Integration of Geographic Information Systems (GIS) into disaster management. A case of Kwazulu-Natal Human Settlements in response to October 2017 storm damage.

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Declaration

I, Mabel Ncumisa Mabengu hereby declare that this research project is the result of my own investigation and research and that it has not been submitted in part or fully for any other degree or to any other institution and the work of other researchers and authors have been herein acknowledged accordingly.

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Signature

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Date:

Abstract

Geographic Information System (GIS) has been used internationally as the support system to better respond to disasters. Since South Africa is not immune to disasters the intention of the study was to establish whether GIS services are integrated into disaster management in KwaZulu-Natal Department of Human Settlements (KZN DHS) focusing on response to the October 2017 storm disaster experienced by the province. As the basis of the discussions in the study literature review was used to contextualise the study and to identify trends in the integration of GIS into disaster responses. A combination of both quantitative and qualitative research methods was considered for data collection and analysis. The results were presented in a tabular and graphical format to display the frequency of responses. The study revealed the existence of Disaster Management and GIS units in KZN DHS but limited interaction amongst the officials. More participants supported the notion of integration of GIS into disaster management in general in order to respond efficiently to disasters.

Keywords: Disaster management, Geographic Information Systems, spatial thinking, storm disaster, KwaZulu-Natal Department of Human Settlements.

Dedication

This work is dedicated to my late father, Michael Mpendulo and my dear mother, Nodumo Busisiwe Mabengu who set an educational foundation at an early age, who believed in me and always encouraged me to reach for the stars. A special dedication to my three daughters, Zolwandle Mnguni, Engakithi Mnguni and Ayangezwa Mnguni, and lastly to my treasured husband, Mpumelelo Mnguni.

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Lastly I wish to express my gratitude to my dear husband, Mpumelelo Bongani Mnguni for being there throughout my journey for his constant support and taking his time off to drive me around, most importantly for encouraging me to chase my dreams.

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CHAPTER ONE
INTRODUCTION AND BACKGROUND TO THE STUDY

1. Introduction

Disasters are a global phenomenon, and many strategies have been used to minimise the risks and vulnerability caused by disasters. South Africa is equally affected by disasters. Therefore, it is imperative to explore all the possible avenues to effectively and efficiently respond to disaster incidents. South Africa has been exposed to cumulative levels of disasters due to a wide range of weather conditions causing widespread hardships and devastation. Our country is prone to various disasters which require an emergency response; which involves decision-making, but limited information makes it difficult to make informed decisions when a disaster occurs. Baguhuna *et al*. (2013) emphasise the importance of taking cognisance of all the disaster management phases, which include pre, during and post-disaster phases. According to disaster management continuum, the pre-disaster phase is comprised of disaster prevention and disaster preparedness; the second phase is the relief which is implemented during a disaster, and the last one takes place after the disaster occurs, which involves rehabilitation and reconstruction.

The researcher is sentient to the fact that GIS can play a vital role in all the phases of disaster management; however, the study will focus on the post-disaster phase which comprises response and recovery.

On the 9th of October 2017, a line of thunderstorm developed east of a low-pressure cut-off system which was over the western parts of the country. Subsequently, the South African Weather Services (SAWS) released an alert for severe thunderstorms. According to the SAWS, severe thunderstorms with heavy downpours and strong winds struck various parts of KwaZulu-Natal, affecting Durban, moving along the South Coast (South African Weather Services 2017). On the 10th of October, KZN Provincial Executive Committee issued warnings confirming storm damage which affected infrastructure in the province, including schools, hospitals, railway lines and houses. The extent of the damage warranted a declaration of provincial disaster as stipulated in section 41 of the Disaster Management Act. On the 12th of October 2017, the Provincial Cabinet declared the storm of the 10 October as a provincial disaster. Most families were left homeless as their houses were severely damaged. The municipalities that were severely affected were the eThekwini metropolitan area and uGu district municipality.

In any disastrous situation, all the government departments and other stakeholders immediately respond to relieve and save families from life-threatening conditions. According to Tomaszewski (2015) disaster management practitioners can better respond to disaster if Geographic Information Systems (GIS) is recognised as a critical tool for the provision of immediate relief and utilised as a decision-making tool. (GIS), if fully utilised, can play a significant role in disaster alleviation. This study seeks to establish the extent to which it was used in response to the disaster mentioned above.

Disaster management advocates for integrated planning from various sectors, but disaster management and GIS are not integrated. The effectiveness of the response provided to a disaster is influenced by information, including geographic information, at hand.

During some disaster incidents, urgent decisions need to be taken to save the threatened lives, reduce potential damage to the infrastructure and utilisation GIS to assist strategic decision-makers in making informed decisions. According to Holser (2016), geospatial technology has made an immense impact in emergency management planning in such a way that it influences all the phases of disaster management and its integration into all aspects of disaster can contribute to immensely inefficient services. This means through the use of GIS in emergencies; respondents can access a robust, standard set of data so that those decisions can be based on shared current, comprehensive information. GIS also provides on-the-ground teams with information about elements like power outages, road closures, and other circumstances that can cause delays in deploying assistance. The use of GIS can thereby improve both the speed and effectiveness of the local response to an emergency.

Notwithstanding the fact, the recognition of GIS in the disaster management field has gradually improved over the years, but there is still room for further improvement (Tomaszewski (2015). It is an undisputed fact that with global warming and everything else that is related to climate change, the intensity of the impact caused by disasters continuously surges. Department of Human Settlements carries the mandate to provide home-ownership using various instruments in both rural and urban areas.

Therefore, in the light of the above statement, it will be ideal for the department to use GIS to deliver on the mandate effectively. Kiani (2014) concurs with the statement above by stating that when responding to disasters, location is important so that the disaster practitioners should know where the beneficiaries and the houses are located. The South African Disaster Management Framework stipulates how the integration of resources should be stretched out in a disaster situation to achieve the element of efficiency; therefore, GIS can also be integrated into the process.

It is common knowledge that during a disastrous event, there are problems to solve so that informed decisions can be made; questions like who is affected; what caused the damage, where it happened. GIS provides a better response to such questions. During this period the element of accuracy becomes imperative and GIS plays a pivotal role as the information can be shared either in an executive suite or the field truck; users can access the network and be confident they are viewing accurate and up-to-date information. Holdeman (2014) agrees with the statement above, emphasising the fact that GIS is more than just mapping as it can be used as an analytical data management and visualisation tool.

"GIS can be used for situational awareness, for identifying ideal locations for prepositioning assets ahead of an impact, for understanding the relationship between hazard exposure and social vulnerability as part of the hazard mitigation planning process. GIS models and simulation capabilities enable decision-makers to both exercise response and recovery plans during non-disaster times and understand near real-time possibilities during an event. Essentially, if you have data, it can be mapped, analysed and utilised to make better decisions in a measurable amount of time." Holdeman (2014). According to Tomaszewski (2015), natural disasters are spatial phenomena because they occur where people live, they affect the environment that surrounds them and in every way from which they draw their livelihood support. Application of spatial thinking in disaster response plays a supportive role when it comes to decision-making, and it should be learnt as a skill for structuring and solving spatial challenges. The above statement is based on the fact that one cannot respond to disasters without establishing the importance of things which include: nearby shelter, safest routes, access roads, etc.

1.1. Background

Choosing the most appropriate and suitable intervention during and post-disaster can be challenging; especially if there is no current information. It is common knowledge that for the intervention to have an impact, enough information should be provided to explore possibilities and to address constraints that may be encountered. Geographic Information Systems is not a new concept, with its first recognition dates back to 1960, and Roger, the Geographer, contributed to the further development of the concept Tomaszewski (2015). As GIS emerged and advanced over the years, it brought about interest in the geography arena. It shows how it improves disaster response. Notwithstanding the lack of awareness on the value of GIS but various disaster incidents brought about the significance of GIS in the disaster management discipline and disaster management practitioners began to value the application of GIS in disaster response, DeCapua (2007). As there was geographic research conducted and GIS conference deliberations at an international level, various recommendations were made, and the most favoured were those published in the National Research Council (2007) according to Hodgson (2014), that advocate for the improvement of living conditions for those affected by disasters.

The response is one of disaster management's cycle phases which will be discussed in detail in chapter three. According to Tomaszewski (2015), it is important to understand what elements of GIS should be incorporated into a disaster response phase in order to make a meaningful impact.

KwaZulu-Natal experienced various disaster incidents which include floods, storm damage and shack fires. The abovementioned events can be attributed to multiple factors, like urbanisation, land invasions, etc. These factors caused people to move into disaster-prone areas. As stipulated in the Constitution of South Africa citizens have rights to shelter should they get affected by disasters. The mandate for the implementation of this right lies with the Department of Human Settlements to play a role during response and recovery phases wherein a damage inspection map and rehabilitation can be developed.

Holser (2018) and Montoya (2003) argue that GIS plays a significant role in all the planning phases of disaster management which are preparedness, mitigation and phases of disasters; however, the study focuses on the response and recovery phase.

In any emergency information becomes key, according to Zlatanova (2000); can be divided into two categorised referred to as static and dynamic. Static information is critical because it provides insight and reference to pre-disasters and will provide the current information of the incident at hand. ESRI White paper (2008) emphasises how GIS is integral in the recovery since it maps all the information on the damaged properties and also contributes to the assessment of critical infrastructure.

1.2. Key definitions

1.2.1 Geographic Information Systems

To understand the definition of GIS, one must first understand the meaning of Information Systems and how it incorporates a spatial perspective. According to Jensen and Jensen (2013), GIS can be used in different disciplines which may sometimes result in different definitions. However, the purpose GIS will always be the same across all disciplines. According to De Gruyter (2015) “GIS refers to a system where geographic information is stored in layers and integrated with geographic software programs so that spatial information can be created, stored, manipulated, analysed, and visualised (mapped).”
Valarich and Schneider (2010) define Information Systems as “a combination of hardware, software and telecommunication networks that people build and use to collect, create and distribute useful data in an organisational setup".

Dueker (1979) provides a much more detailed definition: “A geographic information system is a special case of information systems where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines, or areas. A Geographic Information System manipulates data about these points, lines, and areas to retrieve data for ad hoc queries and analyses”. Uhlenwinkel (2013) argues that without spatial thinking integrated into GIS, and there will be a lot of maps without meaning. Hence the integration is critical so that not only maps are produced and represent the geographical location but to answer geographical questions. Careem *et al*., (2007) define “a Geographic Information System (GIS) as a system for capturing, storing, analysing and managing data and associated attributes which are spatially referenced to the earth and can be used for planning and decision-making.

The last definition to cite is one suggested by Bolstad (2016): he refers to GIS as “a computer-based system to aid in the collection, maintenance, storage, analysis output and distribution of spatial data and information".

1.2.2 Spatial thinking

Bednarz and Bednarz (2008) define spatial thinking as “the knowledge, skills and habits of mind to use concepts of space (distance, direction distribution and association), tools of representation (maps, graphs, and diagrams), and processes of reasoning (cognitive strategies to facilitate problem-solving and decision-making) to structure problems, find answers and express solutions to these problems.”

1.2.3 Geospatial

According to Kruger and Wood, (2016), geospatial is “the field of study that describes the relationships of entities based upon proximity or the relative position of things on the Earth”.

1.2.4 Spatial data

Bolstad (2016) defines spatial data as the information about a physical object that can be represented by numerical values in a geographic coordinate system consisting of points, lines, polygons which can be used to provide location map.

Jensen and Jensen (2013) define spatial data as “any data or information that has spatial attributes with unique geographic coordinates or other spatial identifiers that allow the data to be located in a geographic space”.

1.2.5 Disaster

Disaster Management Act (2002) refers to a disaster as “a progressive or sudden, widespread or localised, natural or human-made occurrence which

a) Cause or threatens to cause;

b) Death, injury or disease;

c) Damage to property, infrastructure or the environment; or

d) Disruption of the life of a community, and

e) Is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their resources.

