UNIVERSITY OF VENDA

A FRAMEWORK TO INTEGRATE BUSINESS INTELLIGENCEAND COLLABORATIVE VISUAL ANALYTICS FOR DECISION SUPPORT IN DISASTER RISK MANAGEMENT IN SOUTH AFRICA

BY

MASHUDU MALIGUDU

11623420

A DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF COMMERCE

IN THE

DEPARTMENT OF BUSINESS INFORMATION SYSTEMS

FACULTY OF MANAGEMENT, COMMERCE AND LAW

SUPERVISOR: PROF. NIXON MUGANDA OCHARA

CO-SUPERVISOR: NAJIYABANU PATALA

10/03/2023

Table of Contents

Acknowledgements

I would like to thank God for caring me through the whole process although it was not easy my God came through for me and gave me strength to pull through till the end. I dedicate this degree to my beloved Mom in heaven, you may not be here to see my progress, but you remain my inspiration and your love and guidance is engraved in my heart forever. I thank my family and friends for all their encouragement and support, we are a winning team. I am extremely grateful to Dr Munyoka my HOD, you are the best and thank you for your support and encouragement, my supervisor Prof. Ochara thank you for your guidance, my co-supervisor Mrs Patala you are by far the sweetest; thank you for believing in me and last but not Least the University of Venda in partnership with Sap that afforded me the opportunity to study further through financial assistance and acceptance into the program.

Thank you all for sharing expertise, sincere guidance and encouragement throughout this project.

Aa!

DECLARATION

I, Mashudu Maligudu, hereby declare that the work contained in the proposal for the Master of Commerce in Business Information Systems, submitted to the Faculty of Management, Commerce, and Law at the University of Venda, has not been submitted previously at any university or other higher education institution for any degree. It is original in design and execution, and I declare that I will fully acknowledge any sources of information and all referenced material I will use for the research according to the Institution's rules.

Signature: _____ **Date:** 10/03/2023_____

SIGNATURE OF THE SUPERVISOR

Name: PROF. NIXON MUGANDA OCHARA

Signature: ___ __ Date: 14/03/2023

SIGNATURE OF THE CO-SUPERVISOR___Mrs. Patala Najiyabanu___, herewith declare that I accept this research for my supervision.

Signature: _____ __ Date: 13/03/2023

Signature of the HOD

Name: Dr. Willard Munyoka

Signature: Date: 15/03/2023

ABSTRACT

Access to real-time information, which can be either information before, during, or after the disaster, is essential to the effectiveness of disaster risk management, prevention and mitigation, preparedness, response, and recovery. The current Visual Analytics in Disaster Risk Management is not equipped to handle a considerable volume of disaster-related information dissipated across various partners. The study's main aim was to design a framework for Collaborative Visual Analytics integration in Disaster Risk Management. The current research used a qualitative methodology, and data was collected through documents. The research addressed collaborative visual analytics for decision assistance in disaster risk management in South Africa. Several theoretical recommendations from the findings were suggested. These are critical towards having a comprehensive understanding over the subject matter, guiding policy, and enriching the body of knowledge.

Keywords: *Disaster, Disaster Risk Management, Integration, Visual Analytics, Decision Support, Collaboration, and Decision support*

List of Acronyms

DRM	Disaster Risk Management
DDRM	Directorate Disaster Risk Management
OPM	Office of the Prime Minister
VA	Visual Analytics
CDM	Collaborative Decision Making
NDMC	National Disaster Management Center
ANT	: Actor Network Theory
BC	: Business continuity
BCDR	: Business continuity and disaster recovery
BCM	: Business continuity management
BCP	: Business continuity plan
BCT	: Business continuity theory
BIA	: Business impact analysis
BR	: Business Recovery
CBOs	: Community-based organizations
COOP	: Continuity of operations planning
CM	: Crisis Management
CPPS	: Contingency planning policy statement
DM	: Disaster management
DPME	: Department: Planning Monitoring & Evaluation
DR	: Disaster recovery
DRAAS	: Disaster recovery as a service
DRMS	: Disaster Risk Management Solution
DRP	: Disaster recovery plan
FVM	: Fit-Viability Model
HR	: Human resources
ICT	: Information communication technology
IT	: Information technology
LG	: Local government
LGSETA	: Local Government Sector Education & Training Authority
MIS	: Management information systems
M&E	: Monitoring and evaluation
NGOs	: Non-governmental organisations

List of figures

List of tables

List of Appendixes

CHAPTER 1: INTRODUCTION

1.1. Background of the study

Effective disaster management is a global challenge (Panrungsri & Sangiamkul, 2017). The world has seen a shocking increase in the occurrence and severity of different disasters in terms of populations affected and magnitude of material losses (Schenck, Blaauw, Viljoen, & Swart, 2019). A disaster is defined as a situation, which overwhelms local capacity, necessitating a request to national or international level for external help or an unforeseen and often sudden event that causes great damage, destruction, and human suffering (Arslan, Roxin, Cruz, & Ginhac, 2017). Many people have been killed by earthquakes, volcanic eruptions, tsunamis, landslides, floods, tropical storms, drought, human and animal diseases, and other natural catastrophes (Jang, Ekyalongo, & Kim, 2020). About 6096 disasters were registered worldwide between 2006 and 2015, the number of people killed because of disasters were 771,917 worldwide and the number of people affected were 1,917, 557 (Sanderson & Sharma, 2016).

Disaster management is defined as 'the integration of all activities required to build, sustain, and improve the capabilities to prepare for, respond to, recover from, or mitigate against a disaster (Arslan et al., 2017). Disaster management is commonly described in four phases including preparedness, response, recovery, and mitigation (Panrungsri & Sangiamkul, 2017). Each phase has the different activities which require the data to support as the following: Preparedness phase is aimed at preventing a disaster at first phase. In the event a disaster occurs, then it will try to control its effect through suitable response and recovery strategies (Panrungsri & Sangiamkul, 2017). The activity of preparedness includes planning, organizing, training, equipping, evaluation and improvement, which requires the related information (plans, resources, and organizations) (Flachberger & Gringinger, 2016). Response phase occurs after the crisis event has occurred, the aim is to minimize losses, save lives, damages, and alleviate suffering (Panrungsri & Sangiamkul, 2017). The Information which is required for the response may contain resources, needs, damages, threats, and collaborations (Flachberger & Gringinger, 2016). The related activities include search, rescue, and emergency relief. Recovery phase wants to return the community's systems and the activities back to normal in long-term. This phase is not similar to the response

phase in its concentrations; recovery efforts are concerned with issues and decisions (Public Safety Canada, 2011). The activities of recovery phase include claims, grants, and repair of important infrastructure. Besides, the information is required for reducing damage (Flachberger & Gringinger, 2016). The mitigation phase: effort to manage and reduce the risk to life and property. The information is required for decision support such as hazard, risk, forecasting, and impact of disaster (Flachberger & Gringinger, 2016).

In disaster management, there are many activities that involve decision making under the time pressure (Horita, de Albuquerque, Marchezini, & Mendiondo, 2017). However, decision making in government usually takes much longer and is conducted through consultation and mutual consent of a large number of diverse actors, including officials, interest groups, and ordinary citizens (Fragkos, Tsiropoulou, & Papavassiliou, 2019). This may be due to standard operating procedures, and top management discussions. How those decisions are made is important, as the result of the decision-making must compromise the citizens and country accepted standards (Zubir et al., 2017). Timely decision-making to direct and coordinate the activities of other people is important to achieve disasters management goals (Sitas et al., 2016).

Moreover, it requires a different analytic approach either because their probability of occurrence is very low or it is difficult to foresee by normal strategy processes (Horita et al., 2017). In response to great pressure for the government to provide service delivery within time and budget constraint, business intelligence and collaborative visual analytics may be one of the possible solutions to consider as government holds a great amount of earth-related data owned by the public agencies and departments (Panrungsri & Sangiamkul, 2017). Decision making in natural disaster management has its own challenge that needs to be tackled. In times of disaster, government as a response organization must conduct timely and accurate decisions (Li et al., 2017).

Business Intelligence (BI) refers to the set of techniques and tools that help to transform a large amount of data from disparate sources into meaningful information to support decision-making and improve organizational performance (Kiani Mavi & Standing, 2018). Most organizations use

BI for analyzing data. BI has emerged as a major driving force for organizational performance (Arnott, Lizama, & Song, 2017). Technically, the processes of BI include Extract, Transformation, and Load (ETL) process, data warehouse, online analytical processing (OLAP), data mining, decision models and visualizations (Zhang et al., 2016). Most BI applications are used in Business and marketing while BI application of disaster management is scanty (Arslan et al., 2017).

Visual Analytics is a body of knowledge that allows us to use techniques with interactive visualization algorithms and methods of data analysis in order to support the analytical reasoning for decision making (Flachberger & Gringinger, 2016).Visual Analytics is used in diverse areas such as science, engineering, business and government (Gómez, 2017). We can find different visual analytics applications in fields such as urban planning, gas explorations, finance, security, natural disasters, health monitoring among others. (Gómez, 2017)

Emergency managers must have a comprehensive understanding of the emergency situation based on accurate information in order to avoid making any wrong decisions that might cost people's lives (Flachberger & Gringinger, 2016; Sarvari, Nozari, & Khadraoui, 2019). Simultaneously, focusing on the insignificant data and neglecting the information flow because of too much trivial data causes unfortunate implications such as misidentifying the true first responders (Ngamassi, Malik, Zhang, & Ebert, 2017). In order to improve disaster responsive, it is important throughout the world to increase knowledge of disaster management (Yu, Yang, & Li, 2018). The entire above objective may be facilitated by incorporating big data systems to process and store real-time voluminous disaster data with reduced time and cost for timely decision making (Kiani Mavi & Standing, 2018).

1.1. Context of the study

South Africa is increasingly prone to major natural disasters. In terms of natural catastrophes, the two most prominent occurrences are two extremes: Floods and droughts. The EM-DAT international disaster database indicates that over the last twenty years (2002-2021) floods (n=793) and droughts (n=137) represented 55% of natural hazards in Africa (n= 1,693), with 14,053 and 20,821 deaths, respectively, therefore, Floods and drought are two extremes of the

hydrological cycle. (Crunch, 2022) Despite their different physical processes, with different spatial and temporal scales, their interplay can enhance the resulting detrimental cascading effects. For instance, drought hazards lead to soil degradation, reduced sub-surface water storage, and a lower capacity for soil infiltration, which increases run off and proneness to flood risk. (Crunch, 2022) There are also isolated incidences of meteorological phenomena, including tropical cyclones, tornadoes, and severe thunderstorms (Pharoah et al., 2016). In South Africa, communities face devastating damages caused by most catastrophic natural disasters such as forest and veldt fires, floods, drought, and human and diseases outbreak and other hazards (Culwick, 2019).

The primary responsibility for disaster management in South Africa rests with the government (Culwick, 2019). In terms of section 41(l) (b) of the Constitution of the Republic of South Africa, all spheres of government are required to “secure the well-being of the people of the Republic”. Accordingly, under Article 41(l) (b) of the Constitution of the Republic of South Africa, all spheres of government are mandated to "ensure the well-being of the citizens of the Country" (The South African Constitution, 5 July, 2021). Disaster management is classified as a substantive region in Part A of Schedule 4 of the Constitution, meaning that both the national and regional levels of government are responsible for the formulation and execution of laws in this sector and have rights and responsibilities in the field of disaster management (Disaster Management Act, 2002). Disaster management in SA consists of a labyrinth of crosscutting facets that requires the participation of a host of sectors and disciplines not only from within the spheres of government (national, provincial and local) but involving the private sector, civil society, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs) (Brewer, van Staden, Le Roux, & van Niekerk, 2017).

Disaster risk reduction in South Africa is strongly guided by legislation (Culwick, 2019). The Disaster Management Act (2002) lays the foundation for disaster risk reduction in the country, and the National Disaster Management Framework (2005) provides details on the development and implementation of the Act for all levels of government (Disaster Management Act, 2002). The

Disaster Management Amendment Act (2015) was adopted to update the 2002 Disaster Management Act with new commitments including climate change adaptation, and adjustments to minimize some of the challenges that were experienced in implementing the original Act (Disaster Management Act, 2002). These changes encourage the government to incorporate climate change projections into disaster risk management (Culwick, 2019).

The National Policy Development Framework 2020 emphasizes the importance of collaboration and coordination between government departments, agencies and non-government actors including communities (Cabinet, 2020). Data and research, including community and Indigenous knowledge, are identified as critical for developing policies and plans to reduce disaster risk (Bruwer et al., 2017). The National Policy Development Framework further emphasises the cost effectiveness of proactively managing disasters to prevent rather than merely recover from disasters. Gaps in data also create problems for effective disaster risk reduction (Culwick, 2019). This highlights the importance of integrating business intelligence and visual analytics as part of improving disasters response (Pharoah et al., 2016).

1.2 Research Problem Statement

There is a persistence of challenges to make sense of complex data gathering for disaster risk management. Regardless of numerous efforts by disaster management professionals and government agencies, disasters continue to occur, and number of deaths remained high throughout the globe including South Africa (Dyssel J, 2018). Disasters continue to occur in South Africa due to inconsistent data during disasters (National & Management, 2005). The vast variety of data sources present in times of a disaster create a need for integration and aggregation of data. There is panic, misguided, misallocation of resources and uncertainty. Inconsistence in data format across organizations affects the effective use of data for disaster and risk management (Dyssel J, 2018).There has been an enormous volume of disaster-related data being gathered, processed, and stored consistently in different organizations in South Africa (zeekoi enterprise solutions, 2023). Disaster management differs as the history, incidents and individuals involved are rarely the same from one incident to another. Each, management function includes a range of different forms of event information from a number of sources (Turoff et al., 2004), such as

information systems, external corporate databases, field resources, Internet of Things detectors, social networking, and other open access networking. A portion of the data can either in an organized, semi-organized, and unstructured format. In any case, the greater part of the data is in an unstructured format and stored in various customary databases. (Pattath, 2010). Catastrophe related information have been set up at a quicker rate than the client's capacity to examine them (Pattath, 2010) . Nowadays, command and control (C2) are packed with cutting-edge technology, visual technologies, such as the new generation of smart phones, tabletops, video walls and e-caves (Dusse et al., 2016). This mixture of data sources and modern technology provides C2 with large volumes of knowledge with considerable heterogeneity.

It shows that not every single data gathered is important and significant, and the ability to gather, analyse, and transform data into notable knowledge is extremely complicated (Bisantz, 2006) (Dusse, 2016). Higher order moving object information is of considerable significance for addressing in-case disaster management situations. Multivariate higher-order knowledge processing is a prerequisite to the effectiveness of disaster response, since emergency management requires the creation of multi resourced strategies (Wang, 2020). (Environmental disasters have the potential to cause catastrophic destruction and major socio-economic damages. The real damage and destruction observed in recent decades has seen a growing pattern (Wang, 2020). As a result, disaster managers need to be primarily accountable for proactively securing their populations through the implementation of relevant response approaches (Sun, 2020). Emergency managers must have a comprehensive understanding of the emergency based on accurate information to avoid making any wrong decisions that might cost people’s lives. To address every one of these issues, business intelligence and visual analytics can be fused into Disaster Risk Management for the mitigation of disasters.

Business intelligence (BI) joins business analytics, data mining, data visualization, data tools and infrastructure, and best practices to assist organizations with making more data-driven choices. Visual analytics integration integrates disparate data sources and likewise enables diverse stakeholders ranging from decision-makers, analysts, and disaster response groups at all levels to

analyse real-time data, display data in an appealing manner, and make intelligent decisions. (Scene, 2017).

1.3 Aim and research objectives

The main aim of the study was to design a framework for Business Intelligence and Collaborative Visual Analytics integration in Disaster Risk Management.

Sub-objectives

The following were the objectives of the study:

- Establish the role and interests of stakeholders in Collaborative Decision-Making environments.
- Investigate the usefulness of visual analytics integration in Disaster Risk Management environment.
- Determine the nature of collaboration in a multi-agent Disaster Risk Management environment.
- Investigate how Business Intelligence and Collaborative Visual Analytics integration can be used for effective Decision-Making support in Disaster Risk Management contexts.

The following set of questions had to be answered by the research study:

Main question

- How can Business Intelligence and Collaborative Visual Analytics be integrated for effective Disaster Risk Management in South Africa?

Sub-questions

- What is the role and interests of different stakeholders in a Collaborative Decision-Making Environment?
- What is the Role of Information Visualization in Collaborative Decision Support?
- What are the forms of collaboration in a multi-agent Disaster Risk Management environment?
- How can Business Intelligence and Collaborative Visual Analytics integration be realized in Disaster Risk Management contexts?

Significance of the study

The significance of the study is to ensure key stakeholders are aware of the various forms of collaboration in a multi-agent Disaster Risk Management environment. Stakeholders would be able to adopt the proposed framework for Business Intelligence and Collaborative Visual Analytics integration in Disaster Risk Management and could prompt all stakeholders to work together in the decision-making process.

1.4 Delimitations of the study

Limitation is any factor that may potentially interfere with successful completion of the research study. Below are the limitations of the study:

- Cost of expenses for data collection and other research running expenses such as data.
- Time limit to complete the study.
- The study only focusses on the natural disaster rather than the technological disasters.

1.5 Definitions of concepts

Business Intelligence

According to study.com (2017) Business intelligence (BI) is a variety of software applications used to analyse an organization's raw data. BI can include data mining, online analytical processing, and business reporting. Most businesses use BI software to help keep track of information and rely on the software to operate effectively. Business intelligence (BI) combines business analytics, data mining, data visualization, data tools and infrastructure, and best practices to help organizations make more data-driven decisions.

1.5.1. Disaster

According to the NDRM Policy (2009), a disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses, which exceed the ability of the affected community, or society to cope using its own resources. Srivastava, (2010) further defined disaster as a sudden, catastrophic event, bringing great damage, loss, destruction and devastation to human life and property. Similarly, disaster is simply described as the harms that the community suffers from which is either physically, economically

or emotionally. Guha-Sapir, Vos, Below, & Ponserre, (2012) classify two generic categories of disaster (natural disasters and technological disasters).

1.5.2 Disaster Risk Management

The UNSDR (2007) defined Disaster Risk Management as an application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk. All these contribute to the strengthening of resilience and reduction of disaster losses.

