Tuama & Hamre 2007)	Europe
	CO | TC	*DS | MO | RG*	(Nath et al. 2000)	Canada
	CO |CX |TC	*DS | MO | RE | RG*	(Gold & Condal 1995)	unknown

Table 2. 1: GIT adoption in organizations in agriculture and natural resources

	Legend for Table 1[2]:		**DRIVERS**		
CO	Compatibility	GP	Government Policy	RA	Relative Advantage
CX	Complexity	IA	Intention to Adopt	TC	Technology
DP	Donor Pressure				
			USES		
CM	*Customer Management*	*PR*	*Prediction*	*SI*	*Simulation*
DS	*Decision Support*	*RE*	*Research*	*SU*	*Suitability Analysis*
ED	*Education*	*RG*	*Resource Management*	*ST*	*Sustainability*
MO	*Monitoring*	*RM*	*Risk Management*		

Studies developed in the agriculture sector point out some examples and practices. Zolekar & Bhagat (2015) and Chen (2010) used a combination of GIS and remote sensing tools to analyse soil suitability for agriculture and rainwater harvesting (Mkiramwinyi et al. 2009), Vopham *et al.* (2015) used GIT tools to estimate agriculture pesticide exposure, and Zhu *et al.* (2009) used GIT tools to improve precision agriculture by providing detailed spatial information on soil characteristics. On the physical side, GIT can provide support in soil analysis (Bandyopadhyay et al. 2009), and predict soil erosion hazard through a combination of the universal soil loss equation and GIS tools (Mati et al. 2000).

In the environmental and natural resources sector, Westen (2013) reported that the adoption of GIT has been motivated to implement disaster risk management procedures and Mohammed *et al.* (2015) adopted it to avoid heavy losses in productive land and environmental degradation. Other related studies include the management of earthquake damage through web-based mapping services, and management of urban forestry (Zook et al. 2010; Tasoulas et al. 2013). Millock *et al.* (2012) refer to the management of externalities (pollution) generated by automobiles through a combination of land based sensors and remote sensing tools as reasons to adopt GIT. Quite a large number of other application related uses is found in the literature, comprising the identification of sustainable urban development in Tehran (Javadian et al. 2011), forestry management in India (Michael Barrett, Sundeep Sahay 2001), improvement of the evaluation of landfill suitability in Iran (Javaheri et al. 2006), land

[2] For a definition of the concepts, please see Appendix (chapter 2)

administration (Karikari et al. 2005) and Puri & Sahay (2003), land use change in Tanzania (Haule et al. 2009), and mineral resource management (Pactwa et al. 2015).

In the marine resources sector the adoption of GIT has been motivated to address a lack of efficient methods for monitoring and managing marine environment processes and resources (Mahboubi et al. 2015), Nunes & Almeida (2011) and Kulawiak et al. (2010), to control critical life habitats Wright & Heyman (2008), and to map the coral reef marine ecosystem (Levine & Feinholz 2015). Nath et al. (2000) and Gold & Condal (1995) introduced GIT in order to support and manage aquaculture and pollution crises in coastal and ocean regions of Europe (oil spills). Finally, Claus et al. (2014) calls for the need to standardize marine geographic names (seas, ocean basins, ridges, seamounts) and boundaries through the use of an open application that will link names to information and maps with geographic location, as well as the need to have a web-based information system to improve management (Tuama & Hamre 2007).

2.3.2. Public service

Table 2.2 shows GIT drivers and uses in public service organizations. Technology policies in the government sector are leading to the adoption and use of GIT, especially because governments wish to promote and encourage citizen participation for example in urban planning and redevelopment (Moody 2007; Rambaldi et al. 2006). Some examples of these actions can be urban governance Ramadhan *et al.* (2011), and management of urban violence (Abdulaal 2009) with the help of georeferencing crime events. On the implementation side Abbott (2003), Yomralioglu (2002), Nourani *et al*. (2011), Liu & Wei (2010), and Nasirin & Birks (2003) see in these technologies the opportunity to integrate and link existing government infrastructures and platforms (eGovernment) and make information more suitable for network transactions.

The education sector has been among those that have actively adopted GIT. The capability to offer innovation and compatibility increases student productivity, and provide virtual environments and rapid problem solving (Korucu 2012; Balram & Dragićević 2008). similar views are expressed by Kim & Bednarz (2011), Lateh & Muniandy (2010), and Lloyd (2001), who examine these technologies as tools to help students acquire critical thinking, spatial skills and social skills (Alibrandi & Palmer-

Moloney 2001). Futhermore, Demirci et al. (2013), Hwang (2013), Yin (2010), and Hong (2014) emphasize the potential of these technologies to create a good learning environment for students and teachers. Because of their potentialities, GITs are capable of going beyond the classroom and can be used in comparitive studies as tools to test potential new teaching methods versus old ones (Amade & Painho 2011).

The health sector also has been among those that have actively adopted GIT and the reason for that lies in the interest in simulation and ability to predict disease outbreaks and spread (epidemiology). Joyce (2009) and McLafferty (2003) reported the use of GIT to improve support in health care delivery, as also advanced by Mahmoud *et al.* (2015) when mentioning that these tools can build a spatial decision-making support system for hospitals, in helping to monitor disease. Other examples include epidemiological studies, and deployment of emergency services (Kistemann et al. 2002). Analysis and understanding of the relationship between geography and disease is probably the main reason for GIT use in the health sector (Patel & Waters 2012) for research, simulation and monitoring. On other hand, one of the factors that has been identified as a constraint for GIT use in health is its cost, and thus Abubakar et al.(2014) point out the need to analyze how open-source GIT tools can provide feasible solutions for data visualization in the health care system and also provide patient record information through atlas database systems built with GIT (Cowper et al. 2004).

Domain	Drivers	*Uses*	Author (s)	Country
Government	TC	*DS | MO | PR |RE*	(Nourani et al. 2011)	Brazil
	CO |GP |	*MO | RE*	(Ramadhan et al. 2011)	Indonesian
	GP | IV	*CM | DS | MO | PR*	(Liu & Wei 2010)	unknown
	CP | GP |	*CM|DS|MO|PR|RM*	(Abdulaal 2009)	Saudi Arabia
	CO | GP |	*CM | MO | RE*	(Moody 2007)	Netherlands
	TC	*CM | MO | RE*	(Rambaldi et al. 2006)	Developing countries
	TC	*DS |ED*	(Abbott 2003)	South Africa
	CP | IV |	*DS | MO |PR*	(Nasirin & Birks 2003)	United Kingdom
	DP | GP	*DS | MO | RG*	(Yomralioglu 2002)	Turkey
Education	CO |IV |	*DS | ED | RG | SI*	(Hong 2014)	United States
	IV | RA |	*CM | DS | ED | SI*	(Demirci et al. 2013)	Turkey
	CO | TC	*ED | RE | SI*	(Hwang 2013)	United States
	TC	*ED | PR |SI*	(Korucu 2012)	Turkey
	CO | RA |	*ED | SI*	(Amade & Painho 2011)	Mozambique
	CO | IV |	*DS | ED | SI*	(Yin 2010)	United States
	GP | TC	*DS | ED | RM*	(Lateh & Muniandy 2010)	Malaysia
	CO | TC	*DS | ED | MO | RG*	(Balram & Dragićević 2008)	Canada
	TC	*ED*	(Alibrandi & Palmer-Moloney	United States
	CO |TC	*ED | SI*	(Lloyd 2001)	United States
Health care system	CO | IV |	*DS | MO |RG | SI*	(Mahmoud et al. 2015)	Saudi Arabia
	CO | IV |	*DS | RG*	(Abubakar et al. 2014)	Tanzania
	IV | TC	*MO | RE | SI*	(Patel & Waters 2012)	unknown
	GP	*DS | MO | RE | SI*	(Joyce 2009)	United Kingdom
	TC	*DS | MO | RG | SI*	(Cowper et al. 2004)	United States
	TC	*MO | RE | RG | UA*	(McLafferty 2003)	United States
	CO |TC	*MO | RE |RG | SI*	(Kistemann et al. 2002)	unknown

Table 2. 2: GIT adoption in organizations in public service

Legend for Table 2:

DRIVERS

CO	Compatibility	GP	Government Policy	RA	Relative Advantage
DP	Donor Pressure	IV	Innovation	TC	Technology
CP	Competitive Pressure				

USES

CM	*Customer Management*	*PR*	*Prediction*	*RM*	*Risk Management*
DS	*Decision Support*	*RE*	*Research*	*SI*	*Simulation*
ED	*Education*	*RG*	*Resource Management*	*UA*	*Use and access*
MO	*Monitoring*				

2.3.3. Other services and manufacturing

The GIT drivers and uses within organizations in other services and manufacturing are presented in Table 2.3. The banking sector is using GIT to improve customer management, decision support, prediction, and risk management. This adoption has been motivated by current problems that banks are facing, namely competition MacDonald (2001), financial fraud Ngai *et al.* (2011), poor customer satisfaction and retention Jafrullah & Uppuluri (2003), loan losses and a lack of decision making mechanisms in distributing loans (Ajah & Inyiama 2011; Gabriela & Ph 2010).

Competitive pressure is leading the manufacturing sector to use GIT. This is the case for planners who need to understand and use these tools to meet their professional requirements (Drummond & French 2008) and for business people to whom these technologies are crucial, especially if the activities are related to space and location management (Freire 2004). The construction of these tools is imperative to solve engineering problems related to spatial data (complex visualizations, integration of information, route planning, cost estimation and others) (Bansal 2007).

In the transport and communication sector the use of GIT has been motivated by the lack of appropriate decision support systems to mitigate communication network damage (Kawamura et al. 2014). Chen *et al.* (2012) point to problems related to communications with network coverage that have been solved with a GIS model to predict network coverage systems. Ma *et al.* (2009) and Mahesh *et al.* (2011) justify GIT use with the need to manage the highway network transportation system, which must respond to an increasing population and number of vehicles, and with urban sprawl; as well as with the safe transportation of dangerous freights in safe conditions (Batarlienė 2007).

2.3.4. Analysis of GIT adoption in organizations and society

The literature reviewed above indicates the pervasive use of GIT in society and how this technology traverses a very large range of economic sectors in the private and public domains. It also shows that these technologies are used worldwide, although the scientific literature for Africa in this area is very scarce. A closer analysis of the different GIT drivers and uses leads to a summary of GIT adoption factors that can help to explain and understand the reasons why organizations take on GIT.

It is clear that public and private organizations are looking to use the spatial domain to improve productivity and performance, predict unusual situations, reduce losses, increase customer satisfaction and face competition. The drivers, indirectly extracted from the text content analysis of the literature, motivating organizations from different sectors to use GIT are: compatibility, competitive pressure, complexity, donor pressure, government policy, intention to adopt, innovation, relative advantage, security and technology competence as shown in tables 2.1, 2.2, and 2.3.

Domain	**Drivers**	***Uses***	**Author (s)**	**Country**
Banks and insurance	CO | CX | SE | TC	*CM |DS |MO |PR |RM*	(Ajah & Inyiama 2011)	Nigeria
	IV | TC	*DS | MO | RE | RM*	(Ngai et al. 2011)	United States
	TC	*DS | MO | RG |SI*	(Gabriela & Ph 2010)	Romania
	CO |CP |IV |SE |TC	*CM | DS | MO*	(Jafrullah & Uppuluri 2003)	unknown
	CP | GP | TC	*DS | PR | RG*	(MacDonald 2001)	Canada
Manufacturing	CP | IV |TC	*DS | MO | RE*	(Chong & Chan 2012)	Malaysia
	CO | IV | TC	*MO | RE*	(Drummond & French 2008)	United States
	TC	*DS | RG*	(Bansal 2007)	unknown
	CO | CP | SE | TC	*DS | MO*	(Freire 2004)	Brazil
Transport and communication	TC	*DS | MO | PR | RG |SI*	(Kawamura et al. 2014)	Japan
	SE | TC	*DS | MO | PR | RG*	(Chen et al. 2012)	Vietnam
	GP | IV | TC	*DS*	(Mahesh et al. 2011)	India
	TC	*DS | MO | RE | SI*	(Ma et al. 2009)	United States
	TC	*DS | MO | PR | RG |SI*	(Batarlienė 2007)	Lithuania
	CO | TC	*ED | PR | RG | SI*	(Harvey & Chrisman 1998)	unknown
	TC	*DS | MO | PR | RE*	(Gutiérrez et al. 1996)	European Union

Table 2. 3: GIT adoption in organizations in other services and manufacturing

	Legend for Table 2:		**DRIVERS**		
CO	Compatibility	GP	Government Policy	SE	Security
CP	Competitive Pressure	IV	Innovation	TC	Technology
CX	Complexity				
			USES		
CM	*Customer Management*	*MO*	*Monitoring*	*RG*	*Resource Management*
DS	*Decision Support*	*PR*	*Prediction*	*RM*	*Risk Management*
ED	*Education*	*RE*	*Research*	*SI*	*Simulation*

Figure 2.1 shows how these drivers are shared among the main domains. Technology competence (TC) and compatibility (CO) are the most common drivers found and are shared by the three domains. Donor pressure (DP) and relative advantage (RA) are driving public services and agriculture and natural resources, while government policy (GP), together with innovation (IV) and competitive pressure (CP), are shared by public services and other services and manufacturing. Security seems to be a driver mostly connected to other services and manufacturing.

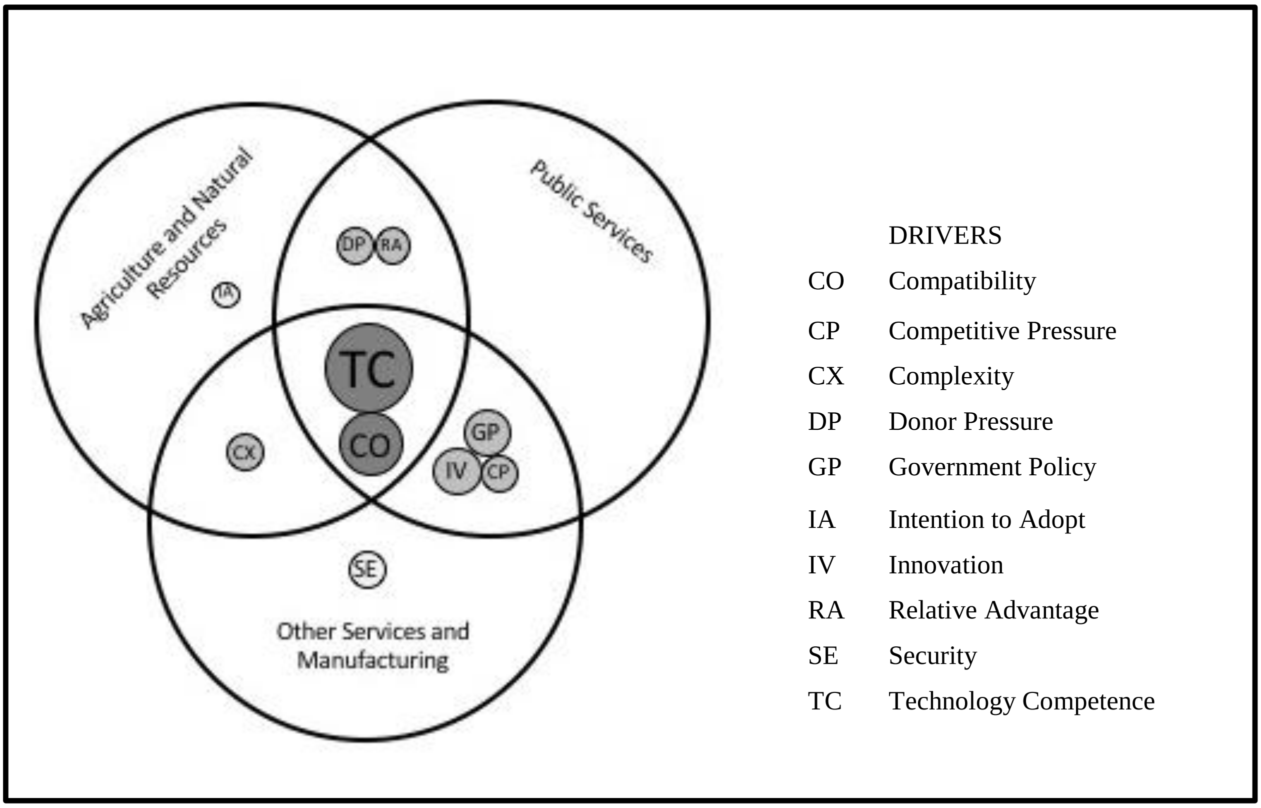


Figure 2. 1: Sharing of drivers by the main sectors (size of drivers, represented as shaded circles, denotes frequency of appearance in the literature)

Most of the uses identified in the literature are shared by the three domains (Figure 2.2), the most important ones (i.e. those occurring most frequently in the literature review) being decision support (DS), monitoring (MO), resource management (RG), and prediction (PR). Education (ED) is mostly utilized, as expected by the public services, which includes the education and research field, and, to a certain extent by the other services and manufacturing domain. Public services have an emphasis on use and access (UA) and agriculture and natural resources on suitability analysis (SU) and sustainability (ST).

In this section we have made an overview of the drivers and uses that are leading organizations to adopt GIT identified through a qualitative analysis of scientific literature. The drivers and uses for GIT identified in this work provide a basis for the further development of a quantitative adoption study.

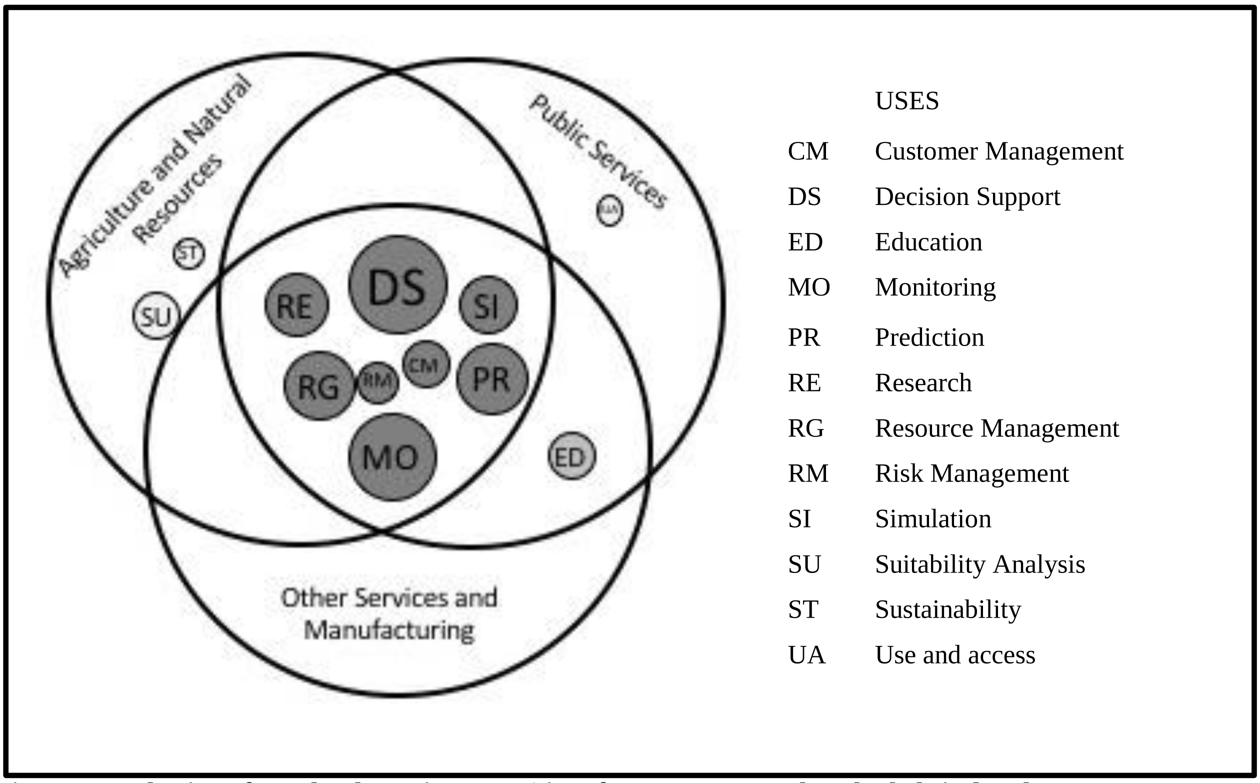


Figure 2. 2: Sharing of uses by the main sector (size of uses, represented as shaded circles, denotes frequency of appearance in the literature).

2. 4. GIT use in Mozambique – state of affairs

In its master plan Mozambican government supports the use of technology to improve the current scenario and move the country forward (Moçambique 2010). The World

Bank strategy for African countries resides in supporting them in their transformation through country strategies. The strategy lies heavily on sectors like manufacturing, agriculture, transportation, education, health, and ICT. A priority of the World Bank is to focus on reforms and public investments including infrastructure development (World Bank 2011).

In what follows we analyze the results of the survey from Mozambican institutions. We will analyze the same sectors as those found in the literature and use Mozambique as a case study of GIT adoption in developing countries. GIT has been widely used by both the public and private sectors since its 1980s. The Mozambican Government (Moçambique 2010) as well as the World Bank (World Bank 2011) have been reinforcing measures and program to invest more in ICT as well as in the need to develop GIT based systems for use in funded projects.

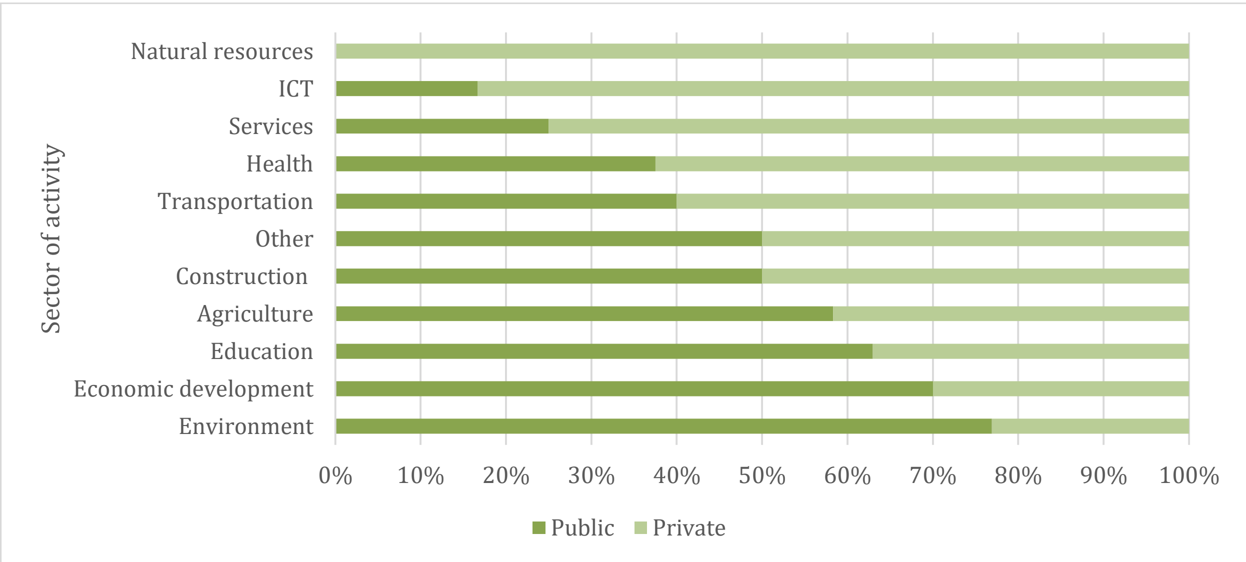


Figure 2. 3: Distribution of public and private institutions by activity sector

The proportion of public and private institutions that responded to the survey is balanced. Figure 2.3 depicts the weight of the public and private in the different sectors. The public sector has been more present in the environment, economic development, education, and agriculture whereas the private sector has more weight in the transportation, health, services, ICT, and natural resources. The proportion of institutions in the construction and other sectors is balanced. The other sector includes tourism management, logistics, public administration including road and urban planning, sports, and water management.

The analysis of the data collected from the questionnaire shows that institutions in the education sector with a percentage of 23% are those that represent most of the GIT use in Mozambique (see Figure 2.4) followed by environment (11%). Other important GIT users can be found in the agriculture (10%), economic development (8%), health (7%), and natural resources (7%) sectors. ICT, transportation, construction, and services sectors are also noteworthy although still in a very early stage of implementation. The other sector class (18%) includes other sectors less important in terms of GIT use such as tourism management, logistics, public administration including road and urban planning, sports, and water management, among others. For the sectors agriculture and environment, it is important to remark that Mozambique public policies are emphasizing the development of these two sectors (Moçambique 2010) given their importance both as a main means of income and food production for the population. The agriculture sector absorbs 75% of the population of Mozambique (FAO 2015).

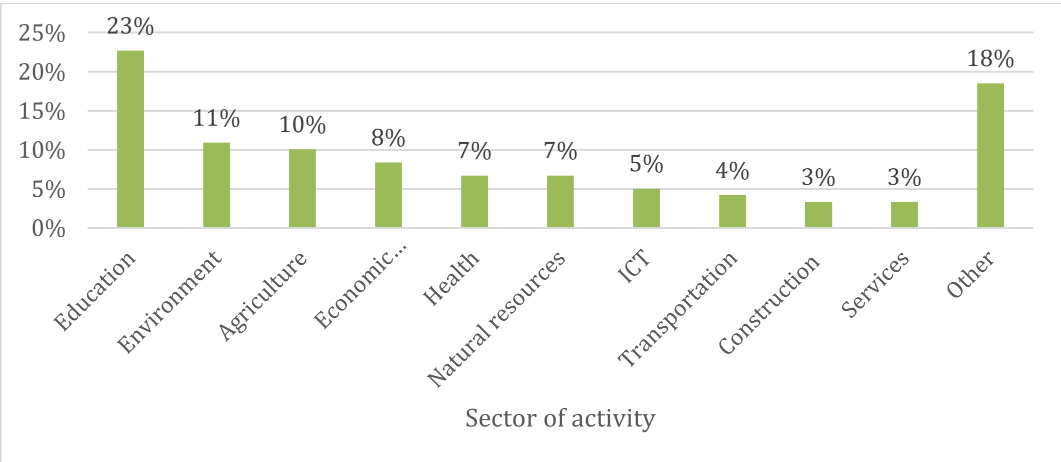


Figure 2. 4: General use of GIT by sector

The environment is facing many challenges such as climate change, biodiversity conservation, among others, which are influencing the productivity of natural and semi-natural ecosystems (Tilman 2001). It is also noteworthy that transportation, construction, and services are the sectors with the least use of GIT among the respondents.

It seems that there is no relationship between organization size and GIT use. The percentage of GIT use by organization size is depicted in Figure 2.5. The organizations were classified in terms of their number of employees (European Commission 2015). More than 50% of the organizations using GIT have over 50 employees. However, it is important to note that GIT use is spread throughout all institutional sizes.