1.2.6 Disaster Management

Disaster Management Act 57 of (2002) defines disaster management as: "a continuous and integrated multi-sectoral, multi-disciplinary process of planning and implementation of measures aimed at: (a) preventing or reducing the risk of disasters; (b) mitigating the severity or consequences of disasters; (c) emergency preparedness; (d) a rapid and effective response to disasters, and (e) post-disaster recovery and rehabilitation"**.**

1.2.7 Disaster Response

Disaster response refers "to the provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected" (Disaster Management Act, 2002).

The United Nations Office for Disaster Risk Reduction defines disaster response as "the provisioning of emergency services and public assistance during or immediately after a disaster to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of those people affected".

1.2.8 Post Disaster Recovery

"Means efforts, including developments aimed at creating a situation where:

(a) Normality in conditions caused by the disaster is restored by the restoration, and improvement, where appropriate, of facilities, livelihood and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors;
(b) the effects of a disaster are mitigated; or
(c) circumstances are created that will reduce the risk of a similar disaster occurring.

1.3. Historical background

1.3.1 Geographic Information Systems

GIS has evolved over the years and got more enhanced by the presence of technology; according to (ESRI 1998) GIS has three historical stages namely; pioneering and development, GIS software commercialisation and user adoption. GIS started with just simple mapping to locate features, and later it grew to a decision-making tool. Using in 1854 United States was hit by a cholera outbreak, and John Snow used mapping paper to map all the outbreak locations which featured roads, water lines and property boundaries and this was regarded as the remarkable spatial analysis (ESRI 1998).

Dimensionality and the amount of data proved to be too much to be handled, then Tomlinson who introduced the GIS saw a need to explore data storage and processing devices, and that is when he introduced the first GIS project. Tomaszewski *et al*., (2015) state that in terms of literature GIS dates to 1960 and the accolade for the excellent work is owed to Roger Tomlinson, who introduced GIS in Canada. They also concur with the statement that there is always a spatial element when dealing with GIS which makes it more relevant to disaster response; hence for more than twenty years, academic papers began to be more common in GIS literature. GIS has been in existence for quite some time, mostly used in disciplines related to geography, and its importance in integrating disaster management came into recognition in the previous century as Abella (2002) infers.

Frederick (2014) cites that Ian McHarg was regarded as the Father of GIS because he introduced map overlays which made a meaningful impact in the GIS industry. Due to his love for the environment, he observed that the new developments made by civil engineering and other sectors were not environment friendly and generally unhealthy. In his interest to protect the environment, he introduced overlap maps to map out natural features like flood zones, wetlands, woody vegetation slopes, etc. and his work was recognised in 1968.

In the early 80s GIS grew to the next level wherein GIS software was introduced in the commercial world combining the first-generation approach; with the second-generation approach with interest focusing on the organisation of attribute data into a structured database. Abella (2002) further argues when it eventually got recognition for use to disaster management, the two main aspects that were identified were the integration and analysis capabilities of GIS.

Since disaster management is multidisciplinary by its nature, it makes it less challenging to integrate GIS with disaster management. According to Dempsey (2018), the importance of spatial analysis was manifested through Dr Snow, who establish the cause of the disease and determine the geographical location where the root causes were identified. In the 20th-century photozincography was introduced, which demonstrated how maps could be divided into various layers. With the advancement of technologies, computers came into being, and Dr Roger Tomlinson introduced GIS in Canada around 1960, which focused more on collecting, storing and analysing the geographical data.

Spatial thinking is appropriate in all the phases of a disaster management cycle depending on the intention or situation at that particular time. Berse *et al*., 2011 mentions three types of spatial thinking as identified by the National Research Council (NRC) namely, (1) awareness in space; (2) awareness about space, and (3) awareness with space. Spatial thinking can be contextualised into our daily routines by simply applying geography in our lives, physical and intellectual spaces. As indicated earlier, these may vary from circumstance to circumstance. For example, the cognition about space is perceived to be highly relevant to recovery, reconstruction and rehabilitation as these require information about the land that will be used for relocation or resettlement, the safety of the land (potential threats, etc.). Abella (2002 argues that it is an undisputed fact that natural disasters are spatially represented, and the spatial data can be more valuable if it is used in conjunction with GIS. He further argues that the value of GIS can also be more significant if the data is adequately surveyed and structured, and also take into cognisance the temporary nature of both natural disasters and the data itself.

1.3.2 Disaster Management

The history of Disaster Management goes back to ancient times. The way societies managed it varied from country to country. Communities have been managing it by exploring various ways to minimize the exposure to various types of disasters. Just like GIS, disaster management improved over the years. Moving from just being reactionary and shifted to an approach that is risk-reduction. Berse et al. argue that it is not disaster management if the phases are not aligned into a disaster realm; wherein response will look to mitigating the same disasters from causing an uncontrollable impact and put preparedness measures in place while recovering from a disaster.

1.3.3. GIS in disaster management

Dash (1997) argues that the importance of GIS in disaster management was first recognised in the early 90s when FEMA used it after the Hurricane Andrew disaster. GIS also assisted Florida in 1993 to analyse the oil spill to respond to oil spills. The system was used for damage assessment and also to determine levels of vulnerability in the area. Various countries manifested the tremendous role that GIS played during the recovery phase of the disaster management cycle, and this was manifested in Florida during the Oakland fire wherein GIS was used for damage assessment mapping the fire perimeter and geo-reference the location. Cova (1999). The well-known September 11, 2001 attack benefited from GIS as it proved to be invaluable during the initial rescue and relief operations (Cahan and Ball 2002). During Hurricane Katrina, GIS was used as a disaster management tool wherein the first responders on the ground shared a great deal of data about street plans, mainly which streets were and were not accessible and the extent of the flooding.

1.3.4. Status

In their review, Tomaszewski *et al*., (2015) of GIS for disaster response, discovered that there was limited and scant literature on the integration of spatial thinking and GIS applicable to disaster response. They further argued that if the distinction among these three aspects can be understood, the decision-makers and practitioners can be able to create a link between hazards and risks within the community.

1.4. Background and study area description

uGu is situated in the South Coast of KwaZulu-Natal province which has 11 districts including one metropolitan municipality. The neighbouring district municipalities are uMgungundlovu and Sisonke District Municipalities, eThekwini Metropolitan and the Indian Ocean. uGu contributes approximately **731 156** or 7 per cent of the total provincial population. Within the uGu district, Hibiscus is the most populated municipality with **265 131** inhabitants and thus contributing an estimated 36.3 per cent of the total population in the district (Stats SA 2014). The study will focus on the uGu district, which is comprised of four municipalities, namely, Ray Nkonyeni, Umdoni, Umziwabantu and Umzumbe; most of these municipalities are semi-rural.

uGu has a fully-fledged Disaster Management Centre (UDMC) to service local municipalities amply and have a more significant impact in the management of disasters in the district and is easily accessible. .

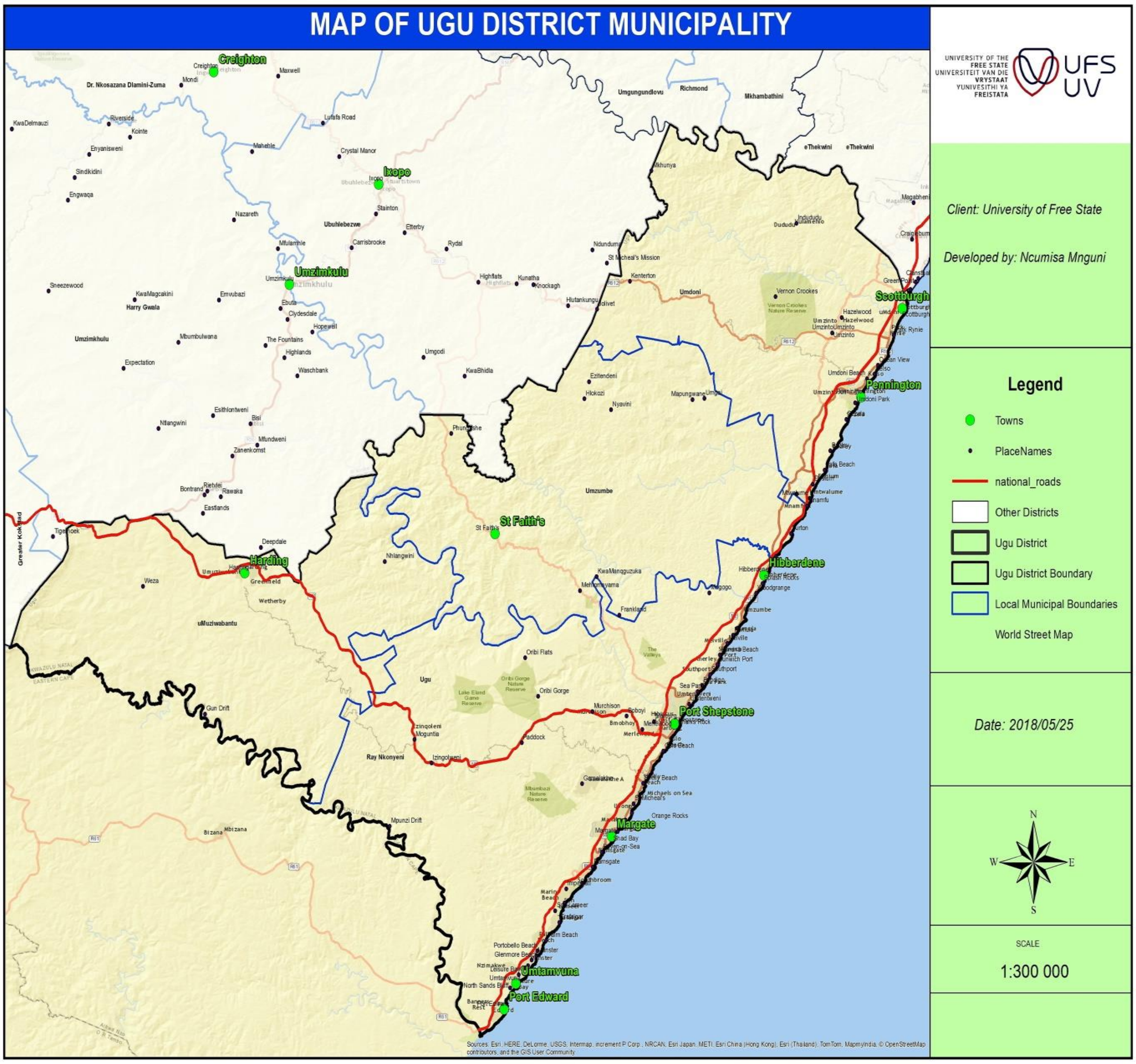

Figure: 1 uGu map

1.5. Problem discussion

Disasters are recurring incidents therefore exploring new systems to respond effectively is critical. With the availability of GIS technology the manner in which practitioners respond to disasters can be improved and become more effective. Hence the interest to establish whether GIS technologies are utilised when responding to disasters. Mansourian *et al*., (2006) argues that spatial information is important when responding to disasters which warrants integration of GIS into disaster management. In essence the availability of spatial information makes disaster response process effective which bring about the question of usage and accessible by the disaster management practitioners. The problem revolves around the availability of GIS services and whether the end -user is aware of such services as well as how such services are integrated into disaster response. (Rajabifard *et al*. 2014). It is common knowledge that timely, valid and accurate spatial information during disaster is paramount to successfully responding to an emergency wherein community members' lives are under threat or the houses they live in are inhabitable.

Disaster Management practitioners and academic researchers perceive GIS as a useful tool in the disaster management discipline. According to Tomaszewski (2015), GIS tools produce diversified maps that support spatial thinking. Response and recovery to disaster management have improved over the years due to the advancement in technologies. As those technologies gradually advance, some disciplines lack information or have limited access to such technologies which impedes urgent implementation of emergency programmes. According to Laituri and Kodrich (2008), there are various disciplines or critical role players in disaster management that are overlooked, which include GIS and this prohibits disaster management practitioners and other service delivery organisations from responding effectively. Each disaster incident brings about new lessons and triggers innovation, thinking on how to improve efficiency in disaster response. Understanding how best to utilise GIS emerges as one of the options to explore.