1.5.3 Visual analytics

Qadir et al., (2016) describe visual analytics as an exploratory data analysis tool that aims to support analytical reasoning through visual interfaces. Visual analytics is used to combine the human perceptual and cognitive capabilities with the computing and processing power of computers (Wang et al., 2014). With the computing power, it helps analysts to gain more insights and reveal the expected and discover the unexpected from data through thorough analysis and exploration (Wang, 2020).

1.5.4 Integration

According to TechTarget, (2015), integration is an action of bringing together smaller components into a single system that functions as one (Yasar, 2015). In an IT context, integration refers to the end result of a process that aims to stitch together different, often disparate, isolated subsystems so that the data contained in each becomes part of a larger, more comprehensive system that ideally, quickly, and easily shares data when needed. This implies that it provides an all-in-one solution to a problem.

1.5.4 Collaboration and Decision support

Collaboration is a multi-disciplinary nature which involves various people with different background and expertise. The decision support is a process that is evolving from a stakeholder to a multi-stakeholder situation in which collaboration is a way to make the decision (Gabrielle Wong-Parodi, 2020). This implies that the community members affected by any decision, share information related to that decision and agree on and apply the decision-making approach and principles (Tisdall, A. 2013).

1.5.6 Business Intelligence analytics

Business intelligence and analytics are data management solutions implemented in companies and enterprises to collect historical and present data, while using statistics and software to analyse raw information and deliver insights for making better future decisions (Chowdhury, 2022). “Since its conceptual beginnings in the 1950s, business intelligence has grown significantly, and you must recognise that business intelligence is not only for major corporations. We are currently in an era where small structures, like start-ups, are much more prevalent, and most BI providers have recognised this shifting dynamic and are modifying their software to meet the needs of customers. This is especially true for SaaS, or Software-as-a-Service, providers.” (Chowdhury, 2022).

1.6 Outline of the research

Chapter 1: Introduction and background

An introduction to the concepts and focus of the research with explanations to the following aspects of the research study is provided in this chapter: the background of the problem statement, aims and objectives, research questions, delimitations, assumptions, and basic definitions of the study.

Chapter 2: Literature Review

A review of the present knowledge published in Business Intelligence and Collaborative Visual Analytics integration for Decision Support is provided in this chapter. This will help in determining the gaps in the literature to form basis for further research. The sources for the literature review are previous research materials, journals, articles, books, and business reports etc. among others.

Chapter 3: Research design and methodology

This chapter described the techniques used for collecting and examining data in a systematic manner by explaining the research methodology, the target population, and methods for collecting data, and the procedures to use in fulfilling the research questions. A background to case study of the research was also be provided in this chapter.

Chapter 4: Presentation of the research findings

The findings of research in detailed founded through the data collected from the participants of the research study are presented in this chapter.

Chapter 5: Discussion of the research findings

The results of study are discussed in this chapter by analysing the research findings and relating these to the literature review.

Chapter 6: Conclusion, recommendations, and summary

A conclusion of the research by producing a summary of the research is described in this chapter. Conclusions are derived from the interpretations of the findings. Recommendations and guidelines for future research are also provided in this chapter.

1.7 Summary

Several aspects were briefly discussed in this chapter such as: the background and context of the study and definition of terms. It also concludes about the statement of the problem that is driving the researcher to conduct the current study. Research questions were constructed in-line with the objectives of the study, and the significance and limitations of study were identified. The next chapter (2) covers the review of existing research studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Literature reviews consist of existing knowledge including the practical findings as well as theoretical and methodological contributions to a subject. Several related research are studied on Business Intelligence and Collaborative Visual Analytics integration for Decision Support in Disaster Risk Management, and they are reviewed to provide the researcher with the insight of how Business Intelligence and Collaborative Visual Analytics can be used for Disaster Risk Management in making informed decisions. This section comprises: Collaborating Decision Making, Visual Analytics Integration, Disaster Risk Management systems, Benefits and Challenges of adoption, Theories of visualization and finally Actor Network Theory.

2.2 Global prevalence of Disasters

At least 207 natural disasters were recorded globally in the first six months of 2020. Natural disasters claimed roughly 2,200 lives during the first half of 2020 (Sanderson & Sharma, 2016). Floods accounted for nearly 60 per cent of the total toll during this time (Talisuna et al., 2020). According to the report, the Asia-Pacific region recorded the maximum number with 1,002 lives lost, even though the value was at its lowest since at least 1972. The estimates in the report showed that Asia Pacific and Africa jointly accounted for 71 percent of lives lost in the first half. Previously, floods and the cyclones claimed over 2,900 lives during the same period and most of the deaths due to tropical cyclones in the first half of 2019 occurred in Africa, according to the report of (Sanderson & Sharma, 2016). The past 12 years has also witnessed some very big changes. The Ebola outbreak in West Africa, beginning in March 2014, led to 11,310 deaths across Liberia, Sierra Leone and Guinea (WHO, 2016). The Haiti earthquake of 2010 provided a terrifying ‘perfect storm’ of a major earthquake striking one of the poorest countries in the western hemisphere (Li et al., 2017). The loss of between 100,000 and 316,000 people (the uncertainty of the figure highlighting the country's precarious governance) served to highlight weaknesses in urban areas unprepared for such disasters, as well as an aid sector unprepared for the urban challenge (Sanderson & Sharma, 2016).

Repeated erratic and extreme weather events in east and southern Africa have caused serious casualties, such as t that in 2019 where at least 1,200 people lost their lives as the result of cyclones, floods and landslides in Mozambique, Somalia, Kenya, Sudan and Malawi (Sasaki, Moriyama, & Ono, 2020). Ten countries across East and Southern Africa namely: Madagascar, Malawi, Mozambique, Zambia, Zimbabwe, South Sudan, Sudan, Ethiopia, Somalia and Kenya are experiencing ongoing weather-induced crises, with an average of 10% of people living in these countries currently experiencing serious hunger (Bassey, 2020). in recent times, the world is experienced the crisis caused by Covid19. The World Health Organization (WHO) announced the COVID-19 outbreak as a pandemic (Fauci, Lane, & Redfield, 2020). The first lesson we learn is that new hazards concerning viruses, such as SARS-CoV-2, producing new diseases (such as COVID-19, as well as SARS and MERS in the past), will continue to occur (Nishiura et al., 2020; Talisuna et al., 2020). Given the devastating losses caused by disasters every year, effective disaster management has become a pressing issue.

2.3 Disaster Management

Given the devastating losses caused by disasters every year, effective disaster management has become a pressing issue for today's world, especially for disaster-prone countries such as China, Japan, and Sub-Saharan Africa including South Africa. (Awuh, 2022) A disaster is defined as a situation, which overwhelms local capacity, necessitating a request to national or international level for external help or an unforeseen and often sudden event that causes great damage, destruction, and human suffering (Arslan, Roxin, Cruz, & Ginhac, 2017). Disaster management is the process of planning and taking actions to minimize the social and physical impact of disasters and reduce the community's vulnerability to the consequences of disasters (Coppola, 2006). The disaster management literature is full of frameworks, models and procedures for coping with disasters (Nojavan, Salehi, & Omidvar, 2018). Perhaps the most common framework that dominates the literature is the disaster management cycle which includes the phases of mitigation/ prevention, preparedness, response and recover (Coppola, 2006).

Disaster management is usually a cyclic process that consists of the following four main phases: 1) *The Preparedness phase* is aimed at preventing a disaster at first phase. That is, if a disaster

occurs, then it will try to control its effect through suitable response and recovery strategies (Panrungsri & Sangiamkul, 2017). The activity of preparedness includes planning, organizing, training, equipping, evaluation and improvement, which requires the related information (plans, resources, and organizations) (Flachberger & Gringinger, 2016). 2) *The Response phase* occurs after the crisis event has occurred, the aim is to minimize losses, save lives, damages, and alleviate suffering (Panrungsri & Sangiamkul, 2017). The Information which is required for the response may contain resources, needs, damages, threats, and collaborations (Flachberger & Gringinger, 2016). The related activities include search, rescue, and emergency relief. 3) *The Recovery phase* wants to return the community's systems and the activities back to normal in long-term. This phase is not like the response phase in its concentrations; recovery efforts are concerned with issues and decisions (Public Safety Canada, 2011). The activities of recovery phase include claims, grants, and repair of important infrastructure. Besides, the information is required for reducing damage (Flachberger & Gringinger, 2016). 4) *The mitigation phase*: effort to manage and reduce the risk to life and property. The information is required for decision support such as hazard, risk, forecasting, and impact of disaster (Flachberger & Gringinger, 2016).

In disaster management, there are many activities that involve decision making under the time pressure (Horita, de Albuquerque, Marchezini, & Mendiondo, 2017). However, decision making in government usually takes much longer and is conducted through consultation and mutual consent of many diverse actors, including officials, interest groups, and ordinary citizens (Fragkos, Tsiropoulou, & Papavassiliou, 2019). This may be due to standard operating procedures, and top management discussions. How those decisions are made is important, as the result of the decision-making must compromise the citizens and country accepted standards (Zubir et al., 2017). Timely decision-making to direct and coordinate the activities of other people is important to achieve disasters management goals (Sitas et al., 2016).

Given the devastating losses caused by disasters every year, effective disaster management has become a pressing issue for today's world, especially for disaster-prone countries such as China, Japan, and Sub-Saharan Africa including South Africa. Disaster management is the process of

planning and taking actions to minimize the social and physical impact of disasters and reduce the community's vulnerability to the consequences of disasters (Coppola, 2006).

Usually, the end of one phase is also the beginning of the next (See figure 1), but sometimes phases can overlap, and several may take place simultaneously (Kanal, 2020). Since disaster management is a multifaceted process, it is imperative to deploy proper management that optimizes planning and responses (Li et al., 2017).

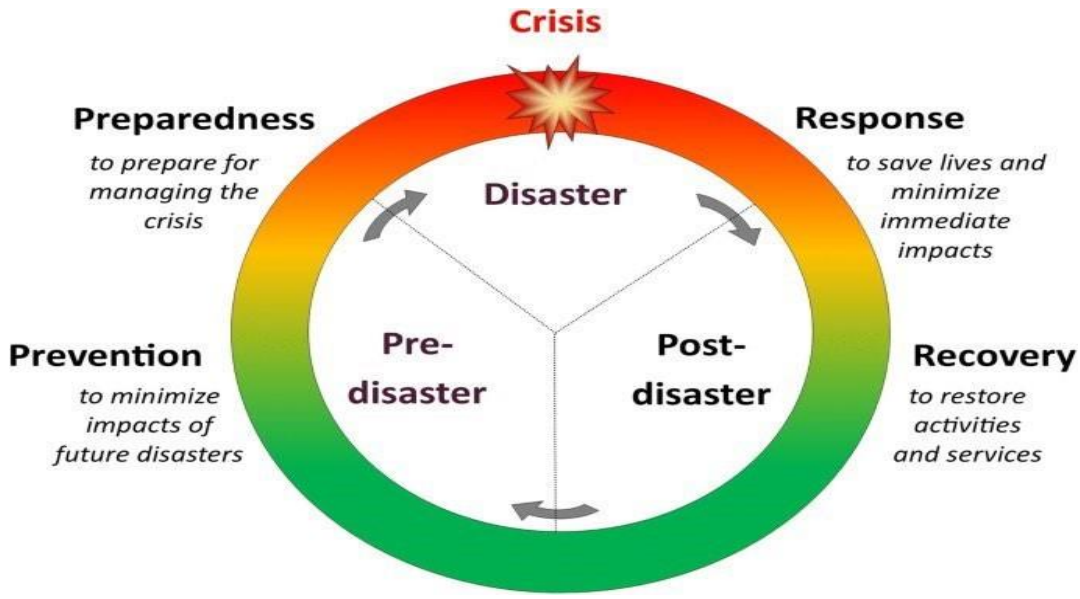


Figure 1: Disaster Management cycle

Timely decision-making during each phase results in better preparedness, earlier warnings, and reduced vulnerability (Nojavan, Salehi, & Omidvar, 2018). The full disaster management cycle also includes the creation of effective plans and public policies for addressing the causes of disasters and/or mitigating their impacts on properties, people, and infrastructures (Sawalha, 2020). In times of disasters, government and authorities who act as decision makers are responsible to take action that demands immediate and fast relief activities in the devastated area. But the quality of the decision depends on the quality of data and information obtained (Emmanouil & Nikolaos, 2015). In the modern world, there are technologies that can be employed to help decision makers, analysts, or emergency response teams to consolidate information, generate

summaries and discover the information space in order to extract useful information (Benaben, Montarnal, Fertier, & Truptil, 2016; Jung, Tran Tuan, Dai Tran, Park, & Park, 2020; Zhang et al., 2016). Visual analytics it is an emerging discipline that is aiming at making the best possible use of massive volume of data in a wide variety of systems or databases by appropriately combining the strengths of intelligent automatic data analysis with the visual perception and analysis capabilities of the human user (Emmanouil & Nikolaos, 2015).

2.3.1 Disaster Management in the Context of South Africa

South Africa is becoming increasingly vulnerable to significant natural disasters. In terms of natural disasters, the two most prominent occurrences are floods and droughts. (Crunch, 2022). There are also isolated incidences of meteorological phenomena, including tropical cyclones, tornadoes, and severe thunderstorms (Pharoah et al., 2016). In South Africa, communities face devastating damages caused by most catastrophic natural disasters such as forest and veldt fires, floods, drought, and human and diseases outbreak and other hazards (Culwick, 2019).

The primary responsibility for disaster management in South Africa rests with the government (Culwick, 2019). In terms of section 41(l) (b) of the Constitution of the Republic of South Africa, all spheres of government are required to “secure the well-being of the people of the Republic”. Accordingly, under Article 41(l) (b) of the Constitution of the Republic of South Africa, all spheres of government are mandated to "ensure the well-being of the citizens of the Country." (The South African Constitution, 5 July, 2021). Disaster management is classified as a substantive region in Part A of Schedule 4 of the Constitution, meaning that both the national and regional levels of government are responsible for the formulation and execution of laws in this sector and have rights and responsibilities in the field of disaster management (Disaster Management Act, 2002). Disaster management in SA consists of a labyrinth of crosscutting facets that requires the participation of a host of sectors and disciplines not only from within the spheres of government (national, provincial, and local) but involving the private sector, civil society, Non-Governmental Organizations (NGOs), and Community-Based Organizations (CBOs) (Bruwer, van Staden, Le Roux, & van Niekerk, 2017).

Disaster risk reduction in South Africa is strongly guided by legislation (Culwick, 2019). The Disaster Management Act of 2002 lays the foundation for disaster risk reduction in the country,

and the National Disaster Management Framework (2005) provides details on the development and implementation of the Act for all levels of government (Disaster Management Act, 2002). The Disaster Management Amendment Act (2015) was adopted to update the 2002 Disaster Management Act with new commitments including climate change adaptation, and adjustments to minimize some of the challenges that were experienced in implementing the original Act (Disaster Management Act, 2002). These changes encourage the government to incorporate climate change projections into disaster risk management (Culwick, 2019).

Data and research, including community and indigenous knowledge, are identified as critical for developing policies and plans to reduce disaster risk (Bruwer et al., 2017).The framework also highlights the financial advantages of proactive disaster management to avoid rather than simply recover from calamities. (Awuh, 2022) Gaps in data also create problems for effective disaster risk reduction (Culwick, 2019). This highlights the importance of integrating business intelligence and visual analytics as part of improving disasters response (Pharoah et al., 2016).

Disasters continue to occur in South Africa due to inconsistent data during disasters (National & Management, 2005). The vast variety of data sources present in times of a disaster creates a need for integration and aggregation of data. Disaster management differs as the history, incidents and individuals involved are rarely the same from one incident to another. Each, management function includes a range of different forms of event information from a number of sources (Turoff et al., 2004), such as information systems, external corporate databases, field resources, Internet of Things detectors, social networking and other open access networking. A portion of the data is either in an organized, semi-organized, and an unstructured format. In any case, the greater part of the data is in an unstructured format and stored in various customary databases. Catastrophe related information have been set up at a quicker rate than the client's capacity to examine them (Pattath, 2010). Nowadays, command and control (C2) are packed with cutting edge technology, visual technologies, such as the new generation of smart phones, tabletops, video walls and e-caves (Dusse et al., 2016). This mixture of data sources and new technology provides C2 with large volumes of knowledge with considerable heterogeneity.

2.4 Business intelligence, Visual analytics, and disaster management

Business Intelligence (BI) refers to the set of techniques and tools that help to transform a large amount of data from disparate sources into meaningful information to support decision-making and improve organizational performance. Business intelligence (BI) is also known as the process of gathering, analyzing, and interpreting data in order to obtain insights and make educated choices inside a company and also helps businesses collect data and interpret it in new ways; in other words, BI is required to interact with business data meaningfully. Therefore, "Business intelligence tools give customers insights into how a company performs now and in the past. By using business intelligence and analytic tools, you can help companies predict what can happen in the future" (coursera, 2023).

Benefits and advantages of business intelligence

Business intelligence is like a flashlight in the dark, helping you understand what's happening with your company and customers. Here are some of the critical benefits that business intelligence offers:

- Track performance over time and in real-time: Business intelligence gives you the foundation to make decisions based on facts and current trends in your company.
- Set benchmarks for performance evaluation: Business intelligence provides metrics to track success and measure performance in various objectives.
- Identify customer preferences and behaviour: Business intelligence tools allow you to observe how customers interact with your brand and products, allowing you to react quickly to trends and marketing messages.
- Improve supply chain efficiency: Business intelligence gives you more accurate information to communicate with suppliers and distributors to keep supply chains running smoothly.
- Faster, more accurate decision-making: Using trusted business intelligence tools, your company can make wiser decisions with less risk because you lower the number of unknown variables.

- Increased profitability: Taken as a whole, these benefits of business intelligence help companies improve their bottom link.

Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces. It is an iterative process that comprises of information collection, data pre-processing, knowledge representation, collaboration and decision making. Visual analytics is a type of reasoning that involves the use of interactive, visual interfaces. Visual analytics allows people to comprehend massive amounts of data by using data analytics, interactive visual representations of the data, and dashboarding. Data visualizations on their own are quite important because they help you answer "what" questions, such as "what are the problems?" or "what are the trends?" When looking for insights in data, though, you must be able to ask why. That is the strength of visual analytics, which enables you to delve deeper into the data. Beyond the limits of a templated dashboard, you may easily develop alternative views and other sorts of visualizations in the data to get to your answer and better understand the patterns or response.