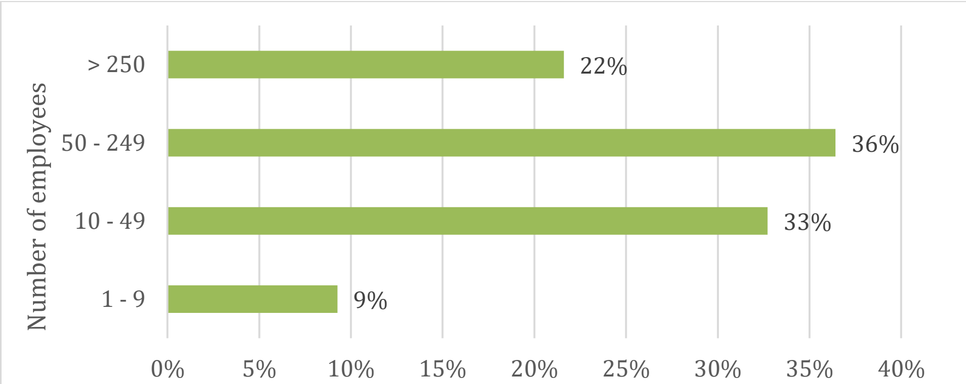


Figure 2. 5: Percentage of GIT use by organization size

Looking at Figure 2.6, it is possible to see that the organizations started to intensify the use of GIT from 1995, and in the period 2010 - 2014 the number of new organizations using GIT reached 44. From 1995 to 2014 the number of organizations using GIT increases very quickly in line with world evolution of GIT use (Henttu, H., Izaret, J.M., & Potere 2012). Before the year 1995 the use of these technologies was very rare and almost insignificant. It is also clear that between 1980 – 1995 organizations were stagnant in terms of new technology approaches.

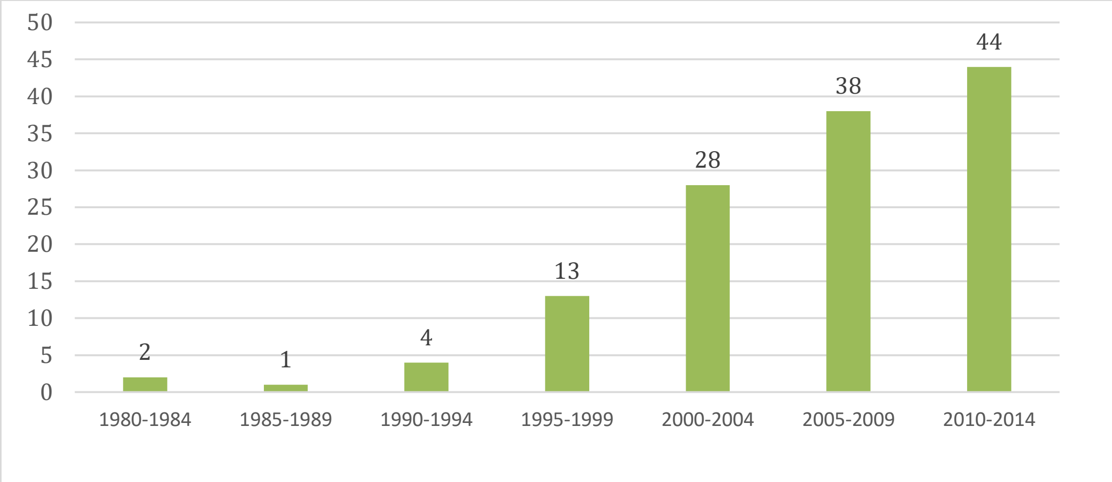


Figure 2. 6: Evolution of GIT use in Mozambican institutions (start date). Number of institutions starting to use GIT per year interval.

Crossing data between sectors of activity and type of most used technologies is illustrated the Figure 2.7. All three GIT types, GIS, GPS, and RS, are led by the education sector. The GIS technology is, as mentioned, topped by the education sector. A second group of sectors in intensity of GIS use includes the environment, agriculture, natural resources, economic development, and ICT. The remaining sectors form a group of low GIS use (five or fewer institutions per sector). In the same the way, Remote Sensing intensity is led by education followed by natural resources, environment, and ICT, leaving all the other sectors in a large group of low use intensity (fewer than five institutions per sector). Finally GPS, the most recent of GIT technologies, is mostly used by the education and environment sectors closely followed by the agriculture, natural resources, and ICT, the remaining forming a group of lower use intensity (five or fewer institutions per sector). The other class sector includes institutions using complementary technologies, of which Google Earth, Google Maps and AIS (automatic information system) are examples. GIS and GPS are the most frequently used technologies in all sectors. Independently of the intensity of use all sectors share a similar pattern of the technology mix use.

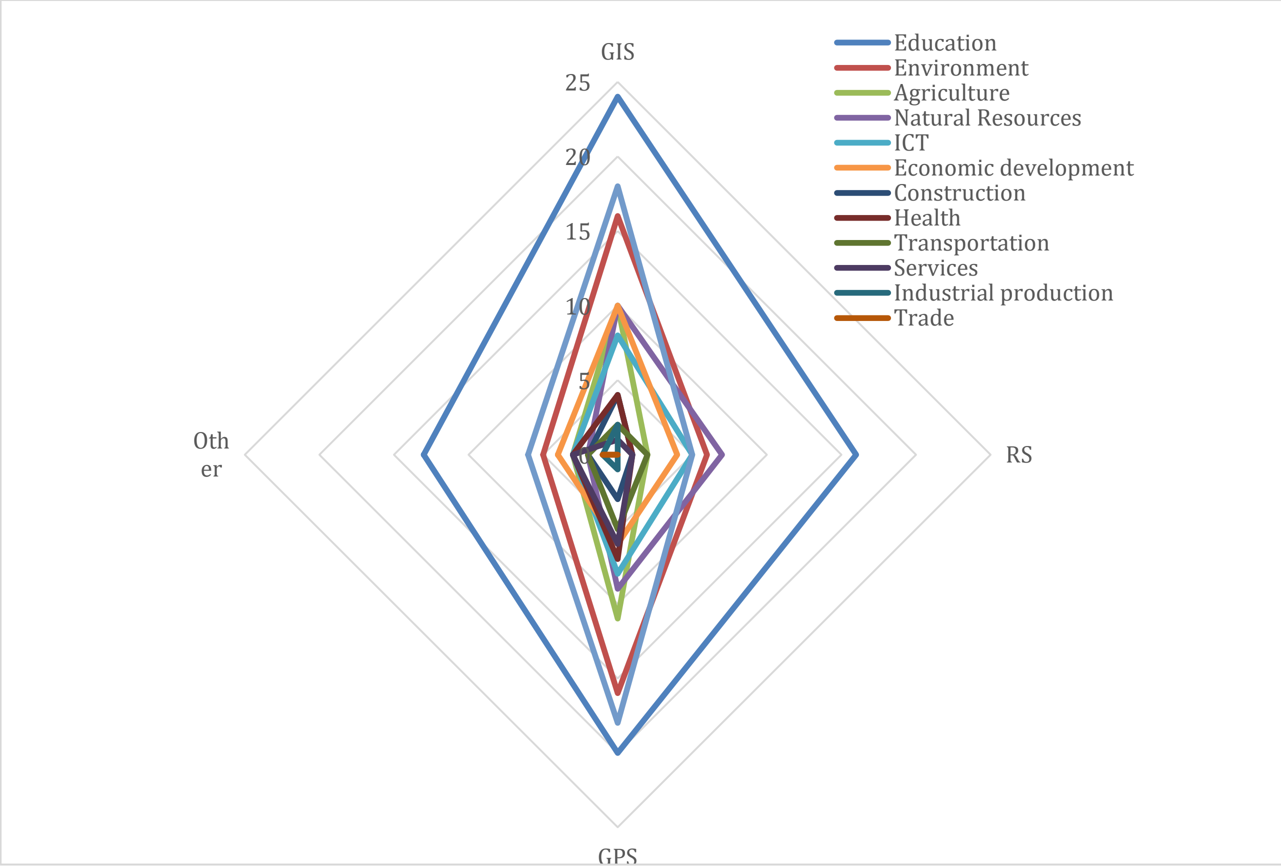


Figure 2. 7: Intensity of GIT type by sector

Using a technology mix of GIT creates synergies and efficiency in work. When looking at the technology mix (Figure 2.8) it is possible to see that the most common technologies used by the institutions (GPS and GIS) are also those that are used together more frequently. Other mixes also exist and about one third of the institutions use some kind of mix including GIS/RS and RS/GPS or a mixture of the three (GIS/GPS/RS). A group of institutions (46) actually use some or all of the identified GIT technologies with complementary ones.

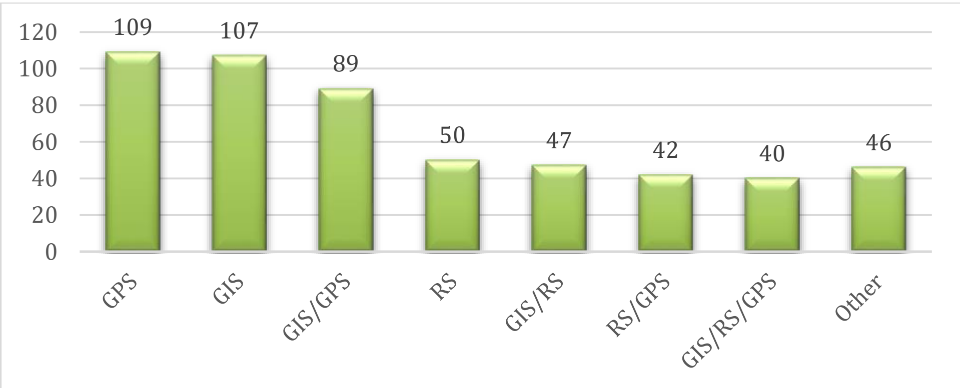


Figure 2. 8: GIT mix use

2.4.1. Summary of GIT use in Mozambique

Analysis of the data collected from the questionnaire shows that GIT is being used by many and diverse sectors in Mozambique. The proportion of public and private institutions that responded to the survey is balanced. The public sector has been more present in the environment, economic development, education, and agriculture, whereas the private sector has more weight in transportation, health, services, ICT, and natural resources (Figure 2.3). Institutions in the education sector with a percentage of 23% are those that represent most of the GIT use in Mozambique (Figure 2.4) followed by environment (11%). More than half of the institutions using GIT have more than 50 employees (Figure 2.5). Organizations started to intensify the use of GIT from year 1995 and in year 2014 the number of new organizations using GIT reached 44 (Figure 2.6). All three GIT types, GIS, GPS, and RS are led by the education sector (Figure 2.7). However, it is important to note that GIT use is spread throughout all institutional sizes and the technologies most used are GIS and GPS in all sectors.

2.5. Conclusions and future research

This paper has analyzed the main drivers and uses GIT has revealed in a literature review and the current situation in Mozambique in terms of GIT use. The literature review showed that the main drivers of GIT use by organizations are compatibility, competitive pressure, complexity, donor pressure, government policy, intention to adopt, innovation, relative advantage, security, and technology competence, with compatibility and technology competence being the mains ones. Organizations of the public and private sectors use GIT for customer management, decision support, education, monitoring, prediction, research, resource management, risk management, simulation, suitability analysis, sustainability, use, and access.

The results of the questionnaire revealed that GIT is being used as well by many and diverse sectors in Mozambique. The public sector has been more present in the environment, economic development, education, and agriculture, whereas the private sector has more weight in transportation, health, services, ICT, and natural resources.

Institutions in the education sector represent the largest sector of GIT use in Mozambique followed by the environment. GIT use started to intensify since 1995 with 44 new organizations using GIT in the period 2010 - 2014. All three GIT types, GIS, GPS, and RS are led by the education sector. However, it is important to note that GIT use is spread throughout all institutional sizes and the technologies most used are GIS and GPS in all sectors.

This first study gave an overview of the state of affairs of GIT use in Mozambique and identified a number of drivers and uses that can form the support to develop a conceptual model inspired on some of the results of the current research.

There are many models on information technology adoption that have been studied and developed over the years operating at individual and organization level. The most important theories operating at organization level are the diffusion of innovation (DOI) theory (Rogers 1995), technology, organization and environment (TOE) framework (Tornatzky & Fleischer 1990) and institutional theory (Dimaggio & Powell 1991). The Diffusion of innovation (DOI) theory explains how new ideas spread through cultures using communication channels. The TOE framework seeks to explain how organizations can reach the right equilibrium between internal and external factors. Finally the institutional theory emphasizes the aspects related to social culture (norms, routines, and rules) and how they become established as authoritative guidelines for social behavior. As future research, we suggest using the remaining answers to the questionnaire to test the existing adoption models at the organization level and enriching them with the findings of the current study in order to understand GIT adoption in Mozambique.

Chapter 3 – Determinants of Geographic Information Technologies Intention and Adoption: Mozambique Institutions' Perspectives

3.1. Introduction

In recent decades institutions have become more open to opportunities that technologies are proposing, and for that, many institutions around the world are adopting different types of technologies to improve efficiency, flexibility, and offer security. Among the most exciting technologies developed, geographic information technologies (GIT) have gained attention based on their ability to support decision makers and provide the right tools for institutions to accomplish their goals (Harrison et al. 2007).

The introduction of new technology approaches in Mozambique such as GIT started recently and the government policies behind their implementation are still to be refined and disseminated (FAO 2015; Renzio & Hanlon 2007; Torres & Garmendia 2011; World Bank 2011; IST-Africa Consortium 2012). Currently, the use of these technologies in institutions claims to be more targeting to competitiveness, donor imposition, need to find new opportunities to maximize efforts and increase the possibilities to reach the goals. For these reasons, it is important to understand the drivers behind the adoption of GIT. Some studies analyze GIT from the institutions' perspective (Berisso & de Vries 2010; Mellino et al. 2015; Bergher et al. 2015; Hasmadi & Imas 2010; Ramadhan et al. 2011; Rose et al. 2015; Al-Kodmany 2012; Gotz et al. 2009; Duval-Diop et al. 2010), and some of these are of a qualitative nature and rely on technology use rather than adoption (Walravens 2015; Feng 2015; Zhu et al. 2016). The reasons prompting institutions to adopt GIT differ from context to context, and include factors such as the ability to have a disaster risk management system, improvements in education methods, competitive pressure, donor pressure, innovation, security, improvements in health system approaches, customer satisfaction, and natural resources management (Berisso & de Vries 2010; Bertazzon 2014; Duval-Diop et al. 2010; Chainey & Ratcliffe 2013; Gotz et al. 2009; Al-Kodmany 2012; Eslami et al. 2011; Elwood 2006; Peduzzi et al. 2009; Van Westen 2013; Armenakis & Nirupama 2012; Unoosa 2010). To the best of the authors' knowledge, no published study has conducted a holistic evaluation of the stages that lead Mozambican institutions to adopt GIT (from intention to adopt GIT and GIT adoption).

Therefore, the literature suggests that an understanding of the African continent and the concept of GIT (Harrison et al. 2007) may be a useful starting point for studying the drivers behind the adoption of these technologies in one of the African countries (Mozambique).

The African continent can be described by its size, natural resources, and rapid population growth. Issues related to spatial planning and resources management become vital to the prosperity of the continent. Studies and initiatives (improvement of drought mitigation, planning rural water supply systems, tracing the spatial variation of diseases, determining and predicting electrical conductivity in soils, examining map conservation areas and water resources, and creating a geodatabase, among others) (Berisso & de Vries 2010; Chirowodza et al. 2009; Rabley Peter International Land Systems 2009; Swetnam & Reyers 2011; Mentis et al. 2015; Münch & Conrad 2007; Cilliers et al. 2013) involving government, private sector, non-governmental organizations (NGOs), and donor pressure have been undertaken in various African countries involving the adoption and use of GIT as decision support tools.

GIT can be described as all types of computer platforms and computer systems used in processing georeferenced information. These technologies include geographic information systems (GIS), desktop mapping systems, remote sensing systems (RSS), global positioning systems (GPS), as well as a vast range of hybrid platforms and sub-systems related to geographic information processing (Harrison et al. 2007).

Overtime, these technologies began to be introduced in Mozambique through institutions supported by the public policy approved in 2000 that encourages and proactively promotes the use of information and communication technology (ICT) (IST-Africa Consortium 2012; World Bank 2011; Torres & Garmendia 2011; Renzio & Hanlon 2007)and through donor pressure.

The present research combines features of two models (diffusion of innovation (DOI) theory (Zhu, Dong, et al. 2006; Zhu, Kraemer, et al. 2006; Chan & Chong 2013; Hameed et al. 2012) and technology organization and environment (TOE) framework (Nkhoma & Dang 2013; Oliveira & Martins 2011)) and the policy context, resulting in an integrated framework to explaining the drivers behind the GIT adoption. The DOI theory seeks to explain how new ideas spread through a social system (Foxon & Pearson 2008) (institutions in the process of adopting a new technology face complex problems based on their organizational structure, which accommodates and aggregates a group of individuals with a set of procedures and norms). TOE framework explains how innovation processes occur in institutions. Therefore, this study presents an analysis of the drivers behind the adoption of GIT for a specific Mozambique institutions context.

3.2. Materials and methods

Pilot interviews were conducted with 30 institutions in Mozambique in 2015, in order to test the questionnaire (accessibility of the questions, structure). The sample was assembled through a random drawing of institutions from public, private, and non-government-organizations. The final sample included 110 institutions and the data were collected from people in those institutions operating with these technologies.

The proposed research model (Figure 3.1) results from a combination of DOI theory, TOE framework, and policy context. The policy context is introduced as a third element in order to enrich and explain the model, in light of the consideration that the variables *donor pressure* and *government policies* seem to be playing a key role in motivating organizations to adopt new technologies.

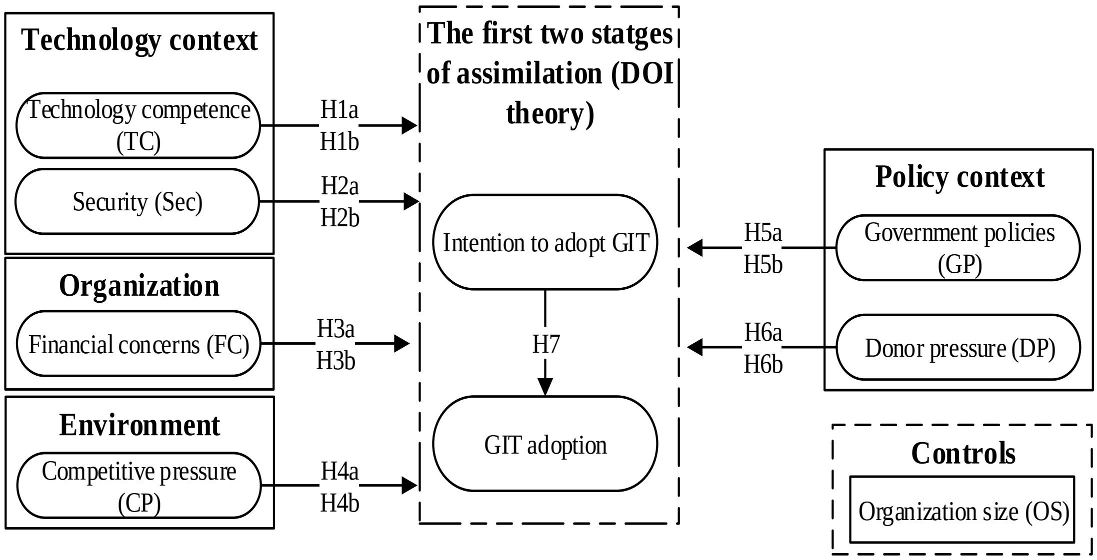


Figure 3. 1: A proposed research model of GIT

3.2.1. Hypotheses on technology

The technology context refers to the technological environment available in an institution including the assets. It includes the specialized human resources, infrastructure, and all of the working procedures. Specialized human resources of an institution are all of the people that have the skills, knowledge, and expertise to operate with the equipment (GIT) (Aboelmaged 2014; Oliveira & Martins 2011; Wang et al. 2010). Hence, the technology competence strongly influences the intention and the adoption of GIT.

H1: *Technology competence will positively influence GIT intention (H1a) and adoption (H1b).*

In the technology context, security is considered the priority to the institution's well-being. A security leak is an incident in which the institution loses its information, personnel records, and/or sensitive data (Rocha Flores et al. 2014). The lack of appropriate tools to deal with data in a secure and efficient way will discourage an institution to adopt GIT. Adopting these technologies will bring new initiatives toward data security to deal with the new data in a secure way. Hence, security is a significant driver.

H2: *Security fears will negatively influence intention to adopt GIT (H2a) and GIT adoption (H2b).*

3.2.2. Hypotheses on organization

The organization context refers to the resources available to support the adoption of an innovation (Lee & Kim 2007; Lippert & Govindrajulu 2006; Oliveira et al. 2014; Park & Ryoo 2013; Chan & Saqib 2015). It refers to the ability of the institution to accept or refuse the adoption and implementation of an innovation. Good financial balance in an institution can contribute to the decision about implementing GIT. Hence, financial concerns will determine the way that GIT will or will not be adopted

H3: *Financial concerns will positively influence GIT intention (H3a) and adoption (H3b).*

3.2.3. Hypotheses on environment

Competitive pressure is recognized as an adoption motivator and driver in the innovation adoption literature (Ruivo et al. 2014). Adopting new technologies is a wise decision that institutions can consider when dealing with market pressure. Adopting GIT, institutions can obtain greater advantages, new procedures, flexibility, improving production and response time to market needs. Hence, competitive pressure will help institutions improve their standards.

H4: *Competitive pressure will positively influence GIT intention (H4a) and adoption (H4b).*

3.2.4. Hypotheses on policy

Government policies in general refer to a group of policies that drive the procedures related to technology adoption. The authority and the vision of the government encourage institutions to implement a technology and continue innovating. When government supports and motivates a specific approach to GIT, institutions will be more willing to adopt GIT (IST-Africa Consortium 2012; Renzio & Hanlon 2007; World Bank 2011). Hence, government policies will motivate institutions to introduce new technologies approaches.

H5: *Government policies will positively influence GIT intention (H5a) and adoption (H5b).*

As in many African countries, Mozambique's economic activities are financially supported by international organizations and developed countries' aid programs (Stubbs et al. 2016; Ward & Dorussen 2015). Many of these programs have technology requirements for implementation, including in some cases the use of GIT. It is thus reasonable to expect Donor Pressure to have an impact on the use of GIT in organizations.

H6: *Donor pressure will positively influence intention to adopt GIT (H6a) and GIT adoption (H6b).*

3.2.5. Hypotheses on DOI

The technology acceptance model addresses the way new technologies are faced according to users' perceptions within a working environment and hypothesizes that beliefs influence attitudes leading to intentions (Wentzel et al. 2010). Institutions having the intention to adopt GIT will multiply the possibilities for technology adoption, hence

H7: *Intention to adopt will positively influence GIT adoption.*

3.2.6. Data collection

To evaluate the theoretical constructs in a questionnaire and apply that evaluation to the target group of Mozambican institutions, the research followed several steps. First, the questionnaire was created in English and revised by a group of university staff. As the questionnaire was administered in Mozambique, where the formal language is Portuguese, it was then translated from English to Portuguese with support of university staff. To ensure the accuracy of the translations, a professional translator was asked to translate from English to Portuguese and vice-versa. The questionnaire items were created based on published studies (Table 3.1), and the authors' motivation. All constructs were measured using a seven-point scale ranging from "strongly disagree" to "strongly agree". To test the instrument, a pilot study involving 30 organizations was conducted in Mozambique, and the results showed that the scales, the approach, and the translation were effective.

Constructs	Measurement items	Source
Technology competence	TC1: The technology infrastructure of my company is available to support GIT.* TC2: My company is dedicated to ensuring employees are familiar with GIT. TC3: My company has good knowledge of GIT. TC4: My company has a GIT training program.	Chang and Chong (Chan & Chong 2013)
Security (Sec)	*How do you perceive the risk that …* Sec1: … the confidentiality and security of your business data are not guaranteed when adopting GIT solutions? Sec2: … in case of damage, present liability law is still unclear about who will bear the damage? Sec3: …the GIT provider will exploit contractual loopholes (i.e., incomplete contracting) to the detriment of your company?	Benlian and Hess (Benlian & Hess 2011)
Financial Concerns (FC)	FC1: The organization has a certain amount of money to invest in GIT. (1- Strongly disagree, 7- Strongly agree,…) FC2: GIT operating budget, as percent of total budget (#) FC3: Percentage of GIT operating budget supported by other institutions (i.e. donor) (#)*	Zhu *et al.*(Zhu, Dong, et al. 2006)
Competitive Pressure (CP)	CP1 – Our organization thinks that GIT has an influence on competition in their field of activity. CP2 – Our organization is under pressure from competitors to adopt GIT. CP3: Some of our competitors have already started using GIT.	Oliveira *et al.* (Oliveira et al. 2014)
Government Policies (GP)	GP1: The government has a policy on technology adoption. GP2: The government policies are implemented and followed. GP3: My organization is under the government policies. GP4: Technology adoption is one of the government pillars.	IST-Africa Consortium(IST-Africa Consortium 2012)
Donor Pressure (DP) (i.e. World bank, USAID)	DP1: Donors encourage implementation of GIT. DP2: Donors recommend implementation of GIT. DP3: Donors require implementation of GIT. DP4: Donors keep the organization innovating.	IST-Africa Consortium(IST-Africa Consortium 2012); Stubbs *et.al.*(Stubbs et al. 2016)
Intention to adopt GIT	GITi1: My company intends to use GIT if possible.	Chan and Chong(Chan & Chong 2013)

	GITi2: My company collects information about GIT with the possible intention of using it. GITi3: My company has conducted a pilot test to evaluate GIT.	
GIT adoption	GITa1: My company invests resources to adopt GIT. GITa2: Business activities in our company require the use of GIT. GITa3: Functional areas in my company require the use of GIT.	Chan and Chong(Chan & Chong 2013)

Table 3. 1: Appendix A

Constructs	**Early respondents (n=82)**		**Late respondents (n=28)**		**Kolmogorov-Smirnov test**
	Mean	S.D.	Mean	S.D.	P-value
Technology competence (TC)	3.816	1.856	3.611	1.803	0.603
Security (Sec)	3.875	1.486	4.362	1.474	0.179
Financial concerns (FC)	4.966	2.988	4.887	3.505	0.818
Competitive Pressure (CP)	3.995	1.494	3.822	1.762	0.584
Government policies (GP)	4.541	1.504	4.805	1.559	0.346
Donor pressure (DP)	4.435	1.732	4.325	1.843	0.818
GIT initiation (GITi)	4.796	1.432	4.473	1.765	0.624
GIT adoption (GITa)	4.469	1.738	4.255	1.732	0.782

Table 3. 2: Mozambique institutions questionnaire results (early and late respondents, and testing possible biases).

Industry	**n (sample size)**	**% (percentage)**
Agriculture	13	12
Environment	10	9
Trade	1	1
Construction	4	4
Education	28	25
ICT	7	6
Industrial Production	1	1
Economic development	8	7
Natural resources	8	7
Services	4	4
Health	9	8
Transport and communications	4	4
Other	13	12
Organization size (number of employees)	**n (sample size)**	**% (percentage)**
Micro (1-9)	11	10
Small (10-49)	35	32
Medium (50-249)	42	38
Large (> 250)	22	20

Table 3. 3: Sample characteristics (n=110) of industry and organization size

The questionnaire was implemented online. An email containing a complete explanation of the research purpose and relevance was then sent to Mozambican public, private, and NGO organizations. The institutions' details including the contact persons were obtained from the yellow pages of Mozambique, official government websites, and persons working in this area. To increase content validity, an explanation of GIT was included in the questionnaire to enable individuals who were not familiar with the topic to answer the questionnaire. To increase response rate, all respondents were invited to provide their email addresses to have the opportunity to receive the findings of the study. The data were analyzed by employing partial least square (PLS) and relevant hypotheses were derived and tested.