When responding to October 2020 disasters ought to have provided immediate relief in form of temporary shelter as stipulated in the housing code,(National Department of Human Settlements 2009). To deliver on the mandate, GIS can be used to determine existing departmental projects in the proximity of the disaster area so that possible duplications can be eliminated, like geotechnical assessments, and land use information as they are requirements when building a new structure. GIS for urban housing agrees that GIS becomes can be used to establish the spatial relationship among various amenities and to understand activities in a specific neighbourhood. Boccardo and Rinaudo (2011) concur to the fact that geomatics techniques have a role in the management of disasters, especially the provision of support and recovery in the aftermath – be it human-made or natural disasters. GIS is perceived as the efficiency tool in disaster response and recovery, and the study seeks to establish the extent to which GIS is utilised in disaster recovery and its significance thereof when integrated into disaster response. Spatial thinking is a skill that needs to be applied in the face of adversities for better reasoning to conceptualise space and create visualisation (Berse *et al*., 2011). According to the departmental line function, it is the responsibility of the department to provide temporary shelter for the disrupted families, and according to the disaster management phase, it falls under the response phase. With the use of GIS mapping to illustrate the extent of the damage as well as the vacant plots that can be used to erect temporary shelter, where applicable, was used (Abella, 2002). Generally, in the past year, the under-utilisation of spatial analysis using GIS for strategic reasons during disasters could be attributed to not available, inaccuracy and low quality of spatial data. Careem (2007). The question, therefore, is that if the GIS was used in response to the incident and if yes, for what purposes?

1.5.1. Research questions

- What role did the GIS unit play during disaster response?
- How is the departmental GIS unit involved in the development of disaster response and recovery plan?
- How were the proposed aftermath interventions implemented and was GIS used?
- What are the proposed solutions to improve the integration of spatial thinking into disaster response and recovery?

1.5.2. Research objective(s)

- To establish if GIS services are used during disaster response in the Department of Human Settlements.
- To determine if the Disaster Management Unit were used GIS services when responding to October 2017 storm disaster?
- To determine the impact that GIS has when responding to disasters.

1.6 Limitations of the study

The study will only focus on the Disaster Management Centre in uGu. The researcher will not conduct face-to face-interviews with the participants; however, they will be provided with questionnaires to complete, to avoid biased responses or discomfort from respondents since the researcher is working with the participants.

1.7 Research design and Methodology

The researcher will use methodology from an interpretivism philosophy which insinuates that in any community, there are social actors who interpret the current situation. The reaction is always goal-oriented (Saunders & Lewis, 2012). The methodological approach to gathering information the various perceptions will be both quantitative and qualitative approach (Gouldkuhl 2012).

1.7.1 Research strategy

This research will be conducted using a qualitative and exploratory design study targeting Disaster Management Practitioners, Project Managers and GIS specialists to establish the integration of GIS practices into disaster response and recovery. The Department of Human Settlements has different chief directorates. Hence, there will be separate questionnaires for each unit. The Project Management Chief Directorate deals with the implementation of projects at a regional level. The GIS unit is under the Planning Chief Directorate as a directorate serving all the chief directorates in need of GIS services. There is a separate unit named Emergency Housing, which coordinates the Emergency Housing programme for implementation by the project management unit.

The reason for choosing the qualitative approach is that it enables one to gather information which will be suitable for the investigation of the phenomena in an in-depth and holistic manner (Polit and Beck, 2008). Burns and Groves 2009; Hancock, Windridge and Ockleford (2009) point out that one of the exploratory studies is to increase the researcher's insight about the research question or interest since the respondents provide details answers to the questions. Perception and practical application of GIS are of primary interest in the study; hence, the choice of the exploratory survey so that narrative material can be collected.

1.8 Summary of the chapter

This chapter introduces the significance of Geographic Information Systems in response to a disaster and disaster recovery as well as how disaster management activities are executed in instances where GIS solutions have been applied. The researcher discussed the study area and motivated the decision. The problem is discussed as well and identified the research objectives and questions. The chapter includes justification to the study and the limitations thereof. Key concepts about disasters and GIS are also defined and discussed.

CHAPTER TWO

2.0. Literature review

This chapter intends to review the literature to understand disaster management, Geographic Information Systems (GIS) as well as spatial thinking and how these concepts can be integrated for effective disaster management response. The aspects above will be reviewed from a global and national perspective focusing on the historical background of GIS applications, theoretical and conceptual frameworks, as well as its successes and failures in the implementation of disaster management. The researcher will also study literature to determine how GIS has been used in various disciplines to respond to disasters. This chapter will also guide in structuring various chapters in the study. Burton (2000: 319) supports the review of literature for its ability to reveal what has been done before about the similar problem which provides an insight to the researcher as to what interventions or approaches other researchers previously used to address the identified problem. The classic examples of instances where interventions that provide spatial data or apply spatial data reduce the impact of the, will also be looked at and vice versa.

2.1. What is a disaster?

The International Federation of Red Cross (IFRC) 2019 defines a disaster as "a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its resources".

The World Health Organisation (WHO) defines disasters as "any occurrence that causes damage, ecological disruption, loss of human life, deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community area". Even though the definitions are different, but the element of the need for external assistance always comes up, hence the need to respond efficiently. Over the last few decades, there has been a drastic increase in magnitude and frequency of natural disasters; however, a significant improvement has been experienced since the consideration of technical capabilities to mitigate them.

2.2. Types of disasters

It is critical to highlight types of disasters because they are the source of disaster management. Van Westen (2002) cites different types of disasters and their distinction, which are natural disasters, human-made disasters and human-induced disasters.

Natural disasters are sudden unexpected events that cause environmental, financial and human loss. These events include avalanches, blizzards, drought, earthquakes, extreme heat or cold, hurricanes, landslides, tornadoes, volcano eruptions, and wildfires. These types mentioned above of disasters as vary in description with caused by natural phenomena, some caused by human activities in the environment and some aggravated by human influence. World Health Organisation classifies natural and human-made disasters into three categories as tabled below.

Natural disasters		**Human-made disasters**	
Classification type	**Examples**	**Classification type**	**Examples**
Meteorological	Floods, Hailstorm, Cyclone, Hurricane, Tsunami, etc.	Technological	Transport failure, Public place failure, fires
Topographical	Earthquakes, volcanic eruptions, landslides, Limnic eruptions, etc.	Industrial	Chemical spills, Radioactive spills
Environmental	Global warming, Solar flare, Ozonde depletion-UVB, El ninõ, etc.	Warfare	Civil unrest, war, terrorism, internal conflicts

Table.1: Types of disasters

2.3. Disaster response

Definitions of disaster response vary from country to country as in some countries disaster is referred to as an emergency; therefore, depending on a definition by particular emergency response and disaster response have a similar definition. Accordingly, the United States Department of Homeland Security (2013) defines disaster response as “capabilities necessary to save lives, protect property as well as the environment and meet basic human needs after an incident has occurred”.

The East African Community (2012) defines disaster response as “the provision of emergency services and public assistance during or immediately after a disaster; to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected”.

2.4. Disaster management?

In terms of the Disaster Management Act of 2002: “disaster management encompasses a continuous, integrated, multi-sectoral and multi-disciplinary process of planning and implementation measures are incorporating strategies for pre-disaster risk reduction as well as post-disaster recovery, aimed at preventing or reducing the risk of disasters, mitigating the severity or consequences of a disaster, emergency preparedness, rapid and effective response to disasters and post-disaster recovery and rehabilitation”. According to Modh (2015), disaster management advocates for integrated resource management and how the resources are utilised efficiently, commendably and impeccably during a disastrous event.

There has been lengthy deliberation about the use of disaster management versus disaster risk management, given the nature of activities involved in the disaster management, post-disaster incidents which advocate for disaster risk reduction during reconstruction (Bosher and Dainty, 2011). Since disaster risk management is the preferred term internationally, reference will be made to it while discussing disaster management.

Notwithstanding the efforts made over the years by organisations and governmental authorities to improve the management of natural disasters, there have been elements of severe deficiencies in the response and recovery phase Schryen and Werx (2012).

Disaster needs to be managed to reduce its impact; mitigate the risks and come up with effective mechanisms to efficiently respond to disasters when they happen. According to ESRI (2008), there are myriads of activities involved in disaster management applied at various stages of disaster management which are before, during and after the disasters as illustrated in figure2. As highlighted in the definition disaster management multi-disciplinary in its nature all government spheres, State-Owned entities, Non-Profit Organisation (NPO) are involved in disaster management all in the name of effective, efficient response and recovery from emergencies. An element of complexity surfaced as the years go by; hence additional discipline was introduced in the management of disaster, including GIS.

Figure 2: Disaster Management cycle. Source: Wisner (2004)

2.4.1 Historical background of Disasters and Disaster Management

Disasters have indubitably affected humans in an indescribable antagonistic manner. Fagan (1999) suggests that disaster knows no boundaries and refers to the Old Egyptian Empire, Norse, and Minoans, etc., which were expected to be destroyed by their enemies. Still, they got struck by floods, famines, earthquakes and tsunamis. In the eighth and ninth centuries, the Mayan empire in Mexico and Tang dynasty in China experienced drought, which led to starvation due to crop failure. All these incidents called for the authorities to explore various approaches to reduce the impact of these catastrophic events included earthquakes tsunamis, volcanic eruptions, etc.

Disaster	**Death toll**	**Year**
Antioch earthquake	250,000	526
Aleppo earthquake	230,000	1138
Shaanzi Earthquake	830,000	1556
Calcutta typhoon	300,000	1737
Caribbean Hurricane	22,000	1780
India cyclone	300,000	1839
Haiphong typhoon.	300,000	1881
Haiyuan earthquake.	73,000	1920
Tangshan earthquake	242,000	1976
Indian Ocean earthquake and tsunami.	227,898	2004
Haiti quake	300,000	2010

Table. 2: History of disaster incidents. Source: Live science.

2.4.2. What is disaster management?

Biblically disaster management has always been prevalent in ancient history; Waseda (2015) relates to Noah's Ark story wherein all the phases were manifested because Noah prepared for the event when the flood warning was received which means the element of preparedness was recognised and contingency measures were implemented to mitigate the impact on planet biodiversity.

The causes of natural disasters in South Africa can be attributed to: extreme weather changes, human activities like mining and global warming and the commonly occurring natural catastrophe are floods. Apart from floods in the historical record five decades ago South Africa recorded a devastating earthquake which took place at 10:04 pm on 29 September 1969 hitting the Boland farming towns of Tulbagh, Wolseley and Ceres.

On the 25th January 1981, what was seen as a blessing to Laingsburg farmers at first, turned out to be the worst natural disaster experienced by South Africa. Due to the bluish shale soil of the area which does not absorb much water, the rain was drained straight into the Buffalo River. A six meter high wall of water built up and ripped through Laingsburg, carrying away people, houses and the N1 road bridge. The Buffalo River that flows north-south through the town, burst its banks. The speed of fast running and swiftly rising water left people with no option but to seek refuge on the rooftops of their houses, until their house too was swept away by the flood (South African Weather Disaster Observation Services 2013).

In 1994 the Free State community near Merriespruit experienced a pollution disaster when a tailings dam failed when 600,000 cubic metres of toxic fluid from a nearby mine flowed 4 km into the town, covering parts up to 2.5 metres. Not only the environment was damaged, but 17 people lost their lives and 80 houses were destroyed (Church, 2015).

South Africa experienced drought more than once in its history – a disaster which was a combination of severe drought and an intense El Niño event, hit South Africa in 2015-16 lasting for several months, with similar characteristics as the 1992-95 drought (Baudoin *et al*., 2017).