What are the advantages of visual analytics?

Visual analytics may aid in more readily comprehending data, making analytics more accessible to non-experts. This can enable the democratization of data analytics within an organization by including business users in the study of data that informs its choices. Because the data is presented in an interactive, graphical format, business users may discover insights in the data without waiting for IT to respond, allowing them to make wiser choices faster. Visual analytics also allows insights and conclusions to be instantly shared across key stakeholders, allowing for easy collaboration to find the correct answers. Visual analytics enables the entire business to gain insights more quickly. Visual analytics liberates you from the constraints of a chart.

2.4.1 Business Intelligence (BI) for disaster management

Most organizations use BI for analysing data. BI has emerged as a major driving force for organizational performance (Ramakrishnan et al., 2012). Technically, the processes of BI include Extract, Transformation, and Load (ETL) process, data warehouse, online analytical processing (OLAP), data mining, decision models and visualizations (Li Zeng et al.,2006; Olczak et al., 2003;

Zhong et al., 2006). The majority of BI apps are utilized in business and marketing, whereas disaster management BI tools are few (Hsinchun Chen, 2012)..

Chen and Storey classified Business Intelligence & Analytics (BI&A) and provide a framework that identifies the evolution, applications, and emerging research fields of Business Intelligence & Analytics (BI&A). They represented the trend and growing of BI (Chen and Storey, 2012). In order to be more proficient and most effective in settling the emergency, the individuals from the reaction aggregate must subscribe to the brought together regulatory control of a data administration framework to guarantee information uprightness (Gao, Wu, Cao & Zeng, 2011). Nascimento, Yeng and Moreng et al. (2016) presented the conceptual architecture to handle the influx of information in Emergency Situations. Their models were used to data implementation (from raw data sources to visual representations). Moreover, the solution to help identify interesting information on the dashboard (Nascimento, Sousa, Ramirez, Francisco, Carriço & Vaz, 2016). AsonMaps is the platform for collection, aggregation, visualization, and analysis. AsonMaps can geolocat information that be extracted from Instagram and Twitter (Feng, 2022). They focus on a use-case scenario on Hurricane Sandy that devastated the East Coast of the United States in fall of 2012. They used NOAA's SLOSH model and P-Surge (probabilistic surge model) to produce a forecast for Hurricane Sandy (Aulov, 2014). Sung (2011) classified applications for the communication of disaster in Taiwan. It can be divided into 5 types include educational apps, Follow-up apps, Disaster message boards, Alert notification, Location, sensor, and hazard maps. The mobile application has more importance in disaster management, so it occurs increasing data sources (Sung, 2011). Calderon et al. studied analysing the sort of communications that happen through social media during a crisis, specifically a case study selected Hurricane Sandy (Stewart, 2015). They claimed two areas of work: namely collective intelligence and group decision-making software. They need to increase effectiveness between people during the crisis, through technology and information. The collective intelligence of users, allowing them to make better individual and group decisions, so to help those afflicted by a disaster or those attempting to provide relief to help themselves. They were not so concerned about information flows. They are interested in information as a necessity for collective decision-making (Calderon et al., 2014). Olszak and Ziemba introduced the methodology of BI system, creation, and implementation. This research focus two

major stages, 1) BI creation stage involves tools and technologies, which include ETL, data warehouse, OLAP, data mining and presentation tools. 2) BI consumption involves the fundamental changes in the enterprise (Arefin, 2015). The researcher focused on the issue that organizations require some cultural background to go along with information system and information technology when building and implementing a BI system. This suggested a methodology of building and implementing BI system also need sound business practices set by the enterprise (Olszak and Ziemba, 2007).

2.4.2 Visual analytics for Disaster Risk management

Visual analytics it is a multi-disciplinary nature evolving multiple processes and wide variety of application areas, thus, it is not easy to define (Wang, 2020). According to D. Keim et al., (2008) Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces. To be more detailed, visual analytics is an iterative process that comprises of information collection, data pre-processing, knowledge representation, collaboration and decision making (Dusse, 2016). Figure 2 shows a theoretical overview of the different stages which is represented through ovals and their transitions represented with arrows in the visual analytics process. The visual analytics process combines automatic and visual analysis methods with a tight coupling through human interaction between data, visualizations, models about the data, and the users in order to gain knowledge from data (Kohlhammer et al., 2011).

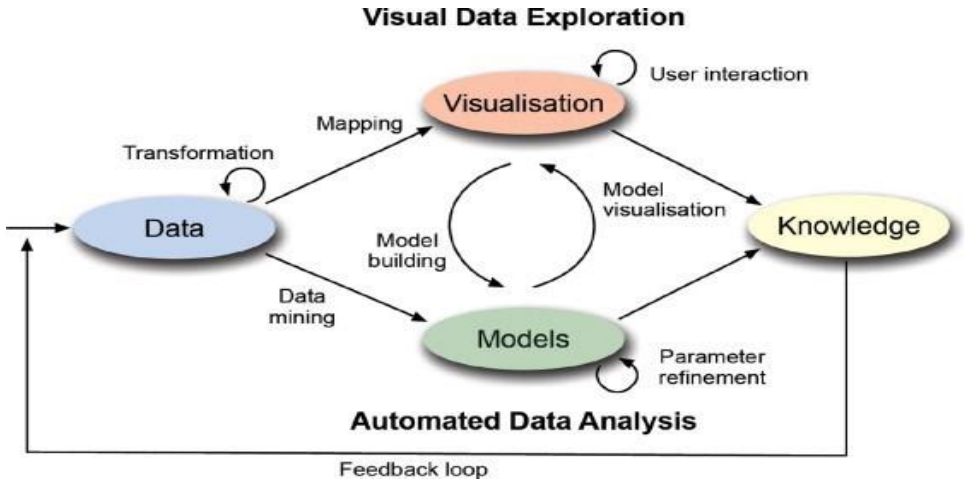


Figure 2: Visual Analytics processes

Source: (Kohlhammer et al., 2011)

The ultimate goal of visual analytics tools and techniques is to blend information and derive insight from massive, dynamic, ambiguous, and often conflicting data and it provides timely, defensible, and understandable assessments, detects the expected and discover the unexpected and communicate assessment effectively for action (Keim, 2009). As highlighted above that visual analytic is a multi-disciplinary nature, it is essential in application areas such as physics, astronomy, climate monitoring, emergency management, security, biology, medicine and commerce (D. Keim et al., 2010). Numerous collaborating organizations require the integration of heterogeneous and distributed databases at run time for efficient operations (Luo, 2022). For Disaster Risk Management, visual analytics is required to aggregate massive volume of data, which is either before the disaster, during the disaster and after the disaster (Marco Angelini, 2016).

Babitski et al., (2011) proposed a visual analytics tool or a prototype called SOKNOS in which information sources and services are explained with ontologies for improving the provision of the right information at the right time. Annotations are used to integrate the existing systems and databases to SOKNOS system and for creating the visualization of information. According to the study on Visual analytics scope and challenges acknowledged that visual analytics could help in determining the ongoing progress of an emergency and can also help in identifying the next countermeasures such as construction of physical countermeasures or evacuation of the population that must be taken to limit the damage (Keim, D., et al 2008). A study on Visual Analytics of Topological Higher Order Information for Emergency Management based on Tourism Trajectory Datasets by Wang et al (2014) further explained each phase of Disaster Risk Management on how visual analytics are used. In mitigation, visual analytics are used to indicate the location of families or people. In preparedness phase, the government and agencies also explore ways to improve damage response operations. For example, monitoring climate and weather is a domain which involves huge amounts of data collected by ground or water-based sensors throughout the world and from satellites. A visual approach can help to interpret the massive amounts of data and to gain insight into the dependencies of climate factors and climate change scenarios that would otherwise not be easily identified commerce (Keim et al., 2010).

2.5. Theoretical framework

Eisenhart defined a theoretical framework as "a structure that guides research by relying on a formal theory…constructed by using an established, coherent explanation of certain phenomena and relationships" (1991, p. 205). Thus, the theoretical framework consists of the selected theory (or theories) that undergirds your thinking with regards to how you understand and plan to research your topic, as well as the concepts and definitions from that theory that are relevant to your topic. Lovitts (2005) empirically defines criteria for applying or developing theory to the dissertation that must be appropriate, logically interpreted, well understood, and align with the question at hand (Grant and Osanloo, 2014). This study was guided by theories such as Theories of Visualization and Actor Network Theory.

2.6. Theories of Visualization

Mavris, Pinon, & Fullmer Jr, (2010) defined visualization as a means to extract and present relevant information from massive volume of generated or compiled data in a format that enables reasoning and analysis while allowing the use to navigate the overall space covered by the data. Liu & Stasko, (2010) argued that there is a general belief that the field lacks sufficient theoretical foundations. Visualization has become essential to sustainable development; thus, theories, frameworks and models need to be developed and adopted in order to describe, validate, and understand the design work (Grant, 2014). Below are different theories for which are might relevant to the study.

2.6.1. A Multi-Analyst Framework for Collaborative Visual Analytics

Brennan et al., (2006) presented in his study an ambitious visualization framework which is intended to support multiple analysts who need to explore multi-dimensional data, analyze and reason about it and collaborate with one another to solve problems in dynamically unfolding scenarios. In this framework, analysts can maintain private perspectives customized in whatever ways they find most intuitive for reasoning (under uncertainty). The framework supports sharing, translating between and fusing representations while keeping track of source information so that perspectives can be easily unpacked or updated when underlying assumptions change. Figure 3 shows a Multi-Analyst Framework for Collaborative Visual Analytics.

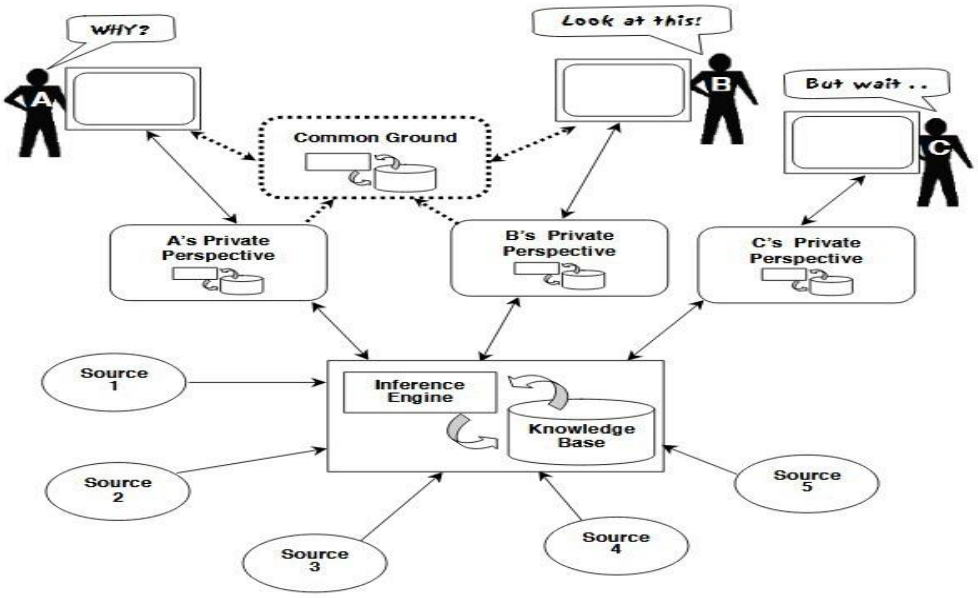


Figure 3: A Multi-Analyst Framework for Collaborative Visual Analytics

2.6.2 Information Visualization reference model

In the Information Visualization Reference Model, data flows from left to right. Firstly, raw data is transformed into appropriate data tables. These data tables are transformed into visual structures through a visual mapping. The visual structures are then transformed into views through a view transformation and presented to a user through a viewport. Interaction flows in the other direction. The user can control the view transformation parameters, the visual mapping parameters, as well as filtering from the database (Fekete, 2013). Figure 4 represent the Information Visualization Reference Model.

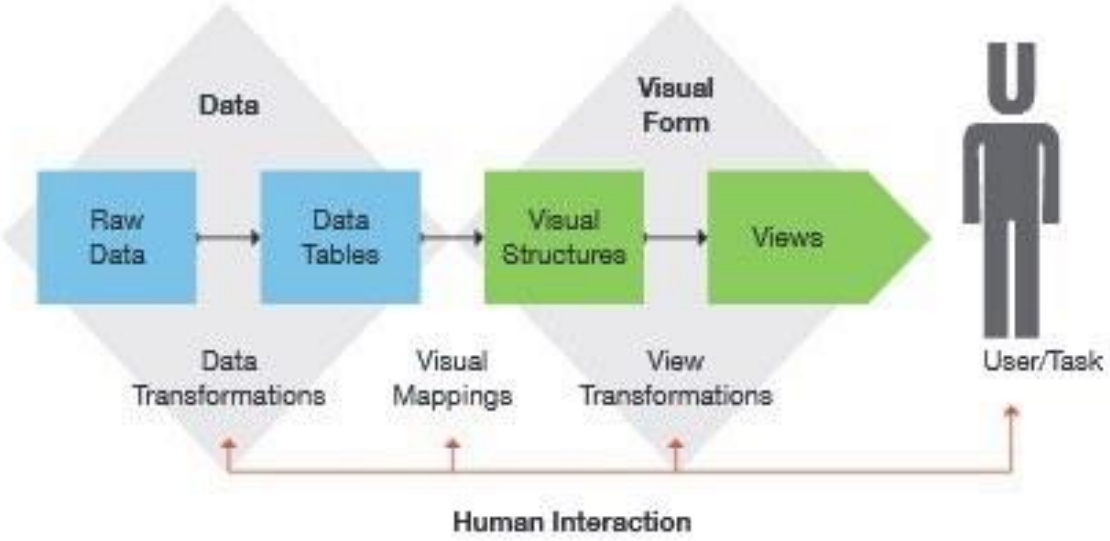


Figure 4: Information Visualization reference model

***Source**:* (N. Elmqvist and J. -D. Fekete, 2010)

2.6.3 Knowledge Generation Model

Sacha et al., (2014) designed a Knowledge Generation model as presented in Figure 5, is divided into two parts. The computer system (oval shape) with data, visualization and analytic models, and the human component modelling the cognitive processes associated with an analytical session. The cloud in the model indicates that there is no clear separation between the computer and the human part since both parts are required for data analysis.

This implies that computers miss the creativity of human analysis, allowing them to create surprising, often delicate or hidden connections between data and the problem domain. Humans are not able to deal efficiently and effectively with large amount of data. In visual analytics the connection between the human and computer uses the human's interaction abilities and perception.

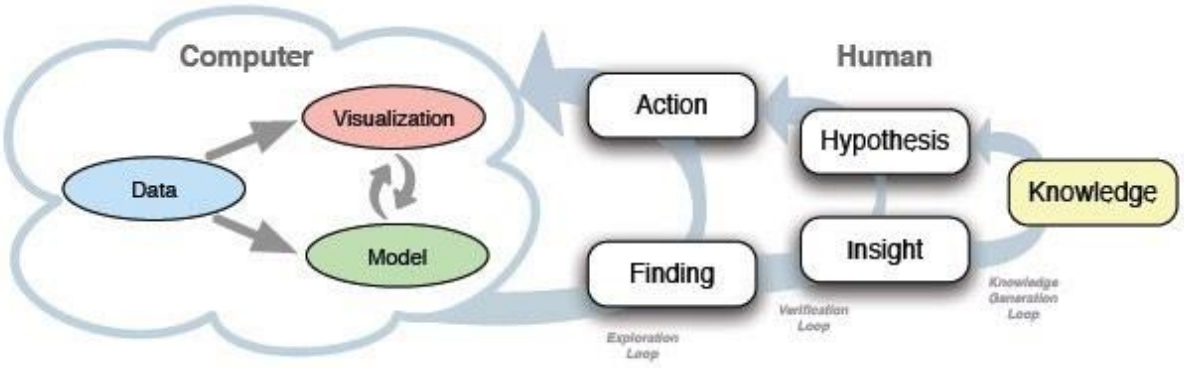


Figure 5: Knowledge Generation Model

Source: (Sacha et al., 2014)

Several previous studies have touched on the human perceptions and computing power. The study of D. A. Keim et al., (2006) highlights challenges on visual data analysis and has discussed on how human factors such as interaction, cognition, perception, collaboration, presentation and dissemination play a significant role in the communication between human and computer as well as decision making process. Keim et al., (2006) argued that decision-makers should be enabled to analyze massive, multi-dimensional, multi-source, time-varying information stream to make effective decisions in time-critical situations and at the same time allowing them to apply advanced computational capabilities to supplement the discovery process. Therefore, it is very crucial to include humans into the data analysis process in order to combine flexibility, creativity and background knowledge with the massive storage capacity and the computational power of today's computers.

The Knowledge Generation model will be adopted as a guiding theory of the current research study and as analytical framework to help in understanding the visualization process and in data analysis and design a framework. In addition, it supports the interaction or combination of the human perceptions with the computing powers which leads to decision making.

2.6.4 Actor-Network Theory

Actor-network theory is initially created by French scholars Latour and Callon as an effort to understand processes of technological innovation and scientific knowledge-creation (Latour, 1996). The Actor-Network theory underlines and considers all surrounding factors as no one acts alone. Actor-network theory is concerned with exploring the social and the technical taken

together or, putting it another way, with the creation and maintenance of coextensive networks of human and non-human components. In the information technology perspective, it includes people, organizations, software, computer and communications hardware, and infrastructure standards (Walsham, 1997). The Actor-Network theory will be adopted as a data collection framework in order to understand the role and interests of different stakeholders that participate in Collaborative Decision Support environments.

2.7. Summary of the chapter

This chapter summarized the findings from prior studies including the Collaborating Decision Making, Visual Analytics Integration, Disaster Risk Management systems, Benefits and Challenges of adoption and Theories of visualization. Therefore, the researcher adopted the Knowledge Generation Model as a theory of visualization and an Actor-Network theory as data collection framework for understanding the roles and interests of stakeholders in Collaborative Decision Support environment.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The aim of the current research study was to design a framework to integrate Business intelligence (BI) and Collaborative Visual Analytics (CVA) for decision support in disaster risk management, to demonstrate how analysts, decision makers and the emergency response teams can effectively use Business Intelligence and Collaborative Visual Analytics in Disaster Risk Management in South Africa for data analysis, presentations and decisions making with an intention of mitigating disasters. This section provides successive steps that was followed to conduct the study. The research methodology was used based on the research objectives of the study in order to answer the research questions. The methods and techniques used for data collection were analysis through document collection, and theoretical thematic analysis for analysing data.