Data were collected during the second semester of 2015. A total of 110 valid responses (82 early respondents and 28 late respondents) were obtained by the end of the period from a universe of approximately 2000 organizations. Non-response was attributed to diverse issues, including invalid email addresses, inbox full, lack of updated emails, and lack of appropriate persons to respond to the questionnaire, among others.

3.3. Statistical analysis

The Kolmogorov-Smirnov (K-S) test was used to compare the sample distributions of the two groups (early and late respondents) (Lopes 2011). The information reported in Table 3.2, indicates that the sample distribution of the two groups did not differ significantly, pointing to an absence of non-response bias. The common method bias was examined using Harman's one-factor test. It reveals that the first factor explains 32.8% of the variance, i.e., none of the factors had variance more than the 50% threshold value. Consequently the common method bias was not a serious concern. The results of the study were obtained through the variance-based technique, using partial least square (PLS) because: (i) some of the items in our data are not distributed normally ($p<0.01$) based on Kolmogorov-Smirnov test; (ii) the research model has not been tested before; and (iii) PLS estimation requires 10 times the largest number of structural paths directed at a particular construct in the structural model (Sarstedt et al. 2014). The sample meets the requirements for using PLS. The research model was estimated using Smart PLS 2.0 M3 software (Hair et al. 2012).

The profiles of the sample and size of responding organization are shown in Table 3.3.

3.4. Results and discussion

The measurement model was analyzed first in order to assess reliability and validity, followed by the structural model.

3.4.1. Measurement model

The results of the measurement model are shown in Tables 3.4 and 3.5, including the construct reliability, convergent validity, indicator reliability, and discriminant validity.

The construct reliability was tested using the composite reliability coefficient, which is greater than 0.7 (Sarstedt et al. 2014). Furthermore, the indicator reliability was evaluated taking into consideration that the loadings should be greater than 0.7 (Henseler et al. 2009; Hair et al. 2012). As seen in Table 3.4, the loadings are greater than 0.7, indicating good indicator reliability. To test the convergent validity, the average variance extracted (AVE) should be greater than 0.5 (Hooper et al. 2008). The discriminant validity of the constructs was assessed using two criteria: cross-loadings and the Fornell - Larcker criterion.

Construct	Items	TC	Sec	FC	CP	GP	DP	GITi	GITa
Technology competence (TC) **(CR = 0.910)**	TC2	**0.891**	0.310	0.553	0.501	0.254	0.343	0.519	0.557
	TC3	**0.898**	0.287	0.495	0.436	0.177	0.320	0.527	0.523
	TC4	**0.846**	0.253	0.447	0.386	0.204	0.267	0.422	0.442
Security (Sec) **(CR = 0.837)**	Sec1	0.371	**0.717**	0.159	0.216	0.128	0.177	0.225	0.156
	Sec2	0.297	**0.883**	0.247	0.281	0.066	0.204	0.371	0.261
	Sec3	0.102	**0.777**	0.112	0.028	-0.029	0.144	0.280	0.093
Financial concerns (FC) **(CR = 0.855)**	FC1	0.579	0.234	**0.923**	0.637	0.408	0.414	0.505	0.636
	FC2	0.376	0.148	**0.802**	0.504	0.239	0.228	0.254	0.460
Competitive pressure (CP) **(CR = 0.883)**	CP1	0.484	0.132	0.597	**0.813**	0.382	0.403	0.427	0.523
	CP2	0.417	0.290	0.615	**0.899**	0.381	0.426	0.527	0.540
	CP3	0.394	0.170	0.499	**0.823**	0.380	0.339	0.491	0.501
	CP4	0.335	0.166	0.433	**0.690**	0.298	0.364	0.280	0.298
Government policies (GP) **(CR = 0.895)**	GP1	0.135	0.041	0.372	0.327	**0.785**	0.276	0.177	0.080
	GP2	0.205	-0.054	0.287	0.369	**0.814**	0.182	0.223	0.155
	GP3	0.159	0.137	0.230	0.313	**0.782**	0.305	0.289	0.175
	GP4	0.262	0.072	0.405	0.444	**0.912**	0.418	0.317	0.293
Donor pressure (DP) **(CR = 0.930)**	DP1	0.312	0.196	0.425	0.490	0.364	**0.936**	0.545	0.502
	DP2	0.333	0.219	0.392	0.428	0.285	**0.951**	0.558	0.513
	DP3	0.413	0.230	0.367	0.475	0.371	**0.920**	0.553	0.517
	DP4	0.136	0.112	0.112	0.190	0.306	**0.673**	0.382	0.233
GIT initiation (GITi) **(CR = 0.834)**	GITi1	0.351	0.195	0.267	0.439	0.362	0.502	**0.758**	0.479
	GITi2	0.496	0.429	0.439	0.450	0.236	0.528	**0.904**	0.626
	GITi3	0.490	0.250	0.394	0.423	0.166	0.354	**0.702**	0.423
GIT adoption (GITa) **(CR = 0.889)**	GITa1	0.674	0.144	0.710	0.626	0.264	0.504	0.606	**0.848**
	GITa2	0.343	0.187	0.392	0.432	0.093	0.362	0.515	**0.837**
	GITa3	0.390	0.275	0.483	0.401	0.215	0.437	0.522	**0.873**

Table 3. 4: Sample results - PLS loadings and cross-loadings

Construct	Mean	S.D.	TC	Sec	FC	CP	GP	DP	GITi	GITa
Technology competence (TC)	3.763	1.836	**0.878**							
Security (Sec)	3.999	1.492	0.324	**0.795**						
Financial concerns (FC)	4.946	3.111	0.571	0.229	**0.864**					
Competitive Pressure (CP)	3.951	1.560	0.505	0.237	0.668	**0.810**				
Government policies (GP)	4.608	1.515	0.241	0.069	0.390	0.447	**0.825**			
Donor pressure (DP)	4.407	1.753	0.355	0.222	0.390	0.470	0.375	**0.878**		
GIT initiation (GITi)	4.714	1.521	0.561	0.379	0.465	0.549	0.320	0.587	**0.793**	
GIT adoption (GITa)	4.414	1.731	0.581	0.229	0.648	0.591	0.236	0.521	0.651	**0.853**

*: The square root of the average variance extracted (AVE)

Table 3. 5: Descriptive statistics, correlations, and AVE of the sample

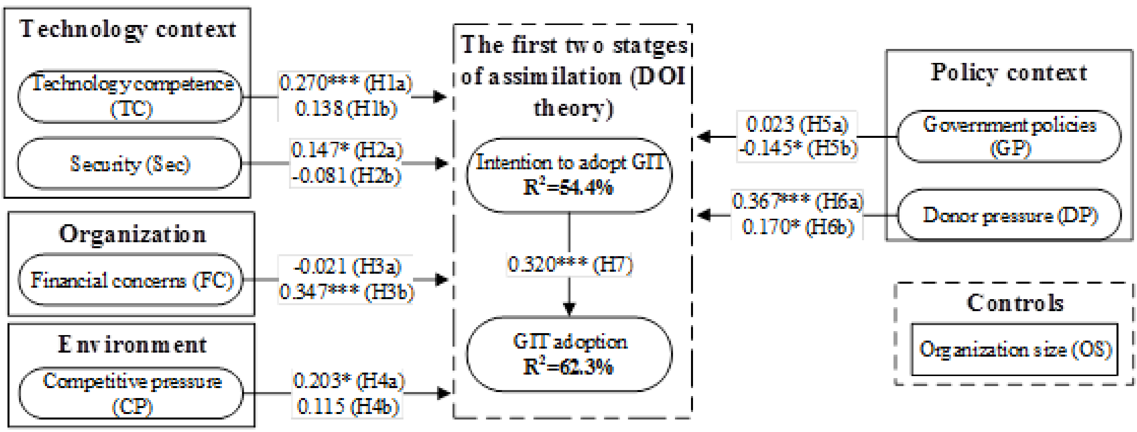
For the cross-loading criterion the loadings of each construct should be higher than all cross-loadings (Henseler et al. 2009; Sarstedt et al. 2014). To meet this criterion we eliminated two items (TC1 and FC3). Table 3.5 reports that the diagonal values (square root of AVE) are greater than off-diagonal values (correlation between constructs). Both criteria were therefore met, providing evidence of discriminant validity of the scales.

Tables 3.4 and 3.5 report that construct reliability, convergent validity, indicator reliability, and discriminant validity are satisfactory, recommending that the constructs are reliable and that it is feasible to test the research model.

4.2. Structural model

Assessing the results of the model, the path significance levels were estimated using bootstrap with 5,000 resamples. The R^2 criterion (Sarstedt et al. 2014)is used to assess the predictive capacity of the structural model and is the essential criterion for assessing the quality of the model. Examination of R^2 (Figure 3.2) shows that the model explains 54.4% of the variation in intention to adopt GIT, and explains 62.3% of the variation in GIT adoption. This reveals that the conceptual model can be considered as substantial. The analysis results can be summarized as follows. Technology competence (TC) ($\hat{\beta}$ =0.270; p<0.01), security (Sec) ($\hat{\beta}$ =0.147; p<0.10), and competitive pressure

($\hat{\beta}$=0.203; p<0.10) are statistically significant in explaining intention to adopt GIT, thus confirming hypotheses H1a, H2a, and, H4a. Financial concerns (FC) ($\hat{\beta}$=0.347; p<0.01), government policies (GP) ($\hat{\beta}$=-0.145; p<0.1), and intention ($\hat{\beta}$=0.320; p<0.01) are statistically significant in explaining the adoption of GIT, thus confirming hypotheses H3b, H5b, and H7. Donor pressure (DP) (H6a=0.367; p<0.01 and H6b=0.170; p<0.1) is statistically significant and is the only construct that explains both intention to adopt GIT and GIT adoption, thereby confirming hypotheses H6a and H6b. The model explains 54.4% of the variation in intention to adopt GIT and 62.3% of the variation in the GIT adoption.



Note: *p<0.1; **p<0.05; ***p<0.01

Figure 3. 2: Structural model results of research model for GIT in Mozambique context *p<0.1, **p<0.05, ***p<0.01

The purpose of this paper was to understand the determinants that explain GIT in two stages of adoption (intention and adoption) in a Mozambique context. The empirical results generally support the model. The subsequent discussion into theoretical and managerial implications.

3.4.3 Theoretical implications

The study brings a threefold contribution: a new context, a new model, and new findings.

While there are many theoretical studies of GIT, few of these have focuses on understanding the determinants behind GIT adoption in Mozambique.

With regard to a new model, the study builds upon the DOI theory (Foxon & Pearson 2008) with a focus on decision stages. The study combined the DOI with the TOE (Aboelmaged 2014; Ruivo et al. 2014; Oliveira & Martins 2011; Wang et al. 2010; Gareeb & Naicker 2015), and added a new feature to the TOE framework, the policy context, which includes government policies and donor pressure. The model proposes that technology competence, security, financial concerns, competitive pressure, government policies, donor pressure, and intention are determinants in explaining intention to adopt GIT in institutions. To the best of the authors' knowledge, this study is the first that seeks to understand the drivers behind the adoption of GIT in the Mozambique context using a research model that combines DOI theory, TOE framework, and policy context as new input for the study.

Regarding new findings, the results show that technology competence, security, competitive pressure, and donor pressure are important drivers to explain the intention to adopt GIT, and that financial concerns, government policies, donor pressure, and intention are important drivers to explain actual adoption of GIT. The results reveal that to better understand GIT adoption it is convenient to estimate a model for a specific domain. This is one of the first efforts to provide concrete empirical support for the theories of GIT adoption in a specific context.

3.4.4 Managerial implications

Recognizing and understanding the determinants that lead institutions to adopt GIT will allow managers to make wise strategic decisions to expand their business and gain perceived benefits of adopting GIT, while at the same time identifying further training needs that may overcome barriers to strategic development. Based on the results of the study, managers will be able to set priorities regarding implementation of GIT in institutions. It should be emphasized that in the particular case of Mozambique the funding, restrictions, and rules imposed by donor organizations will to a great extent determine the intention to adopt GIT and GIT adoption itself (Molenaers et al. 2015). This creates a very special business environment in which the relationship between institution and client is greatly affected by a third party, the donor.

Government policies could encourage the adoption of these technologies, reducing the barriers to these initiatives and promoting feasible technology infrastructure and technical support for institutions.

3.5. Conclusion

Understanding the determinants that leading Mozambique institutions to adopt GIT is crucial in a way that these technologies are spreading all over the country. Financial concerns, government policies, and donor pressure mostly explain adoption of GIT. The donor pressure proved to be the only construct that explains both intention to adopt GIT and the adoption of GIT. It would be interesting to have a future study that analyzes in depth the role of these variables as drivers of the adoption of these technologies.

Chapter 4 – Understanding the determinants of GIT Post-adoption: Mozambique institutions perspectives

4.1. Introduction

In 21st century, technology is a key enabler of the integration and prosperity of any institution. Using it, institutions can have better visibility through real time information sharing that will lead to internal and external improvements. Technology adoption injects reliability in overall process. For these and other reasons, decision makers and top management from institutions are become more presented for the opportunities that technologies are offering. Among the variety of technologies, geographical information technologies (GIT) are gaining special attention based on ability to support institutions to reach their objectives (Harrison et al. 2007). Understanding the factors that leading institutions to adopt new technologies is a permanent issue in the field of information system (Taylor & Todd 1995). For the last decades, institutions around the world started to give more value and increase investments in technologies and ways to adopt it. Thus, there is a clear need to understand the post adoption stage of GIT in institutions, however the existing studies focus more on adoption of technology in general (Amade et al. 2017; Zhu, Dong, et al. 2006; Lippert & Forman 2005; Son & Han 2011; Obal 2017; Li & Liu 2014; Hong 2014; Wolf et al. 2015; Sieber 2000; Eslami et al. 2011; Van Westen 2013) and non for post adoption of GIT for Mozambican context.

Inspired by these issues, the research seeks to improve the comprehension about GIT with attention in identifying the determinants behind the post-adoption use and intention to increase the level of use in Mozambican institutions. Through a proposed model based on a synthesis of three theoretical framework (diffusion of innovation theory (DOI), technology – organization – environment (TOE) framework and institutional theory), the major priority of the study resigns in seeking to comprehend what takes organizations to keep using and increase the level of use GIT.

The paper is organized into seven sections. In the first and second section we provide an overview of GIT, differences with other technologies, and contextualize in Africa continent. This chapter is organized as follows. In the next part an overview of the theoretical background is presented. The work continues with research model and hypotheses. Discussion and implications are presented later. Finally, the conclusion of the work by summarizing and present all the remarks.

4.2. Theoretical Background

4.2.1. The concept of GIT

Having a clear definition of GIT can be trivial and deep because all or most authors define it according to their objective. The term GIT can be used to describe all types of computer systems and sub-systems used in processing georeferenced information (Sánchez-Lozano & Bernal-Conesa 2017; Sánchez-Lozano et al. 2013; Harrison et al. 2007). In other words, it can be assumed as a decision support system that can provide support on data analysis, question, and interpret data, patterns, trends and, handling geographical information. Through over the years, these systems have been applied for different purposes and objectives for decision makers and top manager in institutions, such as, planning infrastrutures (Carsjens & Ligtenberg 2007); land use suitability (Zolekar & Bhagat 2015); resource management (Mahboubi et al. 2015); education (Kim & Bednarz 2011; Lateh & Muniandy 2010; Li & Liu 2014); health care (Joyce 2009); banks (Ngai et al. 2011; Ajah & Inyiama 2011; Gabriela & Ph 2010) and others.

4.2.2. Adoption models

With the advent of technologies, new models and theoretical frameworks emerged seeking to explain the dynamics of the evolution process. These models and theoretical frameworks has focused mostly heavily on use and adoption than post adoption and continuity of use. Among the many theoretical advanced perspectives to explain the post-adoption of technologies in information system at organization level, three theories gain evidence, diffusion on innovation (DOI) (Rogers 1995; Rogers 2003), technology-organization-environment (TOE) framework (Tornatzky & Fleischer 1990) and, Institutional theory (Dimaggio & Powell 1991). The study will be focus on these three theories for many reasons. (1) The DOI theory, TOE framework and institutional theory operates at organizational level; (2) The theories complement each other and validate a theoretical model; (3) The combination of its elements and characteristics brings a new insights that helps to explain the post adoption and continuity of use by institutions for these technologies; (4) The characteristics mentioned in DOI theory, the three contexts from TOE framework and the pressures presented from institutional theory creates conditions to improve the comprehension about the post adoption process of one technology and their continuity use in organizations.

4.2.2.1. Diffusion of innovation (DOI) theory

The theory relates the impact of technological innovation versus the influence that it may create to potential adopters (Rogers 1995). Rogers conceptualizes five main stages (knowledge; persuasion; decision; implementation; and confirmation) to enable the innovation decision process in which an individual or a group of individuals gain an attitude toward the innovation. On the other hand, the theory attributes organizational usage of an innovation to its characteristics: (1) Relative advantage (when an innovation is perceived as better than the idea. The greater it's perceived, the more rapid its rate of adoption is going to be); (2) Compatibility (degree to which an innovation is perceived to be consistent taking into consideration existing values); (3) Complexity (is the degree to which an innovation is perceived as difficult to understand and use. simple ideas will be adopted more rapidly); (4) Trialability (is the degree to which an innovation may be tested with on a limited basis); (5) Observability (is the degree to which the results of an innovation are visible to others). The characteristics four and five (trialability and observability) were not incorporated in the model because the main purpose of the study is to understand post adoption and continuity of use for GIT in organizations. In addition, much of the existing research has focused on adoption and intention to adopt (Fichman, Robert 2000; Amade et al. 2017). Although, this is helpful to understand adoption decisions, we also need a better understand about the post-adoption use. This motivates the present study to focus on post-adoption stage: use and intention to increase the level of use.

The literature illustrates that the DOI theory has a strong theoretical foundation and consistent practical support (Zhu, Dong, et al. 2006; Zhu & Kraemer 2005; Mustonen-Ollila & Lyytinen 2003; Oliveira & Martins 2011; Abdollahzadehgan et al. 2013). In same line, the study combines DOI theory with TOE framework that brings the environment context becoming better to comprehension about the post adoption of GIT.

4.2.2.2. Technology, organization, and environment (TOE) framework

Tornatzky and Fleischer (1990) proposed this theory to explain how innovation processes occur in organizations. The theory seeks to explain how organizations can reach the right equilibrium between internal and external factors (Aboelmaged 2014). In same line, the theory identifies 3 contexts that may influence organization usage of technological innovation (1) technological (the context makes relation between existing technologies and technical skills available in the organization); (2) organizational (refers to internal measures of the organization); and (3) environmental (refers to external environment in which an organization is incorporated (Tornatzky & Fleischer 1990; Lippert & Govindrajulu 2006). The TOE framework, as designated above, has been incorporated in many and used for different purposes (Zhu & Kraemer 2005; Chau & Tam 1997; Zhu et al. 2016). In same line, the TOE framework is incorporated to strengthen and complement the DOI theory.

4.2.2.3. Institutional theory

Institutional theory discuss that the institutional environment provides rule-like social pressures for appropriate organizational operations and practices (Dimaggio & Powell 1991). Pressures are needed to create and maintain legitimacy of the institution (Oliver 1991; Clemens & Douglas 2005). It highlights the aspects related to social culture (norms, routines, rules) and how they become established as guidelines for social behavior (Scott, W. and Christensen 1995; Scott 2004). The internal environment can profoundly contribute to the development of formal structures in an organization (Dimaggio & Powell 1991; Scott 2004). The theory speaks about the pressures (mimetic, normative, and coercive) and stablish a boundary where a powerful organization can apply pressures on its partners by imposing the adoption of technology infrastructure (Thomas et al. 2011). The theory seeks to explain how organizations become more shaped due to pressures (external sources or within organization).

4.2.3. Specifications of African context

The African continent is characterized by its landscape and extension, diversity in plants and animals including wild life and, rapid population growth. Spatial planning and management are vital to the health of the continent. Many studies involving government and Non-Governmental Organizations (NGOs) have taken place in various African countries that involving the use of GIT as decision support tools (Vicente-Serrano et al. 2012; Panek 2013; Tanser & le Sueur 2002; Dambach et al. 2012; Mashimbye et al. 2012; ESRI 2002). From these studies literature showed that these technology has a strong contribution in organizations support. Although, the theoretical support target these technologies to use than adoption and for that sense there're lack of studies that postulates to understand the determinants of GIT post-adoption in organizations.

4.3. Research model

We synthesize the DOI theory, TOE framework and institutional theory and propose a research model as shown in Figure 4.1. We specify three set of factors, technology context and DOI theory (H1-H3: relative advantage, compatibility, complexity), Organization context (H4-H6: organization size, geographic scope, expansion opportunities) and, institutional theory (H7-H9: coercive pressure, normative pressure, mimetic pressure). We also postulate a linkage from GIT use to intention to increase the GIT level (H10). The major goal of the proposed model is to enhance the comprehension about what keeps Mozambican organizations to continue use GIT (increase the level of use).

The proposed model combines three theories and enhance the TOE framework of the organization and the innovation characteristics of GIT that underline the post-adoption of GIT. It's different from the other studies because the model aggregates and reflects a specific context never before explored or shared in this perspective. No study so far empirically validated the indirect effects and the background of the determinants of post-adoption of GIT.

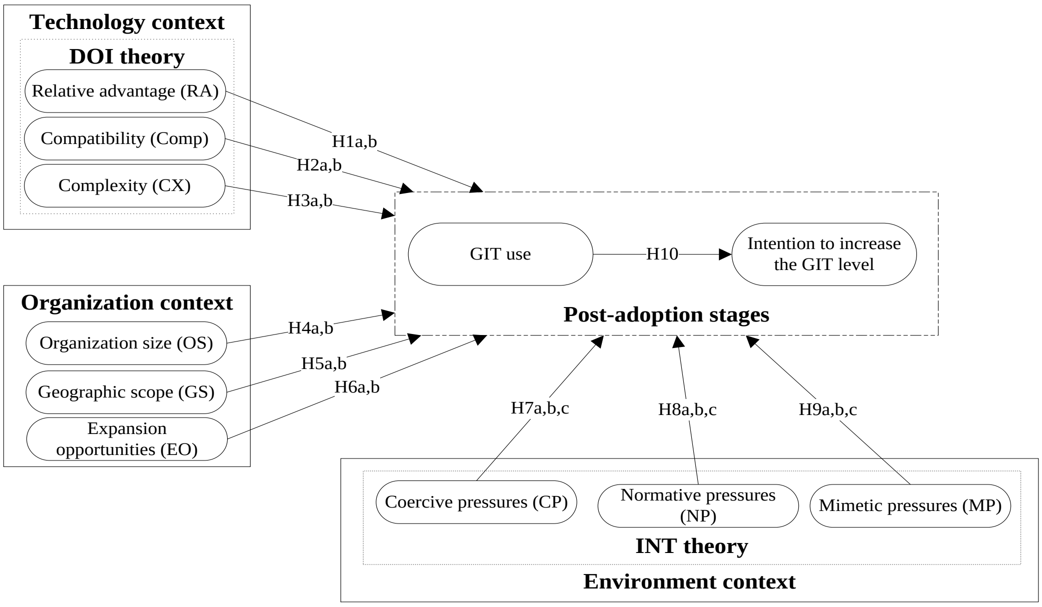


Figure 4. 1: Research model

4.3.1. Hypotheses on technology context and DOI theory

We consider three characteristics in technology context and DOI theory: (1) relative advantage (RA), (2) compatibility (Comp), and (3) complexity (CX). The variables can be identified on literature (Tornatzky & Fleischer 1990; Lippert & Govindrajulu 2006; Lippeveld & Sapirie 2000; Rogers 1995; Cooper & Zmud 1990).

Relative advantage is the "degree to which an innovation is perceived as better than the idea and can bring advantages to an organization" (Rogers 1995). It has been widely recognized as a significant factor leading organization usage. Innovations that strategic creates organization effectiveness by improving productivity, efficiency, cost saving have good impact for adoption (in this case GIT) (Wu & Chen 2014), will positively influence its adoption. Hence,

H1a: *Relative advantage will positively influence the GIT use.*

H1b: *Relative advantage will positively influence users to continue use.*

Compatibility is the degree to "which an innovation is perceived to be consistent taking into consideration existing past values, needs of potential adopters." As an important determinant, compatibility will boost the organization in accomplish their goals (Dedrick & West 2004; D Macredie & Mijinyawa 2011). For example, if the purpose of having GIT in organization is to gain advantage over the competitors, been a compatible technology will help the integration with the existing systems and procedures within the organization. Hence,

H2a: *Compatibility will positively influence the GIT use.*

H2b: *Compatibility will positively influence users continue use GIT.*

Complexity is the "degree to which an innovation is perceived as difficult to understand and use" (Rogers 1995). Revealed to be an important factor to explain innovation usage in organizations. The easier technology illustrates to be friendly integrated into organization operations, greater will be the chances of its adoption. The GIT offers innumerous ways of working environment and data processing. However, adopting GIT in institutions can be challenging if the institutions has lack of expertise (example, integrate data from different layers and sources, predict some event, maintenance). Hence,

H3a: *Complexity will influence negatively the GIT use.*

H3b: *Complexity will influence negatively users continue use.*

4.3.2. Hypotheses on organization context

The GIT in our days is used in different contexts in organizations. Within the organization context, organization size (OS), geographical scope (GS), and expansion opportunities (EO) are key elements to the success of one organization (Lippert & Govindrajulu 2006).

Large organizations usual have an advantage over small organizations because they have allocated more resources to be able to accomplish their goals. On the other hand, studies reveal that in large organizations there is a lot of bureaucracy and a need of everything being well aligned and this can difficult the decision making process regarding to new ideas of introducing new technologies (Lee & Xia 2006). Studies illustrated that small organizations do not adopt instantly new technologies (Lippert & Govindrajulu 2006; Lippert & Forman 2005). The adoption of GIT may create changes in organization structure and data processing. Hence,

H4a: *Organization size will influence positively the GIT use.*

H4b: *Organization size will influence positively the continuity use of GIT.*

In any activity, geographical scope can contribute to give advantage over competitors. Geographical scope reveals to be an important factor to moderate the GIT usage. Hence,

***H5a**: Geographical scope will influence positively the GIT use.*

***H5b**: Geographical scope will influence positively the continuity use of GIT.*

The adoption of technologies opens a window of opportunities in organizations. GIT can easily support organizations to expand their business to other areas. Expansion opportunities reveals to be an important factor to ensure the GIT usage. Hence,

***H6a**: Expansion opportunities will influence positively the GIT use.*

***H6b**: Expansion opportunities will influence positively the continuity use of GIT.*

4.3.3. Hypotheses on environment context

The environment context postulates the way an organization conducts its activity and is influenced by internal and external factors (nature of industry) including competitors (Tornatzky & Fleischer 1990). The determinants that demonstrated to have an impact on GIT post adoption and continuity of use are coercive, mimetic and normative pressures.