A huge south Atlantic storm struck the southern coast of South Africa on 7 June 2017 with wind speeds as high as 120 km/h. Wave heights of 9–12 metres were recorded between Cape Columbine and Cape Agulhas. The storm directly caused eight deaths and damaged 135 schools across the Western Cape. Floods inundated around 800 homes across the city of Cape Town due to the storm.

2.4.3. Disaster Management in a global context

Disaster management is a global phenomenon – most countries have had their experience of disaster incidents, especially the developing countries. Realising the upsurge in disaster incidents strategies to manage various types of disasters were developed to reduce the impact of disasters. According to ADCP (2000), it is an indisputable fact that development contributes towards disaster incidents, in contrary if used as a control tool, disaster risk can be reduced during the development periods which can be associated with the concept of “building back better”.

Since disasters are predominantly natural, most would have been victims of disaster incidents which resulted in numerous disaster management approaches. Even though these approaches were explored and implemented for decades, there were still some gaps identified which varied from disaster to disaster. Different frameworks that were developed include the Sendai frameworks became prominent and is regarded as the guiding framework globally, whereby all the subscribing countries should report on the progress as well as challenges encountered while implementing the plans.

2.4.4. Disaster Management in Africa

According to EM-DAT International Disaster Database, several disasters took their toll on the African continent as illustrated below, ranked according to the largest number of people killed.

Country	Disaster	Date	Killed
Ethiopia	Drought	1983	300,000
Sudan	Drought	1983	150,000
Mozambique	Drought	1981	100,000
Ethiopia	Epidemic	1988	7,385
Nigeria	Epidemic	1991	7,289
Nigeria	Epidemic	1996	4,346
Burkina Faso	Epidemic	1996	4,071
Niger	Epidemic	1995	3,022
Sudan	Epidemic	1988	2,770
Algeria	Earthquake*	1980	2,633

Table.3: History of African disasters: Source: SADC (2012)

Climate change is expected to increase hydro-meteorological hazards in the region further. The temperatures in southern Africa are expected to warm by between 1.0 °C and 3.0 °C by 2080 (SADC 2012). As a result of warmer temperatures, diseases such as malaria are likely to spread to places where it was not previously endemic, and increased heat stress to natural ecosystems and crops are likely to impact negatively on the productivity of rangeland, grazing and food production (SADC 2012). Similarly, since 1950, southern Africa has witnessed a downward trend in rainfall and an increase in cyclone activity in the southwestern Indian Ocean region (SADC 2012). According to the International Council for Science (ICSU) (2007), about 59% of the disasters experienced between 1997 and 2007 in southern Africa were related to hydro-meteorological hazards, mostly floods, cyclones and droughts. Four major droughts have struck the southern African region in recent decades.

The worst floods struck in 2000, which affected eight countries in southern Africa. More than 700 lives were lost in Mozambique alone, with a material loss estimated at $500 million (ICSU 2007). When the floods occurred, barely any of the affected countries had contingency plans. By the end of 2011, all countries in southern Africa had at least some form of a contingency plan for identified priority hazards, ranging from flood contingency plans to cholera contingency plans.

The Seismic risk could be another justification for contingency planning in southern Africa, particularly for countries along the Rift Valley, stretching from Eritrea through Malawi to Mozambique. Along the Rift Valley and on Indian Ocean islands, several volcanoes are known to be active, including Mount Nyiragongo in the Democratic Republic of the Congo and Mount Karthala on the island of Comoros.

These hazards, combined with vulnerabilities, have the potential to cause disasters (Blaikie *et al.*, 1994). Major vulnerabilities include food insecurity, HIV and AIDS, population growth, urbanisation, land degradation, inequalities about gender, education, health and wealth and poor governance (SADC 2012).

2.5. Disaster Management in the South African context

According to the United Nations Development Programme (2012), southern Africa is prone to a variety of natural hazards and related disasters such as drought, floods, cyclones, fires, earthquakes, landslides, livestock diseases, pest infestations and epidemics, which reinforce the need for contingency planning.

Countries in the SADC region are known to be vulnerable to an array of natural disasters and these countries shared a common interest to manage disaster risk; as the events tend to coincide, this called for a collaborative effort among SADC countries. The frequency, magnitude and impact of drought and flood events in Southern Africa date back to 2000.

The Republic of South Africa occupies the southernmost part of the African continent stretching from the Limpopo River in the north to Cape Agulhas in the south. Covering an area of 1,219,090 km², the country shares borders with Namibia, Botswana and Zimbabwe in the north and with Swaziland and Mozambique in the northeast. It also surrounds the Kingdom of Lesotho. To the west, south and east, South Africa borders the Atlantic and southern Indian oceans. The country's coastline covers some 2,968 km. Lying 1,920 km southeast of Cape Town in the Atlantic Ocean are the isolated Prince Edward and Marion islands, which were annexed by South Africa in 1947.

In terms of legislated management of disasters (Vermaak and van Niekerk, 2004) suggest that within the African continent South Africa was the first country to legislate disaster (risk) management effectively. The initiative was impelled by severe flooding that occurred in the Western Cape Province between 1998 and 1999. Before the legislation, there were policy-making processes which started in June 1994 (Vermaak and van Niekerk, 2004). The White Paper on Disaster Management was issued in 1999 by the Ministry of Provincial Affairs and Constitution Development.

The Department of Cooperative Governance and Traditional Affairs (COGTA) is entrusted with the responsibility of managing disasters nationwide guided by the Disaster Management Act (DMA), 2002 which was promulgated in 2003. The DMA seeks to address the delays in disaster response and cutting red tape to ensure that disasters are dealt with efficiently and effectively. The DMA stipulates that a National Disaster Management Centre (NDMC) should be established with reference to section 8 of the Disaster Management Act (2002) which will spearhead the implementation of the Act, supported by Advisory Forums formed in each province. According to section 16 of the DMA the NDMC centre should play an advisory and consultative role in disaster management issues including capacity building as well as education and training.

The NDMC works in accordance with the national disaster management framework. The framework is regarded as a legal instrument as specified by the Act which seeks to advocate for an integrated and consistent approach in implementing disaster management across the country by providing a coherent, transparent and inclusive policy on disaster management as stipulated in Section 7(1) of the DMA. There are three spheres of government in South Africa, namely: national, provincial and local spheres which are all expected to interpret and implement the Act in their respective jurisdictions.

South Africa experienced a series of disasters in the past decade, including huge floods which left Limpopo and Mpumalanga, as well as neighbouring countries in a dire condition. In 2004 alone there were 376 disasters reported in Cape Town, ranging from oil spillage, fires, floods and a drought disaster which was attributed to global warming. The implementation of the legislative framework is lack; however, that is a different subject and not for discussion in this research.

2.6. What is GIS?

Beyond definition, it is crucial to understand what exactly does GIS entail, the definition is a summary of what GIS does; hence a snippet of the distinction of GIS-related terms that are slightly different, will be provided. Estoque (2010) suggests that a difference be made between Geographic Information Science and Geographic Information System – they are both referred to as GIS, but they serve different purposes. Geographic Information Science refers to "the science concerned with the systematic and automatic processing of spatial data and information with the help of computers, and it is the theory behind how to solve spatial problems with computers" (Estoque, 2010). He further unpacks the Geographic Information Systems as "a system that is designed for storing, analysing, and displaying spatial data using hardware, software, data, people, and methods as illustrated below.

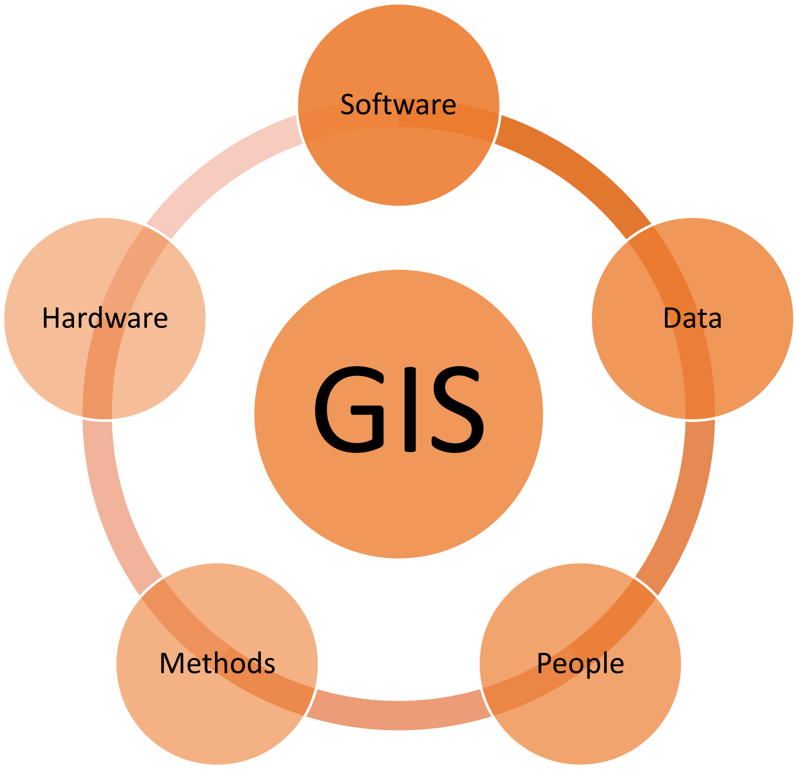

Figure 3: GIS cycle. Source: Jensen (2013)

To understand GIS, the key elements that make the operating system need to be acknowledged. Buckley (1997); Jensen and Jensen (2013) identify the five key elements or components of GIS. The first (1) Hardware, which is the computer, servers, networks, printers, plotters, etc. with which GIS operates, (2) Software in line with the definition that software plays a pivotal role in storing, analysing and displaying geographical data. Jensen and Jensen (2013) suggest that software will not be complete without the following components: Database Management System (DBMS), tools for input; tools for data query and Graphical User Interface (GUI). (3) Data, having understood these components one can establish that there would be no GIS without hardware because the software is used in the computer and the data cannot be manipulated without the software, which brings to the most integral part of GIS, which is data. Buckley (1999) says that (3) data can be presented either in a tabular or spatial format. (4) Users that include people who are using the system to analyse the data as the recipients of the end product. Lastly, (5) methods or procedures: this is a process whereby the stipulated rules for implementation are followed, and these rules may vary from organisation to organisation, depending on the sector.

2.6.1. History of GIS

Brovelli (2010), in his notes, relates GIS to the base maps which were used around 1587. From 1596 to 1665 Pierre de Fermat and Rene Descartes established the relationship between graphed lines and equations using the coordinate systems, mathematics and geometry. Overlays, also known as geographic analysis, were instrumental during the American Revolution wherein were hinged to illustrate the movement of the troops. Mid-19th century, various maps were used for various reasons to provide solutions to epidemiological, statistical challenges which included choropleth, dot maps and pictogram.

According to Jensen and Jensen (2013) computer science was introduced subsequently followed by the introduction of GIS by the University of Washington; their Department of Geography between 1958-61 was interested in the statistical methods, rudimentary computer programming and computer cartography. Their system has four key elements; Nystuen, Tobler, Binge and Berry’s geographical matrix, which were more on distance, orientation, connectivity, points, lines areas and projections.

Roger Tomlinson, due to his love for land management, also hosted Canada Geographic Information Systems (CGIS) intending to collect data and analyse data for Canada Land Inventory for the development of plans.

In 1964 the Harvard Laboratory for Computer Graphics by Howard Fischer became the GIS development hub. Fischer developed Synagraphic Mapping System (SYMAP) which was a mapping package which was upgraded to CALIFORM in the late 1960s. SYMVU was also developed in the late 1960s, which was a first 3D printout of an SYMAP. Then GRID came into the GIS world using raster cells to display spatial data to allow multiple input layers.