3.2 Research paradigms

Research paradigm is essentially a worldview, a whole framework of beliefs, values and methods within which research takes place and researchers work (Joubish, 2011). Johnson & Christensen, (2008) delineate research paradigm as a perspective about research held by community of researcher that is based on a set of shared assumptions, concepts, values and practices. In simple terms, it is an approach to thinking about and doing research. Denzin & Lincoln, (2011) has identified five main contemporary qualitative research, namely, positivism, post-positivism, critical theories, interpretive and participatory paradigms. All research paradigms take a view of ontology (the assumed nature of reality being studied as realist) as a foundation step. It is the combination of a type of epistemology (a direct or indirect way of knowing absolutist) with the type of ontology that outlines the philosophy, and methodology (Hallebone & Priest, 2008).

“Post-positivism focuses on values, passion, and politics. Realty is regarded as multiple, subjective, and mentally constructed. The paradigm seeks truth and evidence that are valid and reliable in terms of phenomena, not in terms of generalisation. Post-positivism is based on a critical-realist ontology.” (Nel, 2020).

Post-positivists acknowledge that earlier experience and present social settings alter our perceptions and consciousness. (Moxley, 2017). They point out, for example, that two witnesses to an event are unlikely to experience it in the same way, and that what is true in one context may not be true in another.

3.3 Design Science Framework

In this section, the researcher explained the criteria used in the design science method which is useful in solving a problem that has been unsolved before or solving a known problem more effectively or efficiently. The Design Science is an outcome-based approach of research in information technology that offers basic criteria for assessment and refinement within research projects. Work in these fields can be interpreted as a quest for understanding human success and enhancement. The design science method is a methodology that is suitable for developing a model that contributes to the growth of knowledge in the domain. According to John and Venable (2006), Design Science (or Design Research) is a scientific methodology which has been under-emphasized in IS analysis in favour of empiric study using constructive and interpretive approaches to natural and social sciences. This has also not been very well combined with other testing methods. The operation of Design Research offers an outstanding incentive for the IS sector to expand its importance to business practice. This article refines present understanding of Design Analysis and its interaction with other analysis methods or paradigms. It introduces a revised structure for understanding Design Research activities, which also compares Design Research activities to research carried out in other paradigms. The framework emphasizes the role of building theory and the type of design (usefulness) theories, but also generalizes practices in either post-positivist or interpretative frameworks to test solution technologies. Post-positivist research principles emphasise meaning and the creation of new knowledge, and are able to support committed social movements, that is, movements that aspire to change the world and contribute towards social justice (Panhwar, 2017).

3.3. Research strategy

Creswell, (2013) has provided definitions of qualitative and quantitative research for which make them differ. Qualitative research is an approach for exploring and understanding the meaning

individuals or groups assigned to a social or human problem. The process of qualitative research involves emerging questions and procedures, data is collected in the participant's setting and data analysis inductively building from particulars to general themes (Bhandari, 2020). Quantitative research is an approach for testing objective theories by examining the relationship among variables which in turn can be measured and analysed using statistical procedures. The primary aim of qualitative, which also constitutes its basic difference with quantitative research, aimed to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour (Loraine Busetto, 2020). The discipline investigates the "why" and "how" of decision making. While on the other hand, quantitative research examines the phenomenon through observations in numerical representations and through statistical analysis (Balanag,2009). Furthermore, qualitative research includes data collection methods such as document collection, reviews, document analysis and observations. On the other hand, quantitative research comprises of data collection methods such as surveys and controlled experiment (Creswell, 2009). To achieve the objectives and answer the questions of the current research study, a qualitative methodology employed as a research strategy with the help of subjective methods such as document reviews and observation to collect essential and relevant data. The qualitative approach is in-line with the current study as it is most appropriate for small samples of the population and it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses (Mohajan, 2018).

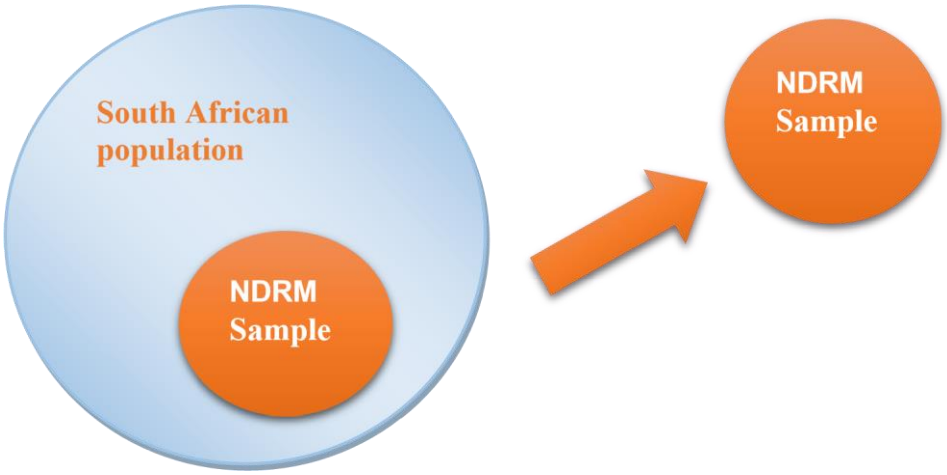
3.4 Research design

De Vaus and de Vaus, (2001) defined research design as an overall approach that a researcher chooses to integrate the different components of the study in a clear and reasonable way. By this means, research design effectively addresses the research problem and establishes the blueprint for the collection and analysis of data (Jilcha, 2019) The study adopted a case study approach, whereby the Directorate Disaster Risk Management in South Africa was the case of the study. The President and Fellows Harvard University, (2008) defined a case study as an approach to research that focused on gaining an in-depth understanding of a particular entity or an event at a specific time (Hollweck, 2016). Zainal, (2007) further explain case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries

between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. In simple words, a case study is a unique way of observing any natural phenomenon which exists in a set of data. The researcher used the case study approach as a research design tool for data collection by means of in-depth document review. As a result, this enabled the researcher to extensively study the data within a specific context and with the adopted research post-positivist paradigm.

3.5 Population and sample of the study

Polit & Hungler (1998) refer to the population as an aggregate or totality of all the objects, subjects or members that conform to a set of specifications. The target population of the study was the participants involved in Disaster Risk Management in South Africa. The sample of the population will be the Directorate Disaster Risk Management and its stakeholders from the Offices/Ministries/Agencies at National level. Table 1 shows the sample size of which 16 documents reviewed.



Population: People that are involved Sample: DDRM and its stakeholders from in Disaster Risk Management O/M/As at National level

Documents	No. of participants

1. Audit reports (2011-2020)	**9**
Cogta-Annual-Report-2011-12	1
Cogta.Ndmc-Annual-Report-2012-2013	1
Cogta-Annual-Report-2013-14	1
Ndmc-Annual-Report-2013-2014	1
Ndmc-Annual-Report-2014-2015	1
Dcogannualreport2015-16FA-Screenres-1	1
Cooperative governance-Annual-Report-2017-18	1

Cogta-2019-Annual-Report-Approved-1-Compressed-1	1
Cogta-AR-2019-2020-19-Nov-FINAL	1
2. Statistical reports	**7**
ADSR_2016	1
2017-Statistics-South-Africa-(Stats-Sa)-Annual-Report	1
Crednaturaldisaster2018	1
2019globalnaturaldisasterassessment	1
NDMC Annual Report 2019-2020	1
SACVI Technical Report	1

Wcdmc_Annual_Report_19_-_20_-_Final	1
Total documents collected	**16**

Table 1. Number of Documents collected.

3.5.1 Sampling method

Nastasi (1999) explained sampling as the selection of individuals, units, and settings to be studied. There are two types of sampling, namely, probability sampling and non-probability sampling techniques, which are further broken down. The study uses purposive sampling as a nonprobability method to identify the people responsible for Disaster Risk Management in different O/M/As. (Snyder, 2019)

3.6 Data Collection

The current research study utilized qualitative data collection tools, namely, document collection the collection of documents, i.e., annual reports and statistical reports was used to gather data relevant to the study's objectives and research questions. The document reviews were formulated to capture how Business Intelligence and Collaborative Visual Analytics can be integrated for effective disaster risk management in South Africa. Furthermore, document reviews were conducted according to the annual and statistical reports, *See figure 1. Documents.*

3.7 Data analysis

The data that were collected from DDRM and its stakeholders were analysed using the theoretical thematic analysis as qualitative data analysis technique. The qualitative results and answers from the participants were presented and discussed in order for conclusions to be drawn.

3.7.1. Theoretical thematic analysis technique

In qualitative research, thematic analysis is common. It focuses on recognizing, analyzing, and understanding qualitative data patterns. You may look at qualitative data in a different way with this approach. It is typically used to describe a collection of texts, such as an interview or a compilation of documents. Thematic analysis is used in qualitative research. It focuses on

detecting, analyzing, and interpreting qualitative data patterns. This approach allows you to look at qualitative data in a different way. It is frequently used to describe a collection of texts, such as an interview or a series of transcripts. The researcher scrutinizes the data for recurring themes: recurrent ideas, subjects, or ways of presenting things (Delahunt, 2017).

“A technical or pragmatic view of research design focuses on researchers conducting qualitative analysis using the method most appropriate to the research question. However, there is seldom a single ideal or suitable method, so other criteria are often used to select methods of analysis: the researcher’s theoretical commitments and familiarity with particular techniques.

The thematic analysis provides a flexible method of data analysis and allows researchers with diverse methodological backgrounds to participate in this type of analysis. Data analytics and data analysis are closely related processes that involve extracting insights from data to make informed decisions.” (Ashley Castleberry a, 2018).

3.8 Ethical Issues

The information collected will not be changed and is reviewed neutrally without being biased. There are no misconceptions, and no personal opinions were used to interfere with the data collection process. The document reviews were only be used to find out how Business Intelligence and Collaborative Visual Analytics can be used effectively in DRM in South Africa.

3.9 Summary

This chapter highlighted how the study was conducted, the research paradigm, research methodology, strategy and design that were used in the study, including the population and sample of the study, data collection and data analysis techniques.

CHAPTER 4: ANALYSIS AND FINDINGS

This chapter presented the analysis of the findings related to the assessment of stakeholder roles and interests, the consequences of the role-playing, and how these are likely to influence disaster management in South Africa.

4.1 Stakeholder roles in Collaborative Decision-Making environments

The South African government has a clear understanding of the community's social, economic, infrastructure, and environmental aspects, which allows it to render assistance in a disaster. Disasters arise from both natural and human causes, and the responses needed could stretch community and government capacity to the limit. For example, in the year 2000, we saw a series of disasters in South Africa: massive floods devastated the Limpopo Province, Mpumalanga, and neighbouring countries; massive fires and an oil spill threatened Cape Town, and separate floods hit rural communities in KwaZulu-Natal and the Eastern Cape. In 2004 Cape Town experienced a drought disaster attributed to global warming. From April 2004 to January 2005, the province experienced 376 disasters, which included mostly fire and flood.

Considering the magnitude and severity of the COVID -19 outbreak, which has been declared a global pandemic by the World Health Organisation (WHO), which mainly focuses on the state of health in the African region and analysis of health system performance based on the services and resilience of the system and classified as a national disaster by the Head of the National Disaster Management Centre. On 15 March 2020 South African President, Cyril Ramaphosa, declared a national state of disaster in terms of the Disaster Management Act, 2002. This declaration enabled the government to have an integrated and coordinated disaster management mechanism that prevent and reduce the outbreak of Covid-19, otherwise known as the Coronavirus. When the notion of problematization is used, what is apparent is how the Government of South Africa, announced measures that South Africa would take to prevent and control the Coronavirus. The National Institute for Communicable diseases (NCID), a resource of knowledge and expertise in regionally relevant communicable diseases to the South African Government, SADC countries, and the African continent, confirmed that Covid-19 is a national state disaster. The National Health Laboratory Service (NHLS) is a diagnostic pathology

responsible for supporting the national and provincial health departments in healthcare delivery. The NHLS provides laboratory and related public health services to over 80% of the population through a national network of laboratories.

- Provide training for health science education.
- Support &conduct research
- Provides cost-effective Health laboratory to the public sectors healthcare providers.

Laboratories are to accurately record the results of each test and provide this information to the NHLS via web service only. Tests performed outside laboratories must be reported via the NHLS COVID-19 Screening Application (CSA) portal.

South African Health Products Regulatory Authority (SAHPRA) is tasked with regulating (monitoring, evaluating, investigating, inspecting, and registering) all health products. This includes clinical trials, complementary medicines, medical devices, and in-vitro diagnostics (IVDs). Furthermore, SAHPRA has the added responsibility of overseeing radiation control in South Africa.

Pharmaceuticals such as Johnson and Johnson (J&J) and Pfizer developed vaccines to help combat the spread of Covid-19, by issuing vaccines to the Department of Health (DoH), which developed the policies and guidelines for administration to patients. Disasters are inevitable, although it is not always known when and where they will happen. But their worst effects can be partially or entirely prevented by preparation, early warning, and swift, decisive responses. Disaster management aims to reduce the occurrence of disasters and reduce the impact of those that cannot be prevented. The government White paper and Act on Disaster Management define the roles of Local Authorities as well as Provincial and National governments in disaster management and their actions which are also influenced by a number of actors captured in Table 1 and based on the preceding analysis, we identify some of the stakeholders as designers; in other words, those actors who were dominant in the policy design process and its implementation and their interests, while the users are generally clustered individuals and businesses.

Table I reveals a group of actors primarily considered as “global” and comprise the cluster of stakeholders responsible for designing the NDMC financing mechanisms. In the *global actor group* is the international consortium of WHO analysers. Their interest is to ensure resilience

based on the health system. The focus of the World Bank is to obtain a finance for every area of development and provide technical assistance in innovative solutions to countries that are disaster struck on the other hand is the Department of Health, whose interest is to craft an effective health policy for the country. Furthermore, the South African presidency, whose goal is to deliver on campaign promises and acts by "shoring" support for those whose interests appear to support the campaign agenda. Also, there are credit rating agencies, whose interest is to rationalize NDMC financing instruments. Consequently, the "local" actor groups are represented by the various media organizations, who have positioned themselves as a conduit for "voicing" the news from various stakeholder groups (both global and local). Then there is civil society organizations representing various interest groups and who have identified themselves as patients. Lastly, various political parties, who make the claim that they represent the wider population Covid-19 victims.

Table 2: Stakeholder groups

Stakeholders/Actors	**Roles**	**Potential interest**
Government-related actors		
Presidency	Designer	Escalation measures to combat Covid-19 pandemic (mitigation) and economic stability.
Department of health	Designer	Develops disaster policy & guidelines.
NHLS	User	Conduct research to identify and diagnose viruses.

SASSA	Designer	Provides financial support and a stimulus relief fund package.
NDMC	Designer	Declaring a disaster, crafting measures for prevention and mitigation of a disaster.
NCID	Designer	Keeping updates of relevant and current information concerning Covid-19 in South Africa.
DMISA	Designer	Provides resources for those interested in professional registration disaster management.
SAHPRA	Designer	Regulation of health products and the vaccination program.
Citizens	Users	Compliance to COVID-19 regulations, policies, and guidelines.
Global actors		
WHO	Designer	The state of health in a region and analysis of the health system performance.
WORLD BANK	Designer	

UN	Designer	promoting food security by alleviating hunger through food assistance, while working to eliminate its root causes.
IMF	Designer	Promotes international financial stability and monetary cooperation. It also facilitates international trade,
		promotes employment and sustainable economic growth and helps to reduce global poverty.
Pharmaceutical companies i.e. J&J and Pfizer	Designer	Developing vaccines
Other stakeholders		
Civil society	Users	Informing communities about the virus, disinformation, and false narratives about COVID19.
Media	Users	Publishing alerts and information on disasters
Anti-vexers	Users	Protesting the vaccination program.

World vision	Designer	To strengthen health systems and workers, collaborate and advocate to ensure vulnerable children are protected, and scale-up preventative measures to limit the spread of the disease.

4.2 Analysis of Actor's Roles and Interests in a Disaster Management in the LG Sector

The starting point in understanding the problematization related to stakeholder roles in disaster management in the Local Government sector is rooted in the Disaster Management Act, 2002 (Act No. 57 of 2002). This was followed by the promulgation of the National Disaster Management Framework (NDMF) in 2005 which put clear guidelines in place for the implementation of the Disaster Management Act (DMA) of 2002. While the DMA gives on the "*what"* of disaster risk management in South Africa should be, the NDMF focuses on "H*ow"* the objectives of the DMA can be realized. The Disaster Management Act, 2002 (Act No. 57 of 2002) mandated the:

- Provision of an integrated coordinated disaster management policy that focuses on preventing or reducing the risk of disasters, mitigating the severity of disasters, emergency preparedness, and rapid effective response to disasters post-disaster recovery.
- Establishment of national, provincial, and municipal disaster centres.
- provision for disaster management volunteers, etc.

The amended act in 2015 of Section 16 (3)(4) further provided that:

- A local municipality must establish capacity for the development and co-ordination of a disaster management plan and the implementation of a disaster management function for the municipality which forms part of the disaster management plan as approved by the relevant municipal disaster management centre.
- A local municipality may establish a disaster management centre in consultation with the relevant district municipality in accordance with the terms set out in a service level agreement between the two parties, in alignment with national norms and standards.

Thus, in the language of ANT, the Disaster Management Act (DMA), 2002, with its amendments in 2015; did not only problematize disaster management but also had provisions for the establishment of certain stakeholders. The South African National Disaster Management Framework of 2005, as well as the Act 57 of 2002 (as amended Act 16 of 2015), state that each sphere of government should have a disaster management centre. Following these demarcations, this section details the distinction of the three key organisational management levels of disaster management to identify the critical role players at different levels.