Coercive pressure can be understood as a set of formal and informal forces exerted on institution by other institution upon which the former institution depend (Teo et al. 2003; Dimaggio & Powell 1991). Coercive pressure highly contributes to the prosperity of the organization in the way that it become aligned with the activity environment. Empirical evidences suggest that coercive pressure contribute to build a relationship between institutions and some dependence. Hence,

***H7a**: Coercive pressure will influence positively the GIT use.*

***H7b**: Coercive pressure will influence positively the continuity use of GIT.*

***H7c**: Coercive pressure will moderate the effect of GIT use on continuity use of GIT.*

Normative pressure relies on the relationship where organizations share information (norms) and get persuaded to behave similarly (Burt 1987; Teo et al. 2003). The impact of sharing information including norms and get involved in many scenarios bring advantage to organization. Sharing norms within a network of organizations facilitates consensus and enhance their influence behavior (Dimaggio & Powell 1991). Normative pressure can highly contribute to align the internal norms of the organization and contribute for the well-being of the activity. Hence,

***H8a**: Normative pressure will influence positively the GIT use.*

***H8b**: Normative pressure will influence positively the continuity use of GIT.*

***H8c**: Normative pressure will moderate the effect of GIT use on continuity use of GIT.*

Mimetic pressure lies when an institution imitates a competitor by adopting their practice and innovation (Soares-Aguiar, A. and Palma-Dos-Reis 2008). In our days, organizations that plays aside of business trends are not capable to survivor on market for many time. For that sense, mimetic pressure ensure that the organization is aligned with the industry. It can manifest themselves in two ways: perceived success and the prevalence of a practice (Teo et al. 2003). Hence,

***H9a**: Mimetic pressure will influence positively the GIT use.*

***H9b**: Mimetic pressure will influence positively the continuity use of GIT.*

***H9c**: Mimetic pressure will moderate the effect of GIT use on continuity use of GIT.*

4.3.4. Hypotheses on Post-adoption context

A technology that is perceived to be easier to use facilitate the user comprehension and increases the interest in the technology. As far as the user can get confirmation experience, more possibilities are open to increase the level of technology. The better the flexibility and adaptability of one technology, the better the continuity of usage. The continuity of use of GIT in one organization will be also determined from a good feedback that the organization are getting (e.g.: good results; levels of productivity increased; compatibility over existing technologies; easier to operate). Thus, higher degrees of post-adoption usage will be associated with levels of adaptability of the GIT. Hence,

***H10**: GIT use will influence positively the continuity use of GIT.*

4.4. Research methodology

4.4.1. Measurement

To develop and estimate a model shown in Figure 4.1, a questionnaire was developed with support on previously published studies. The questionnaire had as target public institutions, private organizations and non-government-organizations from Mozambican country that utilize GIT. The inspirations from the items in the questionnaire coming from different sources (see Appendix chapter 4). The creation of the questionnaire follow different steps, namely: A group of university staff helped to create a feasible questionnaire in English and later on it was translated to Portuguese because the formal language in Mozambique. To guarantee content validity, a professional translator were been asked to translate a questionnaire. To be consistent with the sources, all constructs (relative advantage, compatibility, complexity, organization size, geographic scope, expansion opportunities, coercive pressure, normative pressure, and mimetic pressure) used on the study were measured using a seven-point range scale on an interval ranging from “strongly disagree” to “strongly agree”.

4.4.2. Data

Data were collected using a survey monkey (web-based application). To test the questionnaire and ensure content validity, a pilot study was conducted to 30 Mozambican institutions (public institutions, private organizations and non-government-organizations (NGO’s)). To be able to have the write person’s contact, the study sent an Email to Mozambican institutions containing a complete explanation of the study and their relevance for the country. Other used strategy was through Mozambique yellow pages create a database of contacts. The questionnaire was administrated and data collected in 2nd semester of 2015. The study targets a universe of 2000 Mozambique organizations and get 110 valid responses which 82 represents early and 28 late respondents. The study used a “key informants” approach to identify people more involved in GIT. To reach these respondents we provide a clear description about GIT.

To increase content validity, the researchers introduced a clearly explanation of GIT in the questionnaire. The respondents had the opportunity to choose to receive the results of the study by filling with their emails in the questionnaire.

The weak feedback from the target group was attributed to diverse issues, namely, invalid email addresses, inbox full, lack of updated emails, and lack of appropriate persons to respond to the questionnaire, among others. The nonresponse bias test, the sample distribution of the early and late respondent groups was compared using the Kolmogorov-Smirnov (K-S) test (Wilcox 1998) and the results demonstrated that there’s no statistically differences. Table 2 presents mean and standard deviation of all the constructs.

4.5. Results and analysis

4.5.1. Measurement model

The measurement model results are shown in Table 4.1 and 4.2. The measurement model was tested using composite reliability. From Table 4.2, the results demonstrated that there are greater than 0.7, representing that the scales are reliable (Henseler et al. 2009). To guarantee the appropriate degree of convergent validity in the study, the average variance extracted (AVE) value should be greater than 0.5 (Fornell & Larcker 1981). In Table 4.2 all constructs have AVE greater than 0.5 loadings greater than 0.7 which represents that are statistically significant at the 0.01 level. Finally, the discriminant validity of the constructs was assessed using the criteria's of Fornell – Larcker and cross-loadings. The first criteria suggests that the square root of AVE should be greater than the correlation between the constructs (Fornell & Larcker 1981; Chin 1998) and the second criteria postulates to loadings of each indicator should be greater than all cross-loadings (Chin 1998). Based on Table 4.2 (first criteria) and Table 4.1 (second criteria) both criteria were satisfied.

	RA	Comp	Cx	OS	GS	EO	CP	NP	MP	GITu	GITe
RA1	**0.824**	0.500	0.038	0.250	0.042	0.230	0.201	0.359	0.264	0.309	0.386
RA2	**0.938**	0.363	0.007	0.241	-0.006	0.122	0.294	0.285	0.291	0.202	0.525
RA3	**0.858**	0.264	0.004	0.276	-0.125	0.032	0.309	0.207	0.297	0.109	0.505
RA4	**0.860**	0.291	0.100	0.154	-0.019	0.191	0.295	0.217	0.197	0.177	0.460
Comp1	0.357	**0.745**	0.003	0.194	0.099	0.218	0.182	0.308	0.237	0.286	0.265
Comp2	0.379	**0.845**	-0.084	-0.041	0.043	0.207	0.255	0.285	0.188	0.425	0.278
Comp3	0.314	**0.781**	-0.147	-0.018	0.029	0.224	0.160	0.133	0.187	0.318	0.245
Comp4	0.108	**0.615**	-0.198	-0.053	0.081	0.239	0.060	0.224	0.168	0.269	0.106
Cx3	-0.044	-0.085	**0.794**	-0.119	-0.139	0.122	0.008	0.002	0.006	-0.043	-0.172
Cx4	0.080	-0.133	**0.945**	-0.044	-0.154	-0.063	0.063	-0.100	-0.140	-0.222	-0.199
OS	0.264	0.026	-0.079	**1.000**	0.208	0.092	0.027	0.107	0.041	-0.089	0.091
GS	-0.032	0.078	-0.166	0.208	**1.000**	0.081	-0.118	0.075	0.118	0.231	-0.165
EO	0.162	0.288	0.002	0.092	0.081	**1.000**	0.359	0.489	0.275	0.530	0.258
CP1	0.192	0.231	0.064	0.048	-0.213	0.272	**0.843**	0.472	0.282	0.269	0.313
CP2	0.231	0.222	0.064	-0.011	-0.085	0.287	**0.905**	0.405	0.224	0.288	0.378
CP3	0.361	0.163	0.009	0.034	-0.038	0.352	**0.834**	0.457	0.367	0.355	0.473
NP1	0.265	0.237	-0.012	0.153	0.144	0.443	0.398	**0.869**	0.407	0.583	0.303
NP2	0.259	0.337	-0.139	0.039	0.070	0.390	0.382	**0.858**	0.266	0.552	0.280
NP3	0.196	0.156	-0.008	0.049	-0.096	0.322	0.510	**0.626**	0.218	0.308	0.241
MP1	0.349	0.264	-0.151	0.063	0.026	0.262	0.380	0.392	**0.937**	0.281	0.275
MP2	0.265	0.265	-0.051	0.023	0.158	0.234	0.273	0.330	**0.936**	0.196	0.155
MP3	0.204	0.186	-0.050	0.017	0.183	0.269	0.288	0.338	**0.925**	0.237	0.165
GITu1	0.228	0.482	-0.262	-0.011	0.219	0.505	0.329	0.554	0.307	**0.853**	0.311
GITu2	0.202	0.370	-0.086	-0.065	0.211	0.474	0.294	0.573	0.240	**0.903**	0.297
GITu3	0.161	0.295	-0.113	-0.166	0.174	0.406	0.321	0.520	0.131	**0.871**	0.266
GITe1	0.414	0.283	-0.262	0.100	-0.089	0.250	0.348	0.351	0.217	0.357	**0.838**
GITe2	0.395	0.254	-0.235	0.090	-0.182	0.181	0.433	0.289	0.177	0.286	**0.883**
GITe3	0.565	0.252	-0.051	0.043	-0.149	0.227	0.398	0.246	0.178	0.212	**0.828**

Notes: Relative advantage (RA); Compatibility (Comp); Complexity (CX); Organization size (OS); Geographic scope (GS); Expansion opportunities (EO); Coercive pressure (CP); Normative pressure (NP); Mimetic pressure (MP); GIT use (GITu); Intention to increase de GIT level (GITe).

Table 4. 1: PLS loadings and cross-loadings

	Alpha	CR	AVE	RA	Comp	Cx	OS	GS	EO	CP	NP	MP	GITu	GITe
RA	0.893	0.926	0.759	**0.871**										
Comp	0.741	0.836	0.564	0.404	**0.751**									
Cx	0.710	0.864	0.761	0.041	-0.130	**0.873**								
OS	1.000	1.000	1.000	0.264	0.026	-0.079	**NA**							
GS	1.000	1.000	1.000	-0.032	0.078	-0.166	0.208	**NA**						
EO	1.000	1.000	1.000	0.162	0.288	0.002	0.092	0.081	**NA**					
CP	0.829	0.896	0.742	0.317	0.233	0.049	0.027	-0.118	0.359	**0.861**				
NP	0.701	0.832	0.628	0.305	0.316	-0.072	0.107	0.075	0.489	0.517	**0.792**			
MP	0.927	0.953	0.870	0.302	0.257	-0.099	0.041	0.118	0.275	0.346	0.384	**0.933**		
GITu	0.848	0.908	0.767	0.227	0.441	-0.179	-0.089	0.231	0.530	0.360	0.628	0.262	**0.876**	
GITe	0.808	0.886	0.723	0.540	0.309	-0.213	0.091	-0.165	0.258	0.463	0.346	0.224	0.334	**0.850**

Notes: The diagonal in bold is the square root of the average variance extracted (AVE); Relative advantage (RA); Compatibility (Comp); Complexity (CX); Organization size (OS); Geographic scope (GS); Expansion opportunities (EO); Coercive pressure (CP); Normative pressure (NP); Mimetic pressure (MP); GIT use (GITu); Intention to increase the GIT level (GITe).

Table 4. 2: Descriptive statistics, correlations and AVE

4.5.2. Structural model

Analyzing the correlation table for evidence of multicollinearity among exogenous constructs in Table 4.2, showed that the highest correlation between exogenous constructs is 0.54. Variance inflation factor (VIF) are lower than 3, which is less than the conservative threshold of 5. The point suggests that there are no concerns of multicollinearity.

	GIT use		**Intention to increase the GIT level**	
	R^2=59.2%		**R^2=57.0 %**	
	Path coeff.	**t-Value**	**Path coeff.**	**t-Value**
Relative advantage (RA)	0.060	0.748	**0.416**	**3.688*** **
Compatibility (Comp)	**0.190**	**2.344** **	-0.008	0.083
Complexity (Cx)	-0.121	1.637	**-0.230**	**3.052*** **
Organization size (OS)	**-0.231**	**2.670*** **	-0.015	0.222
Geographic scope (GS)	**0.208**	**2.986*** **	**-0.171**	**2.207** **
Expansion opportunities (EO)	**0.268**	**3.516*** **	0.127	1.347
Coercive pressure (CP)	0.045	0.593	**0.251**	**2.744*** **
Normative pressure (NP)	**0.429**	**5.217*** **	-0.057	0.555
Mimetic pressure (MP)	-0.086	1.115	-0.024	0.257
GIT use (GITu)	-	-	0.088	0.860
CP*GITu	-	-	**-0.297**	**3.463*** **
NP*GITu	-	-	-0.011	0.124
MP*GITu	-	-	**0.157**	**1.924* **

Note: * Significant at p<0.10, ** Significant at p<0.05, *** Significant at p<0.01

Table 4. 3: Relevant constructs for the structural model

The analysis of the ten hypotheses was based on the examination of the standardized paths. The path significant levels were estimated using the bootstrapping method with 5000 re-samples and the results of the analysis are presented in Table 4.3. The examination of R^2 as a descriptive measure shows that the research model explains 59.2% of variation in GIT use and 57% of variation in intention to increase the GIT level of use.

The hypotheses on GIT use: compatibility (H2a) ($P<0.05$), geographical scope (H5a) ($P<0.01$), expansion opportunities (H6a) ($P<0.01$), and normative pressure (H8a) ($P<0.01$) are confirmed. The hypotheses relative advantage (H1a), complexity (H3a), organization size (H4a), coercive pressure (H7a), and mimetic pressure (H9a) are not confirmed.

The hypotheses on intention to increase the GIT level of use: relative advantage (H1b) ($P<0.01$), complexity (H3b) ($p<0.01$), coercive pressure (H7b) ($P<0.01$), coercive pressure moderate the effect of GIT use (H7c) ($P<0.01$), mimetic pressure moderate the effect of GIT use (H9c) ($P<0.10$), are confirmed. The hypotheses compatibility (H2b), organization size (H4b), geographical scope (H5b), expansion opportunities (H6b), normative pressure (H8b), mimetic pressure (H9b), normative pressure moderates the effect of GIT use (H8c) ($P>0.10$), and GIT use (H10) are not confirmed.

4.6. Discussion

GIT use

Continuous GIT use in an organization can be fostered by opening the organization to new business (expansion opportunities) and geographic (geographic scope) areas. The continuous use can be strengthened if the expansion is performed by maintaining current organization conditions which make GIT use compatible in the current technological context (compatibility). The use of GIT is also reinforced if the internal and external relations of a network of similar organizations develops an environment for sharing best practices and norms (normative pressure). Organizations that require GIT, use geographic information as a basis (or complement) for their normal functioning. In these cases, all expansion plans (new business or geographical area) will demand a stable technical environment that can promote the expansion opportunities as well as respond to norms established in the institutional setup of similar organizations. Expansion opportunities is not statistically significant on intention to increase the GIT level as many organizations don't include on their master plan of expansion the technology agenda. Compatibility variable contributes is only statistically significant on GIT use. On the other hand, the variable is not statistically significant on intention to increase GIT level. A system can be useful when it is compatible with other existing systems (Dedrick & West 2004; Zhu, Dong, et al. 2006; Chan & Chong 2012). Normative pressure usually come from indirect sources in one organization. The variable contributes to explain a positive impact for GIT use (Tornatzky & Fleischer 1990; Burt 1987; Dimaggio & Powell 1991). On the other hand, it is not statistically significant in continuity to use GIT because the policies and regulations are not promoting and motivating the organizations to increase the level of GIT.

The difficulty of certain aspects of the management of geographic information and geographic information technology increases with the dimension of the data sets and as well as with the intricacy of the institutional organization. These factors tend to increase with the size of the organizations and thus, organization size seems to negatively affect GIT use. Organization size variable proved to be statistically significant for GIT use because most of the companies that adopt these technologies are small (Zhu, Dong, et al. 2006; Lippert & Govindrajulu 2006; Lippeveld & Sapirie 2000). On the other hand, the hypothesis is not verified on intention to increase the GIT level because large organizations usually have a lot of procedures, policies and rules that may turn processes to be inefficient.

Intention to increase GIT level

The perception that an idea can bring advantages to an organization (relative advantage) together with an external technological environment (coercive pressure) create a technological context that is appropriate for the development of GIT. In many organizations and sectors where geographic information plays an important role such as in natural resource exploitation or transportation, innovation GIT can promote an increase in its use (Amade et al. 2017). The external environmental composed of different stakeholders that include, similar competitive organizations, the government and, in general, demanding clients, such as international donors, lead organizations to increase their level of GIT use (Amade et al. 2017). Relative advantage plays an important role in helping organizations to boost business activity. In our study the variable revealed to be not statistically significant for GIT use. It is only statistically significant for increase the GIT level in organization (Ruivo et al. 2014; Rogers 1995; Zhu, Dong, et al. 2006). Coercive pressure represents the internal and external forces that the organizations facing. It contributes to explain the positive impact to increase the intention of GIT level (Tornatzky & Fleischer 1990; Dimaggio & Powell 1991). The variable is not statistically significant on GIT use because the organization may be assuming that it has all the needed skills, competences and technology to run the business, in order to face the competitors and industry.

In the same way that organization size has a negative effect on GIT use, complexity will also negatively influence the intention to increase GIT level. As the applications of geographic information get more specialized and establish different relationships with the diverse information systems from the various organization sectors, they will get more technically complex as well. Innovations proposed for these systems are perceived as difficult to implement and thus, will play a negative role in the intention to increase GIT use. Complexity is not statistically significant on GIT use which satisfies the hypothesis. Complex systems are oftentimes put aside in organizations because they are not user friendly and sometimes not compatible (Rogers 1995; Ruivo et al. 2014). On the other hand, the results proved that complexity variable is statistically significant to increase the GIT level, contradicting the hypothesis. The reason lies on complex system many times offer security and stability for the organization.

It is interesting to observe that in the organizational context, geographic scope, organizations find it necessary to use GIT in order to manage their assets, processes and business models that are spread throughout a territory. It is thus natural to expect that geographical scope would positively influence both GIT use and intention to use GIT level. While the former is true, the latter revealed instead to have a negative impact. This could be explained by the fact that an increase in geographical scope will necessarily increase the complexity of the systems to be developed, the business processes and respective workflows. Furthermore, it also contributes in a negative way in intention to increase the GIT level over organizations that have their branches thousands kilometers away (Zhu, Dong, et al. 2006). This dispersed situation may lead to an increase in difficulty to control growth of GIT level GIT level.

Mimetic pressure variable does not have a positive impact over the use and intention to increase the GIT level. For this scenario, the adoption of technology doesn’t reflect the aims of the organization (Teo et al. 2003).The variable does not meet the hypotheses declared because many times the industry plays a different role from the organization master plan, vision and policies.

The model demonstrated that the environment context variables moderates the relation between use and intention to continue use. Through the Figures 4.2 and 4.3, it is possible to identify that the pressure can help to explain the intention to increase the GIT use. From the Figure 4.2, we can see that in a context of low coercive pressure the GIT use has a positive effect on intention to increase GIT use. In the opposite for high coercive pressure GIT use has a negative effect on intention to increase GIT use. From the Figure 4.3, we can see that in a context of high mimetic pressure GIT use has a positive effect on intention to increase GIT use. In the opposite for low mimetic pressure context the GIT use has a negative effect on intention to increase GIT use.

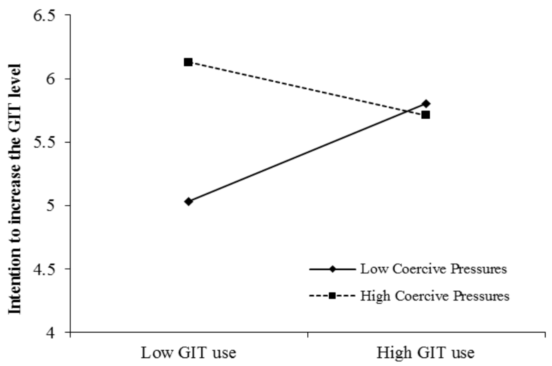


Figure 4. 2: The moderate effect of coercive pressure on GIT use over continuity use of GIT

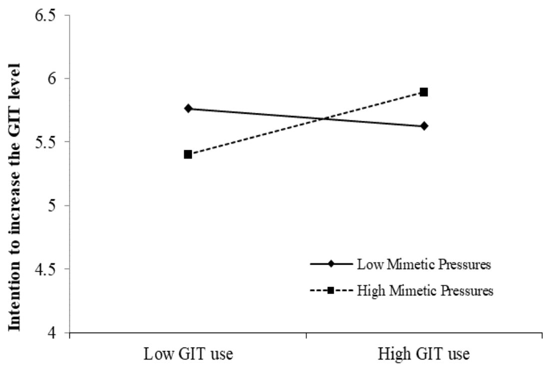


Figure 4. 3: The moderate effect of mimetic pressure on GIT use over continuity use of GIT

4.6.1. Theoretical implications

The theoretical contributions of this study is that it pushes the edge of GIT post-adoption research further out to institutions by understanding what determine the continuity of users to keep using GIT in a post-adoption stage. In this study we contribute to the information technology (IT) field in a post-adoption stage by providing empirical and practical evidence. An important implication of this study lies the strengths of the newer model used to explain the post-adoption of GIT in Mozambican institutions. Other important implication lies in a new model be used as a vehicle to study in a specific type of institution (public, private or NGO) and be target to other African countries and in the end creates a comparative study based on different realities. To be able to come up with a feasible research model, the researchers combined three models and theories that works at institutional level namely, DOI theory, TOE framework, and institutional theory. The research model is composed with ten hypotheses. Future studies can extend to these determinants by integrating and combining with existing adoption models and exposed in different realities (institutions and countries).

4.6.2. Managerial implications

Through the study is possible to show some implications. To start, the study bring important characteristics for post adoption of GIT that managers have to analyze. The variables declared on the study, relative advantage, compatibility, complexity, organization size, geographical scope, expansion opportunities, coercive pressure, normative pressure, mimetic pressure are subjects of consideration for managers on concerning to GIT use and increase the GIT level. The study also covers three contexts, technological, organization, and environment contexts. Top managers from institutions/organizations need to put it into consideration. The results demonstrated a critical role that the variables compatibility, organization size, geographical scope, expansion opportunities and normative pressure are contributing to explain the GIT use. On the other hand, the variables relative advantage, complexity, geographical support, coercive pressure, and the moderation effect of mimetic pressure on GIT use are pointing to explain the intention to increase the GIT level. To better run the organization, managers have to understand the role of each variable.

4.6.3. Limitations and further research

Our research has some limitations. The first limitation inherits from a tool that the researchers used (online survey). The current study does not include users who do not use e-mail address, thus a segment of potential users was not able to cover. The second limitation was related to the process of acquiring the potential e-mail addresses and the way the process takes places, for Mozambique still a big challenge to have all contacts of institutions updated in the internet or in a database. The third limitation found was related to the terminology of our research, the GIT still a new technology for Mozambique and many users still on the process to assimilate the technologies. Another limitation is related to the target group, Mozambican institutions that started to use this technologies in the last years. While the limitations were identified, it'll not influence on the results of the study. The research model is focus in understanding the determinants that takes GIT to post-adoption stages in Mozambican institutions. We encourage additional studies that focus on the continuity of use GIT in Mozambican institutions. The study targets public, private and non-governmental institutions, thus, we encourage further studies to a specific type of institution with more than one country in order to cross data between countries.

4.7. Conclusion

Geographical information technologies (GIT) boosts the way processes and data are collected, stored, manipulated, analyzed, processed and presented in organizations. This study sought to understand the determinants of GIT post adoption in Mozambican institutions based on a research model that combines three theoretical models, DOI theory, TOE framework, and institutional theory. The results on GIT use show that compatibility, geographical scope, expansion opportunities, and normative pressure contributes in a positivity way and are confirmed. The remaining hypotheses are not confirmed on GIT use. On the other hand, the hypotheses relative advantage, complexity, coercive pressure, mimetic pressure contributes in a positive way to explain the intention to increase the GIT level of use and are confirmed. The remaining hypotheses was not confirmed. We can conclude that the drivers for GIT use are not the same of drivers for intention to increase the GIT level. From these results we can figure out that future research should analyses different adoption stage to better understanding of GIT diffusion process. Coercive and mimetic pressure moderate the effect of use on intention to increase GIT use. Our study also demonstrates the importance of moderator’s effects on intention to increase the GIT level. Finally, the model explains 59.2% of variation in GIT use and 57.0% of variation in intention to increase the GIT level that reveals that our model has a substantial power of explanation for the GIT post-adoption.

Chapter 5 – Conclusions

Geographic information technologies has been defined, interpreted and study in several ways including their use as decision support systems and as integrated backbones for the organizational information systems.

Mozambique adopt these technologies after the independence, and four decades later these technologies have been spread all over the country.

The purpose of these work is be able to understand the drivers behind their adoption, use and continuity of use by increasing the levels of GIT. Our work main findings, contributions, and limitations are presented as follow.

5.1. Summary of findings

Our study is supported the importance to understand the drivers behind the adoption of geographic information technologies in institutions, their use and continuity of use by increasing the levels of use applied for Mozambique context. Having that in mind, three studies were developed and presented in the previous chapters (two, three and four).

In chapter two the study seeks to understand the main drivers and uses of geographic information technologies in organizations and give an overview of the usage of these technologies in developing countries with focus on a case study for Mozambique. The main drivers of GIT use by organizations are compatibility, competitive pressure, complexity, donor pressure, government policy, intention to adopt, innovation, relative advantage, security, and technology competence, with compatibility and technology competence being the mains ones. Organizations of the public and private sectors use GIT for customer management, decision support, education, monitoring, prediction, research, resource management, risk management, simulation, suitability analysis, sustainability, use and, access. Our study also finds that the Mozambique public sector has been more present in the environment, economic development, education, and agriculture domains, while the private sector has more weight in transportation, health, services, ICT, and natural resources. Education is the sector with the most GIT use in Mozambique followed by the environment. The model explains 54.4% of the variation in intention to adopt GIT and 62.3% of the variation in the GIT adoption, revealing that our model has a substantial power of explanation.

In chapter three, the purpose of the study was related to investigate the drivers behind the adoption of GIT at two stages of adoption (intention and adoption) applied to Mozambique context. The study identify that technology competence, security, competitive pressure, are important drivers to explain the intention to adopt GIT. Financial concerns, government policies, donor pressure, and intention to adopt are important drivers to explain adoption of GIT. The donor pressure is the only driver that is statistically significant in both intention to adopt GIT and adoption of GIT.
In chapter four, the main goal of the study were to understand the determinants behind the post-adoption of GIT in Mozambique institutions. In the study we seek also what takes institutions to continue use these technologies and increase the level of use. The variables compatibility, geographical scope, expansion opportunities, and normative pressure contribute to explain the GIT use. The relative advantage, complexity, coercive pressure and mimetic pressure contribute to explain the intention to increase the GIT level of use. The model explains 59.2% of variation in GIT use and 57.0% of variation in intention to increase the GIT level, revealing that our model has a substantial power of explanation for the GIT post-adoption.

5.2. Main contributions

This work provides several contributions for research, practice, advancement of knowledge, for experts in the field of these technologies, society and institutions.

In chapter two, through a literature review a synthesis of findings from existing research of geographical information technologies was presented. As far as we know, it is the first time that a study with focus for Mozambican context is made in geographical information technologies, contributing to a concise view and comprehension of these technologies and their potentialities.

In chapter three, we seek to understand the drivers behind the adoption GIT at two stages (intention and adoption) applied for Mozambique context. Through an integrated framework resulting from a combination of DOI theory, TOE framework and police context (introduced as a third element in order to enrich and explain the model, in light of the consideration that the variables donor pressure and government policies seem to be playing a key role in motivating organizations to adopt new technologies.), it was possible to explain the drivers behind GIT adoption. Financial concerns, government policies, and donor pressure mostly explain adoption of GIT. The donor pressure proved to be the only construct that explains both intention to adopt GIT and the adoption of GIT.