In 1969 GIS began to gain commercial momentum as people used it for marketing the business as well as for development purpose. Before the construction, the developers would first locate social amenities to establish if that development would have a return on investment ESRI (2008). A drastic evolution in GIS was noticeable in the 1980s because it changed the ball game whereby software packages were extended to provide end-users with the flexibility to sort, reclassify and re-project the data contextualised in their analysis. Software packages like ARC-Info, GIS-GRASS, MapInfo, IJGIS, SPANS, and IDRISI, etc. were introduced. Mid 1980s satellites became Operational introducing SPOT which was an Earth Observation System, followed by Remote Satellite Sensing launched in various countries like India and Japan, some with Enhanced Thematic Mapping.

2.6.2. Why is it important to integrate GIS into disaster response?

The trail of GIS in disaster response dates back to 1992 when GIS became commercial, and most private companies developed GIS software.

Disaster incidents in various countries show that GIS is vital in disaster response. De Gruyter (2015) refer to what is known as “nascent literature body” which was established to compile instances wherein GIS was used for disaster response either in science or real application. Disaster response phase has become very common across all sectors due to physical, economic, psychological and social impacts post-disasters and thus demands a multi-sectoral approach from different departments. Frequent occurrences of disasters, be it human-made or natural, has immensely contributed to the prominence GIS amongst disaster management practitioners (Hodgson *et al*., 2014). It is common knowledge that during disaster incidents there are bound to be elements of danger and applying geographic context assist the response team in determining safety problems, set priorities, build consensus, allocate resources, and measure progress. De Gruyter (2015) supports the statement above as he confirms the power of GIS that has been displayed during disaster response through map-making and spatial analysis. Risk assessments and damaged assessments can only be conducted using building maps as a means to understanding potential impacts Stimson (2011). One of the pros of location-based analytics is that it can be interpreted into meaningful information, for example, as a predictive modelling tool to determine smoke drift helps keep communities safe (Russ Johnson, 2016).

Many exercises are executed during the disaster relief phase. GIS plays an extremely pivotal role in searching and rescue operations by using a Global Positioning System to establish which areas have been too devastated and where it is difficult to find one's bearings. With utilisation, the disaster practitioners organize the information for damaged assets, post-disaster census information as well as for the evaluation of sites for reconstruction effectively and efficiently. It is an undisputed fact that the effects of disasters can be detrimental, and the integration of GIS in response to disasters can play a valuable role in providing spatial data to emergency management response units. Its value is manifested when it is used as a tool to address disaster management processes wherein managers and first responders are provided with concise information through response and rehabilitation processes.

With agencies various organisation now using GIS, the emergency response has been made easy because the response professionals can overlay spatial data for roads, population and land and convert it into a map to depict the actual damage on the ground. In an emergency situation, instant information becomes valuable in order for the principals to make informed decisions. The very same information can be used for short- and long-term solutions to bring back the impacted areas to restore some normalcy. Johnson (200) supports the above statement that GIS data is vital in identifying areas that will require instant repairs and to determine the extent and gravity of a disaster. He further suggests that the same information can be used for rehabilitation by eliminating threats from high-risk areas identified on the map to mitigate the potential reoccurrence.

On the other hand, the disaster information is illustrated as a GIS distribution layer that enables the decision-makers to understand the disaster distribution at a glance and make an appropriate emergency response. The digitization function of GIS can determine the location of a disaster, and the disaster information can be inputted or re-edited via the GUI tools of the DSSER (Hsu & Lin 2005).

GIS has proven to supports the response mission in various ways as listed below by:

- “Provide warnings and notifications to the public of pending, existing, or unfolding emergencies based on the location or areas to be impacted by the incident.
- Areas in harm's way can be identified on the map, and mass notification can be performed from a GIS.
- Determine appropriate shelter activations based on the incident location and optimum routing for affected populations to access proper shelters.
- Maintain shelter location continuity of operations: supply inventories, external power requirements, shelter population capacities, etc.

- Identify the locations and capabilities of existing and mutual aid public safety resources.
- Provide facilities for the assembly of department heads to collaborate, make decisions, and develop priorities.
- Provide the capability to create remote connections to the command centre for officials and others who need to participate but are unable to come to the command centre.
- Establish the capability to collect and share information among department heads for emergency decision-making to support emergency operations and sustain government operations.
- Support incident management operations and personnel, provide required resources and exchange internal and external information.
- Prepare maps, briefs, and status reports for the executive leadership (elected officials) of the jurisdiction".

Even during the recovery phase, when the government and communities strive to restore the affected area to its original state, GIS becomes integral as it can be used. In some countries, it is used to access central information repository for assessment of damage and losses that provides a full picture of the extent of the damage and geo-referencing can be made for the professional assessors or inspectors to code parcels with the degree of damage in order to visualize specific problems as well as area trends. The aforementioned exercises can be done using GIS on mobile devices which have proven to be useful in ensuring that the damage assessment is fast-tracked; problems and photographs and damage reports linked to the specific geographic sites Cova (1999).

In 2006 the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) was launched with the aim to provide solutions to access challenges encountered by the developing countries when it comes to disaster management. The remote sensing for earth observation, satellite-based telecommunication and global navigation satellite systems were regarded as beneficial tools in disaster management as well as emergency response. The primary mandate of the UN-SPIDER was to avail space-based information in all phases of the disaster management that will enhance disaster response operations through knowledge sharing and the strengthening of institutions in the use of space technologies (UN-SPIDER, 2013). The benefits of the satellite became evident in Iran and Pakistan when they were affected by floods and droughts as they were able to determine which roads were still accessible and households that were affected.

2.6.3. What is spatial thinking?

The National Research Council (2006) describes spatial thinking as “one form of thinking, is a collection of cognitive skills which consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise operate on this knowledge”. Further to that anyone in a spatial environment needs to understand the three conceptual elements of spatial thinking which are: space, tools of representation and processes of reasoning. The above-stated description shed light in the inter-relationship between spatial thinking and GIS; in essence, GIS is the technology to support spatial thinking. De Gruyter (2015) sees spatial thinking as one of the vital skills that can be utilised to structure, reason and make a judgement for problem-solving and can be best advantageous when combined with GIS tools.

According to Berse *et al*., (2011) in disaster response, spatial thinking becomes fundamental because it can assist in establishing evacuation routes, the extent of damage in the infrastructure as well as in conceptualising the spatial relationship between physical, cyber and natural environments. Spatial thinking has been depicted in various disciplines, including public health, natural disasters, humanmade disasters, etc.; irrespective of the discipline, the main objective remains the same to know where is what? As well as to establish the link between the two.

Taking the classical case of mapping arsenic in Bangladesh where the community of Araihazar Upazilla was concerned about the increasing problem of arsenicosis from the groundwater pumped from wells. A spatial pattern of variability was depicted using the available support system, Global Position System and satellite images which eventually enabled the Health Practitioners to link the high level of arsenic in some areas and gave causal explanations. Through representation within the spatial context and reasoning process the problem of arsenicosis was solved (see figure 4 below) as villagers were advised to drill deeper when installing wells to avoid arsenic contamination National Research Council (2006).

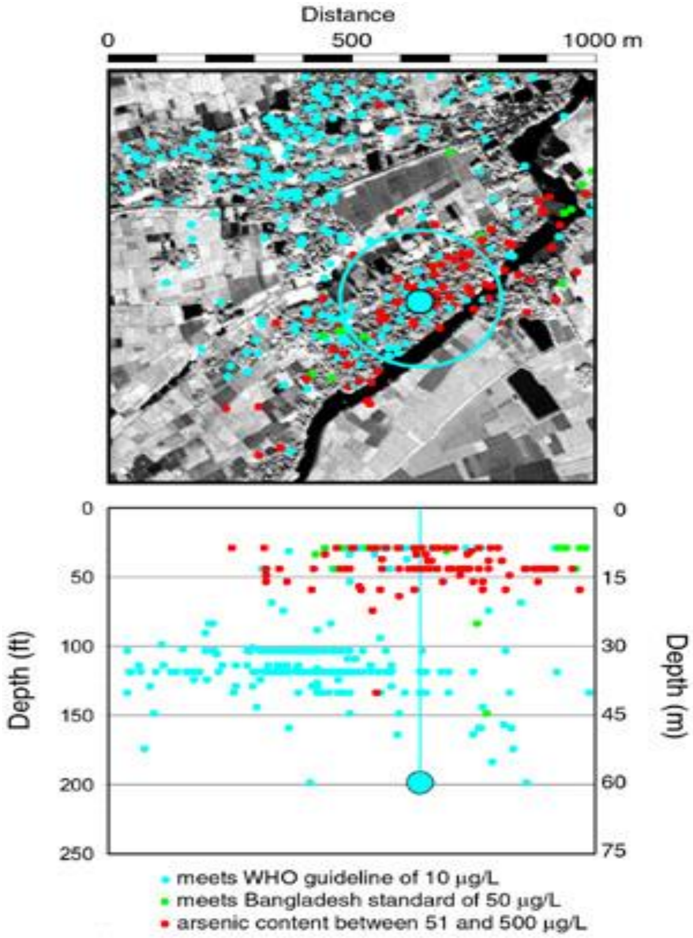

Figure 4: The upper panel based on an IKONOS satellite image of the village and surrounding rice fields shows the location and arsenic content of individual wells. Satellite image by: spaceimaging.com

Hurricane Katrina

Berse *et al*., (2011) make reference to the 2005 London bomb and Hurricane Katrina in 2016, stating how beneficiary it would have been if spatial information was effectively used during the incidents. The extent of the impact could not have been that severe if the current spatial information was used; hence Berse et al. advocate for informal education in local government for disaster practitioners to respond promptly into disasters.

2.6.4 Interrelation between spatial thinking, GIS and Disaster Management.

Over the years, various systems were integrated with disaster management to improve the implementation of disaster management. One of these systems was GIS. According to (Stoimenov *et al*., 2007) the aspects above cannot be used in isolation; therefore, for disaster management to be efficient spatial planning must also be included.

During an emergency, GIS instantly provide relevant data to emergency practitioners, in most instances the spatial and non-spatial data is usually geographically dispersed and stored in heterogeneous databases, but information systems like GIS come in handy as it can solve semantic heterogeneity (Stoimenov *et al*., 2007).

2.7 Conceptual models

Over time disaster management evolved, and the subsystem became more and more complex. Hence Kelly (1998) came up with four various models suitable for disaster management. Chosen theoretical models and the intention behind its development will be discussed as well as the pros and cons. Detailed analysis and critique of each model will be provided to its relevance to the study. The study will look at how disaster management models and GIS models can blend in together during disastrous situations and the contribution they add in expediting the response process. Pore (2013) argues that the element of spatiality cannot be taken away from disasters as they are spatial. GIS techniques can enhance decision-making as it allows for the analysis of different GIS layers which can ultimately play a vital role in tackling disastrous conditions. Stoimenov *et al*., 2007 argues that GIS can be used to meet the objectives of disaster management which advocate for the protection of lives, environment and property. The objectives can be better understood when demonstrated using the phases of disaster, as illustrated in figure 5 below.