The DMA stipulates the decentralization of DRR activities which allows the three tiers of government to assume roles in the management of risk. Emphasis is placed on the establishment of proper institutional structures to promote diverse actions at different levels for disaster risk reduction and management. At the national level, the National Disaster Management Centre (NDMC) under the Department of Cooperative Governance (DCOG). The mandate of the NDMC is to promote an integrated and coordinated system of disaster management, with special emphasis on prevention and mitigation, by national, provincial, and municipal organs of state, statutory functionaries, other role-players involved in disaster management and communities (http://www.ndmc.gov.za/Pages/overview.aspx). This mandate of the NDMC is executed through various officers such as the Head of Centre and Chief Directors: Disaster Risk Reduction Capacity Building Intervention; Legislation and Policy Management; Integrated Provincial Disaster Management Support; Monitoring and Evaluation Systems; Fire Services; and Information Technology, Intelligence, and Information Management Systems. The National Disaster Management Advisory Forum (NDMAF) also operates at the national level as a technical forum that encompasses all role players including the structures of state, and communities.

At the provincial level, the act envisages the setup of Provincial Disaster Management Centres (PDMCs) to be responsible for enhancing disaster related research and to build and enhance capacity of the local role players to be prepared for and react to disasters. When it comes to disaster, or looming disaster, it is the role of the PDMC to give the necessary guidance and support to the relevant Metropolitan/Municipal Disaster Management Centres (MDMCs). Just like at the provincial level, municipalities are also expected to establish disaster risk management

centres (MDCMs) which have a DRM policy framework, a DRM committee, and an advisory forum, which all integrate the relevant stakeholders (Van Niekerk and Wentink, 2017). Article 51 of the DMA envisages the MDMC as a structure in which metropolitan or district municipality and the relevant role players consult each other and coordinate their DRM activities (Van Niekerk & Wentink, 2017). The local sphere has been identified as the playing the most significant role in disaster risk reduction (Botha et al., 2011). Given the significance of the local sphere, the Disaster Risk Management (DRM) plan, incorporating IT elements, should be incorporated into the municipal IDP. Other structures linked to the local sphere are Municipal Disaster Management Advisory Forums (MDMAFs), Ward structures and Volunteers.

Table 2 captures the roles of the various stakeholders (whether human or nonhuman) and their interests in Disaster Risk Reduction (DRR) in the local government sector. The roles of these stakeholders, while captured generically in the DMA and other policy documents, will be discussed as the relate to service disruptions that emanate from IT.

Table 3: Stakeholder Roles and Interests

Actor	***Role***	***Potential Interests in DM***
United Nations (UN)	Designer	Convenes partners and coordinates activities to create safer, more resilient communities.
SADC	Designer	Building a culture of safety and disaster resilience by strengthening the preparedness and response for early recovery in the SADC region by 2030.
CoGTA	Designer	Oversight of Disaster Management.
NDMC	Designer	Facilitate and monitor the implementation of policies and legislation. Disaster risk assessment.
NDMAF	Designer	National platform for disaster risk reduction in South Africa
PDMC	Designer /User	Strengthen disaster preparedness for effective response at all levels.

SALGA	Designer	Collate local government sector interests.
MDMC	Designer	Information management and communication; use knowledge, innovation, and education to build a culture of safety and resilience at all levels.
MDMAF	Designer /User	Coordination of DRM activities in the local sphere.
DMISA	Designer	Provides resources for those interested in professional registration disaster management.
Volunteers	Users	Minimize disaster risk at the local sphere.
LG Staff	Users	Avoid service disruption from IT disasters.
IT Vendors	Designers/Users	Provides technology for mitigating service disruptions.
Citizens	Users	Users of local government services.
Civil Society	Users	Provides community advocacy pre- and post-disasters.
Media	Users	Reporting on effectiveness of disasters response.

In delineating the key roles players in disaster risk management in the local government sector, the characterization of actors as either designers or users is adopted for the purpose of categorization. Further, with the promulgation of the Disaster Management Act and its subsequent amendments, resources are required at the local government in terms of technology, human capital, financial resources, even public private partnerships to intensify the effectiveness of disaster risk reduction strategies initiatives. Subsequent discussions focused on what these resources are for ensuring effective IT disaster risk reduction.

Table 3 reveals that there is a group of actors largely considered as "***global***" (GA) and comprise the cluster of stakeholders (UN, SADC, CoGTA, NDMC, NDMAF) responsible for designing disaster management frameworks either at the international, regional, or national levels. Financing

mechanisms for disaster management also arise from this actor group. On the other hand, the "***local***" actor groups (LA) are represented by those stakeholders that implement the disaster management acts, policy frameworks and strategies enacted by the global actor group. SALGA represents the local actor group, MDMC, MDMAF, DMISA, Volunteers, LG Staff, IT Vendors, Citizens, and the Civil Society. For instance, the media positions themselves as a as a conduit for "voicing" the news from various stakeholder groups (both global and local); civil society organizations representing various community interest groups, while DMISA has positioner herself as a body for professionalizing disaster management in South Africa.

4.3 Impact of Key Decisions on Resources for Disaster Management

Having identified the strategic role players involved in disaster management, this section delves into the consequences of a series of milestone decisions that have had an impact on the *resourcing* of disaster management in South Africa over time. Following Mawela, Ochara and Twinomurinzi (2016), consequences can be assessed positively or negatively as used in Actor Network Theory (ANT). A positive consequence implies that an action by an actor/stakeholder improves decision making in disaster management in the local government sector. A negative consequence implies that an actor's decision impacts negatively and does not result in an improvement.

Table 4 below summarizes and discusses the critical milestones that impacts the disaster management in the local government sector.

Table 4: Impact of Actions on Disaster Management

Actor	***Actions***	***Local Impact***	***Global Impact***	***Impact on Resources***
UN	Establishment of the Africa Multi-Hazard Early Warning System for DRR	Diverse investment opportunities for local communities	Mobilizing support for regional platforms.	Minimal (+) LA; Major (+) GA.

SADC	2011: Inauguration of SADC Regional Platform for Disaster Risk Reduction	Pilot focus on Agricultural Information Systems	Increased R & D on DRM.	Major (+) LA; Major (+) GA.
CoGTA	Enactment of the DMA (2002); NDMF (2005)	Mobilization of local support for DM.	Support from international agencies.	Major (+) GA; None (+) LA.
NDMC	2006: Demonstration of the Integrated National Disaster Information Management System (INDIS)	Implementation of the INDIS in Eastern Cape	Legitimization of global actors	Major (+) GA; Moderate (+) LA.
NDMAF	Establishment of the first NDMAF in 2007	Visibility of disaster management	Prioritization of disaster r management at Cabinet level	Major (+) GA; Moderate (+) LA.
SALGA	1997: Establishment of SALGA 2012: Municipal ICT	Clarity of the role of ICT in DM.	Increased benchmarking opportunities.	Major (+) LA; Moderate (+) GA.
PDMC; MDMC; MDMAF	2003: Establishment of Disaster Management Centres in 8 provinces.	Provide consultative leadership at local	Establishing partnerships with local actors.	Slight (+) LA; Minimal (+) GA.
		government level		
DMISA	1985: Founding of DMISA	Local skills development	Networking and Information Sharing	Minimal (+) LA; Minimal (+) GA.

LG Staff	2020: Skills Mismatch Research by LGSETA	Local skills mismatch	Critical ICT Skills shortages	No (+) LA; No (+) GA.
Media	2013: Establishment of the NationalCoGTA Twitter Account	Sensitization and advocacy	Sensitization and advocacy	Major (+) LA; Moderate (+) GA.
Volunteers, Citizens, Civil Society	1991: The Kathmandu Declaration 1996: DiMP 2011: RADAR.	Integrating volunteerism as part of disaster response. Advocacy by civil society	Funding mechanism to fund volunteers, civil society.	Minimal (+) LA; Minimal (+) in GA.
IT Vendors	2011: Regional Platform for Disaster Risk Reduction	Involvement in community initiatives	-	Minimal (+) LA; Minimal (+) in GA.

The establishment of the first National Disaster Management Advisory Forum (NDMAF) and the National Disaster Management Centre (NDMC), which is the second highest national structure dealing with disaster matters in South Africa, was established on 26 January 2007 in terms of section 5 of the Disaster Management Act. The establishment of the first NDMAF was a milestone in energizing the diverse stakeholders, not only in the country, but also globally. The effect of the establishment of the NDAF has therefore has a major impact on the recruitment of global as well as local actors.

The founding of the South African Local Government Association (SALGA) in 1997 marked a watershed moment for the transformation and support of local governments in South Africa. SALGA has played a critical role in galvanizing the collective voice of the local government body politic in South Africa. Since its inception, SALGA has continued to focus on its mission of supporting the transformation of local governments in a complex environment characterized by a highly diverse community membership base. Two milestone decisions in 2012 are critical for the study's focus on disaster management. SALGA emphasized that disaster management was

deficient in local government systems and went on to recommend that local government entities should regularly demonstrate that they have business resilience arrangements in place for disaster recovery. The publication of these guidelines, followed by the e-participation workshop may have played a key role in galvanizing local government entities to prioritize disaster management planning, thus channelling additional resources for management of disasters. The consequence from these two milestones may be linked to a major increase in LAs, coupled with a moderate increase in GA.

At the local government level, there have also been milestones that are associated with disaster management, particularly related to disaster management. Three entities are influential in understanding these milestones: the Provincial Disaster Management Centres and forums (PDMC, PDMAF); Metropolitan and Municipal Disaster Management Centres and Forums (MDMC, MDMAF). Cascading from the NDMC and the NDMAF, the PDMC, PDMAF, M/MDMC, and the M/MDMAF are structures that have been set up at the local government levels to mimic the roles of the NDMC and NDMAF. While the setup of the PDMCs, PDMAFs MDMCs and the MDMAFs can be seen as positive, the implementation of these decisions in different local government entities in relation to disaster management has been fraught with several challenges. Key amongst these challenges include a lack of direction with no dialogue amongst stakeholders; lack of stakeholder participation; and lack of management of information (Humby, 2012). While the establishment of the eight PDMCs in 2003 can be viewed as positive in the recruitment of local stakeholders, the challenges mentioned stifled this process, thus only resulting in a slight improvement in stakeholders and resources linked to this milestone.

The formation of the Disaster Management Institute of Southern Africa (DMISA) in 1985 also marked an important milestone given that she plays a critical role in the professionalization of disaster management. DMISA has several SAQA accredited designations such as Disaster Management Professional (PrDM), Disaster Management Practitioner (DMPc), Disaster Management Associate (DMA) and Disaster Management Technician (DMT). IT related courses associated with these approved SAQA designations under the ambit of disaster management include Geographical Information Systems (GIS) for Disaster Risk Management, Information

Technology and Management and Communications. DMISA has sought to professionalize disaster management in local regions by identifying coaches to various municipalities. These initiatives have had an impact in identifying skilled personnel by establishment of disaster management professionals' register. At a global level, DMISA holds regular conference and publishes a journal which are initiatives that have bolstered networking and the information sharing for disaster management stakeholders.

Local government staff at different municipalities are also a critical stakeholder group as they are charged with implementing disaster recovery plans. A 2020 report by City Insight on the effects of skills mismatch in the local government sector to LGSETA[1] identified priority skills for local government related to research and policy skills (conceptual, analytic, and problem-solving skills for sector decision-makers); financial planning and management skills; strategic leadership and management skills; project and contract management skills; and ICT skills. The ability to ability to ensure the formulation and implementation of a spatial development framework, a disaster management plan, and Integrated financial plan were also identified as critical skills requirements for senior managements in local government.

The media, in all its forms, have also continued to play a critical role in sensitization of the public on disaster situation in various parts of the country. For instance, the establishment of the twitter account for the National Department of Cooperative Governance and Traditional Affairs (National CoGTA) has ensured that all citizens are kept abreast of disaster situations, not only at the national level, but also in local municipalities. The establishment of this National CoGTA twitter account has also played a role in galvanizing local municipalities to setup various social media accounts that they use to provide information to citizens and other stakeholders regarding the disaster situation in their localities.

The role of citizens as volunteers and civil society has always been recognized in disaster management situations. The United Nations recognizes volunteerism as a powerful means for engaging people in tackling development challenges, and it can transform the pace and nature of development. The Kathmandu Declaration of 1991 entrenched the involvement of international and national volunteers in disaster preparedness and recovery. Additionally, with the holding of

the first UN International Year of Volunteer, the programme has continued to be part an parcel of disaster management (Lough, 2015). The practice of using volunteers in South Africa is common, with Vermaak & Van Niekerk (2004) noting that the Eastern Cape Province having over 8000 trained volunteers. Contrastingly, the use of volunteers is sadly not as widespread in all the provinces. However, there are systems and programmes that have been developed in South Africa that can be placed under the ambit of volunteering. For instance, the University of Stellenbosch originally established Disaster Mitigation for Sustainable Livelihoods Programme (DiMP), which was eventually transformed to RADAR[1] focusing on enhancing knowledge about disaster risks within South Africa and on the continent, promoting risk reduction for more resilient and sustainable societies.

4.4 Consequences of actions on the Covid-19 pandemic reporting

After identifying the strategic role players in disaster management, this section examines the ramifications of a series of landmark choices that have influenced disaster management reporting in South Africa over time. According to Mawela, Ochara, and Twinomurinzi (2016), repercussions in Actor-Network Theory can be rated positively or negatively (ANT). A favorable outcome indicates that an actor's/activity stakeholder enhances analytics reporting capabilities for disaster management in local government. A negative consequence is that an actor's decision which has a negative influence and does not improve things. Such an analysis aims to determine the context and sources of disaster management reporting capabilities, which will serve as a foundation for determining future resource requirements.

This section following the table above addresses the consequences of Covid-19 reporting by global and local actors. According to Michel Callon, Bruno Latour, and John Law, during the 1980s, a recognition that actors build networks combining technical and social elements and that the elements of these networks, including those entrepreneurs who have engineered the network, are, at the same time, both constituted and shaped within those networks. A positive consequence in the manner used in this thesis implies that an action by an actor/stakeholder improves analytics reporting capabilities for COVID-19. A negative consequence has the opposite effect. Looking at the consequences is essential

because it allows the researcher to determine whether Covid-19 reporting is vital or not. The table 5 below summarized and discussed the critical milestones related to disaster management reporting.

Table 5: Disaster management milestones

Date	Milestone description	Consequence on the reporting capabilities	Reference
1985	Founding of DMISA	Positive	DMISA
1991 1996: DMP 2011: RADAR	The Kathmandu Declaration, DiMP	Positive	Volunteers, Citizens, Civil Society
	RADAR and Integrating volunteerism as part of disaster response.		
2002	Enactment of the DMA and NDMF (2005)	Positive	CoGTA
2003	Establishment of Disaster Management Centres in 8 provinces	Positive	PDMC MDMC; MDMAF
2006	Demonstration of the Integrated National Disaster Information Management System (INDIS)	Positive	NDMC
2007	Establishment of the first NDMAF	Positive	NDMAF
2011	Inauguration of SADC Regional Platform for Disaster Risk Reduction	Positive	SADC

2013	Establishment of the National CoGTA Twitter Account	Positive	Media
31 December 2019	WHO was informed of cases of pneumonia of unknown cause in Wuhan City, China.	Positive impact	WHO
07 January 2020	A novel coronavirus was identified as the cause by Chinese authorities	Positive impact	WHO
11 March 2020	The WHO Director-General announced that the outbreak was a pandemic.	Positive impact	WHO
11 March 2020	UN gives responsibility to protect and ensure international peace and security.	Negative	WHO
April 2020	Worldbank covid crisis response project was established.	Negative	Worldbank www.worldbank.org
May 2020	Countries resistant to reporting of Covid 19; i.e., Tanzania; COVID-19 denialism, misinformation, and lack of transparency from the country's government.	Negative impact	Devex news www.devex.com
11 December 2020	The first COVID-19 vaccine released	Negative	FDA
2021 March	National Lockdown	Positive	Media

2022 Presidency	Announced the end of the national state of disaster.	Positive	Media

According to Ulku Halatci Ulusoy (Assoc. Prof. Dr. Ankara University, Law School and Honorary Lecturer, University of Aberdeen), the United Nations (UN), which was entrusted with the primary responsibility of protecting and ensuring international peace and security, is incapable of responding to COVID-19, as it is incapable of responding to many other issues. The World Health Organization (WHO), the UN's specialized organization, has designated the COVID-19 disease, caused by a novel coronavirus, to be a pandemic on March 11, 2020, owing to its presence in more than 114 states;(www.abdn.ac.uk). Tanzania's government stopped reporting COVID-19 cases to WHO in May 2020, and President John Magufuli denied the virus's presence in the country and warned against vaccines, implying that Tanzanians would be used as guinea pigs. While the government is eligible for donated vaccines from the COVAX Facility, no steps have been taken to receive doses. The pandemic's lack of control is causing it to spread. According to the statement, Tanzanian travelers to neighboring countries and elsewhere have tested positive for COVID-19. In disaster management scenarios, the involvement of residents as volunteers and civil society has always been acknowledged. The United Nations recognizes volunteering as a vital tool for engaging people in addressing development concerns, and it has the potential to change the speed and type of development. The Kathmandu Declaration of 1991 established the participation of international and national volunteers in disaster preparation and recovery. With the hosting of the first UN International Year of Volunteers, the program has remained an integral aspect of disaster management (Lough, 2015). Volunteering is prevalent in South Africa, with Vermaak and Van Niekerk (2004) stating that the Eastern Cape Province has over 8000 trained volunteers. However, the employment of volunteers is not as prevalent in many regions. Nevertheless, there are methods and programs that have been built in South Africa that may be categorized as volunteering.

In terms of section 5 of the Disaster Management Act, the first National Disaster Management Advisory Forum (NDMAF) and the National Disaster Management Centre (NDMC), which are the second-highest national organizations dealing with disaster concerns in South Africa, were

funded on January 26, 2007. The first NDMAF was a watershed moment in mobilizing numerous stakeholders in the country and around the world. As a result, the NDAF's foundation has had a significant impact on the recruitment of both global and local actors.

The establishment of the South African Local Government Association (SALGA) in 1997 was a turning point in South Africa's development and support of local governments. SALGA has been helpful in strengthening the collective voice of South Africa's local government bodies. SALGA has been committed to its purpose of assisting local governments in transforming a complicated environment with a wide range of community members since its establishment.

SALGA stated that disaster management was lacking in local government incident reporting and that local government entities should demonstrate that they have business resilience plans in place for disaster recovery regularly. The publishing of these principles, followed by the participations workshop, may have sparked local government organizations to prioritize disaster management planning, resulting in greater resources being redirected for disaster management. These two milestones may have resulted in a significant positive impact on local actors and a negative impact on global actors.