In chapter four, the main goal was to understand the determinants behind GIT at post-adoption stage for Mozambique institutions. A research model have been proposed through a combination of DOI theory, TOE framework and institutional theory. The model reveals substantial power of explanation for GIT post-adoption. The model explains 59.2% of variation in GIT use and 57% of variation in intention to increase the GIT level.

For researchers the work developed and presented in chapters two, three and four, provides a basis for future research's in the field of geographic information technologies applied for Mozambique. For practitioners, understanding the key elements that drives the adoption of these technologies is crucial because it can determines the next steps. Further research and work in GIT are still needed to confirm and refine the main conclusions identified in our studies.

5.3. Limitations and future work

The study has several limitations requiring further analysis and additional research. As any research, care actions should be taken into consideration. The theoretical models proposed need to be replicated with different samples, environments and contexts. Introducing new variables and contexts, could reinforce the results and bring new perspectives. The other limitation inherits from the tool that the researchers used (online survey). The current study does not include users who do not use e-mail address, thus a segment of potential users was not able to cover. The process of acquiring the potential e-mail addresses was conducted in a very hard way, institutions in majority are making available outdated contacts. The tool used to process information (PLS), still new approach that bring several advantages but at same time some inconsistencies, not yet explored. Finally, the terminology of our study still a new for Mozambique and many users still on the process to assimilate the technology.

Chapter 6 - References

Abbott, J., 2003. The use of GIS in informal settlement upgrading: its role and impact on the community and on local government. *Habitat International*, 27(4), pp.575–593. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0197397503000067.

Abdollahzadehgan, A. et al., 2013. The organizational critical success factors for adopting cloud computing in SMEs. *Journal of Information Systems Research and Innovation*, 4(1), pp.67–74.

Abdulaal, W.A., 2009. Framework for enterprise GIS for Saudi municipalities. *International Journal of Geographical Information Science*, 23(6), pp.687–702. Available at: http://www.tandfonline.com/doi/abs/10.1080/13658810701378838.

Aboelmaged, M.G., 2014. Predicting e-readiness at firm-level: An analysis of technological, organizational and environmental (TOE) effects on e-maintenance readiness in manufacturing firms. *International Journal of Information Management*, 34(5), pp.639–651.

Abubakar, B. et al., 2014. Adoption of free open source geographic information system solution for health sector in Zanzibar Tanzania. *Journal of Health Informatics*, 8(1), pp.1–11. Available at: http://jhidc.org/index.php/jhidc/article/view/110.

Ajah, I. & Inyiama, C., 2011. Loan fraud detection and IT-based combat strategies. *Journal of Internet Banking and Commerce*, 16(2).

Ajzen, I., 1985. From intentions to actions: A theory of planned behavior. In *Action control: From cognition to behavior*. pp. 11–39. Available at: http://link.springer.com/book/10.1007/978-3-642-69746-3.

Ajzen, I. & Fishbein, M., 2005. The influence of attitudes on behaviour. In *The Handbook of Attitudes*. pp. 173–221.

Al-Kodmany, K., 2012. Utilizing GIS in Nonprofit Organizations for Urban Planning Applications: Experiences from the Field. *Journal of Geographic Information System*, 4(4), pp.279–297. Available at: http://www.scirp.org/journal/PaperDownload.aspx?DOI=10.4236/jgis.2012.44034.

Alibrandi, M. & Palmer-Moloney, J., 2001. Making a place for technology in teacher education with geographic information systems (GIS). *Contemporary Issues in Technology and Teacher Education*, 1(4), pp.483–500. Available at: http://www.editlib.org/p/10739.

Amade, N. & Painho, M., 2011. Google earth como ferramenta didáctica - Um estudo de caso numa escola secundária. *REID*, pp.1–14. Available at: http://reid.ucm.ac.mz/index.php/reid/article/view/6.

Amade, N., Painho, M. & Oliveira, T., 2017. Determinants of Geographic

Information Technologies Intention and Adoption and Mozambique Institutions' Perspectives. *Research Journal of Information Technology*, 9(2), pp.64–73. Available at: http://www.scialert.net/abstract/?doi=rjit.2017.64.73.

Armenakis, C. & Nirupama, N., 2012. Prioritization of disaster risk in a community using GIS. *Natural Hazards*, pp.15–29.

Balram, S. & Dragićević, S., 2008. Collaborative spaces for GIS-based multimedia cartography in blended environments. *Computers & Education*, 50(1), pp.371–385. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0360131506001114.

Bandyopadhyay, S. et al., 2009. Assessment of land suitability potentials for agriculture using a remote sensing and GIS based approach. *International Journal of Remote Sensing*, 30(4), pp.879–895. Available at: http://www.tandfonline.com/doi/abs/10.1080/01431160802395235.

Bansal, V.K., 2007. Potential of GIS to find solutions to space related problems in construction industry. *Proceedings of World Academy of Science Engineering Technology*, 136119, pp.307–310. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=28543451&lang=es&site=ehost-live.

Batarlienė, N., 2007. Implementation of advanced technologies and other means in dangerous freight transportation. *Pažangių technologijų ir kitų priemonių diegimas vežant pavojinguosius krovinius.*, 22(4), pp.290–295. Available at: http://proxy-remote.galib.uga.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=30058222&site=ehost-live.

Benlian, A. & Hess, T., 2011. Opportunities and risks of software-as-a-service: Findings from a survey of IT executives. *Decision Support Systems*, 52(1), pp.232–246.

Bergher, I. et al., 2015. GIS tools use to identify routes for ecological corridors formation between Atlantic forest (Mata Atlântica) fragments in the south region OFESPÍRITO Santo, Brazil. *Australian Journal of Basic and Applied Sciences*, 9(20), pp.273–281. Available at: http://www.mundogeomatica.com.br/Publicacoes/Artigo_70.pdf.

Berisso, Z.A. & de Vries, W.T., 2010. Exploring Characteristics of GIS adoption decisions and type of induced changes in developing Countries: The case of Ethiopia. *The Electronic Journal of Information Systems in Developing Countries*, 40(2), pp.1–16.

Bertazzon, S., 2014. GIS and Public Health. *ISPRS International Journal of Geo-Information*, 3(3), pp.868–870. Available at: http://www.mdpi.com/2220-9964/3/3/868/.

Burt, R., 1987. Social Contagion and Innovation. *American Journal of Sociology*, 92(6), pp.1287–1335. Available at: http://www.jstor.org/stable/2779839.

Carsjens, G.J. & Ligtenberg, A., 2007. A GIS-based support tool for sustainable spatial planning in metropolitan areas. *Landscape and Urban Planning*, 80(1–2), pp.72–83.

Chainey, S. & Ratcliffe, J., 2013. *GIS and Crime Mapping*,

Chan, E.Y. & Saqib, N.U., 2015. Online social networking increases financial risk-taking. *Computers in Human Behavior*, 51, pp.224–231. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0747563215003647.

Chan, F.T.S. & Chong, A.Y.-L., 2013. Determinants of mobile supply chain management system diffusion: a structural equation analysis of manufacturing firms. *International Journal of Production Research*, 51(4), pp.1196–1213. Available at: http://www.tandfonline.com/doi/abs/10.1080/00207543.2012.693961.

Chan, F.T.S. & Chong, A.Y.L., 2012. A SEM-neural network approach for understanding determinants of interorganizational system standard adoption and performances. *Decision Support Systems*, 54(1), pp.621–630.

Chau, P.Y.K. & Tam, K.Y., 1997. Factors Affecting the Adoption of Open Systems: An Exploratory Study. *MIS Quarterly*, 21(1), pp.1–24.

Chen, X., Wu, H. & Tri, T.M., 2012. Field strength prediction of mobile communication network based on GIS. *Geo-spatial Information Science*, 15(3), pp.199–206. Available at: http://www.tandfonline.com/doi/pdf/10.1080/10095020.2012.720457.

Chen, Y., Yu, J. & Khan, S., 2010. Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. *Environmental Modelling & Software*, 25(12), pp.1582–1591. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1364815210001842.

Chin, W.W., 1998. Issues and Opinion on Structural Equation Modeling. *MIS Quarterly*, 22(1), p.1.

Chirowodza, A. et al., 2009. Using participatory methods and geographic information systems (GIS) to prepare for an HIV community-based trial in vulindlela, South Africa (project accept-HPTN 043). *Journal of Community Psychology*, 37(1), pp.41–57.

Chong, A.Y.-L. & Chan, F.T.S., 2012. Structural equation modeling for multi-stage analysis on radio frequency identification (RFID) diffusion in the health care industry. *Expert Systems with Applications*, 39(10), pp.8645–8654.

Christian, N., 2002. *Exploring Geographic Information Systems*, John Wiley & Sons, Inc.

Cilliers, D.P., De Klerk, T.C. & Sandham, L.A., 2013. Reflecting on GIS-related research in South Africa: 1980–2012. *South African Geographical Journal*, 95(1), pp.70–90. Available at: http://www.tandfonline.com/doi/abs/10.1080/03736245.2013.806106.

Claus, S. et al., 2014. Marine Regions: Towards a Global Standard for Georeferenced Marine Names and Boundaries. *Marine Geodesy*, 37(2), pp.99–125. Available at: http://dx.doi.org/10.1080/01490419.2014.902881.

Clemens, B.W. & Douglas, T.J., 2005. Understanding strategic responses to institutional pressures. *Journal of Business Research*, 58(9 SPEC. ISS.), pp.1205–1213.

Cooper, R.B. & Zmud, R.W., 1990. Information Technology Implementation Research: A Technological Diffusion Approach. *Management Science*, 36(2), pp.123–139.

Cowper, D. et al., 2004. Using GIS in Government: An Overview of the VHA's Healthcare Atlas, FY-2000. *Journal of Medical Systems*, 28(3), pp.257–269. Available at: http://link.springer.com/10.1023/B:JOMS.0000032843.52406.2f.

D Macredie, R. & Mijinyawa, K., 2011. A theory-grounded framework of Open Source Software adoption in SMEs. *European Journal of Information Systems*, 20(2), pp.237–250. Available at: http://link.springer.com/10.1057/ejis.2010.60.

Dambach, P. et al., 2012. Utilization of combined remote sensing techniques to detect environmental variables influencing malaria vector densities in rural West Africa. *International journal of health geographics*, 11(1), p.8. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84858742605&partnerID=tZOtx3y1.

Davis, F.D., 1985. *A technology acceptance model for empirically testing new end-user information systems: Theory and results*. Available at: http://en.scientificcommons.org/7894517.

Dedrick, J. & West, J., 2004. An exploratory study into open source platform adoption. In *37th Annual Hawaii International Conference on System Sciences, 2004. Proceedings of the*. p. 10 pp. Available at: http://ieeexplore.ieee.org/document/1265633/.

Demirci, A., Karaburun, A. & Ünlü, M., 2013. Implementation and Effectiveness of GIS-Based Projects in Secondary Schools. *Journal of Geography*, 112(5), pp.214–228. Available at: http://www.tandfonline.com/doi/abs/10.1080/00221341.2013.770545.

Dimaggio, P. & Powell, W., 1991. The new institutionalism in organizational analysis. *The International Encyclopedia of Organization Studies*, pp.144–145. Available at: http://web.stanford.edu/group/song/papers/NewInstitutionalism.pdf.

Dong-Ju, C., 2013. Whither should ICT4D go in Africa? *African Affairs*, 33(1), pp.227–246.

Drummond, W.J. & French, S.P., 2008. The Future of GIS in Planning: Converging Technologies and Diverging Interests. *Journal of the American Planning Association*, 74(2), pp.161–174. Available at: http://www.tandfonline.com/doi/pdf/10.1080/01944360801982146#.VU9sMdyBpxg.

Duval-Diop, D., Curtis, A. & Clark, A., 2010. Enhancing equity with public participatory GIS in hurricane rebuilding: faith based organizations, community mapping, and policy advocacy. *Community Development*, 41(1), pp.32–49.

Elwood, S., 2006. Beyond cooptation or resistance: Urban spatial politics, community organizations, and GIS-based spatial narratives. *Annals of the Association of American Geographers*, 96(2), pp.323–341.

Eslami, A. et al., 2011. Implementation of GIS in natural resources. *Annals of Biological Research*, 2(5), pp.533–540. Available at: http://scholarsresearchlibrary.com/ABR-vol2-iss5/ABR-2011-2-5-533-540.pdf.

ESRI, 2002. *GIS for Africa ESRI Brings International Communities Together*, Available at: http://www.esri.com/library/brochures/pdfs/gis-for-africa.pdf.

European Commission, 2015. What is an SME? Available at: http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/index_en.htm [Accessed December 10, 2015].

FAO, 2015. Mozambique. Available at: http://www.fao.org/mozambique/fao-in-mozambique/en/ [Accessed December 9, 2015].

Feng, G.C., 2015. Factors affecting Internet diffusion in China: A multivariate time series analysis. *Telematics and Informatics*, 32(4), pp.681–693. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0736585315000210.

Fichman, Robert, G., 2000. The Diffusion and Assimilation of Information Technology Innovations. *Framing the Domains of IT Management*, pp.105–127. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.24.4539&rep=rep1&type=pdf.

Fishbein, M. & Ajzen, I., 1975. *Belief, attitude, intention and behaviour: An introduction to theory and research*, Available at: http://people.umass.edu/aizen/f&a1975.html.

Fornell, C. & Larcker, D.F., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research (JMR). Feb1981*, 18(1), p.39–50. 12p. 1 Diagram.

Foster, V. & Dominguez, C., 2011. *Zambia's infrastructure: A continental perspective*, The World Bank. Available at: http://www.ppiaf.org/sites/ppiaf.org/files/publication/AICD-Mozambique-country-report.pdf.

Foxon, T. & Pearson, P., 2008. Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime. *Journal of Cleaner Production*, 16(1 SUPPL. 1), pp.148–161.

Freire, N., 2004. *O geonegócio - as geotecnologias e a emergência de novos mercados em regiões periféricas: o caso de Maceió - AL*. Available at: http://hdl.handle.net/123456789/6070.

Gabriela, L. & Ph, D., 2010. Geographical Information Systems - Applicability in Investments and Banking. *Annals of Computational Economics*, 2(38), p.8.

Available at: http://feaa.ucv.ro/annals/v2_2010/0038v2-030.pdf.

Gareeb, P.P. & Naicker, V., 2015. Determinants for South African SMEs to adopt broadband internet technologies. *Electronic Journal of Information Systems in Developing Countries*, 68.

Ghobakhloo, M., Arias-Aranda, D. & Benitez-Amado, J., 2011. *Adoption of e-commerce applications in SMEs*,

Gold, C.M. & Condal, A.R., 1995. A spatial data structure integrating GIS and simulation in a marine environment. *Marine Geodesy*, 18(3), pp.213–228. Available at: http://www.tandfonline.com/doi/abs/10.1080/15210609509379757.

Gotz, C., Frates, J. & Weschler, S., 2009. Geographic Information Systems (GIS) In Health Organizations : Emerging Trends for Professional Education. *Health (San Francisco)*, 49, pp.87–106.

Gutiérrez, J., González, R. & Gómez, G., 1996. The European high-speed train network. *Journal of Transport Geography*, 4(4), pp.227–238. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0966692396000336.

Hair, J.F. et al., 2012. An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science*, 40(3), pp.414–433.

Hameed, M.A., Counsell, S. & Swift, S., 2012. A conceptual model for the process of IT innovation adoption in organizations. *Journal of Engineering and Technology Management - JET-M*, 29(3), pp.358–390. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84861810490&partnerID=40&md5=a70d5216fa0d037eae17d6626d3feba3.

Harrison, T. et al., 2007. Geographic information technologies, structuration theory, and the world trade center crisis. *Journal of the American Society for Information Science and Technology*, 58(14), pp.2240–2254.

Harvey, F. & Chrisman, N., 1998. Boundary objects and the social construction of GIS technology. *Environment and Planning A*, 30(9), pp.1683–1694. Available at: http://epn.sagepub.com/lookup/doi/10.1068/a301683.

Hasmadi, I.M. & Imas, S.S., 2010. Journal of GIS Trends. *Journal of GIS Trends*, 1(1), pp.1–7.

Haule, C., Mlozi, M. & Mulengera, M., 2009. The pattern and magnitude of land use/cover change in three wards of Ludewa district, Tanzania and its implications to smallholder farmers' livelihoods. *African Affairs*, 25(1), pp.31–58.

Hendriks, P.H.J., 2000. An organizational learning perspective on GIS. *International Journal of Geographical Information Science*, 14(4), pp.373–396. Available at: http://www.tandfonline.com/doi/abs/10.1080/136588100500242 96.

Henseler, J., Ringle, C.M. & Sinkovics, R.R., 2009. The use of Partial Least Squares Path Modeling in International Marketing. *Advances in International Marketing*, 20, pp.277–319. Available at: http://eprints.lancs.ac.uk/47737/.

Henttu, H., Izaret, J.M., & Potere, D., 2012. Geospatial services : A $ 1.6 trillion growth engine for the U.S. economy. *Boston Consulting Group*, (June), pp.1–4. Available at: https://www.bcg.com/documents/file109372.pdf.

Hill, R.J., Fishbein, M. & Ajzen, I., 1977. Belief, attitude, intention and behavior: An introduction to theory and research. *Contemporary Sociology*, 6(2), p.244.

Hong, J.E., 2014. Promoting Teacher Adoption of GIS Using Teacher-Centered and Teacher-Friendly Design. *Journal of Geography*, 113(4), pp.139–150. Available at: http://www.tandfonline.com/doi/abs/10.1080/00221341.2013.872171.

Hooper, D., Coughlan, J. & Mullen, M., 2008. Structural Equation Modelling : Guidelines for Determining Model Fit Structural equation modelling : guidelines for determining model fit. *Dublin Institute of Technology ARROW @ DIT*, 6(1), pp.53–60.

Horler, D. & Barber, J., 1981. Plants and the daylight spectrum. Principles of remote sensing of plants. *London: Academic press*, pp.43–63.

Hwang, S., 2013. Placing GIS in sustainability education. *Journal of Geography in Higher Education*, 37(2), pp.276–291. Available at: http://www.tandfonline.com/doi/abs/10.1080/03098265.2013.769090.

IST-Africa Consortium, 2012. *Guide to ICT Policy in IST-Africa Partner Countries*, Available at: http://ist-africa.org/home/files/IST-Africa_ICTPolicy_200412.pdf.

Jafrullah, M. & Uppuluri, S., 2003. An integrated approach for banking GIS. *Map India ...*. Available at: http://www.gisdevelopment.net/application/business/pdf/140.pdf.

Jankowski, P. & Nyerges, T., 2001. *GIS for group decision making*, Available at: http://books.google.com/books?hl=en&lr=&id=C37k7BVZtHgC&pgis=1.

Javadian, M., Shamskooshki, H. & Momeni, M., 2011. Application of Sustainable Urban Development in Environmental Suitability Analysis of Educational Land Use by Using Ahp and Gis in Tehran. *Procedia Engineering*, 21, pp.72–80. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877705811048235.

Javaheri, H. et al., 2006. Site selection of municipal solid waste landfills using analytical hierarchy process method in a geographical information technology environment in giroft 1. , 3(3), pp.177–184.

Joyce, K., 2009. “To me it’s just another tool to help understand the evidence”: Public health decision-makers’ perceptions of the value of geographical information systems (GIS). *Health & Place*, 15(3), pp.831–840. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1353829209000112.

Kaplan, E. & Hegarty, C., 2005. *Understanding GPS: principles and applications* 2nd ed., Artech house.

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

http://www.tandfonline.com/doi/abs/10.1080/13658810412331280149.

Kawamura, Y. et al., 2014. Using GIS to develop a mobile communications network for disaster-damaged areas. *International Journal of Digital Earth*, 7(4), pp.279–293. Available at: http://www.tandfonline.com/doi/abs/10.1080/17538947.2013.808277.

Kim, M. & Bednarz, R., 2011. GIS education for teachers in South Korea : Who participates and why ? *Korean Geographical Society*, 46(3), pp.382–395. Available at: http://www.kgeography.or.kr/homepage/kgeography/www/old/publishing/journal/46/03/11.PDF.

Kistemann, T., Dangendorf, F. & Schweikart, J., 2002. New perspectives on the use of Geographical Information Systems (GIS) in environmental health sciences. *International Journal of Hygiene and Environmental Health*, 205(3), pp.169–181. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1438463904701431.

Korucu, M.G., 2012. GIS and Types of GIS Education Programs. *Procedia - Social and Behavioral Sciences*, 46, pp.209–215. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877042812012244.

Kulawiak, M., Chybicki, A. & Moszynski, M., 2010. Web-Based GIS as a Tool for Supporting Marine Research. *Marine Geodesy*, 33(2–3), pp.135–153. Available at: http://www.tandfonline.com/doi/abs/10.1080/01490419.2010.492280.

Lateh, H. & Muniandy, V., 2010. ICT implementation among Malaysian schools: GIS, obstacles and opportunities. *Procedia - Social and Behavioral Sciences*, 2(2), pp.2846–2850. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877042810004660.

Lee, G. & Xia, W., 2006. Organizational size and IT innovation adoption: A meta-analysis. *Information and Management*, 43(8), pp.975–985.

Lee, S. & Kim, K., 2007. Factors affecting the implementation success of Internet-based information systems. *Computers in Human Behavior*, 23(4), pp.1853–1880. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0747563205000944.

Levine, A.S. & Feinholz, C.L., 2015. Participatory GIS to inform coral reef ecosystem management: Mapping human coastal and ocean uses in Hawaii. *Applied Geography*, 59, pp.60–69. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0143622814002884.

Li, H. & Liu, Y., 2014. Understanding post-adoption behaviors of e-service users in the context of online travel services. *Information & Management*, 51(8), pp.1043–1052. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0378720614000883.

Liang, H. et al., 2007. Assimilation of Enterprise Systems: the Effect of Institutional Pressures and the Mediating Role of Top Management 1. *Assimilation of Enterprise Systems MIS QuarterlyAssimilation of Enterprise Systems Quarterly*, 31(1), pp.59–87.

Lippert, S.K. & Forman, H., 2005. Utilization of Information Technology: Examining Cognitive and Experiential Factors of Post-Adoption Behavior. *IEEE Transactions on Engineering Management*, 52(3), pp.363–381. Available at: http://ieeexplore.ieee.org/document/1468406/.

Lippert, S.K. & Govindrajulu, C., 2006. Technological, Organizational, and Environmental Antecedents to Web Services Adoption. *Communications of the IIMA*, 6(1), pp.146–158.

Lippeveld, T. & Sapirie, S., 2000. 14 approaches to strengthening health information systems. *Design and implementation of health information systems*, pp.243–252. Available at: http://www.uio.no/studier/emner/matnat/ifi/INF5761/v12/undervisningsmateriale/Lippeveld and Sapirie - 2001 - Approaches to strengthening health information sys.pdf.

Liu, H. & Wei, Y., 2010. The Application of Web GIS in E-Government. In *2010 International Conference on E-Business and E-Government*. IEEE, pp. 519–522. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5590665.

Lloyd, W.J., 2001. Integrating GIS into the Undergraduate Learning Environment. *Journal of Geography*, 100(5), pp.158–163. Available at: http://www.tandfonline.com/doi/abs/10.1080/00221340108978443.

Lopes, R.H.C., 2011. Kolmogorov-Smirnov Test. In *International Encyclopedia of Statistical Science*. pp. 718–720. Available at: http://link.springer.com/10.1007/978-3-642-04898-2_326.

Low, C., Chen, Y. & Wu, M., 2011. Understanding the determinants of cloud computing adoption. *Industrial Management & Data Systems*, 111(7), pp.1006–1023. Available at: http://www.emeraldinsight.com/doi/10.1108/02635571111161262.

Ma, Y. et al., 2009. A Framework for Performance Evaluation of Communication Alternatives for Intelligent Transportation Systems. *Journal of Intelligent Transportation Systems*, 13(3), pp.111–126. Available at: http://www.tandfonline.com/doi/abs/10.1080/15472450903084212.

MacDonald, E.H., 2001. GIS in banking: Evaluation of Canadian bank mergers. *Canadian Journal of Regional Science*, 24(3), pp.419–442. Available at: Publisher's%5CnURL.

Mahboubi, P. et al., 2015. Using expert informed GIS to locate important marine social-ecological hotspots. *Journal of Environmental Management*, 160, pp.342–352. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0301479715300037.

Mahesh, A., Zellner, M.L. & Zielinski, S., 2011. Emerging Private Sector Roles in Urban Transport: A Case Study of an Innovative Telecom-GIS Solution in Bangalore. *Journal of Urban Technology*, 18(3), pp.67–80. Available at:

http://www.tandfonline.com/doi/abs/10.1080/10630732.2011.615568.

Mahmoud, M.S.A. et al., 2015. Development of health care systems in subareas of KSA using GIS concept. *Journal of Information Sciences and Computing Technologies*, 1(1).

Mashimbye, Z.E. et al., 2012. Model-Based Integrated Methods for Quantitative Estimation of Soil Salinity from Hyperspectral Remote Sensing Data: A Case Study of Selected South African Soils. *Pedosphere*, 22(5), pp.640–649. Available at: http://dx.doi.org/10.1016/S1002-0160(12)60049-6.

Mati, B.M. et al., 2000. Assessment of erosion hazard with the USLE and GIS: A case study of the Upper Ewaso Ng'iro North basin of Kenya. *International Journal of Applied Earth Observation and Geoinformation*, 2(2), pp.78–86. Available at: http://dx.doi.org/10.1016/S0303-2434(00)85002-3.

McLafferty, S.L., 2003. GIS AND HEALTH CARE. *Annual Review of Public Health*, 24(1), pp.25–42. Available at: http://publhealth.annualreviews.org/cgi/doi/10.1146/annurev.publhealth.24.012902 .141012.

Mellino, S., Buonocore, E. & Ulgiati, S., 2015. The worth of land use: A GIS–emergy evaluation of natural and human-made capital. *Science of The Total Environment*, 506–507, pp.137–148. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0048969714015307.

Mentis, D. et al., 2015. Assessing the technical wind energy potential in africa a GIS-based approach. *Renewable Energy*, 83, pp.110–125.

Michael Barrett, Sundeep Sahay, G., 2001. Information Technology and Social Transformation: GIS for Forestry Management in India. *The Information Society*, 17(1), pp.5–20. Available at: http://192.73.31.230/ContentServer/FullTextServer.asp?format=fulltext&ciid=071D4FBFF63798B1FED14F1D141FC153514AF0301A93245BD7669A85EDBA594865433D6AF4BBDB7B&ftindex=1&ext=.pdf.

Millock, K., Xabadia, A. & Zilberman, D., 2012. Policy for the adoption of new environmental monitoring technologies to manage stock externalities. *Journal of Environmental Economics and Management*, 64(1), pp.102–116. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0095069612000344.

Mkiramwinyi, F.O. et al., 2009. Identification of potential sites for rainwater harvesting using remote sensing and GIS in the Makanya river catchment, Same district, northern Tanzania. *African Affairs*, 25(1), pp.169–184.

Moçambique, R. de, 2010. Programa Quinquenal do Governo para 2010 - 2014. Available at: http://www.mpd.gov.mz/index.php/documentos/instrumentos-de-gestao/programa-quinquenal-do-governo-pqg/2015-2019 [Accessed December 9, 2015].

Mohammed, K.S. et al., 2015. GIS and remote sensing techniques for measuring agriculture land loss in Balik Pulau region of Penang state, Malaysia. *Asian Journal of Agriculture and Rural Development*, 5(2), pp.30–41.