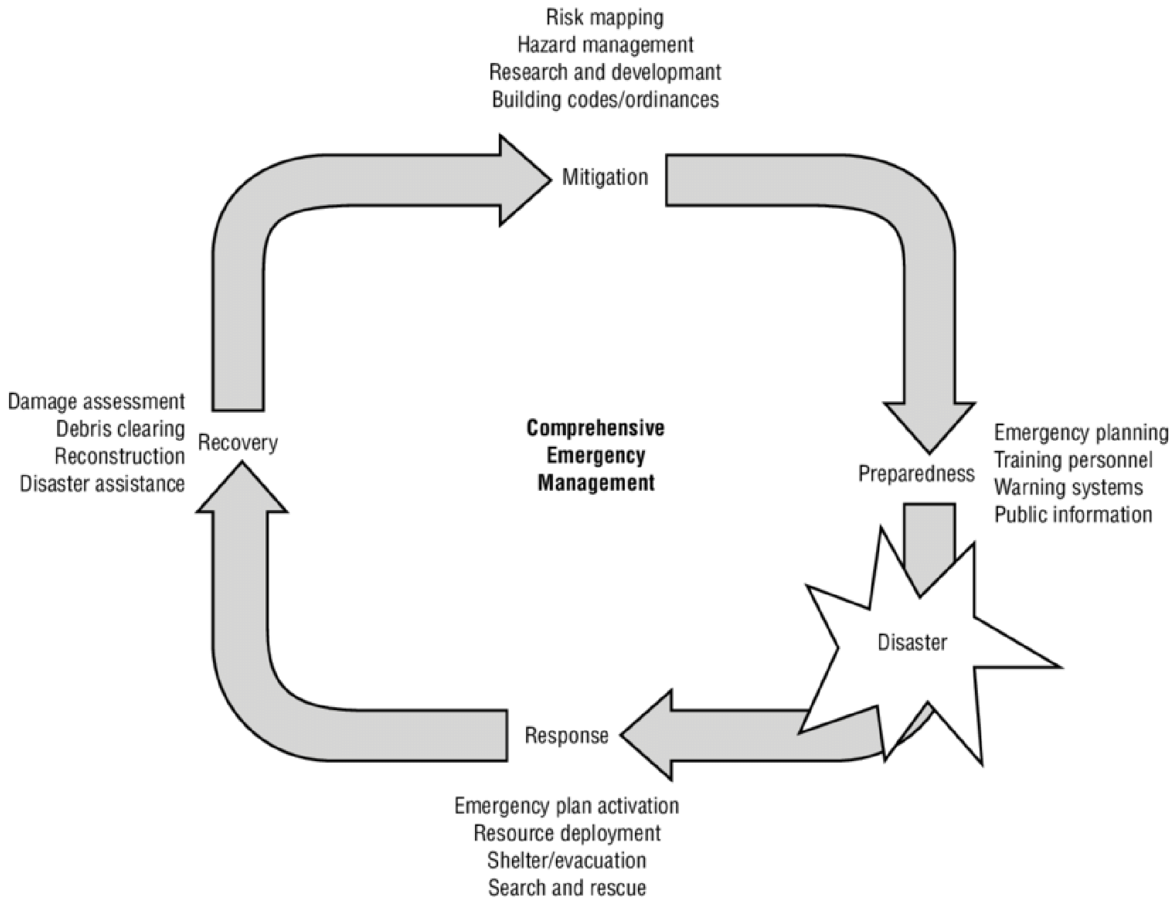

Figure 5: Disaster incidents phases: Source: World Health Organisation (2000)

Logical models	Integrated models	Cause models	Combinatorial models	Other models
• Traditional model • Circular model of disaster • Lechat model • Mitroff and Pearson Model • Gupta model • Mitroff model • Two-part model • Iceberg Model • Contreras Model	• Manitoba model • McConkey model • Weichselgartner model • Moe and Pathranarakul model • McEntire et al. model • Onion model • PDCA model • Integrated system- oriented model • Monitoring and evaluating model of disaster risk management	• Crunch cause model • Pressure and release (PAR) model • Fink's comprehensive audit model • Littlejohn six-stage model	• Risk management proactive model • Disaster risk Mangement Framework model • Wheel-shape model • Cuny model • Saldana-Zorrilla model • Institutional model for collaborative disaster risk management	• Ibrahim et al. model • González, Herrero and Pratt model

Figure 6: Disaster models: Source: Wisner (2004)

2.7.1.1 Logical models

According to Asghar *et al*., logical models define the disaster stages focusing on the basic events and actions that culminate in a disaster. He further categorises logical models into sub-categories: Traditional model, Expand and contract model, Kimberly model Tuscaloosa model and Circular model.

2.7.1.1.1. Traditional model

For decades, disaster management practitioners regarded a traditional approach as the best approach to disaster management, which was implemented from the premise of phased sequences of action or a continuum commonly as a cycle. Albtoush *et al*., (2011) describe the traditional model as a phased approached which covers pre-disaster risk-reduction and post-disaster recovery phase. This model subscribes to the humanitarian aid principle which advocates for immediate relief post-disaster, which include dispatch of a rescue team, provision of material and medical services. According to ADPC 2000, this model is relief-oriented, focusing more on what services have been offered in relief of the affected families and how such services have been provided using economic standards as a measurement tool. Relief is approached from the quantity perspective, what is regarded as a deliverable in this model in quantity more than quality. For example, the management would be more interested in the number of people that have been assisted post-disaster not the quality of services rendered.

Irrespective of the magnitude of the disaster the traditional model addresses the element of relief from the current situation. According to Nojovan *et al*., (2018) the impact of the traditional approach is short-term as the provision of relief focuses on rescuing the current situation without addressing the future. Another characteristic of the traditional approach identified by Albtoush *et al*., (2011) is the pyramidal management whereby the participatory management is not evident and in most cases results in centralised decision-making. Dube (2018) views the traditional model as a model that is more aligned to disaster continuum as it manages disaster according to the phases of disaster phases.

2.7.1.1.2 Expand and contract model.

This model promotes the involvement of communities in the management of disasters and depicts how disaster response can be managed concurrently as opposed to the sequential approach proposed by the traditional model (ADCP, 2000). The relative weighting of the actions (contracting and expanding as needed) will also vary depending on the relationship between the hazardous event and the vulnerability of the community involved. In this model, the expansion and contract are evident in different phases of a disaster. ADCP (2000) refers to it as a strand. The demand in both strands expands and contracts when one phase has passed. A classic example is when the disaster strikes, the expansion becomes evident as the demand is on relief and response from disaster management practitioners; once the response has been provided with the strand contracts and the expansion moves to the reconstruction and rehabilitation.

2.7.1.1.3. Kimberly model.

The application of a model varies from incident to incident and goes further to what has been experienced. Kimberly (2003) conceptualised this model to address complex challenges encountered while managing disasters which condenses to the four phases of mitigation, preparation, response and recovery. Albtoush *et al*. (2011) perceive this model as a level oriented model as it places the phases of disaster management at a top or bottom level depending on the nature of activities. In terms of levels, the post-disaster activities which are in the recovery stage are placed at the top as they take longer with visible outputs. According to Kimberly (2003), preparedness and the mitigation phase occupy the bottom level as they are at the initial stage influencing response and recovery phases.

2.7.1.1.4. Tuscaloosa model

The Tuscaloosa model is applicable or rather evident during the mitigation stage, which is part of the preparedness stage as well as the end of the cycle during the response stage. Assad (2019) believes that for this model to be used, managers who can predefine disaster in advance have to be considered to make appropriate and informed decisions.

2.7.1.1.5. Circular model

Richard Kelly developed this model on the premise of complexity reduction as well as to handle the nonlinear nature of disaster events and broke it down into eight phases as illustrated in figure 7 below Kelly (1999). The main advantage of this model is the ability to learn from the actual disaster. Albtoush (2011) is most effective when a comprehensive database of disaster is developed with well-trained personnel to handle this information. He further suggests an advanced technological infrastructure to gain optimum results.

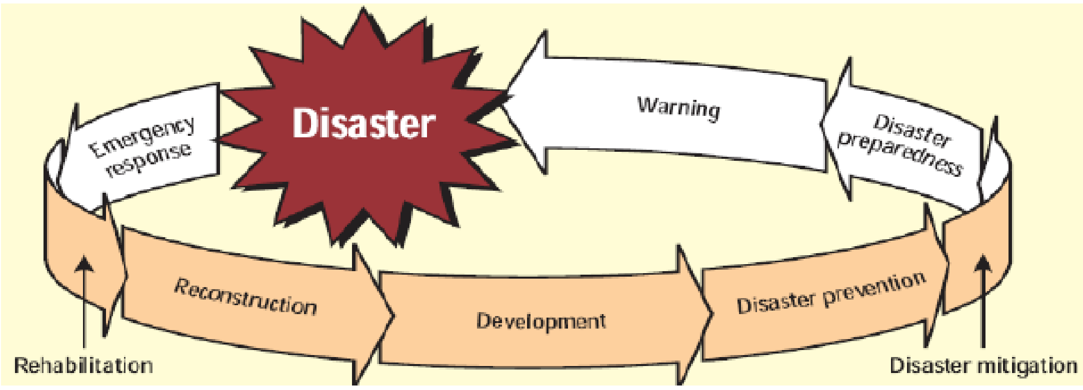

Figure 7: Disaster Circular model. Source: ADCP (2000)

2.7.1.2. Integrated models

These models take us back to the definition of disaster management, which advocates for an integrated approach, giving a broader implementation approach in integrating related disaster activities. Therefore, this model depicts how various activities in disaster management are interlinked in as much as they are independent in an application. With this model, the most focus areas are hazard assessment, risk management, mitigation, preparedness as well as monitoring and evaluation. The successful management of a disaster implies not to lose sight of the abovementioned elements that are interlinked (Asghar *et al.* 2006). If the sequence is not followed, disasters cannot be managed successfully; for example, one cannot manage the risk if the risk assessment has not been conducted. The assessment reports inform what risks there are, and those can be managed accordingly. Imagine a situation whereby the community is vulnerable to floods, and the risk management plan is for earthquakes – all the efforts towards mitigating the risk will be all in vain. The beneficial aspect of this model is that there is room for relaxation of processes to accommodate specific needs of disasters. These models have two sub-categories which are Manitoba and Welchselgartner models.

2.7.1.2.1. Cause models

The model is self-explanatory and seeks to address the cause of the disaster. It is better understood when applying the crunch and release model which are looking at the progression of vulnerability and the pressure and release model focusing on preventative and mitigation solutions. Even though the research is not about the application of models, the practical example will be made to display how the model could have been applied. To provide the applicability of this model in the case of the researcher to manage disasters in uGu, the research was going to establish the cause which exposed the community's vulnerability to storms (crunch model). In terms of pressure and release model, one would have looked at the existing pressure and how those pressures can be released to reduce the risk (pressure and release model). This means that when responding to the disaster, the point of departure would be to establish the cause and then when reconstructing, the identified caused will be addressed.

2.7.1.2.2. Crunch model

ADPC (2000) suggests a vibrant description of the crunch model as “a framework for understanding and explaining the causes of the disaster and adopts a cause-effect perspective. It is a pressure model. Vulnerability (pressure) is seen as rooted in socio-economic and political processes”. The Crunch model focuses more on vulnerability, looking at the underlying factors that expose communities to vulnerability. It suggests that “a disaster happens only when a hazard affects vulnerable people” Cannon (2004). According to ADCP (2000), this model demonstrates the progression of vulnerability to pinpoint underlying causes of vulnerability, focusing on dynamic pressure and unsafe conditions. Marcus 2005 believes that socio-economic and political pressures are the sources of vulnerability, especially in poor communities. He further unpacks the vulnerability progression process from underlying factors which are mostly dynamic pressure within a particular community that leads to unsafe conditions, exposing such communities to disaster risks as illustrated in the figure below. Figure 8 below depicts hazards and vulnerability which are linked, as a hazard is more impactful to vulnerable people resulting in a disaster only when triggered by the event. He further suggests that the most vulnerable community is the community that is pressurised by age-related discrimination, exclusion or exploitation based on gender, ethnic or religious factors Azizpour *et al*., (2015).