The Provincial Disaster Management Centers and Forums (PDMC, PDMAF) are crucial in understanding these milestones, as are the Metropolitan and Municipal Disaster Management Centers and Forums (MDMC, MDMAF). The PDMC, PDMAF, M/MDMC, and M/MDMAF are local government entities that have been put up to replicate the duties of the NDMC and NDMAF. While establishing the PDMCs, PDMAFs, MDMCs, and MDMAFs is a welcome step, implementing these choices in various local government organizations in connection to disaster management has proven to be difficult.

Table 6: Project decisions and impact on reporting

	Decision	Local consequences	Global consequences	The resultant impact on reporting
A.	Enactment of the Disaster Management Act (DMA) by CoGTA	Mobilization of local support for Disaster management (DM)	Support from international agencies.	Major (+) GA; None (+) LA.
B.	Demonstration of the Integrated National Disaster Information Management System NDMC	Implementation of the INDMIS in Eastern Cape	Legitimization of global actors	Major (+) GA. Moderate(+) LA.
C.	PDMC; MDMC; MDMAF Establishment of Disaster Management Centres in 8 provinces.	Provide consultative leadership at local government level	Establishing with partnerships global actors.	Slight (+) LA; Minimal (+) GA.
D.	DMISA founding for provision of resources for those interested in professional registration disaster management	Local skills development	Networking and Information Sharing	Minimal (+) LA; Minimal (+) GA.
E.	Establishment of the Africa Multi-Hazard Early Warning System for DRR (UN)	Diverse investment opportunities for local communities	Mobilizing support for regional platforms.	Minimal (+) LA; Major (+) GA.
F.	Media: Establishment of the National CoGTA Twitter Account	Sensitization and advocacy	Sensitization and advocacy	Major (+) LA; Moderate (+) GA.

G.	Presidency announces the end of the Nation-state of disaster	Relief on Covid measures nationwide. The country can relive and rebuild the country amidst the presence of the virus.	Several countries that have dropped restrictions have seen subsequent increases not only in cases, but also in hospitalizations and deaths, although the link between cases and severe outcomes has decoupled.	Major (+) LA; Major (+) GA.

The problematization began with the implementation of the (DMA) Disaster Management Act (Network Analysis–A), which became the primary goal of the COGTA for Mobilization of local support for Disaster Management (DM) decision support in the disaster management network cooperation from international organizations. As a result, the NDMC's plan for decision support in disaster management includes obtaining additional funds from outside parties. The global consequences included providing support from international agencies with the resultant impact for Global Acors has a minimal impact on reporting. However, the local consequences include mobilization of local support for Disaster Management (DM), resulting in no impact on Local Actors.

Another part of the problematization phase was the establishment of NDMC. The DMTN is a financial instrument that allows for flexibility in raising finance for disaster management. Network Analysis-B demonstrates the Integrated National Disaster Information Management System NDMC. Wherein the global actor legitimization is a consequence, and Implementation of the INDMIS (Integrated Disaster Management & Information System) in the Eastern Cape is a consequence for local actors. These consequences result in a significant increase in the impact on global actors and a moderate increase in local actors.

4.5 Disaster Management Resilience Assessment

Following consideration of the impact of role participants' actions on DM resourcing, the graph below examines how the decisions described above have influenced the "framework" for decision making arising from various stakeholder roles in the local government sector. The resulting

conclusion from the foregoing research is that stakeholder enrolment is extremely low, particularly at the local level, where DRM should be prioritized. The GA receives most of the institutional support in terms of resources, especially with NDMC serving as the Obligatory Point of Passage (OPP). The mobilization of network stakeholders happens when social engagements reach a threshold where removal from the network is improbable, according to Willcocks & Mingers (2004). The concept of irreversibility is utilised as a metaphor in the method of ANT to describe the resilience of disaster management in the local government sector through the evaluation of the strength of engagement of stakeholders indicated in the preceding study.

4.4.1. Impact on Global Actors (GA) Chart A

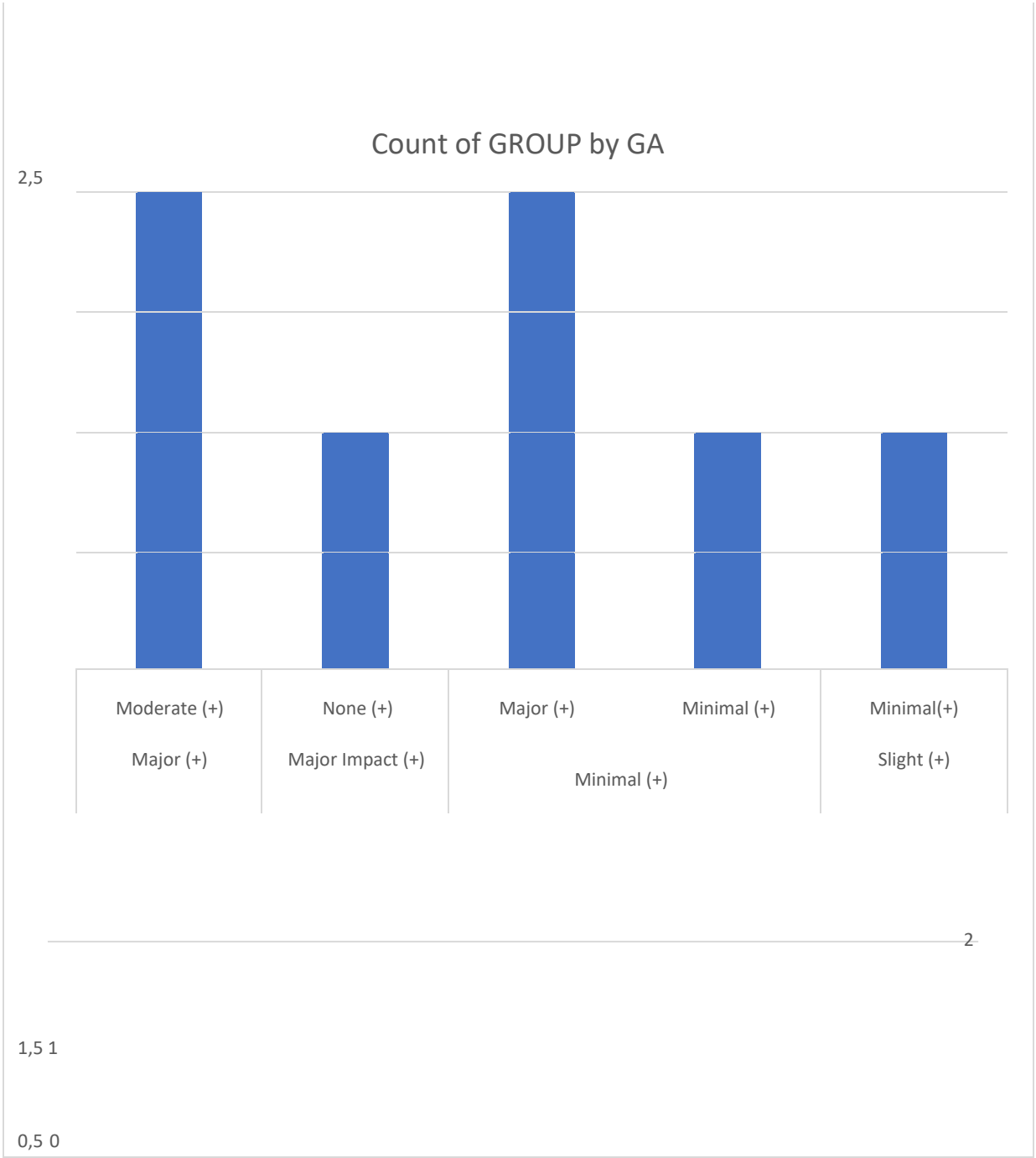


Figure 7: Impact on global actors

The consequences started off with a moderate to major impact on global actors (GA), with minimal increase in the impact on report the end result of consequences on GA's was slightly minimal.

4.4.2. Impact on Local Actors Chart B

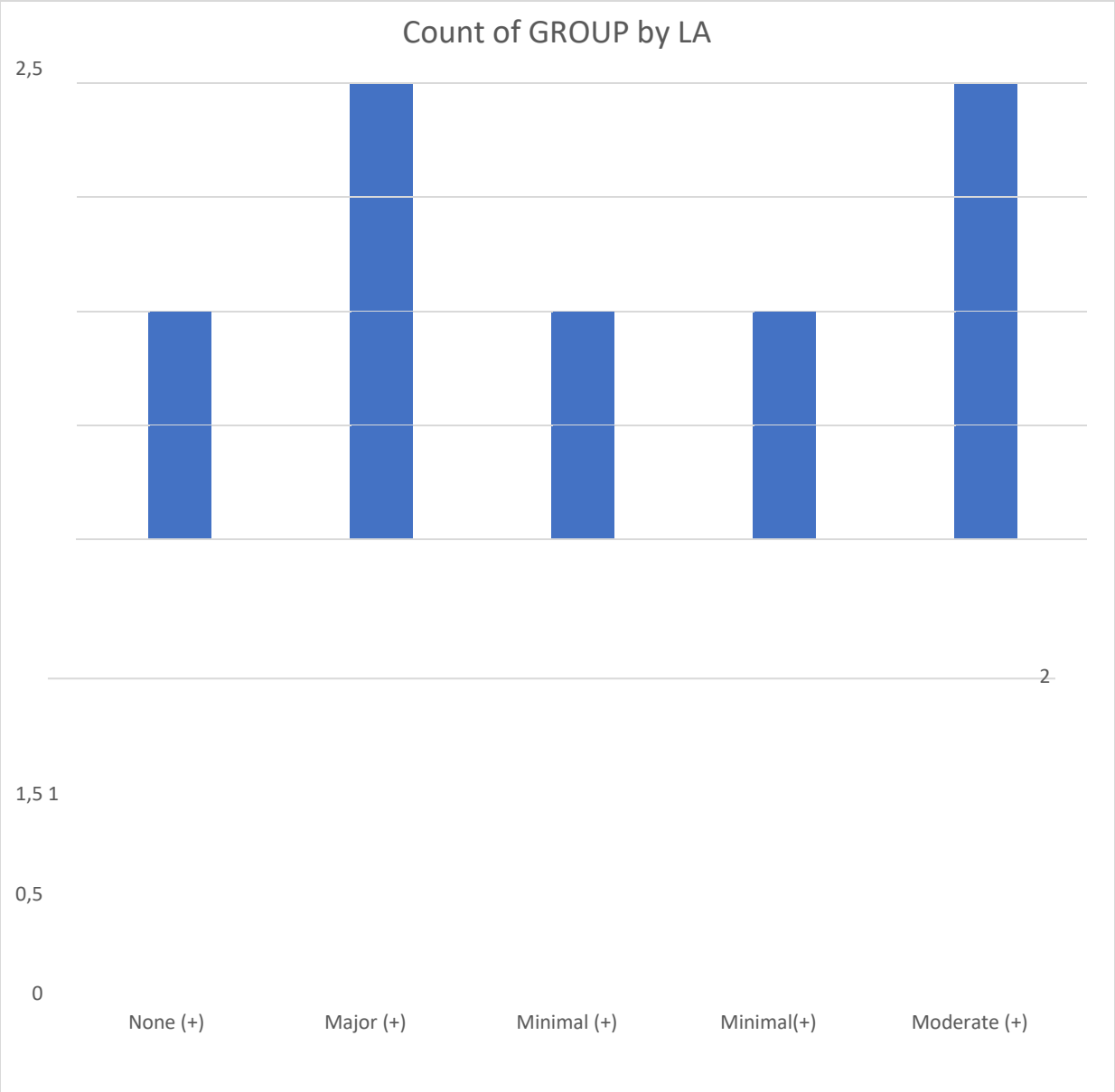


Figure 8: *Impact on Local actors*

4.4.3. Resultant impact on Local actors vs Global actors

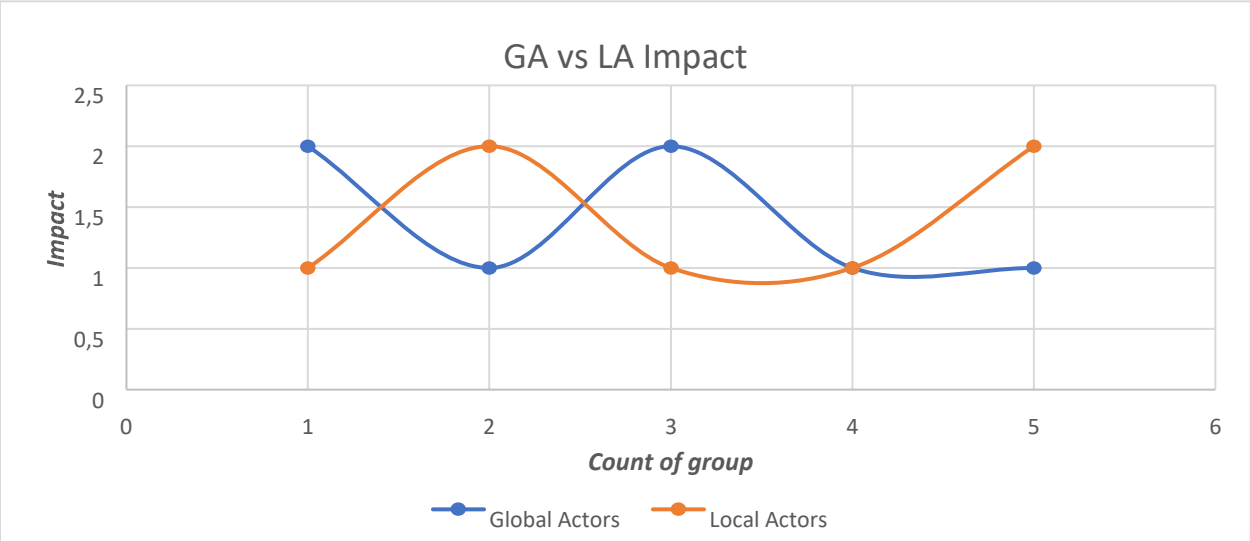


Figure 9: *Resultant impact on Local actors vs Global actors*

4.5 Assessing the Impact of Stakeholders on Disaster Management

After considering the impact of role players' decision on resourcing for DM, the graph below analyses how the above decisions have impacted the "conditions" for resource investments stemming from various stakeholder roles in the local government sector. The emerging assessment from the analysis above is that stakeholder enrolment, particularly at the local level where there should be greater focus for DRM, is quite weak. Generally, institutional support in terms of resources is predominantly concentrated at the GA, particularly with NDMC as the Obligatory Point of Passage (OPP). According to Willcocks & Mingers, (2004), the mobilization of a network stakeholders occurs when social investments reach a point where withdrawal from the network would be unlikely (irreversibility). The concept of irreversibility in the manner of ANT is used as a metaphor to explain the resilience of disaster management in the local government sector through the assessment of the strength of mobilization of stakeholders identified in the analysis above.

The impact over influence chart below, provides an indication, stemming from the analysis above, which stakeholder(s) need to be engaged given their possible influence in DR. The results show that predominantly, the GA/global stakeholders have had an influence of the trajectory of

DR, but with minimal impact at the local municipality level. This implies that resources for DR activities are concentrated at the "global", with now clear path of how these resources are channeled from the global to the local level. Though there are stakeholders that have potential to interact closely with local municipalities, their position in the lower left quadrant of the stakeholder map shows that they had minimal impact on DR activities. Despite this scenario, there is need to maintain these stakeholders, and as stakeholder dynamics change or shift positively, these stakeholders can be useful in collaborative activities related to DR activities at the local level.

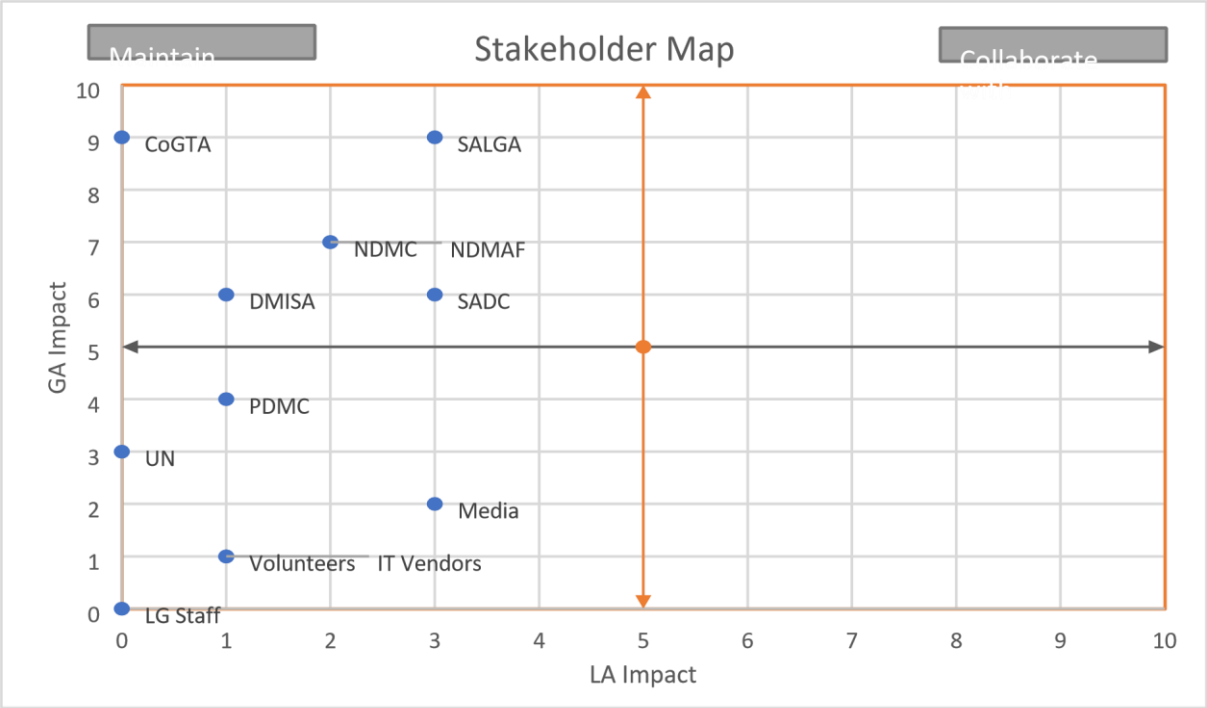


Figure 10: Stakeholder Map

Given the dominance of the global stakeholder groups from the analysis above, respondents were asked to make recommendations as to who are the most critical stakeholders who should be involved in decision making in the NDMC. The respondents made 128 suggestions, categorized into 17 stakeholder groups as shown in Figure 8 above. The frequencies shown in the Pareto chart gives an indication of the importance attached to the suggested stakeholders. Thus, ICT Vendors and Software Suppliers are ranked one, followed by employees, management (particularly, senior management) and community members, etc.