Molenaers, N. et al., 2015. What Determines the Suspension of Budget Support? *World Development*, 75, pp.62–73. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0305750X14002903.

Moody, R., 2007. *Electronic Government* M. A. Wimmer, J. Scholl, & Å. Grönlund, eds., Berlin, Heidelberg: Springer Berlin Heidelberg. Available at: http://www.springerlink.com/content/0721608144250272/?p=426788d0198743f4b3974a62452d4c56&pi=29.

Moore, G.C. & Benbasat, I., 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, 2(3), pp.192–222.

Münch, Z. & Conrad, J., 2007. Remote sensing and GIS based determination of groundwater dependent ecosystems in the Western Cape, South Africa. *Hydrogeology Journal*, 15(1), pp.19–28.

Mustonen-Ollila, E. & Lyytinen, K., 2003. Why organizations adopt information system process innovations: A longitudinal study using diffusion of innovation theory. *Information Systems Journal*, 13(3), pp.275–297.

Nasirin, S. & Birks, D.F., 2003. DSS implementation in the UK retail organisations: a GIS perspective. *Information & Management*, 40(4), pp.325–336. Available at: http://ac.els-cdn.com/S0378720602000150/1-s2.0-S0378720602000150-main.pdf?_tid=53bc5892-f970-11e4-923b-00000aacb362&acdnat=1431522336_092927de9db49382c73bc2c0442e8c86.

Nath, S.S. et al., 2000. Applications of geographical information systems (GIS) for spatial decision support in aquaculture. *Aquacultural Engineering*, 23(1–3), pp.233–278. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0144860900000510.

Ngai, E.W.T. et al., 2011. The application of data mining techniques in financial fraud detection: A classification framework and an academic review of literature. *Decision Support Systems*, 50(3), pp.559–569. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0167923610001302.

Nkhoma, M.Z. & Dang, D.P.T., 2013. Contributing Factors of Cloud Computing Adoption : a Technology - Organisation - Environment Framework Approach. *International Journal of Information Systems and Engineering*, 1(1), pp.38–49. Available at: http://researchbank.rmit.edu.au/view/rmit:22196.

Nourani, F., Saenz, M.C. & Castreghini, M.I., 2011. Tecnologias de informação geográfica no apoio à tomada de decisão em políticas públicas de controle da violência. *Revista do Laboratório de Estudos da Violência da UNESP/Marília*, pp.141–153. Available at: http://200.145.171.5/revistas/index.php/levs/article/download/1659/1414.

Nunes, C. & Almeida, O., 2011. A atuação das instituições governamentais na atividade pesqueira e o uso de geotecnologias na Amazônia. *Formação Online*, 1(18), pp.214–237. Available at: http://revista.fct.unesp.br/index.php/formacao/article/view/875/1088.

Obal, M., 2017. What drives post-adoption usage? Investigating the negative and positive antecedents of disruptive technology continuous adoption intentions. *Industrial Marketing Management*. Available at: http://linkinghub.elsevier.com/retrieve/pii/S001985011730007X.

Oliveira, T. & Martins, M., 2011. Literature review of information technology adoption models at firm level. *The Electronic Journal Information ...*, 14(1), pp.110–121. Available at: http://www.researchgate.net/publication/258821009_Literature_Review_of_Information_Technology_Adoption_Models_at_Firm_Level/file/9c960528fdf0cc370b.pdf.

Oliveira, T., Thomas, M. & Espadanal, M., 2014. Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors. *Information & Management*, 51(5), pp.497–510. Available at: http://www.sciencedirect.com/science/article/pii/S0378720614000391.

Oliver, C., 1991. Strategic Responses to Institutional Processes. *Academy of Management Review*, 16(1), pp.145–179. Available at: http://www.jstor.org.access.korea.ac.kr:8010/stable/258610.

Pactwa, K., Blachowski, J. & Górniak-Zimroz, J., 2015. GIS as a Support Tool in Regional Management of Rock Mineral Resources – Experiences from SW Poland. *Procedia Earth and Planetary Science*, 15, pp.488–494. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1878522015003173.

Panek, J., 2013. Participatory GIS for water provision and community planning - case study Koffiekraal, South Africa. In *13th SGEM GeoConference on Informatics, Geoinformatics And Remote Sensing*. pp. 845–852. Available at: http://dx.doi.org/10.5593/SGEM2013/BB2.V1/S11.030.

Park, S.C. & Ryoo, S.Y., 2013. An empirical investigation of end-users' switching toward cloud computing: A two factor theory perspective. *Computers in Human Behavior*, 29(1), pp.160–170. Available at: http://linkinghub.elsevier.com/retrieve/pii/S074756321200235X.

Patel, A. & Waters, N., 2012. Using Geographic Information Systems for Health Research. In *Application of Geographic Information Systems*. InTech. Available at: http://www.intechopen.com/books/export/citation/EndNote/application-of-geographic-information-systems/using-geographic-information-systems-for-health-research.

Peduzzi, P. et al., 2009. Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. *Natural Hazards and Earth System Science*, 9(4), pp.1149–1159. Available at: http://www.nat-hazards-earth-syst-sci.net/9/1149/2009/.

Puri, S.K. & Sahay, S., 2003. Participation through communicative action: A case study of GIS for addressing land/water development in India. *Information Technology for Development*, 10(3), pp.179–199. Available at: http://www.tandfonline.com/doi/abs/10.1002/itdj.1590100305.

Rabley Peter International Land Systems, I., 2009. GIS in Africa. *GIS Best Practices*

GIS in Africa, (March), pp.39–46. Available at: http://www.esri.com/library/bestpractices/gis-in-africa.pdf.

Ramadhan, A., Sensuse, D.I. & Arymurthy, A.M., 2011. Assessment of GIS implementation in Indonesian e-Government system. In *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*. IEEE, pp. 1–6. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6021515.

Rambaldi, G. et al., 2006. Participatory spatial information management and communication in developing countries. *The Electronic Journal of Information Systems in Developing Countries*, 25(1), pp.1–9. Available at: http://www.ejisdc.org/ojs2/index.php/ejisdc/article/view/237.

Renzio, P. De & Hanlon, J., 2007. Contested sovereignty in Mozambique: The dilemmas of Aid dependence. Available at: http://www.globaleconomicgovernance.org/sites/geg/files/De Renzio Hanlon_GEG WP 2007_25.pdf.

Rocha Flores, W., Antonsen, E. & Ekstedt, M., 2014. Information security knowledge sharing in organizations: Investigating the effect of behavioral information security governance and national culture. *Computers and Security*, 43, pp.90–110.

Rogers, E., 2003. *Diffusion of Innovations* 5th ed., Free Press, New York.

Rogers, E.M., 1995. Diffusion of preventive innovations. *Addictive behaviors*, 27(6), pp.989–93. Available at: http://hollis.harvard.edu/?itemid=%7Clibrary/m/aleph%7C006256656.

Rose, R.A. et al., 2015. Ten ways remote sensing can contribute to conservation. *Conservation Biology*, 29(2), pp.350–359.

Ruivo, P., Oliveira, T. & Neto, M., 2014. Examine ERP post-implementation stages of use and value: Empirical evidence from Portuguese SMEs. *International Journal of Accounting Information Systems*, 15(2), pp.166–184. Available at: http://dx.doi.org/10.1016/j.accinf.2014.01.002.

Sánchez-Lozano, J.M. et al., 2013. Geographical Information Systems (GIS) and Multi-Criteria Decision Making (MCDM) methods for the evaluation of solar farms locations: Case study in south-eastern Spain. *Renewable and Sustainable Energy Reviews*, 24, pp.544–556. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1364032113001780.

Sánchez-Lozano, J.M. & Bernal-Conesa, J.A., 2017. Environmental management of Natura 2000 network areas through the combination of Geographic Information Systems (GIS) with Multi-Criteria Decision Making (MCDM) methods. Case study in south-eastern Spain. *Land Use Policy*, 63, pp.86–97. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0264837716309188.

Sarstedt, M. et al., 2014. Partial least squares structural equation modeling (PLS-SEM): A useful tool for family business researchers. *Journal of Family Business Strategy*, 5(1), pp.105–115.

Scott, W. and Christensen, S., 1995. The institutional construction of organizations: international and longitudinal studies. *Thousand Oaks, CA, Sage Publications*.

Scott, W.R., 2004. Institutional theory : contributing to a theoretical research program. *Great Minds in Management The Process of Theory Development*, 37(3–4), pp.460–484. Available at: http://www.loc.gov/catdir/enhancements/fy0635/2005296318-d.html.

Sieber, R.E., 2000. GIS Implementation in the Grassroots. *Urisa Journal*, 12(1), pp.15–29.

Soares-Aguiar, A. and Palma-Dos-Reis, A., 2008. Why do firms adopt E-procurement systems? Using logistic regression to empirically test a conceptual model. *Engineering Management, IEEE Transactions on*, 55(1).

Son, M. & Han, K., 2011. Beyond the technology adoption: Technology readiness effects on post-adoption behavior. *Journal of Business Research*, 64(11), pp.1178–1182. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0148296311002062.

Stubbs, T.H., Kentikelenis, A.E. & King, L.P., 2016. Catalyzing Aid? The IMF and Donor Behavior in Aid Allocation. *World Development*, 78, pp.511–528. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0305750X15002326.

Swetnam, R.D. & Reyers, B., 2011. Meeting the challenge of conserving Africa's biodiversity: The role of GIS, now and in the future. *Landscape and Urban Planning*, 100(4), pp.411–414.

Tanser, F.C. & le Sueur, D., 2002. The application of geographical information systems to important public health problems in Africa. *International journal of health geographics*, 1, p.4.

Tasoulas, E. et al., 2013. Development of a GIS Application for Urban Forestry Management Planning. *Procedia Technology*, 8, pp.70–80. Available at: http://www.sciencedirect.com/science/article/pii/S221201731300073X.

Taylor, S. & Todd, P., 1995. Understanding information technology usage: A test of competing models. *Information Systems Research*, 6, pp.144–176.

Teo, H.H., Wei, K.K. & Benbasat, I., 2003. Predicting intention to adopt interorganizational linkages: An institutional perspective. *Mis Quarterly*, 27(1), pp.19–49. Available at: http://dx.doi.org/30036518.

Thomas, R.W., Esper, T.L. & Stank, T.P., 2011. Coping with time pressure in interfirm supply chain relationships. *Industrial Marketing Management*, 40(3), pp.414–423.

Tilman, D., 2001. Forecasting Agriculturally Driven Global Environmental Change. *Science*, 292(5515), pp.281–284. Available at: http://www.sciencemag.org/cgi/doi/10.1126/science.1057544.

Tornatzky, L. & Fleischer, M., 1990. The process of technology innovation, Lexington, MA. *Lexington Books.*, 4, pp.117–125.

Torres, C.D. & Garmendia, C.B., 2011. Mozambique's infrastructure: A continental perspective.

Tuama, É.Ó. & Hamre, T., 2007. Design and Implementation of a Distributed GIS Portal for Oil Spill and Harmful Algal Bloom Monitoring in the Marine Environment. *Marine Geodesy*, 30(1–2), pp.145–168. Available at: http://www.tandfonline.com/doi/abs/10.1080/01490410701296671.

Unoosa, 2010. *Geoinformation for Disaster and Risk Management. Examples and Best Practices*, Available at: http://www.isprs.org/news/announcements/Geoinformation_for_Disaster_and_Risk_Management.pdf.

Venkatesh, V. et al., 2003. User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), pp.425–478. Available at: http://0-search.ebscohost.com.millenium.itesm.mx/login.aspx?direct=true&db=buh&AN=10758835&lang=es&site=eds-live.

Venkatesh, V. & Davis, F.D., 2000. A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2), pp.186–204.

Venkatesh, V., Thong, J. & Xu, X., 2012. Consumer acceptance and user of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, 36(1), pp.157–178. Available at: http://ezproxy.library.capella.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=iih&AN=71154941&site=ehost-live&scope=site.

Vicente-Serrano, S.M. et al., 2012. Challenges for drought mitigation in Africa: The potential use of geospatial data and drought information systems. *Applied Geography*, 34, pp.471–486. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0143622812000136.

VoPham, T. et al., 2015. Linking pesticides and human health: A geographic information system (GIS) and Landsat remote sensing method to estimate agricultural pesticide exposure. *Applied Geography*, 62, pp.171–181. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0143622815000922.

Walravens, N., 2015. Mobile city applications for Brussels citizens: Smart City trends, challenges and a reality check. *Telematics and Informatics*, 32(2), pp.282–299. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0736585314000641.

Wang, Y.-M., Wang, Y. & Yang, Y., 2010. Understanding the determinants of RFID adoption in the manufacturing industry. *Technological Forecasting and Social Change*, 77(5), pp.803–815. Available at: http://dx.doi.org/10.1016/j.techfore.2010.03.006.

Ward, H. & Dorussen, H., 2015. Public Information and Performance: The Role of Spatial Dependence in the Worldwide Governance Indicators among African Countries. *World Development*, 74, pp.253–263. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0305750X15001114.

Wentzel, J.P. et al., 2010. of E-Commerce/E-Business Success: Constructs, Antecedents & Moderators in Adoption of Technology Enabled Products &. *Usc.Edu*, pp.924–929. Available at: http://www.usc.edu/dept/ise/caie/Checked Papers [ruhi 12th sept]/word format papers/REGISTRATION PAID PAPERS FOR PROCEEDINGS/pdf/304 9 DRIVERS OF E-COMMERCEE-BUSINESS SUCCESS CONSTRUCTS, ANTECEDENTS &.pdf.

Van Westen, C.J., 2013. 3.10 Remote Sensing and GIS for Natural Hazards Assessment and Disaster Risk Management. In *Treatise on Geomorphology*. Elsevier, pp. 259–298. Available at: https://www-sciencedirect-com.bibliopam.ecp.fr/science/article/pii/B9780123747396000518.

Wilcox, R., 1998. Kolmogorov–Smirnov Test. *Encyclopedia of Biostatistics*, pp.83–90. Available at: http://onlinelibrary.wiley.com/doi/10.1002/0470011815.b2a15064/full.

Wolf, I.D. et al., 2015. The use of public participation GIS (PPGIS) for park visitor management: A case study of mountain biking. *Tourism Management*, 51, pp.112–130. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0261517715000989.

World Bank, 2011. *Africa's future and the World Bank's support to It*, Available at: http://siteresources.worldbank.org/INTAFRICA/Resources/AFR_Regional_Strategy_3-2-11.pdf.

World Bank, 2016. GDP growth (annual %). Available at: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries/MZ?display=graph [Accessed January 20, 2016].

Wright, D.J. & Heyman, W.D., 2008. Introduction to the Special Issue: Marine and Coastal GIS for Geomorphology, Habitat Mapping, and Marine Reserves. *Marine Geodesy*, 31(4), pp.223–230. Available at: http://www.tandfonline.com/doi/abs/10.1080/01490410802466306.

Wu, I.L. & Chen, J.L., 2014. A stage-based diffusion of IT innovation and the BSC performance impact: A moderator of technology-organization-environment. *Technological Forecasting and Social Change*, 88, pp.76–90.

Yin, L., 2010. Integrating 3D Visualization and GIS in Planning Education. *Journal of Geography in Higher Education*, 34(3), pp.419–438. Available at: http://www.tandfonline.com/doi/abs/10.1080/03098260903556030.

Yomralioglu, T., 2002. GIS activity in Turkey. *International symposium on GIS*, pp.23–26. Available at: http://web.itu.edu.tr/tahsin/tahsin/Yayn_BildiriEN_files/72_14.pdf.

Zhu, D.H., Chang, Y.P. & Luo, J.J., 2016. Understanding the influence of C2C communication on purchase decision in online communities from a perspective of information adoption model. *Telematics and Informatics*, 33(1), pp.8–16. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0736585315000519.

Zhu, K., Dong, S., et al., 2006. Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies. *European*

Journal of Information Systems, 15(6), pp.601–616. Available at: http://northumbria.summon.serialssolutions.com/link/0/eLvHCXMwY2BQMEkCdnssDU0TDVMNgDjZODU10cQiJc0g2cAgLckiFWWqAKk0dxNlCHVzDXH20IXeA6CbbAiaYTQ0NktMNUhLBDYVDBLNk8xNTdMSgQ0DoC1pqUnJQDsszVPSgA2JNGBrBzRvZ2qcDBpdSUlKAu0xMjM3EGNgAfalU_kk_zbpcku53Zm5I_N27AavSgDsU.

Zhu, K. & Kraemer, K.L., 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), pp.61–84. Available at: http://rady.ucsd.edu/docs/faculty/zhu/ISR05_Post-adoption_UsageValue_CrosscountryStudy.pdf.

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

Zhu, Z., Zhang, R. & Sun, J., 2009. Research on GIS-Based Agriculture Expert System. In *2009 WRI World Congress on Software Engineering*. IEEE, pp. 252–255. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5319404.

Zolekar, R.B. & Bhagat, V.S., 2015. Multi-criteria land suitability analysis for agriculture in hilly zone: Remote sensing and GIS approach. *Computers and Electronics in Agriculture*, 118, pp.300–321. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0168169915002914.

Zook, M. et al., 2010. Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake. *World Medical & Health Policy*, 2(2), pp.6–32. Available at: http://doi.wiley.com/10.2202/1948-4682.1069%5Cnhttp://onlinelibrary.wiley.com/doi/10.2202/1948-4682.1069/abstract.

Chapter 7 - Appendix

Appendix (chapter 2)

List of questions used in article (translation into English between brackets and in italics)

Caracterização da instituição (*Insituttional description)*

1. Qual o sector de actividade da sua instituição (seleccione por favor uma das opções abaixo)?

(*What is the activity sector of your institution (select one of the options below)?*

- Agricultura (*Agriculture*)
- Ambiente (*Environment*)
- Comércio (*Trade*)
- Construção (*Construction*)
- Educação (*Education*)
- Informação e Comunicação (*Information and Communication*)
- Produção e Indústria (*Porduction and Industry*)
- Desenvolvimento Económico e Social (*Social and economic development*)
- Recursos Naturais (*Natural Resources*)
- Serviços (*Services*)
- Saúde (*Health*)
- Transportes e Comunicações (*Transport and comunications*)
- Outro (especifique) (*Other (specify)*

2. Quais as Tecnologias de Informação Geográfica (TIG) utilizadas na sua instituição? (*What Geographic Information Technologies are used in your institution?*)

- Sistema de Informação Geográfica (*Geographic Information Systems*)

- Deteção Remota (*Remote Sensing*)
- Sistemas de posicionamento global (*Global Positioning Systems*)
- Outras (especifique) (*Other (specify)*)
- Nenhuma (*None*)

3. Na sua instituição utiliza as seguintes Tecnologias de Informação Geográfica (TIG): (*In your institution Geographic Information Technologies are used*)

- No computador pessoal (*In a personal computer*)
- Na Web/Internet (*on the web/internet*)

4. Há quantos anos a sua instituição utiliza Tecnologias de Informação Geográfica (TIG)? (*For how many years has your institution has been using Geographic Information Technologies (GIT)?*)

5. Qual o número de trabalhadores da instituição (aproximadamente)? (*How many people, approximately work in your institution?*)

6. Aproximadamente qual o volume de negócios anual da sua instituição em Moçambique? (*What the annual trade volume of your institution?*)

- Até 80.000.00 MZN (*Up to...*)
- 81.000.00 MZN 400.000.00 MZN
- 401.000.001 MZN 2.000.000.00 MZN
- Superior a 2.000.000.000.001 MZN (*Above...*)
- Não aplicável a instituições do Estado (*Does not apply to governmental institutions)*

7. Qual o cargo que ocupa na sua instituição? (*What is your position in the institution?*)

8. Caso esteja interessado em receber os resultados deste estudo, indique por favor o seu e-mail: (*If you are interested in receiving the results of the study please provide your email*)

Definition of the concepts

Compatibility (CO) – Is the harmonization between the potential adopter's, existing values, previous practices, and current needs (Rogers 2003).

Competitive Pressure (CP) - It refers to the pressure felt by the firm from industry competitors (Low et al. 2011).

Complexity (CX) – It reflects the interrelationships within the organization and the degree of

difficult to use the innovation (Rogers 2003).

Donor Pressure (DP) – A person or organization who donates something voluntary and puts pressure to a specific goal be accomplished (self-developed).

Government Policy (GP) – Group of polices and rules set by government to regulate a specific activity (self-developed).

Intention to Adopt (IA) – Desire or belief to implement something (Nkhoma & Dang 2013).

Innovation (IV) - The process of translating an idea or invention into a good or service that creates value for a customer's (Nkhoma & Dang 2013).

Relative Advantage (RA) - Degree to which a new product is more advantageous to the customers than the competing brands the extent to which an innovation is better than the previous generation (Nkhoma & Dang 2013; Wang et al. 2010). Security (SE) – Reflects the degree of concern of one organization with data security (Chan & Chong 2012; Wang et al. 2010).

Technology Competence (TC) – Can be understood as the ability to improve an organizations product portfolio (Zhu, Dong, et al. 2006; Zhu, Kraemer, et al. 2006; Zhu & Kraemer 2005).

Appendix (chapter 3)

Constructs	Measurement items	Source
Technology competence	TC1: The technology infrastructure of my company is available to support GIT.* TC2: My company is dedicated to ensuring employees are familiar with GIT. TC3: My company has good knowledge of GIT. TC4: My company has a GIT training program.	Chang and Chong (Chan & Chong 2013)
Security (Sec)	*How do you perceive the risk that …* Sec1: … the confidentiality and security of your business data are not guaranteed when adopting GIT solutions? Sec2: … in case of damage, present liability law is still unclear about who will bear the damage? Sec3: …the GIT provider will exploit contractual loopholes (i.e., incomplete contracting) to the detriment of your company?	Benlian and Hess (Benlian & Hess 2011)
Financial Concerns (FC)	FC1: The organization has a certain amount of money to invest in GIT. (1-Strongly disagree,7- Strongly agree,…) FC2: GIT operating budget, as percent of total budget (#) FC3: Percentage of GIT operating budget supported by other institutions (i.e. donor) (#)*	Zhu *et al.*(Zhu, Dong, et al. 2006)
Competitive Pressure (CP)	CP1 – Our organization thinks that GIT has an influence on competition in their field of activity. CP2 – Our organization is under pressure from competitors to adopt GIT. CP3: Some of our competitors have already started using GIT.	Oliveira *et al.* (Oliveira et al. 2014)
Government Policies (GP)	GP1: The government has a policy on technology adoption. GP2: The government policies are implemented and followed. GP3: My organization is under the government policies. GP4: Technology adoption is one of the government pillars.	IST-Africa Consortium(IST-Africa Consortium 2012)
Donor Pressure (DP) (i.e. World bank, USAID)	DP1: Donors encourage implementation of GIT. DP2: Donors recommend implementation of GIT. DP3: Donors require implementation of GIT. DP4: Donors keep the organization innovating.	IST-Africa Consortium(IST-Africa Consortium 2012); Stubbs *et.al.*(Stubbs et al. 2016)

Intention to adopt GIT	GITi1: My company intends to use GIT if possible. GITi2: My company collects information about GIT with the possible intention of using it. GITi3: My company has conducted a pilot test to evaluate GIT.	Chan and Chong(Chan & Chong 2013)
GIT adoption	GITa1: My company invests resources to adopt GIT. GITa2: Business activities in our company require the use of GIT. GITa3: Functional areas in my company require the use of GIT.	Chan and Chong(Chan & Chong 2013)

Appendix (chapter 4)

Constructs	Authors
Relative Advantage (RA) RA1: GIT allows you to manage business operations in an efficient way. RA2: The use of GIT improves the quality of operations. RA3: Using GIT allows you to perform specific tasks more quickly. RA4: Using GIT allows you to increase business productivity.	(Oliveira et al. 2014)
Compatibility (Comp) **Comp1:** GIT is compatible with existing IT infrastructure. **Comp2:** GIT is compatible with business processes and operations. **Comp3:** GIT is easily compatible with other platforms. **Comp4:** It is easy to integrate GIT with other existing systems (e.g. Primavera, ERP, CRM, and SCM).	(Chong & Chan 2012; Zhu, Dong, et al. 2006)
Complexity (CX) **CX1:** The use of GIT requires a lot of mental effort.* **CX2:** The use of GIT is frustrating.* **CX3:** The use of GIT is too complex for business operations. **CX4:** The skills needed to adopt GIT are too complex for employees of the institution.	(Oliveira et al. 2014)
Organization Size (OS) **OS1:** Logarithm number of the company employees. **OS2:** Annual business volume.	(Zhu, Dong, et al. 2006)
Geographic Scope (GS) Please check the box that describes the geographic extent of your operations (check as many as apply): **GS1:** Your organization has one establishment. **GS2:** Your organization has more than one establishment (branches in other Provinces). **GS3:** Your organization has establishments outside your country. **GS4:** Your organization has headquarters outside your country.	(Zhu *et.al.*, 2006; Self-developed)
Expansion Opportunities (EO) **EO1:** My organization has plans to expand to the rest of country.	(Self-developed)

EO2: GIT is taking my organization beyond local boundaries.*	
Coercive Pressure (CP) **CP1:** The local government requires our institution to use GIT **CP2:** The industry association requires our institution to use GIT **CP3:** The competitive conditions require our firm to use GIT	(Liang et al. 2007; Teo et al. 2003)
Normative Pressure (NP) **NP1:** The extent of GIT adoption by your firm's suppliers **NP2:** The extent of GIT adoption by your firm's customers **NP3:** The extent to which the Government's promotion of Information	(Liang et al. 2007; Teo et al. 2003)
Mimetic Pressure (MP) *Our main competitors who have adopted GIT:* **MP1:** Have greatly benefitted **MP2:** Are favorably perceived by others in the same industry **MP3:** Are favorably perceived by their suppliers and customers	(Liang et al. 2007; Teo et al. 2003)
GIT use **GITu1:** We have integrated GIT with our existing backend/legacy systems **GITu2:** GIT is being implemented with our trading partners **GITu3:** GIT is being implemented with our customers	(Chan & Chong 2013)
Intention to increase the GIT level *To what extent do you agree with the following statements:* **GITe1:** If there is a superior GIT solution, it should be used for the application domain I am in charge of **GITe2:** Our company should increase the existing level of adopting GIT applications **GITe3:** I support the further adoption of GIT applications	(Benlian and Hess 2011)
Note: *Eliminated due low loading.	

Appendix (article published under PhD program)

Assessing Mozambique's exposure to coastal climate hazards and erosion

Pedro Cabral[1], Gabriela Augusto[1], Adeoluwa Akande[1], Anjos Costa[1,2], Nelson Amade[1,2], Sérgio Niquisse[1,2], Ali Atumane[1,2], António Cuna[1,2], Kiana Kazemi[1], Ramires Mlucasse[1,2], Rubini Santha[1]

[1] NOVA IMS, Universidade Nova de Lisboa, 1070-312, Portugal

[2] Universidade Católica de Moçambique, Beira, Moçambique

* Corresponding author, pcabral@novaims.unl.pt

Abstract

An increasing number of people in the world are living in coastal areas characterized by high geophysical and biophysical sensitivity. Thus, it is necessary to provide coastal planners with tools helping them to design efficient management plans to mitigate the negative effects caused by a growing number of coastal climate hazards that threaten life and property. We calculate an Exposure Index (EI) for the coastline of Mozambique and assess the importance of the natural habitats in reducing exposure to coastal climate hazards. We estimate, for year 2015, an increase of 276% in the number of people affected by a high, or very high, level of exposure when compared to a "Without habitats" scenario, i.e. excluding the protective effects of sand dunes, mangroves, and corals. The results of the EI are supported by the Desinventar Database, which has historic data concerning loss and damage caused by events of geological or weather related origin. These results also indicate where the most exposed areas are thereby providing useful information to design effective coastal plans that increase resilience to climate hazards and erosion in Mozambique.