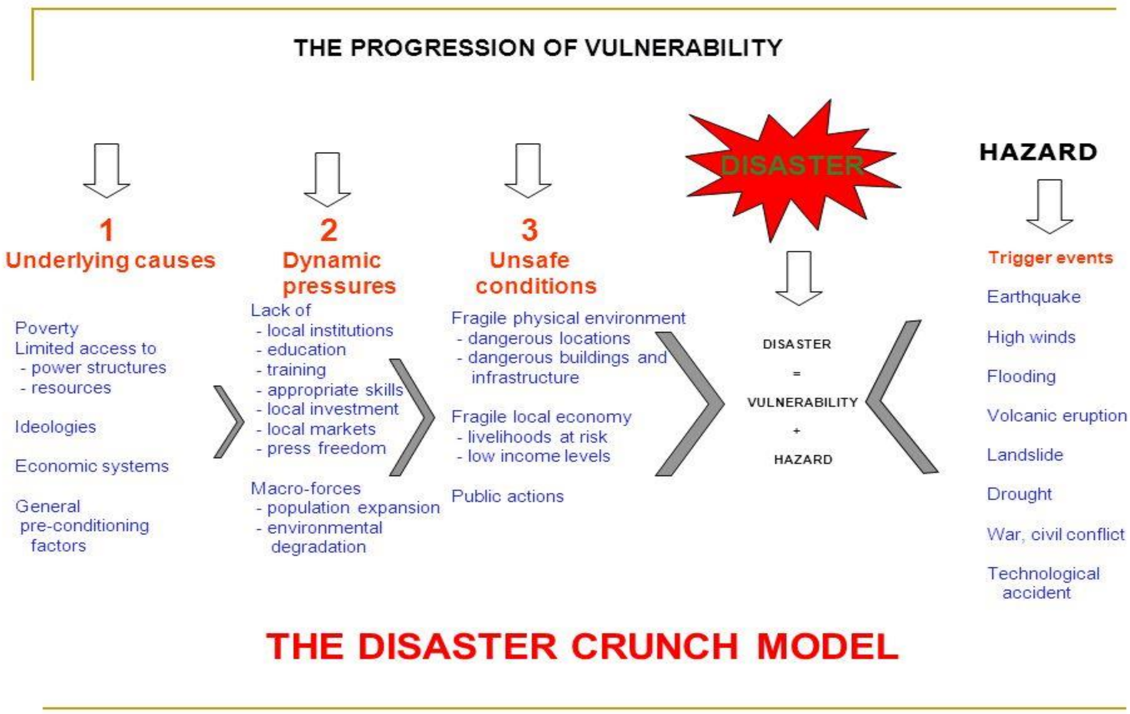

Figure 8: Crunch model. Source: Wisner, 2004,

2.7.1.2.3 Pressure and Release model

In the cause category PAR is one of the common models advocating for disaster risk reduction. Cannon et al. (2004) refer to this model as a reverse model as it intends to address challenges identified in the crunch model, for example, it responds to underlying factors through the provision of services. The focus is more on how to prepare communities for disaster and mitigate the risks thereof to secure safer conditions. Cannon et al. (2004) refer to it as a “progression of safety”. The critical part of this model is the risk reduction part which forms part of the preparedness and mitigation phases.

Risk cannot be managed without executing the following activities: risk identification, risk reduction and risk transfer. Different circumstances inform risk management – it is important to understand the area before engaging in risk management, and according to ADPC (2000), it cannot be uniform as countries are prone to different hazards.

2.7.2 GIS models

In a Geographical Information System, context modelling is defined as “an occurring operation of the GIS attempt to emulate processes in the real world, at one point in time or over an extended period” (Goodchild, 2009). He further highlights a data model allows the user to create a representation of how the world looks. A combination of GIS layers representing one or more aspects of the real world and transforms them to create a new picture. It is also important to highlight that models can be static or dynamic.

According to Goodchild, when a model is static models “takes the form of indicators, combining various inputs to create a useful output". The classic example of this model in the context of housing will be soil classification data combined with layers of mapped information about slope, used to indicate the soil to determine the type of foundation required for a house. Dynamic models are often utilised determining the impact of weather and human behaviour to predict forest degradation.

2.7.2.1 Data models

Tasha and Shelly (2006) define data models as **“**set of rules or constructs used to describe and represent aspects of the real world in a computer available in two primary data models namely: raster data and vector data models”. Tasha and Shelly (2006) define the raster data model as “a conceptual model used in GIS for representing real-world entities or phenomena”. According to Tomlin (1990), the raster data model can be described as the model consisting of rows and columns of equally sized pixels interconnected to form a planar surface which is used as building blocks for creating points, lines, areas, networks, and surfaces”. He further provides the origin of the word which originates from the German word for a screen, which implies a series of orthogonally oriented parallel lines typically used to record, analyse and visualize data with a continuous nature such as elevation, temperature or reflected or emitted electromagnetic radiation. Tasha and Shelly (2006) also highlight that there are two types of raster data, namely: continuous and discrete, which can either be presented in aerial and satellite imagery. Discrete raster data is more relevant to a quantity like population density, and continuous data examples are temperature and elevation measurements. Figure 9 below illustrates how raster data is organised.

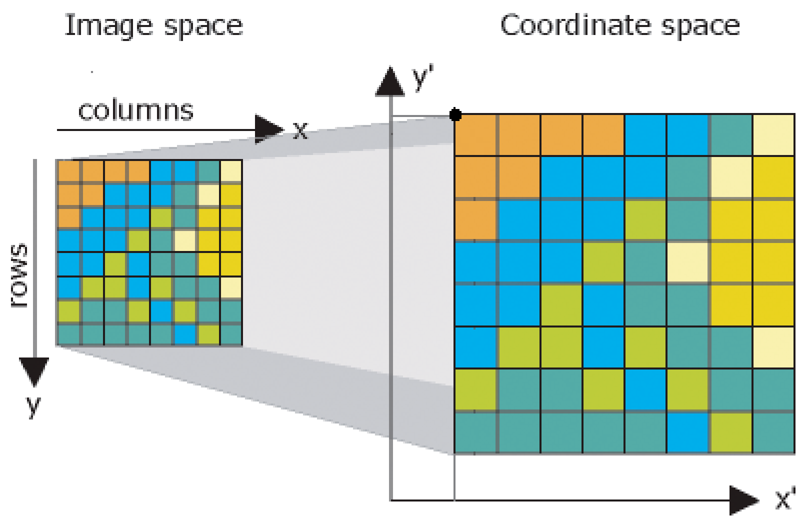

Figure 9: Raster themes. Source: Maguire(2000)

The second model is the vector data model, which is used to store data, which has discrete boundaries like country borders, land parcels and roads. According to Maguire (2000), the vector-based model can be distinguished by its basic units of spatial information: points, lines (arcs) and polygons and geospatial data is represented in the form of co-ordinates as depicted in figure 10.

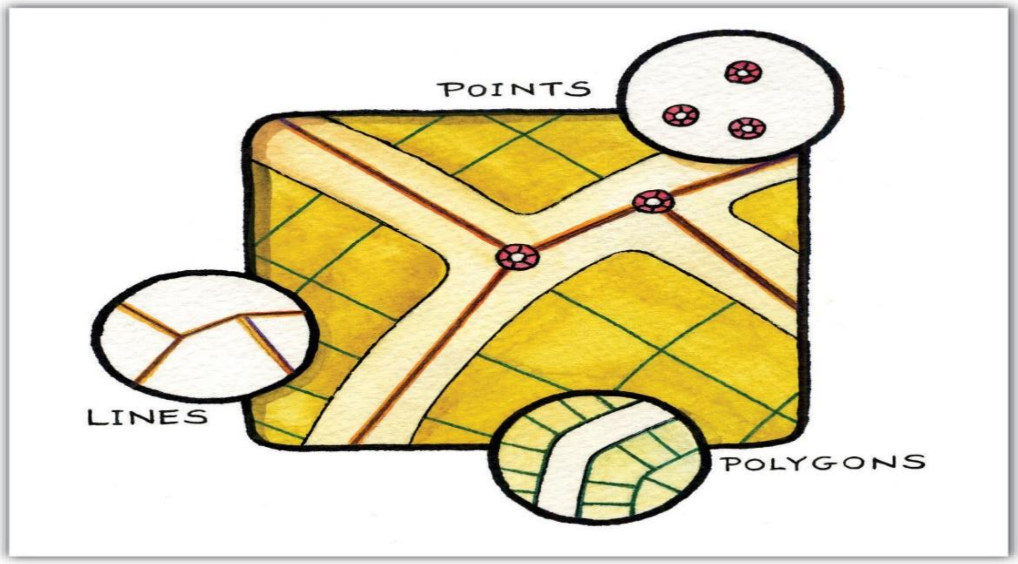

Figure 10: Vector themes. Source: Cooper (2003)

2.7.3. Spatial Data Models

2.7.3.1. Spatial Data Infrastructure (SDI) Model

Rajabifard *et al*., (2014) note that SDI is an information infrastructure that is an appropriate framework for bringing the disaster response components together and facilitating decision-making for disaster management. The reason being strategic decision-makers can easily take resolutions that can effectively improve the efficiency in disaster management. This model is illustrated in the figure below depicting how SDI influences decision-making in all the disaster management phases, hence its popularity in the GIS field.

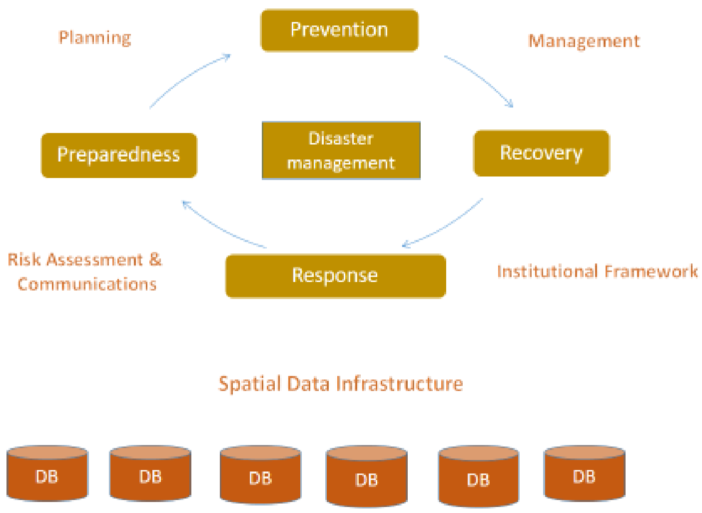

Figure 11: Spatial Data Infrastructure model. Source: Cooper (2003)

SDI and disaster management are both comprised of standard components which are determined by people, policies, standards, information and accessing network Rajabidarf *et al*., (2004). The main intention in disaster management is to save people lives during a disaster; therefore, the availability of the spatial data makes the response more efficient as the location of the people in danger can be accessed. Better decisions can be made. With time needs grew significantly and there was an increased need to ensure that spatial data is organised and once it is organised it had to be accessible to various stakeholders for different needs, hence the conceptualisation of SDI. The response team during disasters is comprised of multi-sectorial practitioners providing various forms of information for analysis to make informed decisions. According to Rajabifard *et al*., (2004) it is an undisputed fact that SDI has significantly displayed its ability to organise data from multi-discipline and merge into one illustrative map that will make sense to various decision-makers at different executive levels. Disasters require readily available and accessible spatial data and SDI with such elements make response significantly more efficient (Mansourian *et al*. 2006).

2.7.3.2. Fit model

Jarupathirun and Zahedi (2001) identified another framework GIS-based: Spatial Decision Support Systems. The fit theory has been popular in the strategic management for strategy/context fit – in this theory technology performance depends on technology utilization and the fit between the technology and the tasks it is intended to support. As submitted earlier, this theory subscribes to the notion of assimilating and analysing spatial for the decision-makers to make informed decisions. Wakabayashi (2011) views spatial thinking as a constructive amalgam which revolves around concepts of space, tools of representation and processes of reasoning that support decision-making.