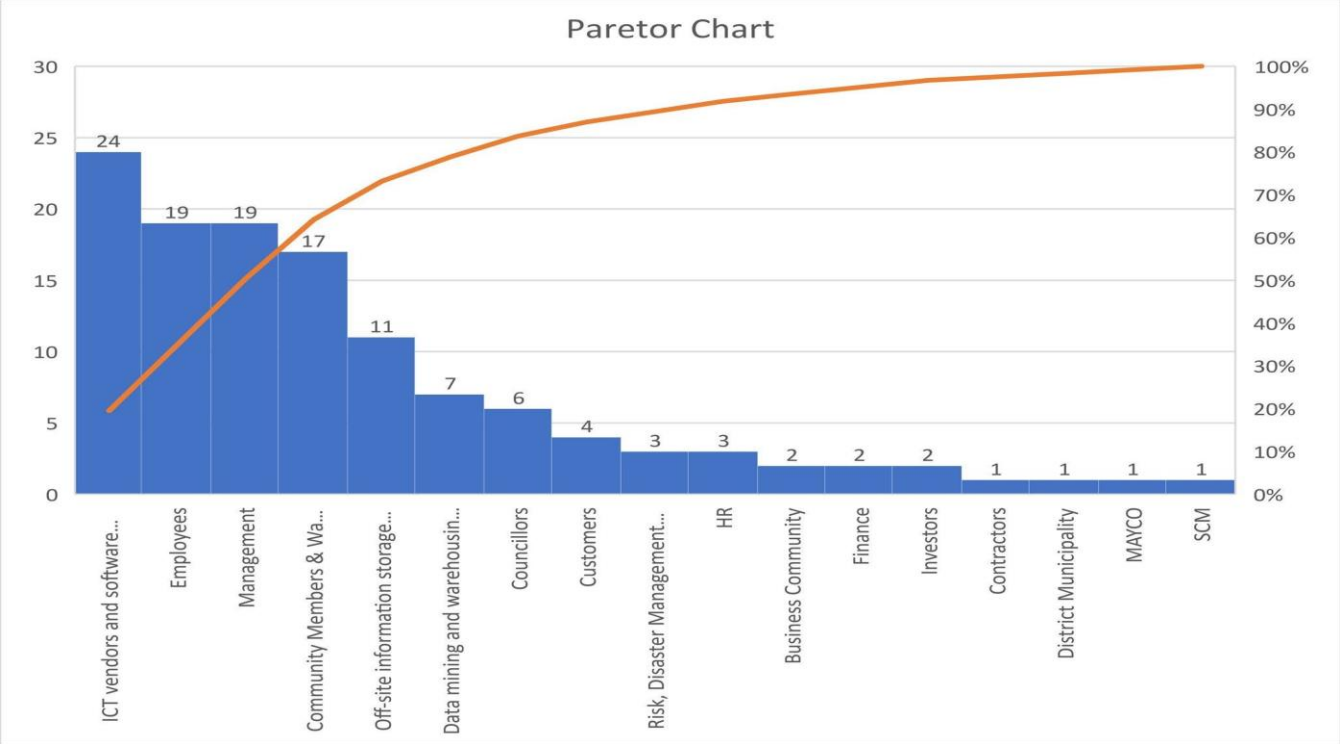


Figure 11: Recommended Stakeholders

As captured in Figure 8, these suggestions from internal stakeholders clearly identified who are considered as the critical stakeholders in DR activities of the local municipalities. Key suggestions that stand out is the need to involve ICT vendors and software suppliers, which was considered the most important stakeholder group by the respondents. Thus, the lack of involvement of local stakeholders in CVA and DR has been demonstrated by the respondents, as they clearly suggested who needs to participate in these activities as summarized in Figure 9.

4.6. What is the role and interests of different stakeholders in a Collaborative Decision-Making Environment?

In disaster management scenarios, understanding strategic role playing and requisite resources are essential factors. According to Stoney and Winstanley (2001), the stakeholder idea has been extended beyond the management environment to the realm of government, where policy implications have been investigated (Stoney, 2001). Given that stake-holding requires some kind of collaboration among many stakeholders, it is necessary to investigate how strategic stake-holding affects decision-making in disaster risk management. the type of ties among the stakeholders. According to Michael (1991), cooperative individuals are always pursuing their own aims in a typically harmonious manner. In addition to investigating the dynamics of interactions among stakeholders, it is necessary to fully understand the nature of interactions between stakeholders and the resources they demand. Interactions are expected to be characterized as practices of deliberate actions in accordance with negotiated intentions. Accordingly, significations are presumed created through discourse, in which various stakeholders participate. In addition, since there are normally several stakeholders involved in decision-making in DRM, there are no assumed objectives (intentions); and that the evolving state is an evolving negotiation between the various stakeholders.

4.7. Forms of collaboration in a multi-agent Disaster Risk Management environment

Collaboration might take on a variety of forms such as transboundary collaborative response by voluntary organisations during disasters (Lai 2012). The success of different variants of collaboration, however, depends not only on the capacities of collaborative agencies but also on how adequately they collaborate during different phases of disasters (Samba 2010). Over the last two decades or so, the scale and scope of natural and man-made disasters have dramatically increased. The ineffectiveness of traditional disaster management approaches has given way to the emergence of decentralised emergency management systems. This shift is being prompted by the exigency to collaborate during various stages of a disastrous situation (Kapucu & Garayev 2011).

Multi-agency collaboration serves as an integral component of modern disaster management (Waugh & Streib 2006). Disasters, be that natural or man-made, open up window of opportunity for bringing multiple actors together. Often, such actors not only belong to different nationalities but also vary considerably in terms of their capacities, values, norms and objectives (Kettl 2008; Mitchell 2006). The effectiveness and efficiency of such organisations, however, largely depend upon the level of collaboration in disaster situations (Bryson et al. 2006; Drabek & McEntire 2002; Vangen & Huxham 2003). The effectiveness of various collaboration variants, however, is dependent not only on the capacity of collaborating agencies but also on how well they collaborate during various stages of a disaster (Samba 2010).

4.8 Chapter summary

This chapter has provided the results that were established from the document analysis or the collection of results. The results were presented in this study and the next chapter will provide the conclusion and recommendations.

Chapter 5: Conclusions and recommendations

5.1. Introduction

The results presented in chapter four and discussions from chapter 4 enabled the researcher to draw conclusions on the research study. The contributions of the research towards the knowledge body are highlighted in this chapter. Furthermore, the limitations to the research study are outlined. The chapter seeks to highlight recommendations as well as the suggestions for future research. Lastly, the concluding remarks of the study are provided. The prior analyses above and various literature review sources form the basis for this synthesis section. The Qualitative Analysis, focused on the identification and analysis of the key role players in decision making in NDM. Key findings showed that, in the context of South African local municipalities, "global" stakeholders play a prominent role at the expense of "local" stakeholders. However, the study respondents were emphatic that local stakeholders need to play a much more direct role. This claim was voiced through their identification of specific stakeholders who should be involved in disaster risk management at the local municipalities. Analysis focused on specific variables associated with the constructs of "impact," "decision making Role" supported this overall assessment.

Using the synthesis of findings from these sections as the basis, this section responds to the emerging inadequate situation of decision-making assessment. Local municipalities by recommending and proposing a viable framework for local municipalities. This approach is in line with the requirements of the study project's fifth objective. A discussion of the findings with the intention of pointing out the inadequacies of the current stakeholders in Disaster Management conceptualization in South African local municipalities.

5.2. Disaster Management Paradox in South African Local Government

There are three synthesis areas that are addressed in this section. The first is a re-statement of the social problem that stake holders in Disaster Management attempts to address in the context of local municipalities. The social problem that stake-holders in DR attempts to address was presented in Chapter 1 and was also intertwined in discussions in other previous sections. It was highlighted that disasters are inevitable, but there can be a difference in the aftermath of a

disaster depending on how prepared the local municipality or community is to face a disaster and the planning to recover from it. Local governments, as direct service providers to local communities and as first responders in times of disaster, have grappled with various disaster responses on the ground at an unprecedented scale, despite sometimes immediate and major disruptions to their budgets (Cameron, 2021). In the face of truly catastrophic circumstances, many local government entities have sought to step up their efforts to provide a strategic vision to support the continued provision of essential services in the face of various disasters (Dzigbede et al., 2020). Particularly since the onset of COVID-19 in December of 2019, decision-making in DR management has been brought to the fore, with Frameworks designed to integrate Business Intelligence and collaborative visual analytics for decision support in disaster risk management.

5.3. Discussion of Findings

In the context of South Africa's local municipalities, seeking an understanding the stake-holders infrastructure in decision making in risk and exploring skills development interventions in addressing the service disruptions is timely. However, despite the envisaged role that can be played by local municipalities, they are plagued by numerous challenges, which have been confirmed in this study, in the implementation of disaster risk reduction strategies, not only generally but also related to stake-holders infrastructure. For instance, the exploration of the collaborative visual analytics in DRR, was critical; but challenges remain related to: managerial decision making that is inconsistent with business continuity principles and improper business continuity planning; improper, inefficient, ineffective, confusing and difficult disaster management processes and procedures; poor documentation of disaster management processes and procedures that impacts The integration between business intelligence and collaborative visual analytics for decision support in disaster risk management.

While considering the role of decision making in disasters was apt, the respondents also mulled over the current known risks that are facing their local municipalities. This was important what risks/threats are likely to cause significant damage. From a risk assessment perspective, the results, as revealed in Table 7 shows the following ranking of the known risks, in order of priority:

The link from the risk assessment levels can also be connected to other constructs associated with the other objectives of the study. For instance, it was also firmly established that various decision-making related skills necessary for DRR are woefully lacking in the local municipalities. Inadequate or lack of skills in the local municipalities emphasized the need to develop capability to analyze current stake-holders infrastructure, being able to develop tools for disaster identification, development of necessary back procedures for restarting systems that fail and running offsite storage facilities. Capability to develop a disaster recovery plan is also necessary, with these plans containing impact analysis details related to infrastructure, and systems. Prior studies have confirmed that the lack of decision-making skills in South African local municipalities is an incessant problem and need to be addressed. Rosendo et al., (2018) identified decried challenges in the context of local government administration and characterised them as a general lack of expertise, technical skills and capacity.

The study also sought to link “business resilience” as the dependent construct that can be used to analyse the ability of the local government municipality to manage and recover from disasters and identified the critical resilience activities necessary for DR which confirmed a valid model for the assessment of “business resilience” for local government municipalities in South Africa. Common to the understanding of “resilience” is the notion of recoverability, “bouncing back” and/or “bounding forward” (Leck & Simon, 2018), which links well with understandings of DR. Specifically in relation to understandings of the role of stake-holders in DR, this study has confirmed the strong link between to collaborative visual analytics, impact of disasters on decision making for disaster management, link to risk assessment evaluation and levels (*risk*) and decision making skills . A further analysis confirmed strong associations between respondents’ responsibilities (*positions*) with these variables, establishing that, despite diverse responsibilities, there is concurrence as to the role of these variables in understanding the role of stakeholders in DR in local municipalities of South Africa

The findings given in this part are aimed at identifying and analyzing the strategic role actors as well as the resources needed to handle potential service interruptions in the local government sector. The idea of "actor" is used to identify and analyze role actors and resources, which acknowledges both human stakeholders and non-human stakeholders (resources). As a result,

the study in this section was driven by Actor-Network theory. The following is an outline of the section: The first section focuses on identifying the actors, their roles, and their interests in a disaster recovery program; the second section assesses the consequences of the actors' actions in a disaster management program; and the final section assesses the likely impact of the consequences of the actors' actions in a disaster management program. The qualitative research focuses on identifying and analyzing important stakeholders and their roles in disaster risk management decision making in global and local participants. Key findings revealed that, in the context of South Africa, "global" stakeholders took precedence over "local" stakeholders. However, research participants were unanimous in their belief that local stakeholders must play a far more direct role. This assertion was made by identifying certain stakeholders who should be included in disaster risk management decision-making. The qualitative analysis also focused on the role of stakeholders in DR. Based on an ANT analysis, stakeholders were characterized as either global actors (GA), or local actors (LA). The ANT analysis confirmed that the GA played a much more dominant role in DR activities at the national level, with minimal influence at the local municipalities level. This affected resource allocation for local municipalities, as the impact of DR by the GA is mostly felt at the national and provincial levels, though there is some indirect “trickle-down” effect associated with funding that comes from the central government. Excluding local stakeholders in the provision of disaster related solutions has proven difficult if they are left out of decision-making processes since effective disaster preparedness need to utilize the capacities of local authorities and community (Zamisa & Mutereko, 2019).

Given the minimal involvement of the LA in the ANT analysis, it was necessary to identify who, among the LA group can play a significant role in DR in local municipalities. The response from the respondents was to recommend several local stakeholders who are critical for the resilience of the DR programme at the local government municipality level. The recommended groups of local stakeholders can be characterized as a political nexus triad (PNT) in a manner offered by Moon & Ingraham, (1998) as a way of offering administrative reform of decision making in DR. The PNT takes politics, administration, and civil society as a set of interactions which can be

combined to produce a public policy. The 17 local stakeholders, identified by the respondents can be classified using the PNT, as below (Table 7).

Table 7: PNT of Local Stakeholders

Politics	**Administration**	**Civil Society**
Councilors	Employees	Stakeholder
District Municipality	Management	Data Mining & Warehousing Vendors
Ward Committees	Back-Up Sites	Customers
	HR	Business Community
	Finance	Investors
	MAYCO	Contractors
	SCM	Community Members

The PNT characterization above brings to the fore, the need for local stakeholder participation in, not only decision-making processes of DR, but also active involvement disaster operations. For effective local stakeholder participation of the PNT, there needs to be stable political systems (Vaagaasar, 2011), the use of indigenous knowledge and mainstreaming of disaster risk reduction in policy processes (Kelman et al., 2012), improving good governance and the institutional capacity of local government municipalities (Manyena et al., 2019), and empowering local communities (Paton & McClure, 2013). In the next section, the study builds on the synthesis of these findings and additional literature to evolve a nomadic framework, based on systems theory, for effective decision making in DR in local municipalities of South Africa.

The synthesis of findings demonstrated the ineffectiveness of the current conceptualization of des disaster management in the local context of South Africa's local municipalities. This section is structured as follows: the first section synthesizes certain proposals from the information infrastructure perspective of building digital information infrastructures for Disaster Recovery

(DR) in local government. The information management literature, together with findings from this study are used to motivate for a nomadic model for Disaster Risk Management (DRM) in local municipalities of South Africa. The second section will provide a summary and conclusions of the study, as well as provide certain recommendations necessary for DRR in local municipalities.

5.3.1 Key Findings of the Research Study

Applying Kimball's methodology and Munzner's framework allowed the researcher to develop a strategy for creating flexible, fast risk observatories that fulfil end-user needs. The proposed risk analyzes allowed intuitively to make decisions aimed at the process of disaster risk reduction. It is necessary to state that the analyses that were made were of passive type, that is, they are analyzes to obtain reports, and measurements on the available data. It would be interesting and even pertinent to apply data mining techniques to perform types of active analysis.

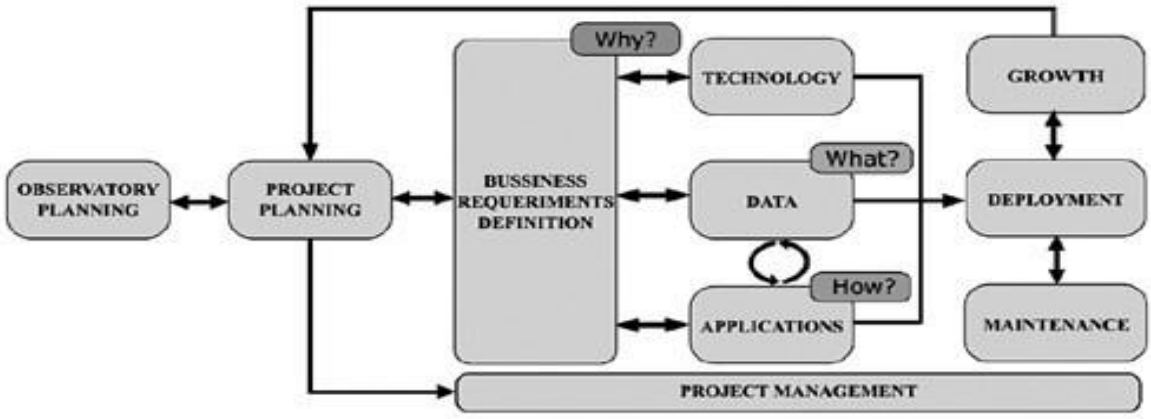


Figure 12: Proposed strategy for disaster risk management observatories that integrates Kimball's methodology with Munzner's framework.

5.3.2 The Disaster Risk Management Framework

Based on the findings of this study and additional review of literature from information infrastructure perspectives, the ***"Disaster Risk Management Framework***" to guide the rethinking of DR in local municipalities of South Africa. The framework is undergirded primarily by literature that is anchored on the building information infrastructure perspective and nomadic computing

(See Aanestad et al., 2017; Hanseth & Henningson, 2013; Hanseth & Lyytinen, 2016; Tilson et al., 2010). A nomadic information environment is viewed as an interconnected assemblage of technological and organizational elements, which enables physical and social mobility of computing and communication services between organizational actors both within and across organizational borders (Lyytinen & Yoo, 2002). The multi-perspective orientation of building information infrastructures is well established in Information Systems research. For instance, Hanseth & Monteiro (1998) exposition on building information infrastructures identifies certain defining aspects, including:

- Infrastructures have a supporting or enabling function.
- An infrastructure is shared by a *larger community or a collection of users and user groups.*
- Infrastructures are open.
- Information infrastructures are more than 'pure' technology; *they are rather sociotechnical networks.*
- Infrastructures are connected and interrelated, constituting ecologies of networks.
- Infrastructures develop through extending and improving the installed base.