Key-words: InVEST; climate change; ecosystem services; coastal hazard; Desinventar

1. Introduction

The severity of the impacts of extreme and non-extreme weather and climate events depends strongly on the level of vulnerability and exposure to these events [1]. It is widely accepted that coasts will be exposed to increasing climate hazards in the coming decades due to climate change and sea-level rise [2]. Exposure is defined as "the situation of people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses" [3] and vulnerability refers to "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" [2]. Exposure is also referred to as biophysical vulnerability, site, and situation of the place, whereas vulnerability is referred to as social vulnerability comprising the built environment and the social fabric [4,5].

Coastal regions are particularly exposed, although with different levels of vulnerability, to the adverse effects of climate change and sea-level rise, leading to increased risks that include loss and damage by climate hazards and coastal erosion, which may be exacerbated by increasing human-induced pressures [6]. However, coastal areas are attracting an increasing number of people because they often provide more subsistence resources than those found inland, more access points to marine trade and transport, more recreational, and cultural opportunities and, for some, a special sense of place at the land/sea interface [7]. This population growth, and the associated high urbanization rates, are driven by fast economic development and migration toward the coast [8,9]. Consequently, the degree of exposure coastal populations is being boosted by the pressures added to coastal systems that need to accommodate more and more people and associated infrastructures [10,11], and by the expected increase in coastal flooding and sea level rise [12]. The exposure of coastal areas depends greatly on their geomorphologic characteristics, and a significant reduction in the exposure of coastal areas to climate hazards and erosion can be achieved through the conservation of natural habitats that provide protection to the coast (e.g. dunes, mangroves, corals, seagrasses, etc.), or by building coastal protection infrastructures [13–16]. The former is generally an option for most countries, but the latter is only viable for countries that can afford to pay for expensive engineering infrastructures [17].

The need exists to study coastal exposure and a considerable number of studies have been carried out for many regions in the world using different methodologies [10,13,18–23]. However, with some exceptions [24,25], these studies are scarce for Africa. Historic data availability for African countries, and particularly on sea-level rise, is fairly limited when compared to other regions in the World [26]. In Mozambique, a country that has been identified as being particularly exposed to increased flooding due to the occurrence of tropical storms [27,1,28], with the exception of a study for the city of Beira [28], there is no study reported to date about exposure to coastal climate hazards and erosion. Besides having one of the longest African coastlines (approximately 2,700km) this country also has approximately 60% of its population located in coastal districts [29–31].

In this article we calculate the exposure index of the Mozambique coast to climate hazards and erosion using a 1km^2 spatial resolution. To assess the model pertinence, the results of the exposure index (EI) are compared with the Desinventar Database [32], which has historical data concerning loss and damage caused by events of geological or weather related origin. We also assess the importance of the habitats in reducing exposure to coastal climate hazards and erosion.

2. The study area

Mozambique is located in southeast Africa and comprises a land surface of about 800,000 km^2. Maputo is the capital and the country's largest city (Figure 1). The country had an estimated population of 25 million inhabitants in 2014 [33]. About 70% of Mozambicans live in rural areas, and 40% of them are located in the districts of Nampula and Zambézia [33]. About 45% of the population is under 14 years old, and the elderly represent about 3.5% of the total population [33]. Typically Mozambicans live in large families, 53.9% of the families have more than 5 members, and the presence of collateral related family, or unrelated elements in the household is relatively common (15%) [34]. The purchasing power in Mozambique has been rising sharply, but on average each Mozambican spends less than 21 USD per month, or about 14 USD per month if living in a rural area [34]. Most lodgings are built of adobe; only 18% of the houses are made of bricks, and 30% of the families live in houses made of precarious building materials [34]. Safe water supply reaches roughly half of the households, and the electric utility network is poor or nonexistent in rural households. Safe sanitation covers less than 1% of rural households. Nearly 45% of the Mozambican population cannot write or read, and this percentage is higher among women (58%) [34].

Mozambique is divided into 11 provinces and shares borders with Tanzania, Malawi, Zambia, Zimbabwe, South Africa, and Swaziland. After a devastating civil war that ended in 1992 [35], the first democratic elections took place in 1994, and since then the country has enjoyed political stability and rapid economic growth (7.4% of annual GDP growth in 2014) (World Bank, 2016). A Gross Domestic Product (GDP) of US$16.961 billion and a Gross National Income (GNI) per capita of US$600 in 2014 (World Bank, 2016) make Mozambique one of the poorest countries in the world. This country ranked 180th out of 188 countries in the most recent Human Development Index (HDI) [37].

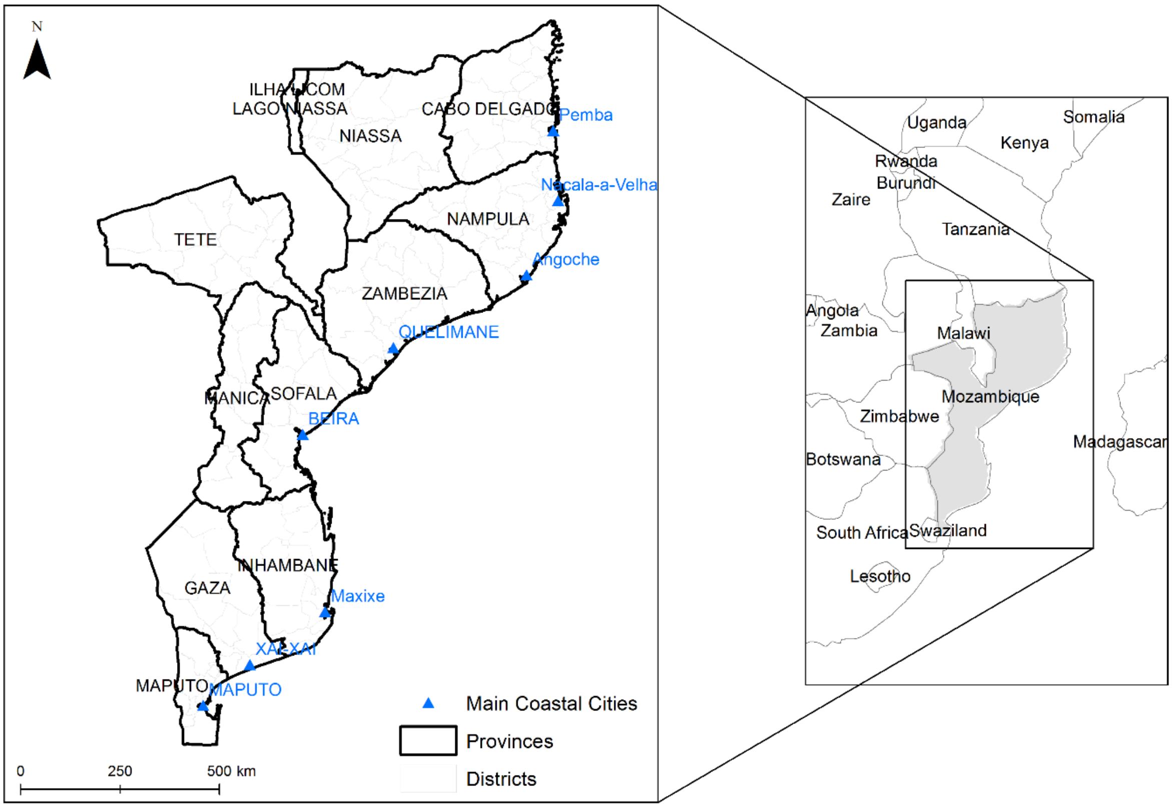


Figure 1 Study area

There are 104 identified river basins flowing into 11 major rivers, with the Zambezi and Limpopo being the two largest, that drain the water from the Central African high plateau into the Indian Ocean [38,39]. The majority of the rivers have a torrential, wet season regime with high waters during 3-4 months, and low, dry season flows (sometimes totally dry) for the remainder of the year. Up to 52% of the country is within international river basins [39]. The continental shelf is wider in the center (approximately 145km, near Sofala), decreasing in both north and south [40,41].

The Mozambican coast is divided into three main areas: the sandy coastline in the south, the estuarine coast in the center, and the coralline coast, with coral limestone in the north [40,42]. The sandy coastline starts at the South African border and extends to the Save Delta. It is a lowland coast dominated by sand dunes, lakes, lagoons, and bays receiving river estuaries, namely the Maputo bay, which accepts the estuaries of four rivers [41,42]. This lowland coast is bordered by an extensive dune system [41] dominated by wetlands of the deltas of large rivers in the estuarine coastline. The estuarine coastline starts at the mouth of the Save (130km south of Beira), and extends to Angoche, encompassing the Zambezi river delta. The coralline coastline covers over 700km from Angoche until the Tanzanian border. This is a narrow coastline with the bordering plateau sloping into hills and highlands. The whole coast is also punctuated by numerous coral and sandy islands, some very popular for recreation and leisure. The coast of Mozambique has 49 districts, belonging to different provinces, evenly distributed among the three natural areas.

Mozambique has a tropical climate with two distinct climatic seasons, a wet summer from October to March and a dry winter from April to September. The tropical cyclone season in the South Indian Ocean occurs between November and April, and over half of the storms that occur during a typical season appear in January or February [43]. On average 1.16 tropical cyclones per year made landfall in Mozambique, between 1980 and 2007 [44]. About half of those were formed in the Mozambique Channel [45]. The frequency and intensity of tropical cyclones has increased since 1993, with seven cyclones of category 3 to 5 hitting the coastline in the period 1994-2007, against only two in the previous 12 years [43]. Of the 15 cyclones occurring on the Mozambican coast between 1980 and 2007, eight hit the estuarine coastline, four in the coralline coastline, and three in the sandy coastline [46].

The Mozambique coast is largely dominated by natural habitats, although their conservation status is not always optimal [40,47]. Sand dunes are common all along the coast. In the southernmost part of the Mozambique coast, the sandy coastline consists of a low lying coastal plain separated from the coast by an uninterrupted undulating cordon of sand dunes extending for 100km, up to 2km width and rising to over 100m above sea level at some points [48]. This extensive dune system is interrupted on the estuary coast in the center by wetlands, where the dominant natural habitat is mangroves. In the narrow coralline coast north of Angoche the sand dunes are small, alternating with cliffs and attached beaches[48]. Mangroves occur along the whole Mozambican coast. In the coralline coast, where rivers are non-tidal, mangroves are mainly confined to the vicinity of river mouths. In the estuarine coast, the estuaries and deltas of big rivers such as the Save, Zambezi, Púnguè, and Buzi, allow for mangroves to extend for dozens of kilometers inland and hundreds of kilometers along the coast. Mangroves are also found in the sandy coastline, again in the estuary of rivers, notably in the Morrumbene estuary and on the bays of Maputo and Inhambane.

There are nine species of mangrove trees in Mozambique, and the estimated area of this forest in the country is over 350,000ha [40]. The estimated area of coral reefs in Mozambique coast ranges from 413 to 570km^2 [38]. In the northernmost part of the coast, coral reefs constitute an almost continuous fringing reef for more than 700km on the eastern shores of the islands and in the exposed mainland coast. The turbidity of the coast around the main river mouths on the estuarine coast does not allow coral reefs to thrive, but along the sandy southern coast, for about 850km, coral reefs are again found, although more sparsely than in the north. Coral reefs are one of the major attractions for the coastal tourism industry, and many infrastructures are already in place for that activity [47].

Mozambique is likely to be severely affected by climate change and the rising sea level because of its location in the inter-tropical conversion zone, its long coastline with large portions below sea level, and because it is a catchment zone of large international river basins[31]. Coastal erosion is also a pressing concern in Mozambique. South of Maputo the estimated average coastal retreat increased from 0.11m/year in the period 1971-1975 to 1.1m/year in the period of 1999-2004 [49], caused by climate change and land cover changes [50]. Coastal erosion is also a major concern in the mangrove region, threatening the mangroves and forcing population displacement [50,51].

3. Materials and methods

The Exposure Index

The relative exposure of the Mozambican coastline to coastal erosion and inundation was estimated using the Coastal Vulnerability model available in InVEST [52]. InVEST is a free open-source tool developed by the Natural Capital Project, available at www.naturalcapitalproject.org. It includes a set of different ecosystem service models. Besides being an intuitive tool, it has also been designed for data poor environments as is the case of this study. The Coastal Vulnerability model provides an Exposure Index (EI) map by ranking biophysical variables for each coastline segment, or pixel (Eq. 1):

$$EI = (R_{Geomorphology} R_{Relief} R_{Habitats} R_{WindExposure} R_{WaveExposure} R_{Surge})^{1/7} \qquad \text{(Eq. 1)}$$

where EI is the Exposure Index and R_i represents the ranking of the i^{th} bio-geophysical variable used to calculate the EI. The variables used in this model are the following [53]: $R_{Geomorphology}$ is the rank of geomorphology for each coastline segment; R_{Relief} is the relief ranking of each coastline segment; $R_{Habitats}$ is a natural habitat ranking for each coastline segment; $R_{WindExposure}$ is the wind exposure ranking of each coastline segment; $R_{WaveExposure}$ is the average height of adjacent seas, and R_{Surge} is the distance ranking between the coastline and the edge of the continental margin. Although this model allows for the inclusion of a variable of sea-level rise (SLR), this variable was not considered in this study due to the lack of data.

This model weights equally the variables that consider the effect of storms on exposure by incorporating wind, waves, and surge potential data as well as data and models for habitat type, geomorphology, relief, and sea level rise [13]. This model was selected because it is freely accessible and because it provides spatially explicit and quantitative outputs, making it useful for coastal management assessments [13,52]. Additionally, it requires a relatively low quantity of data and has been successfully applied in different study areas [13,53,54]. The model also enables the estimation of the population subject to coastal hazards and erosion by extracting population values from the grid cell that overlaps the shoreline segment [52].

Habitat scenarios

The habitats considered in this study, i.e. mangroves, coral reefs and sand dunes, are generally accepted as important factors in the protection of coastlines worldwide. The ability of mangroves to protect population and infrastructure from storms and cyclones has been widely assessed in numerous scientific studies [15,55]. Coral reefs have also been acknowledged for dissipating wave energy and, therefore, helping to avoid the worst effects of sea storms on habitats and infrastructures of nearby coasts [56,57]. Sand dunes are important in preventing coastal erosion and flooding [58,59]. Despite the presence of other important habitats, such as seagrass beds, and their importance in coastal protection [13], these were not included in the model due to data unavailability.

To assess the role of coastal ecosystems in reducing exposure to sea-level rise and storms, two scenarios were developed: (i) the “With habitats” scenario, which included the three habitats (mangroves, coral reefs, and sand dunes) in the exposure index; and (ii) the “Without habitats” scenario, which assumed that those habitats no longer provide protection. The “With habitats” scenario corresponds to the “current state” of the system. The “Without habitats” scenario is an extreme situation that is used to evaluate where, and to what extent, habitats play a significant role in protecting people, and to determine where their loss would affect exposure from coastal hazards. Future scenarios are expected to vary along this spectrum between the “current state” of the system and a total degradation of the protective effect of habitats.

Data and preprocessing

A national-scale database was developed to assess the Mozambican coastal exposure. This included data gathered from local (GIS Center of the Catholic University of Mozambique – UCM, in Beira) and state agencies (CENACARTA, National Centre of Cartography, http://www.cenacarta.com), as well as through the Internet to access global datasets produced by several organizations (Table 1). All the data were preprocessed using ArcGIS software [60] and had, or were converted into the Universal Transverse Mercator (UTM) projected coordinate system using the World Geodetic System datum 84 (WGS 84).

Dataset	Description	Source
Land polygon	Geographic shape of the coastal area of interest, depicting the boundaries of land and seascape.	[61]
Relief	The Digital Elevation Model (DEM) that was used to compute the relief ranking of each shoreline segment was the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) which has a spatial resolution of 30 meters.	[62]
Geomorphology	The geomorphology map was obtained using the shoreline map from the Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG) and a lithology map from CENACARTA.	UCM GIS Center, CENACARTA and [61]
Natural habitats	The dune and mangrove habitats were extracted from the Mozambican land cover map of 1999 produced by CENACARTA. The coral reefs polygon ESRI shapefile was provided by the UCM GIS Center.	CENACARTA and UCM GIS Center (1999)
Climate forcing grid	This input was used to compute the Wind and Wave Exposure ranking of each shoreline segment. We used the full-spectral third-generation wind-wave model WaveWatch III.	[63]
Continental shelf	Depth contour used as an indicator for surge level.	[52]
Bathymetry	This input is used to compute the average depth along the fetch rays to determine the exposure of each shoreline segment and in the computation of the surge potential. This grid has a spatial resolution of 30 arc-second.	[64]
Population	We used the estimates of the Gridded Population of the World (GPW) population data for year 2015 with a spatial resolution of 2.5 arc minutes.	[65]

Table 1 Description of datasets used in the study

The lithology map used to compute the $R_{Geomorphology}$ variable was reclassified from 1 (very low erodibility) to 5 (very high erodibility) with the help of experts from the Portuguese National Laboratory of Energy and Geology (LNEG). Alluvions and terraces were given the maximum value of erodibility (i.e., 5). Undifferentiated deposits received value 4. Sandstones, clays, and related rocks were classified with 3. Basic and carbonate rocks were classified with 2. Gneisses, migmatites, granites, and related rocks were given value 1. Finally, a GIS procedure was used to assign the value of the reclassified lithology polygons to the shoreline map.

The natural habitats were associated with an increasing exposure rank, from 1 (very low) to 5 (very high) [13]. The coral reefs and mangroves were classified with value 1, and dunes with value 2. The corals and mangroves protective distance considered was 2000m. The dunes' protective distance was set to 300m [52].

Model validation

To validate the ability of the exposure index to capture the exposure to coastal climate hazards, we used the publicly available Desinventar Database [32]. This database compiles records of disaster loss and damage from events of geological or weather related origin in 82 countries, including Mozambique. The data contained in the Desinventar Database are allocated by district, so we report the exposure index of individual cells also using the district level. The districts have different numbers of cells, each with its own computed and classified exposure index, and for this reason we decided to classify as "Exposed" any district in which 10% or more of its cells belonged to the "High" or "Very High" classes of the exposure index. Using this criterion, data concerning loss and damage from coastal climate events from the Desinventar Database were compared to investigate if "Exposed" districts had a significantly different record from the districts considered "Less exposed" by the model concerning climate hazards typically associated with the coast: tropical depression, surge, strong wind, storm, rains, floods, flash flood, and cyclone. A total of 2003 records of damage and loss due to these events occurred in the 128 districts of Mozambique, 711 of these were located in 48 coastal districts.

4. Results

4.1 The Exposure Index (EI)

The exposure index (EI), which is a relative index resulting from the InVEST Coastal Vulnerability model, was calculated for the "with" and "without" habitats scenarios. The values of the cells of the two resulting rasters (one for each scenario) were combined together and classified into five quintiles as follows: Very low" (<2.54); "Low" (2.54 to 2.90); "Moderate" (2.90 to 3.22); "High" (3.22 to 3.53); and "Very high" (> 3.53). Figure 2 shows the relative exposure to coastal hazard and erosion of each 1km^2 compared with all other segments of Mozambique in the "With habitats" scenario.

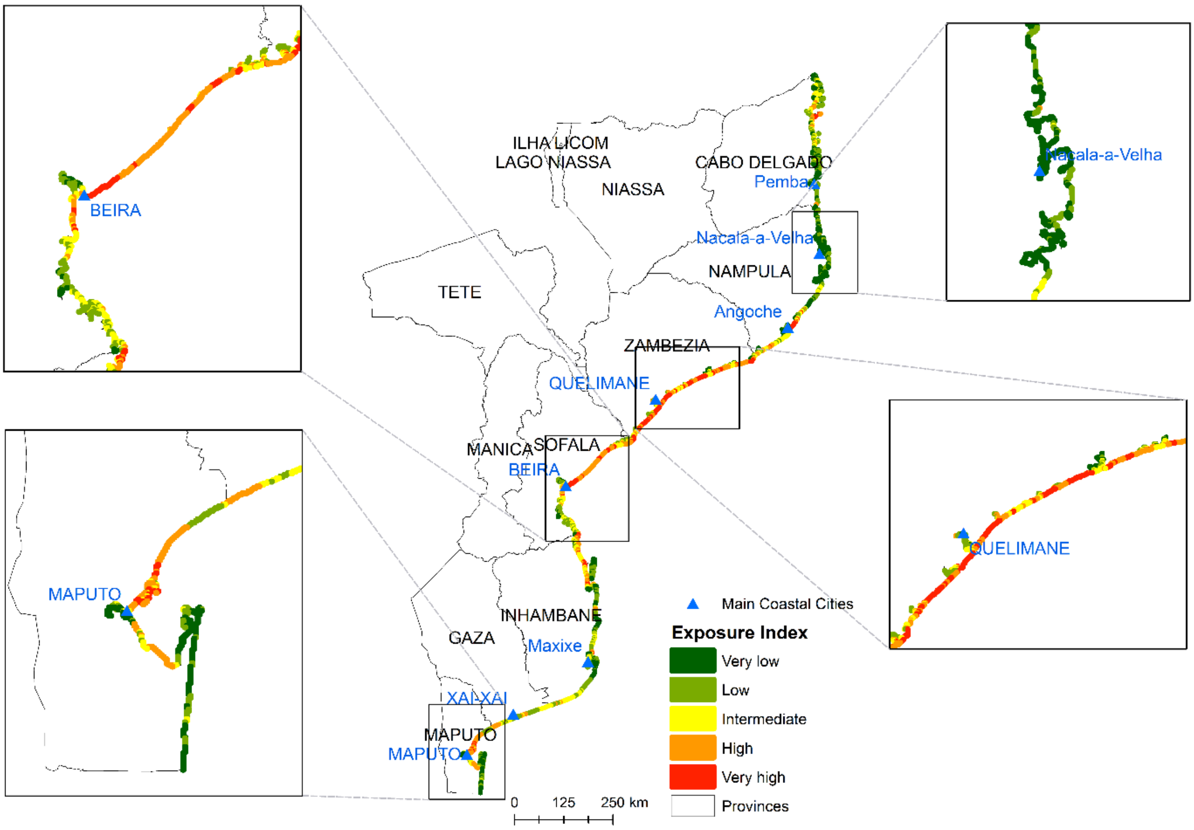


Figure 2 Exposure Index for Mozambique in the “With habitats” scenario

The most important concentration of cells classified as “High” and “Very high” exposure are located in the Provinces of Zambézia and Sofala, which correspond to lowlands with unfavorable geomorphology.

4.1.1 The habitats’ importance in coastal protection

About 23.4% of the cells of the resulting EI for the Mozambique coast were classified with “High” or “Very high” exposure to coastal climate events and erosion in the “With habitats” scenario. This value increases to 57.8% in the “Without habitats” scenario; 26 coastal districts (out of a total of 49) have 10% of more of their cells classified as “High” or “Very high” exposure level in the “With habitats” scenario. In the “Without habitats” scenario this number would increase to 41 (Figure 3). The absence of the protective effect of the habitats in Mozambique coast would expose about 577,448 people to coastal climate hazards and erosion, representing an increase of 276% in the number of exposed people. The average EI for the Mozambique coast would increase from 2.81 in the “With habitats” scenario to 3.26 if the protective effect of habitats was removed, i.e., an increase of 16%.

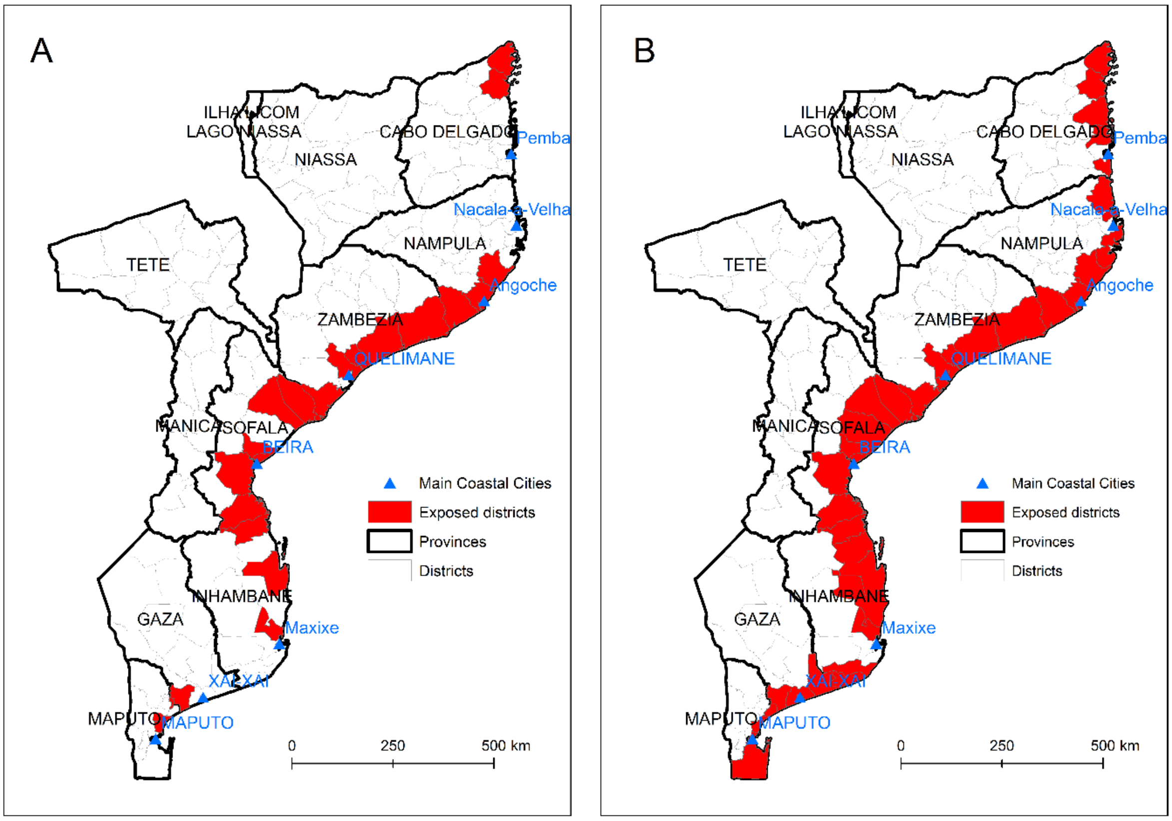


Figure 3 Exposed districts in the "With habitats" (A, map on the left) and in the "Without habitats" (B, map on the right) scenarios

4.2 Comparison of EI with recorded history of coastal climate events causing loss and damage

For validation purposes, we considered only the exposed districts of the "With habitats" scenario, as this is assumed to be the "current state" of the system. The coastal districts in this scenario were split into two sets regarding coastal climate hazards types according to the Desinventar Database, one referring to the districts deemed exposed by the model, and the other set with the districts that the model considers less exposed (Figure 3). On average, each exposed district suffered 15.8 climate related events causing loss or damage, whereas the less exposed districts suffered on average 12.7 events for the same period of time (Table 2). This difference is not statistically significant (p-value= 0.199).