Conclusion

From the obtained results, it is clear that this is a topic of pivotal importance because the findings of this study elucidated key principles related to the assessment of stakeholder roles and interests, the consequences of the role-playing, and how these are likely to influence disaster management in South Africa. The need for employing a visualization framework arises when there are multiple ways to represent data. Moreover, previous work on how to represent a given problem should be studied, and researchers should review the documentation of prior proposals to comprehend them**.** Although studies articulate the assessment of stakeholder roles and interests, the consequences of the role playing and how such have exacerbated disaster management were conducted, contrastingly, this dimension is rarely discussed in the literature. As such, this study provides additional insight into this area for practical implications. This study adopted a different approach by exploiting Kimball's methodology and Munzner's framework which allowed to develop a strategy for creating flexible, fast risk observatories that fulfil end-user needs.

The proposed risk analyses allowed intuitively to make decisions aimed at the process of disaster risk reduction. The use of this method has the potential to drive many new applications in the near future. It is necessary to state that the analyses that were made were of the passive type, that is, they are analysed to obtain reports, and measurements on the available data. There have been multiple previous attempts to solve this problem, however, this study has the potential to impact disaster management in South Africa.

Moreover, It would be interesting and even pertinent to apply data mining techniques to perform types of active analysis. Future advancements are expected to result in this area regarding mining techniques. A negative consequence has the opposite effect. Looking at the consequences is essential because it afforded the researcher to determine whether Covid-19 reporting is vital or not. This study builds on and contributes to work in disaster management in the advent of the COVID-19 transition.

References

Arnott, D., Lizama, F., & Song, Y. (2017). Patterns of business intelligence systems use in organizations. *Decision Support Systems, 97*, 58-68.

Arslan, M., Roxin, A.-M., Cruz, C., & Ginhac, D. (2017). *A review on applications of big data for disaster management.* Paper presented at the 2017 13th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS).

Bassey, N. (2020). A year of climate disasters in Africa. *Green Left Weekly*(1254), 12.

Benaben, F., Montarnal, A., Fertier, A., & Truptil, S. (2016). *Big-Data and the question of horizontal and vertical intelligence: a discussion on disaster management.* Paper presented at the Working Conference on Virtual Enterprises.

Bruwer, A., van Staden, M., Le Roux, A., & van Niekerk, W. (2017). Disaster management and risk reduction in South Africa. *Global Change*, 105.

Coppola, D. P. (2006). *Introduction to international disaster management*: Elsevier.

Culwick, C. (2019). Disasters and Disaster Risk Management in South Africa. In *The Geography of South Africa* (pp. 295-304): Springer.

DisasterManagementAct. (2002). Republic of South Africa (RSA) Disaster Management Act.

Emmanouil, D., & Nikolaos, D. (2015). *Big data analytics in prevention, preparedness, response and recovery in crisis and disaster management.* Paper presented at the The 18th International Conference on Circuits, Systems, Communications and Computers (CSCC 2015), Recent Advances in Computer Engineering Series.

Fauci, A. S., Lane, H. C., & Redfield, R. R. (2020). Covid-19—navigating the uncharted. In: Mass Medical Soc.

Flachberger, C., & Gringinger, E. (2016). *Decision Support for Networked Crisis & Disaster Management-A Comparison with the Air Traffic Management Domain.* Paper presented at the ISCRAM.

Fragkos, G., Tsiropoulou, E. E., & Papavassiliou, S. (2019). *Disaster management and information transmission decision-making in public safety systems.* Paper presented at the 2019 IEEE Global Communications Conference (GLOBECOM).

Horita, F. E., de Albuquerque, J. P., Marchezini, V., & Mendiondo, E. M. (2017). Bridging the gap between decision-making and emerging big data sources: An application of a modelbased framework to disaster management in Brazil. *Decision Support Systems, 97*, 12-22.

Jang, S., Ekyalongo, Y., & Kim, H. (2020). Systematic review of displacement and health impact from natural disasters in Southeast Asia. *Disaster medicine and public health preparedness*, 1-10.

Jung, D., Tran Tuan, V., Dai Tran, Q., Park, M., & Park, S. (2020). Conceptual Framework of an Intelligent Decision Support System for Smart City Disaster Management. *Applied Sciences, 10*(2), 666.

Kanal, A. S. (2020). Unit-6 Disaster Management Cycle with Focus on Preparedness, Prevention and Mitigation. In: IGNOU.

Kiani Mavi, R., & Standing, C. (2018). Cause and effect analysis of business intelligence (BI) benefits with fuzzy DEMATEL. *Knowledge Management Research & Practice, 16*(2), 245257.

Li, T., Xie, N., Zeng, C., Zhou, W., Zheng, L., Jiang, Y., . . . Huang, Y. (2017). Data-driven techniques in disaster information management. *ACM Computing Surveys (CSUR), 50*(1), 1-45.

Ngamassi, L., Malik, A., Zhang, J., & Ebert, D. S. (2017). *Social Media Visual Analytic Toolkits for Disaster Management: A Review of the Literature.* Paper presented at the ISCRAM.

Nishiura, H., Oshitani, H., Kobayashi, T., Saito, T., Sunagawa, T., Matsui, T., . . . Suzuki, M. (2020). Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19). *MedRxiv*.

Nojavan, M., Salehi, E., & Omidvar, B. (2018). Conceptual change of disaster management models: A thematic analysis. *Jàmbá: Journal of Disaster Risk Studies, 10*(1), 1-11.

Panrungsri, T., & Sangiamkul, E. (2017). *Business Intelligence Model for Disaster Management: A Case Study in Phuket, Thailand.* Paper presented at the ISCRAM.

Pharoah, R., Holloway, A. J., Fortune, G., Chapman, A., Zweig, P., & Schaber, E. (2016). *Off the Radar-Synthesis Report: High Impact weather events in the Western Cape, South Africa*. Retrieved from

Sanderson, D., & Sharma, A. (2016). World Disasters Report 2016. *Resilience: saving lives today, investing for tomorrow. International Federation of Red Cross and Red Crescent Societies*. Sarvari, P. A., Nozari, M., & Khadraoui, D. (2019). The Potential of Data Analytics in Disaster Management. In *Industrial Engineering in the Big Data Era* (pp. 335-348): Springer.

Sasaki, D., Moriyama, K., & Ono, Y. (2020). Main features of the existing literature concerning disaster statistics. *International journal of disaster risk reduction, 43*, 101382.

Sawalha, I. H. (2020). A contemporary perspective on the disaster management cycle. *foresight*.

Schenck, C. J., Blaauw, P. F., Viljoen, J. M., & Swart, E. C. (2019). Exploring the potential health risks faced by waste pickers on landfills in South Africa: a socio-ecological perspective. *International journal of environmental research and public health, 16*(11), 2059.

Sitas, N., Reyers, B., Cundill, G., Prozesky, H. E., Nel, J. L., & Esler, K. J. (2016). Fostering collaboration for knowledge and action in disaster management in South Africa. *Current Opinion in Environmental Sustainability, 19*, 94-102.

Talisuna, A. O., Okiro, E. A., Yahaya, A. A., Stephen, M., Bonkoungou, B., Musa, E. O., . . . Djingarey, H. M. (2020). Spatial and temporal distribution of infectious disease epidemics, disasters and other potential public health emergencies in the World Health Organisation Africa region, 2016–2018. *Globalization and health, 16*(1), 1-12.

Yu, M., Yang, C., & Li, Y. (2018). Big data in natural disaster management: a review. *Geosciences, 8*(5), 165.

Zhang, J., Ahlbrand, B., Malik, A., Chae, J., Min, Z., Ko, S., & Ebert, D. S. (2016). *A visual analytics framework for microblog data analysis at multiple scales of aggregation.* Paper presented at the Computer Graphics Forum.

Zubir, S., Thiruchelvam, S., Mustapha, K., Muda, Z. C., Ghazali, A., & Hakimie, H. (2017). *An Evaluation on Factors Influencing Decision making for Malaysia Disaster Management: The Confirmatory Factor Analysis Approach.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Arefin, M. &. H. M. &. B. Y., 2015. The impact of business intelligence on organization's effectiveness: an empirical study Article information: For Authors.. *Journal of Systems and Information Technology,* Volume 17, pp. 263-285.

Ashley Castleberry a, A. N., 2018. Thematic analysis of qualitative research data: Is it as easy as it sounds?. *Currents in Pharmacy Teaching and Learning,,* 10(6), pp. 807-815.

Awuh, H. E., 2022. Disaster Risk Reduction and Management: A Conceptual Overview. *Emerald Publishing Limited, Bingley,* pp. 3-33.

Bhandari, P., 2020. *What Is Qualitative Research? | Methods & Examples.* [Online]
Available at: https://www.scribbr.com/methodology/qualitative-research/
[Accessed 22 June 2023].

Bisantz, A. M., 2006. The role meta-information in C2 decision support systems. June, pp. https://www.researchgate.net/publication/235136412_The_Role_of_Meta-Information_in_C2_Decision-Support_Systems.

Cabinet, 2020. *Gov.za.* [Online]
Available at: https://www.gov.za/sites/default/files/gcis_document/202101/national-policy-development-framework-2020.pdf

Chowdhury, M., 2022. *Analytics insight.* [Online]
Available at: https://www.analyticsinsight.net/the-relationship-between-business-intelligence-and-data-management/#:~:text=Data%20management%20is%20a%20subset,line%20with%20the%20business%20goal.
[Accessed 14 July 2022].

coursera, 2023. *coursea.org.* [Online]
Available at: https://www.coursera.org/articles/business-intelligence?utm_medium=sem&utm_source=gg&utm_campaign=B2C_EMEA__coursera_FTCOF_career-academy_pmax-nonNRL-within-14d-country-SA&campaignid=20158335004&adgroupid=&device=c&keyword=&matchtype=&network=x&devicemode
[Accessed 15 June 2023].

Creswell, 2009. *Qualitative versus Quantitative research methods.* [Online]
Available at: https://www.ukessays.com/essays/psychology/qualitative-research-versus-quantitative-

research-methods-psychology-essay.php#:~:text=Qualitative%20research%20is%20defined%20by,data%20analysis%20inductively%20building%20from

Crunch, C., 2022. The interplay of drought-flood extreme (2001-2021). *UCLouvain,* Issue 69, p. 1.

Delahunt, M. M. &. B., 2017. Doing a Thematic Analysis: A Practical, Step-by-Step. *Aishe J,* Volume 3.

Denzin, N. a. L. Y., 2011. *The Sage handbook of qualitative research.* s.l.:s.n.

Dusse, F. J. P. A. A. N. R. V. V. a. M. M., 2016. Information visualization for emergency management: A systematic mapping study.. *Expert Systems with Applications,* Volume 45, pp. pp.424-437.

Dyssel J, 2018. *Disaster Management Overview, Legislation and Guidelines,* Capricorn District Municipality: Department of Cooperative Governance,.

Feng, Y. &. H. X. &. S. M., 2022. Extraction and analysis of natural disaster-related VGI from social media: review, opportunities and challenges. *International Journal of Geographical Information Science.*

Gabrielle Wong-Parodi, K. J. M. K. J. K. D. S., 2020. Insights for developing effective decision support tools for environmental sustainability. *Current Opinion in Environmental Sustainability,* Volume 42, pp. 52-59,.

Gómez, J. A. G., 2017. *johnguerra.co.* [Online]
Available at: https://johnguerra.co/classes/visual_analytics_fall_2017/
[Accessed 2017].

Grant, C. O. A., 2014. Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your “House”. *Administrative Issues Journal Education Practice and Research,* 4(2).

Hollweck, T., 2016. The Canadian Journal of Program Evaluation.. *Sage,* Volume 5, p. 282.

Hsinchun Chen, R. H. L. C. a. V. C. S., 2012. Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Quarterly,* 36(4), pp. 1165-1188.

Jilcha, K., 2019. Research Design and Methodology. *Intechopen,* p. 27.

Johnson, M. C. C. a. K. H., 2008. Reinventing your business model. *Harvard business review,* 86(12), pp. 50-59.

Joubish, M. K. M. A. A. F. S. a. H. K., 2011. Paradigms and characteristics of a good qualitative research.. *World applied sciences journal,* 12(11), pp. 2082-2087.

Keim, D. M. F. S. A. Z. H., 2009. Visual Analytics. In: LIU, L., ÖZSU, M.T. (eds). *Encyclopedia of Database Systems,* p. 3341–3346.

Loraine Busetto, W. W. &. C. G., 2020. *Neurological Research and Practice.* [Online]
Available at: https://neurolrespract.biomedcentral.com/
[Accessed 27 May 2020].

Luo, Q., 2022. Real-Time Query Method Based on Distributed Database Demand Information. *Mathematical Problems in Engineering ,* pp. 1-8.

Marco Angelini, T. C. M. M. &. G. S., 2016. Visual Analytics and Mining over Big Data. Discussing Some Issues and Challenges, and Presenting a Few Experiences. *First online,* Volume 10084.

Mohajan, H., 2018. Qualitative Research Methodology in Social Sciences and Related Subjects. *Journal of Economic Development, Environment and People,,* 10 December, 7(1), pp. 23-48.

Moxley, J. M., 2017. *writting commons.org.* [Online]
Available at: https://writingcommons.org/section/rhetoric/rhetorical-situation/audience/research-communities/postpositivists/
[Accessed 2017].

N. Elmqvist and J. -D. Fekete, 2010. Hierarchical Aggregation for Information Visualization: Overview, Techniques, and Design Guidelines. *IEEE Transactions on Visualization and Computer Graphics,* 16(3), pp. 439-454.

Nel, H., 2020. *intgrty.co.za.* [Online]
Available at: https://www.intgrty.co.za/tag/post-positivism/#:~:text=Summary,on%20a%20critical%2Drealist%20ontology.
[Accessed 08 October 2020].

Panhwar, D. A. H. &. A. D. &. S. A., 2017. Post-positivism: An Effective Paradigm for Social and Educational Research.. *International Research Journal Arts & Humanities (IRJAH),* Volume 45, pp. 253-260.

Pattath, 2010. Interactive visualization for mobile visual analytics. *Doctoral dissertation, Purdue University*.

Snyder, H., 2019. Literature review as a research methodology: An overview and guidelines. *Journal of Business Research,* Volume 104, pp. 333-339.

Stewart, M. &. W. B., 2015. The dynamic role of social media during Hurricane #Sandy: An introduction of the STREMII model to weather the storm of the crisis lifecycle. *Computers in Human Behavior ,* 54(5).

Stoney, C. a. W. D., 2001. Stakeholding: confusion or utopia? Mapping the conceptual terrain.. *Journal of Management studies,* 38(5), pp. 603-626.

The South African Constitution, 5 July, 2021. *Co-operative Government.* [Online]
Available at: https://www.justice.gov.za/constitution/chp03.html
[Accessed 5 July 2022].

Thomas, G. &. T. G. &. C. C.-W. &. B. E. &. C. F. &. T. M. &. F. S. &. H. B., 1990. Heterogeneous Distributed Database Systems for Production Use.. *ACM Coputing surveys,* 22(3), pp. 237-266.

Wang, 2020. Visual analytical tools for multivariate higher-order information for emergency management. *Journal of Visualization,* 23(4), pp. 721-743.

Yasar, K., 2015. *Integration.* [Online]
Available at: https://www.techtarget.com/searchcustomerexperience/definition/integration
[Accessed 2015].

zeekoi enterprise solutions, 2023. *Data Inconsistencies and Errors: The Consequences of Using Non-Integrated Software Systems..* [Online]
Available at: https://www.linkedin.com/pulse/data-inconsistencies-errors-consequences-using-non-integrated-software/
[Accessed 10 June 2023].

Appendix A

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Ms M Maligudu

STUDENT NO:
11623420

PROJECT TITLE: A framework to integrate business intelligence and collaborative visual analytics for decision support in disaster risk management in South Africa.

ETHICAL CLEARENCE NO: SMS/21/BIS/02/1304

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof NM Ochara	University of Venda	Supervisor
N Patala	University of Venda	Co - Supervisor
Ms M Maligudu	University of Venda	Investigator – Student

Type: **Masters Research**
Risk: **Minimal risk to humans, animals or environment (Category 2)**
Approval Period: **April 2021 – April 2023**

The Research Ethics Social Sciences Committee (RESSC) hereby approves your project as indicated above.

General Conditions
While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principal investigator) must report in the prescribed format to the REC:
  - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project
  - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
  - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes in the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the REC. Would there be deviance from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the REC retains the right to:
  - Request access to any information or data at any time during the course or after completion of the project.
  - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
  - withdraw or postpone approval if:
  - Any unethical principles or practices of the project are revealed or suspected.
  - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
  - The required annual report and reporting of adverse events was not done timely and accurately.
  - New institutional rules, national legislation or international conventions deem it necessary

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: March 2021

Name of the RESSC Chairperson of the Committee: Prof Takalani Mashau

Signature:

UNIVERSITY OF VENDA
OFFICE OF THE DIRECTOR
RESEARCH AND INNOVATION
2021 -04- 19
Private Bag X5050
Thohoyandou 0950

APPENDIX B

EDITOR'S LETTER

07 March 2023

To whom it may concern

Dear Sir/Madam

This is to confirm that I, **Zitha Innocent** have proofread and edited a dissertation for the degree of Master of Commerce in the **Department of Business Information Systems** in the Faculty of Management, Commerce, And Law at the University of Venda, titled: **A FRAMEWORK TO INTERGRATE BUSINESS INTELLIGENCE AND COLLABORATIVE VISUAL ANALYTICS FOR DECISION SUPPORT IN DISASTER RISK MANAGEMENT IN SOUTH AFRICA** by Mashudu Maligudu (11623420).

I have further suggested several amendments which the student has undertaken to effect before the dissertation is finally submitted: spelling, grammar, structure, and format of chapters. This mini-dissertation was inspected meticulously for consistency and correctness for register usage and citations. Should there be any inquiry, please do not dither to contact me. However, it remains the candidate's responsibility to effect changes.

Best Regards

Zitha I
Cell Phone: 0715430998/ 015 962 8922
Email:Innocent.Zitha@univen.ca.za

BA (English), BA (Hons) English, MA English

Lecturer (English) at Science Foundation

University of Venda