	Average in exposed districts	Average in less exposed districts	p-value

Coastal climate events causing damage and/or loss	15.8	12.7	0.199
Coastal climate events causing human casualties	5.28	2.48	0.012

Table 2 Coastal climate events causing damage and/or loss and human casualties between 1975 and 2015 (Source: Desinventar Database, 2016 [32])

However, the human casualties occurring as a direct consequence of climate related events are still the most important indicator of the severity of the event. Thus, the most pertinent variable to be considered in the model assessment is the number of events causing fatalities, as this is the first consequence to be avoided. According to the Desinventar Database, there were 147 climate related events that caused deaths in the coastal districts of Mozambique between 1975 and 2015. Cyclones, floods, and flash floods accounted for the large majority of these events (Figure 4). On average, the exposed districts suffered 4.66 climate related events causing death among their population, whereas the less exposed districts suffered 2.65 deadly climate related events. This difference is statistically significant (p-value of 0.012).

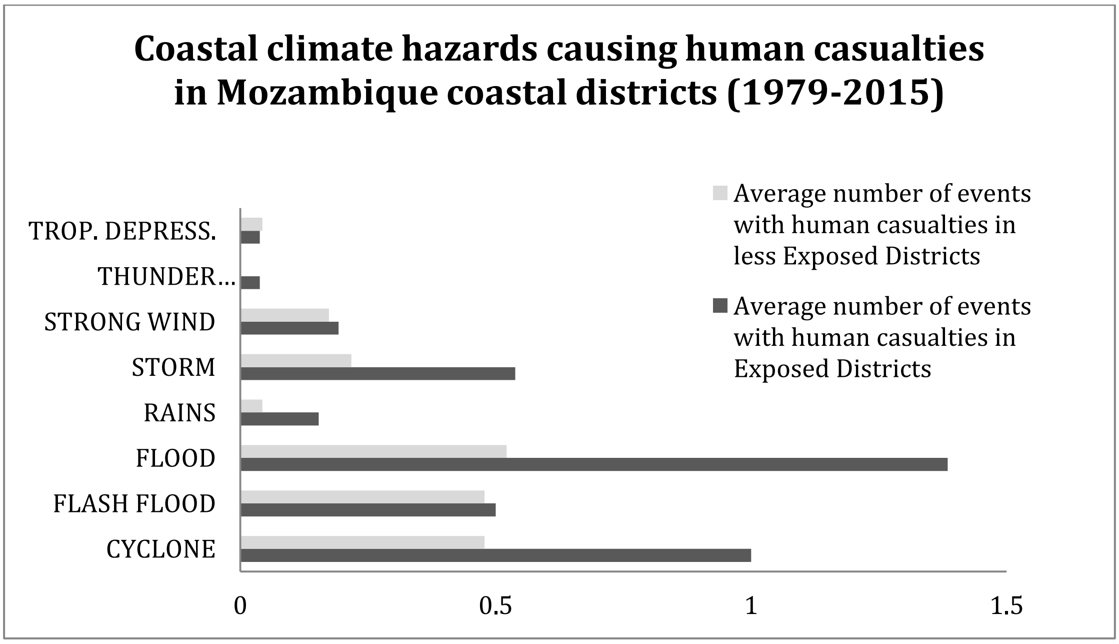


Figure 4 Coastal climate hazards causing human casualties in Mozambique's coastal districts (1979-2015) (Source: Desinventar Database, 2016)

These results support the pertinence of the EI indicating that exposed districts are more likely to suffer damage and loss from climatic events, and are also more likely to suffer fatalities from cyclones, floods, and storms. As the two sets of data are totally unrelated except for the geographic location, and the Desinventar Database records the historic “ground truth” of coastal climate hazards, it is therefore reasonable to assume that the EI is a pertinent measure of coastal exposure to climate coastal events and erosion on the Mozambique coast.

5. Discussion

An Exposure Index for Mozambique

The Mozambique coast is attracting considerable interest for development projects in agriculture, aquaculture, energy crops, tourism, and related infrastructures [31,66]. Whereas most of these projects are desirable and may help to improve the life of a growing population, the local and national decision makers should account for all ecosystem services whenever a natural habitat is replaced by some other land use required for these projects. The protection of the coast is one of the ecosystem services seldom accounted for. The EI map proposes a first glance regarding the exposure to climate hazards and erosion of the whole Mozambique coast. Moreover, it provides valuable hints regarding the importance of habitat conservation for the protection of coastal populations from climate hazards and coastal erosion.

Results point to the particularly high exposure of districts belonging to the central estuarine region, where 14 out of 15 have more than 10% of their coastal area classified as “High” or “Very high” by the EI. The removal or extreme deterioration of mangrove in this region would place all the districts of the estuarine region into the situation of highly exposed. Coincidently, the estuarine coast is also the region where cyclones hit twice as often as in the north or the south [46], and is the coastal region more prone to suffer from floods due to the transnational and torrential nature of its big rivers. Moreover, mangroves due to the extraordinary range of goods and services provided to the local population [51,55], attract a great number of inhabitants who tend to dwell very close to the coastline. As a consequence, the number of people affected by coastal hazards is greater in this region. It should also be noted that while providing protection to the coast mangroves themselves are affected by climate hazards [67]. The importance of mangrove conservation and management is clearly expressed by the Mozambique government national strategy and action plan for mangrove protection and rehabilitation of mangrove forests [30]. It should be stressed though that the regular flow of freshwater, crucial for the conservation status of mangroves [30,40], requires the management of river basins well outside of Mozambique.

The importance of the wooded dunes in the sandy coast is also clearly highlighted by the EI results. The absence of this habitat would expose nine more districts to coastal climate hazards and erosion. Without sand dunes, 14 of the 15 districts in the southern coast would be highly and very highly exposed to climate events and erosion. Wooded sand dunes are also under considerable pressure due to the development of tourism and increasing reclamation of land for agriculture, and this region of the coast is particularly subject to coastal erosion due to sea dynamics [50].

The absence of habitats in the coral coast would also increase the number of exposed districts by 58%. The deficient management of fishing is one of the main threats to coral reefs on the Mozambique coast [47], while inland pollution and the deterioration of mangroves trapping sediments from inland are also a concern [31]. It must be noted however that many of the coral reefs of Mozambique are located in the dozens of islands that were not included in this study.

Model validation

Model validation is an important aspect to consider when producing exposure maps, or any kind of modelling output, in order to demonstrate the correctness of the theoretically presumed indications of exposure and the validity of the indicators [68,69]. In this paper we used the publically available Desinventar Database [32] to assess the accuracy of our model. This freely available database has proved to be an extremely valuable asset to be used in exposure studies. The validation method developed in this study shows how to take advantage of this database in a very straightforward way.

Limitations

A number of limitations of this modeling approach are identified in the InVEST model manual including the simplification of the exposure index calculation into the geometric mean of seven variables and exposure categories [52]. In addition to those, we would like to stress some features, such as the quality and conservation status of the habitats that were not considered in our model. Other identified limitations include data scarcity, which was an important hindrance we had to deal with. For instance, data about the sea level rise for Mozambique come from a single station in Maputo. If more observations were available, it would be possible to estimate the trend of sea level variation by fitting the available observations to a linear regression and producing different sea level rise scenarios. For this reason, we did not create scenarios of sea level rise in this study.

The habitats dataset was produced in 1999, which makes it outdated. Nevertheless, we must accept its important impact on the results. Future versions of this model should use more recent maps of habitats, as well as consider additional habitats that are important for coastal protection (e.g. seagrass beds, kelp forests, others) [13], mostly because there has been a strong upturn in tourism and other economic activities in Mozambique coastal areas. We used estimates of Mozambican population for year 2015, which may also inaccurately represent the number of people actually living in the coastal districts of Mozambique. Additionally, and regarding the importance of casualties caused by climate related events, the lack of estimates for population in Mozambique districts in the period covered by the database, precludes further investigation. During that time period the Mozambique population more than doubled, and there were massive unmonitored population displacements during the civil war. Another point to address concerns the coastal morphology. South of mouth of the Zambezi river the coast is a large lowland plain where the land morphology provides no physical obstacles to storm progression, and therefore the 1km inland distance may not be the appropriate measure to estimate the population and infrastructure likely to be affected by cyclones or floods. This is especially the case for the estuarine region, where mangroves encourage the settlement of more population than sand dunes or beaches. Thus, the affected population is likely to be largely underestimated in these areas. Bearing in mind that most lodgings in the country are of light construction, cyclones do cause loss and damage hundreds of kilometers inland.

Finally, it is important to stress that this is not a vulnerability model for the Mozambique coast [4]. The EI map only addresses exposure, or the “biophysical vulnerability”. Studies concerning the social vulnerability to climate hazards in Africa will undoubtedly be of utmost importance and interest, especially in highly dynamic demographic regions, as is the case of Mozambique.

6. Conclusions

Material losses due to climate events in developing countries, such as Mozambique, have severe implications in the lives of the populations [51,70]. Climate related events often cause the loss of crops and infrastructures, endangering the lives and health of the population through famine, water contamination, and blocking much needed aid for the population during and long after the disaster [51,70]. Mozambique is demonstrating an astonishing capacity to prepare and adapt its population to climate hazards with very limited resources and capacities [71]. Some challenges demand international support as pressure on coastal areas will increase with the economic development of an increasing population and ongoing climate change. This support is especially crucial in the management of the large rivers that the country shares with neighboring states: more than the impact of the level of fresh water flow on the welfare of the local population and the conservation of coastal habitats, we should note that according to the Desinventar Database, the main events causing casualties, loss, and damage in Mozambique are droughts and floods.

This study presented a methodology for obtaining an EI for the Mozambique coastline. The results are statistically supported by independent validation data from the Desinventar Database. The EI is a valid indicator to assess the coastal exposure and anticipate the effects of land cover changes in the exposure of coastal infrastructures and populations to coastal climate hazards and erosion. The model provides a consistent framework to assess and analyze coastal exposure in a country which needs to deal with coastal hazards regularly, and where coastal erosion is a pressing challenge. Additionally, the study reveals the importance of preserving the natural habitats to save lives from coastal hazard events. This is particularly important for poor countries that do not have the financial means to build and maintain coastal protection infrastructures. Finally, it also demonstrates the importance of having updated datasets for building better exposure models. The model's accuracy can be easily improved with the update of the multiple underlying datasets and some local adjustments to expand affected areas according to coastal morphology. The findings of this study may help decision makers to prioritize conservation efforts to avoid the worst effects of climate coastal hazards and coastal erosion in Mozambique.

Acknowledgements

The authors would like to acknowledge the contributions of Aurete Pereira and Tomás Oliveira from LNEG for helping with information about the lithology map. We would also like to thank Gregg Verutes from the Natural Capital Project, who helped us decisively in calibrating and interpreting some results of the InVEST coastal vulnerability model.

References

[1] O.-D. Cardona, M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, et al., Determinants of Risk: Exposure and Vulnerability, in: C.B. Field, V. Barros, T.F. Stocker, Q. Dahe (Eds.), Manag. Risks Extrem. Events Disasters to Adv. Clim. Chang. Adapt., Cambridge University Press, Cambridge, 2012: pp. 65–108. doi:10.1017/CBO9781139177245.005.

[2] C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, eds., Coastal Systems and Low-Lying Areas, in: Clim. Chang. 2014 Impacts, Adapt. Vulnerability, Cambridge University Press, Cambridge, 2014: pp. 361–410. doi:10.1017/CBO9781107415379.010.

[3] UNISDR, Terminology on Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction, (2009). http://www.unisdr.org/we/inform/publications/7817 (accessed January 11, 2016).

[4] S.L. Cutter, B.J. Boruff, W.L. Shirley, Social Vulnerability to Environmental Hazards, Soc. Sci. Q. 84 (2003) 242–261. doi:10.1111/1540-6237.8402002.

[5] V.N. Martins, D.S. Silva, P. Cabral, Social vulnerability assessment to seismic risk using multicriteria analysis: the case study of Vila Franca do Campo (São Miguel Island, Azores, Portugal), Nat. Hazards. 62 (2012) 385–404. doi:10.1007/s11069-012-0084-x.

[6] R.J. Nicholls, P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, et al., Coastal systems and low-lying areas. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change., in: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, C.E. Hanson (Eds.), Clim. Chang. 2007 Impacts, Adapt. Vulnerability, Cambridge University Press, Cambridge, UK, 2007: pp. 315–356. https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter6.pdf.

[7] B. Neumann, A.T. Vafeidis, J. Zimmermann, R.J. Nicholls, Future coastal population growth and exposure to sea-level rise and coastal flooding--a global assessment., PLoS One. 10 (2015) e0118571. doi:10.1371/journal.pone.0118571.

[8] G. McGranahan, D. Balk, B. Anderson, The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones, Environ. Urban. 19 (2007) 17–37. doi:10.1177/0956247807076960.

[9] K. Smith, We are seven billion, Nat. Clim. Chang. 1 (2011) 331–335. doi:10.1038/nclimate1235.

[10] V.N. Martins, R. Pires, P. Cabral, Modelling of coastal vulnerability in the stretch between the beaches of Porto de Mós and Falésia, Algarve (Portugal), J. Coast. Conserv. 16 (2012) 503–510.

[11] EEA, The changing faces of Europe's coastal areas, Copenhagen, Denmark, 2006. http://www.eea.europa.eu/publications/eea_report_2006_6.

[12] IPCC, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], Geneva, Switzerland, 2014.

[13] K.K. Arkema, G. Guannel, G. Verutes, S.A. Wood, A. Guerry, M. Ruckelshaus, et al., Coastal habitats shield people and property from sea-level rise and storms, Nat. Clim. Chang. 3 (2013) 913–918. doi:10.1038/nclimate1944.

[14] E.B. Barbier, Valuing the storm protection service of estuarine and coastal ecosystems, Ecosyst. Serv. 11 (2015) 32–38. doi:10.1016/j.ecoser.2014.06.010.

[15] S. Das, A.-S. Crépin, Mangroves can provide protection against wind damage during storms, Estuar. Coast. Shelf Sci. 134 (2013) 98–107. doi:10.1016/j.ecss.2013.09.021.

[16] S. Das, The role of natural ecosystems and socio-economic factors in the vulnerability of coastal villages to cyclone and storm surge, Nat. Hazards. 64 (2012) 531–546. doi:10.1007/s11069-012-0255-9.

[17] S. Brown, R.J. Nicholls, C.D. Woodroffe, S. Hanson, J. Hinkel, A.S. Kebede, et al., Sea-Level Rise Impacts and Responses: A Global Perspective, in: Springer Netherlands, 2013: pp. 117–149. doi:10.1007/978-94-007-5234-4_5.

[18] P.D. Kunte, N. Jauhari, U. Mehrotra, M. Kotha, A.S. Hursthouse, A.S. Gagnon, Multi-hazards coastal vulnerability assessment of Goa, India, using geospatial techniques, Ocean Coast. Manag. 95 (2014) 264–281. doi:10.1016/j.ocecoaman.2014.04.024.

[19] M.E. Hereher, Vulnerability assessment of the Saudi Arabian Red Sea coast to climate change, Environ. Earth Sci. 75 (2016) 30. doi:10.1007/s12665-015-4835-3.

[20] G.S. Dwarakish, S.A. Vinay, U. Natesan, T. Asano, T. Kakinuma, K. Venkataramana, et al., Coastal vulnerability assessment of the future sea level rise in Udupi coastal zone of Karnataka state, west coast of India, Ocean Coast. Manag. 52 (2009) 467–478. doi:10.1016/j.ocecoaman.2009.07.007.

[21] R.S. Mahendra, P.C. Mohanty, H. Bisoyi, T.S. Kumar, S. Nayak, Assessment and management of coastal multi-hazard vulnerability along the Cuddalore–Villupuram, east coast of India using geospatial techniques, Ocean Coast. Manag. 54 (2011) 302–311. doi:10.1016/j.ocecoaman.2010.12.008.

[22] T. Wu, X. Hou, Q. Chen, Coastal economic vulnerability to sea level rise of Bohai Rim in China, Nat. Hazards. 80 (2016) 1231–1241. doi:10.1007/s11069-015-2020-3.

[23] P. Sheik Mujabar, N. Chandrasekar, Coastal erosion hazard and vulnerability assessment for southern coastal Tamil Nadu of India by using remote sensing and GIS, Nat. Hazards. 69 (2013) 1295–1314. doi:10.1007/s11069-011-9962-x.

[24] K.A. Addo, Assessing Coastal Vulnerability Index to Climate Change: the Case of Accra – Ghana, J. Coast. Res. 165 (2013) 1892–1897. doi:10.2112/SI65-320.1.

[25] I.O. Adelekan, Vulnerability of poor urban coastal communities to flooding in Lagos, Nigeria, Environ. Urban. 22 (2010) 433–450. doi:10.1177/0956247810380141.

[26] P. Woodworth, A. Aman, T. Aarup, Sea level monitoring in Africa, African J. Mar. Sci. 29 (2007) 321–330. doi:10.2989/AJMS.2007.29.3.2.332.

[27] R.J. Nicholls, R.S.J. Tol, Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century, Philos. Trans. R. Soc. A Math. Phys. Eng. Sci. 364 (2006) 1073–1095. doi:10.1098/rsta.2006.1754.

[28] D. Chemane, H. Motta, M. Achimo, Vulnerability of coastal resources to climate changes in Mozambique: a call for integrated coastal zone management, Ocean Coast. Manag. 37 (1997) 63–83. doi:10.1016/S0964-5691(97)00073-2.

[29] INE, Recenseamento Geral da População e Habitação, (2016). http://www.ine.gov.mz/operacoes-estatisticas/censos/censo-2007/rgph-2007.

[30] República de Moçambique, Estratégia e plano de acção nacional para restauração de mangal 2015-2020. Ministério da Terra, Ambiente e Desenvolvimento Rural, Centro de Desenvolvimento Sustentável para as Zonas Costeira, (2015) 43.

[31] República de Moçambique, Estratégia Nacional de Adaptação e Mitigação de Mudanças Climáticas 2013-2025, Ministério para a Coordenação da Acção Ambiental, (2015) 71. http://www.cgcmc.gov.mz/pt/politicas-estrategias/94-estrategia-nacional-de-adaptacao-e-mitigacao-de-mudancas-climaticas.

[32] UNISDR, DesInventar, Disaster Information System, United Nations Office for Disaster Risk Reduction, (2016). http://www.desinventar.net/.

[33] INE, Estatísticas e Indicadores Sociais, Maputo, Mozambique, 2014. http://www.ine.gov.mz/estatisticas/estatisticas-demograficas-e-indicadores-sociais/estatisticas-e-indicadores-sociais/estatisticas-e-indicadores-sociais-2014/view.

[34] INE, Relatório final do inquérito ao orçamento familiar - IOF-2014/15, Maputo, Mozambique, 2016. http://www.ine.gov.mz/operacoes-estatisticas/inqueritos/inquerito-sobre-orcamento-familiar/relatorio-final-do-inquerito-ao-orcamento-familiar-iof-2014-15/view.

[35] R. Brouwer, M.P. Falcão, Wood fuel consumption in Maputo, Mozambique, Biomass and Bioenergy. 27 (2004) 233–245. doi:10.1016/j.biombioe.2004.01.005.

[36] World Bank, Mozambique, (2016). http://data.worldbank.org/country/mozambique (accessed March 19, 2016).

[37] UNDP, Human Development Report 2015 - Work for Human Development, 2015. http://hdr.undp.org/sites/default/files/2015_human_development_report_1.pdf.

[38] C. Wong, M. Roy, A.K. Duraiappah, Focus on Mozambique, 2005.

[39] F. Tauacale, Water Resources of Mozambique "and the situation of the shared rivers," in: River Basin Inf. Syst. Meet., Nairobi, Kenya, 2002. http://www.unep.org/DEWA/water/RiverBasin/documents/Presentations/Francisco.doc.

[40] F.M.A. Barbosa, C.C. Cuambe, S.O. Bandeira, Status and distribution of mangroves in Mozambique, South African J. Bot. 67 (2001) 393–398. doi:10.1016/S0254-6299(15)31155-8.

[41] S.J. Armitage, G.A. Botha, G.A.T. Duller, A.G. Wintle, L.P. Rebêlo, F.J. Momade, The formation and evolution of the barrier islands of Inhaca and Bazaruto, Mozambique,

Geomorphology. 82 (2006) 295–308. doi:10.1016/j.geomorph.2006.05.011.

[42] MICOA, Centro de Desenvolvimento Sustentável para as Zonas Costeiras, Ministério para a Coordenação da Acção Ambiental, (2016). http://www.zonascosteiras.gov.mz/rubrique.php3?id_rubrique=2O/;Jny 2001. 67 393-398 (accessed June 12, 2016).

[43] A. Mavume, L. Rydberg, M. Rouault, J. Lutjeharms, Climatology and Landfall of Tropical Cyclones in the South- West Indian Ocean, West. Indian Ocean J. Mar. Sci. 8 (2010). doi:10.4314/wiojms.v8i1.56672.

[44] P. Bettinger, K.L. Merry, Relative vulnerability of the forests along southeastern African coasts to cyclones, Singap. J. Trop. Geogr. 33 (2012) 320–334. doi:10.1111/sjtg.12000.

[45] C.J. Matyas, Tropical cyclone formation and motion in the Mozambique Channel, Int. J. Climatol. 35 (2015) 375–390. doi:10.1002/joc.3985.

[46] K. Asante, R. Brito, G. Brundrit, P. Epstein, A. Fernandes, M. M.R., et al., Main Report: INGC Climate Change Report: Study on the impact of climate change on disaster risk in Mozambique, (2009) 55. http://www.mz.undp.org/content/mozambique/en/home/library/environment_energy/study_on_the_impact_of_climate_change_on_disaster_risk_management.html.

[47] H. Motta, M. Pereira, M. Gonçalves, T. Ridgway, M. Schleyer, Coral reef monitoring in Mozambique. II: 2000 report. MICOA/CORDIO/ORI/WWF, (2002) 31.

[48] J. Palalane, M. Larson, H. Hanson, D. Juízo, Coastal Erosion in Mozambique: Governing Processes and Remedial Measures, http://dx.doi.org/10.2112/JCOASTRES-D-14-00020.1. (2016).

[49] M.E. Moreira, A dinâmica dos sistemas litorais do Sul de Moçambique durante os últimos 30 anos, Finisterra. 40 (2005). doi:10.18055/FINIS1495.

[50] J.V.Q. Langa, Problemas na zona costeira de Moçambique com ênfase para a costa de Maputo, Rev. Gestão Costeira Integr. 7 (2007) 33–44. doi:10.5894/rgci8.

[51] E.A. Massuanganhe, C. Macamo, L.-O. Westerberg, S. Bandeira, A. Mavume, E. Ribeiro, Deltaic coasts under climate-related catastrophic events – Insights from the Save River delta, Mozambique, Ocean Coast. Manag. 116 (2015) 331–340.

doi:10.1016/j.ocecoaman.2015.08.008.

[52] H. Tallis, T. Rickets, A. Guerry, S. Wood, R. Sharp, E. Nelson, et al., InVEST 3.1.1 User's Guide: Integrated Valuation of Environmental Services and Tradeoffs. The Natural Capital Project, (2015). http://ncp-dev.stanford.edu/~dataportal/invest-releases/documentation/current_release/.

[53] M.G. Chung, H. Kang, S.-U. Choi, Assessment of Coastal Ecosystem Services for Conservation Strategies in South Korea, PLoS One. 10 (2015) e0133856. doi:10.1371/journal.pone.0133856.

[54] T. Hopper, M.S. Meixler, Modeling Coastal Vulnerability through Space and Time, PLoS One. 11 (2016) e0163495. doi:10.1371/journal.pone.0163495.

[55] E.B. Barbier, The protective service of mangrove ecosystems: A review of valuation methods, Mar. Pollut. Bull. 109 (2016) 676–681. doi:10.1016/j.marpolbul.2016.01.033.

[56] B.T. van Zanten, P.J.H. van Beukering, A.J. Wagtendonk, Coastal protection by coral reefs: A framework for spatial assessment and economic valuation, Ocean Coast. Manag. 96 (2014) 94–103. doi:10.1016/j.ocecoaman.2014.05.001.

[57] M.B.S.F. Costa, M. Araújo, T.C.M. Araújo, E. Siegle, Influence of reef geometry on wave attenuation on a Brazilian coral reef, Geomorphology. 253 (2016) 318–327. doi:10.1016/j.geomorph.2015.11.001.

[58] M.E. Hanley, S.P.G. Hoggart, D.J. Simmonds, A. Bichot, M.A. Colangelo, F. Bozzeda, et al., Shifting sands? Coastal protection by sand banks, beaches and dunes, Coast. Eng. 87 (2014) 136–146. doi:10.1016/j.coastaleng.2013.10.020.

[59] J.P. Doody, Sand Dune Conservation, Management and Restoration, Springer Netherlands, Dordrecht, 2013. doi:10.1007/978-94-007-4731-9.

[60] ESRI, ArcGIS, (2014). www.esri.com.

[61] NOAA, Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG), National Oceanic and Atmospheric Administration, Natl. Ocean. Atmos. Adm. (2015). http://www.ngdc.noaa.gov/mgg/shorelines/ (accessed March 3, 2016).

[62] NASA/METI, ASTER Global DEM data (GDEM V2), (2012).

http://earthexplorer.usgs.gov/.

[63] H.L. Tolman, User Manual and System Documentation of WAVEWATCH III version 3.14 Technical Note, 2009.

[64] GEBCO, General Bathymetric Chart of the Oceans (GEBCO), (2014). http://www.gebco.net/.

[65] CIESIN, Center for International Earth Science Information Network (CIESIN), Columbia University; and Centro Internacional de Agricultura Tropical (CIAT). Gridded Population of the World Version 3 (GPWv3). Palisades, NY: Socioeconomic Data and Applications Center, (2005). doi:http://sedac.ciesin.columbia.edu/plue/gpw.

[66] OECD, Investment Policy Reviews: Mozambique, (2013) 29. https://www.oecd.org/daf/inv/investment-policy/IPR-Mozambique-Oct2013-Summary.pdf.

[67] C.C.F. Macamo, E. Massuanganhe, D.K. Nicolau, S.O. Bandeira, J.B. Adams, Mangrove's response to cyclone Eline (2000): What is happening 14 years later, Aquat. Bot. 134 (2016) 10–17. doi:10.1016/j.aquabot.2016.05.004.

[68] A. Fekete, Validation of a social vulnerability index in context to river-floods in Germany, Nat. Hazards Earth Syst. Sci. 9 (2009) 393–403. www.nat-hazards-earth-syst-sci.net/9/393/2009/ (accessed August 11, 2016).

[69] V.N. Martins, P. Cabral, D. Sousa e Silva, Urban modelling for seismic prone areas: the case study of Vila Franca do Campo (Azores Archipelago, Portugal), Nat. Hazards Earth Syst. Sci. 12 (2012) 2731–2741. doi:10.5194/nhess-12-2731-2012.

[70] C.J. Matyas, J.A. Silva, Extreme weather and economic well-being in rural Mozambique, Nat. Hazards. 66 (2013) 31–49. doi:10.1007/s11069-011-0064-6.

[71] N. Viana, Coping with floods: Mozambique and Britain, Contemp. Rev. 290 (2008) 493. http://connection.ebscohost.com/c/articles/36321574/coping-floods-mozambique-britain.

Book Spine

June 2018

Diffusion perspective of Geographic Information Technology across Mozambican institutions

Nelson Amade

PhD