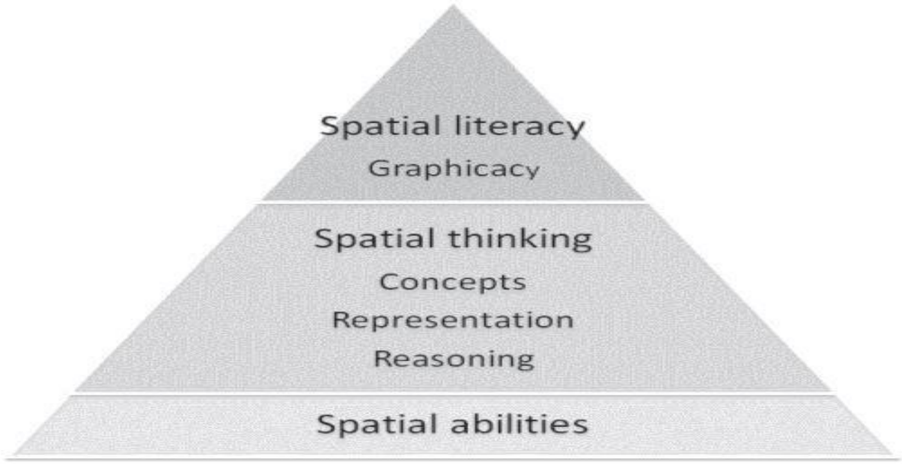

Figure 12: A conceptual scheme of spatial thinking and related terms. Source: Wakabayashi and Ishikawa (2011)

2.8. Summary of the chapter

It is evident that GIS is technologically oriented and technology is never static; it will, therefore, be updated all the time. Thus, the practitioner will need to keep abreast with new developments to respond effectively and efficiently to disasters, which are also unpredictable with the surfacing of global warming. Notwithstanding the benefits of using GIS in all the phases of disaster continuum, there are limitations as well. For the efficiency and effectiveness of integrating GIS into disaster management, it can be evident if there is sufficient, accurate and updated data to work with. However, some institutions are still lagging behind in storing updated data. Suppose during a disaster incident people are displaced, and they need to be relocated, and GIS data on an unused land parcel is outdated by the time preparation is made or a team goes to view the land, only to find that there is already infrastructure on the identified land. Such like that can happen if the data is not updated on the database.

- Other limitations can be associated with challenges in recognizing deficiencies in models, problems with software and the inability to identify the needs of the end-users Simson (2011). Change is inevitable in any industry, and this also applies to the broader world of GIS academic research and industry practice for disaster response. Various GIS technology platforms were in place to allow big data to be carried without compromising the speed (Crooks *et al*., 2013). In as much as GIS has been regarded or recommended as the best tool to support disaster management, there have also been challenges identified which include interalia: Limited information for large-scale disasters which can be attributed to the setup of a GIS database.
- Outdated information with short timeframes – this becomes a challenge in instances whereby the information can only be valid for a few days.
- Non-availability of geospatial expertise during the incident.
- The format in which data is provided – the data coming from various departments comes in different formats which make it difficult to convert into the desired format in an emergency situation.

CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

3. Introduction

The methodology used in the research is discussed in this chapter. Expanding on the data collection instrument, research population as well as how data has been analysed. The research has been influenced by the interpretivism philosophy, which insinuates that human beings are bound to be social actors who will perceive and interpret the current situation differently. Reactions are always goal-oriented (Saunders & Lewis, 2012). The methodological approach used to gather such perceptions from the targeted population was both quantitative and qualitative approach (Gouldkuhl, 2012).
According to Welman, Kruger and Mitchell (2007:2), the elements above bring about how research activities will unfold to gather the perceptions of the intended population without providing leading responses.

3.1. Research methodology and design

Without research methods the researcher will not be able to interpret ideas, to find an answer to existing questions or the assumptions on a specific aspect hence Schwardt 2007, Cresswell & Tashakkori 2007, and Tashakkori & Teddlie 2009) consider research design as the most critical and guiding framework to research. In the study, a qualitative survey research survey was used. The researcher chooses qualitative research because of its ability to gather empirical knowledge. Tashakkori & Teddlie 2009 state that qualitative research familiarises the researcher with the phenomenon in question, which in this instance was the integration of GIS into disaster management with a specific interest in disaster response. A qualitative research method is known to be the best approach in understanding human perception and the manner in how they react into situations at hand Burns & Grove (2001). The study intended to understand the perceptions of the officials around the integration of different aspects to disaster management. The method described was found relevant to the research. Burns & Grove (2001) advocate for research design because it serves as a guide to the researcher to approach the study in an objective-driven manner. The research design helped the researcher to establish how officials working in the Disaster Management and GIS units within the Department of Human Settlements perceive the benefits of integrating their expertise in their daily activities.

3.2. Population and Sampling

The research population was comprised of officials within the Disaster Management and GIS units in the KwaZulu-Natal Department of Human Settlements. The population included Professional GIS Practitioners, GIS Technicians as well as Professional and non-Professional Disaster Management practitioners. The department has different units which are both based at the Head Office, and the above-mentioned units were surveyed, which in total had ten officials.

3 Unit of analysis

The reason behind choosing the purposive sampling was that the researcher made the judgment to select those respondents that were thought to be useful for the study (Saunders & Lewis, 2012).

3.4 Measurement Instrument

This research was conducted using open-ended questionnaires which were distributed to the respondents. The questionnaires were divided according to the targeted units, namely: Disaster Management Unit; Project Management Unit, GIS unit and uGu Disaster Management centre. The questionnaires were self-administered and gave room for further elaboration by the respondents.

3.5 Data collection

According to Leedy & Ormrod (2014) when conducting qualitative research, we operate on the premise of the assumptions that reality cannot be divided into measurable and discrete variables. In qualitative research, the researcher becomes more involved in the setup; hence the researcher chose to select participants who were better position to provide information on the phenomenon under investigation. The questionnaires were aimed to explore and understand the effects of GIS and its integration into disaster management daily activities; the extent to which the officials understood the Disaster Management and GIS concepts and integration thereof. The integration of the concepts above is assumed to improve disaster response and recovery process if there is an element of integration – to what extent it has contributed in the process (Rangarajan, Gelb and Vandaveer, 2017).

An open-ended question was used with an intention to gather participants views with regards to the integration of GIS into disaster management and the manner in which GIS is used to respond to a disaster incident. Strauss & Corbin, and Saunders & Lewis (2012) support this approach as they believe that open-ended questions provide room from comprehensive responses and allow the participants to think critically. According to Rowley (2014), open-ended questions are suitable in instances whereby responses cannot be predicted, for example on some questions the respondents had to provide reasons for the answers they had given which the researcher could not have predicted.

3.6 Data Analysis

According to Shammo & Rensik (2003: 322), data analysis is a most critical part of the research because the responses provided by the participants are interpreted and analysed to get research findings and to determine whether the objectives of the study have been met. The collected data was reduced into meaningful tables and graphs narrating the research outcomes and making some conclusion out of the responses provided by the participants (Leedy & Ormrod 2014. Shammo & Rensik (2003: 322) further emphasise the importance of organising the data before the analysis process, the researcher used Microsoft Excel to organise data and to produce graphical presentations. It was against this backdrop that the data that was collected was analysed to present the findings of the study. The results were presented in graphs and frequency tables to identify trends and to establish activities that are performed by the Disaster Management Unit in responding to disaster incidents.

3.7. Coding

According to Stuckey (2015) Coding "is a process used in the analysis of qualitative research, which takes time and creativity which involves the following steps; reading through the data and creating a storyline; categorizing the data into codes, and using memos for clarification and interpretation". The researcher considered the principles mentioned above and interpreted the data to the research questions, and the storylines were developed with the research questions in mind.

3.8 Editing

Data is defined as "those pieces of information that at any particular situation gives to an observer" (Leedy & Ormrod 2014), he further refers to it as a naked truth with the elements of defectiveness which can affect the validity of the conclusions of the researcher. In light of the above, the data was edited to avoid any distortion that could be caused by data that is not admissible.

3.9 Validity and Reliability

Golafshani (2003) emphasises the importance of understanding the meaning of reliability and validity, which he perceives as the quality of the research. Leedy & Ormrod (2014) argues that for the instrument to be valid, it has to measure what the instrument intended to measure. In the case of the current study, the instrument intended to understand the phenomenon of integrating GIS into Disaster Management and the perceptions thereof. Leedy & Ormrod (2014) states irrespective of the type of scale the measurement instrument a proof of validity and reliability of the purpose of the research should be provided. He further argues that the conclusion drawn from the finding is influenced by validity and reliability of the measurement instruments. The research was reliable because the study was consistent, as emphasised by Leedy & Ormrod (2014).

3.10 Ethical Consideration

The researcher was cognisant of the research ethics, which were addressed in such a way that the participation was voluntary. The reason behind the letter of consent was to provide the participants with an opportunity to decline in instances where they were not willing to partake in the research, and those who did not wish to take part were allowed to decline. The researcher highlighted the element of confidentiality. Hence it was stated in the letter that the research would be confidential.

3.11 Limitations

Due to time and financial constraints, the study only focused on the Department of KwaZulu-Natal Department of Human Settlements. The officials from uGu Disaster Management centre did not return the questionnaires.

3.12 Conclusion

This chapter discussed the processes followed in conducting the study. It entails research methods, the methods used for collecting and analysing the data. The limitations of the study and research ethics that were followed are highlighted. The research design was the most important part of the study because it is where the researcher elaborated on the master plan on how the research was conducted specifying the method and approach procedure. There was no best research design, but it was crucial to ensure that data collection was relevant to address the research problem, which is the primary objective of the research design (Zikmund *et al*., 2009). Qualitative exploratory research assisted the researcher in establishing opinions, thoughts and feelings of the respondents, which could provide a better understanding of the phenomena based on the respondents' experiences. Guidelines from the literature were applied in this research to ensure the research was answered without bias from the researcher.

CHAPTER 4

DATA PRESENTATION, ANALYSIS OF RESULTS AND KEY FINDINGS

4.1. Introduction

This chapter presents the results from the questionnaire with the support from the literature review and theoretical study chapter. The application of the positive deviance approach will be discussed in this chapter. This chapter discusses further the key findings from the responses received from the participants.

For better analysis of the results in terms of the responses the researcher revisited the research objectives and purpose to discuss the findings in line with the purpose and objectives. The biographical information of the officials was requested so that the researcher can contextualize the findings which were characterized by qualifications, years of employment and position held.

4.2. Discussion of participants and interview method

The researcher targeted ten respondents from the Department of Human Settlements, Project Management, GIS sections, as well as participants from uGu Disaster Management Centre. Ten questionnaires were sent to the participants working in the mentioned sections and institutions. Eight questionnaires were returned, which represents a 72% response of the targeted audience. The researcher continued with analysis as the percentage of returned questionnaires is more than 50%. Three questionnaires were prepared for each section (Project Management, GIS unit and Disaster Centre). The first three questions in the questionnaires for both units were shared as the interest was to establish the level of qualifications of the respondents and the number of years they have worked in that particular unit.
The researcher found the purposive and convenience sampling suitable for the study as they were at the forefront of the disaster recovery process. According to (Saunders & Lewis, 2012), it is critical to select respondents that will add value to the research. The researcher based the convenience sampling decision on the willingness and availability of the respondents. The respondents were all in the management and senior management level. To ensure a high-quality study Hancock *et al*., (2009) suggested the researcher take careful consideration during sampling by making sure

that the sample was made out of respondents that were not going to confirm your pre-conceived ideas of the phenomena through being honest when sampling.

The researcher will present research results in a graphical approach with a brief narrative following the order of the questions in the questionnaire.

4.3 Interpretation of the questionnaire for Disaster Management and GIS unit

Similar questions were asked to the officials working for the Department of Human Settlements in the Disaster Management unit within the Special Projects section.

4.3.1 Period of work within the department

Five staff members from the GIS unit returned the questionnaires; this unit is fairly small with a staff complement of six, and the duration of employment as illustrated below depicts that out of five who returned the questionnaires, five have been with the department for more than five years. In the disaster management unit out of three participants who responded, two staff members have been with the department for more than three years, and one has been with the department for seven years.

Figure 13 shows that the most significant number of years worked by the respondents was between 3-4 years out of eight respondents, which translates to 25% of the respondents who have worked over three years within KZN DHS. Two respondents have worked for more than four years; one has worked for six years, and the other one worked for seven years. The researcher found that during the disaster in question, 75 % of the respondents were already employed by the department. Therefore, one can safely confirm that KZN DHS employed the majority of the respondents during the October 2017 disaster from both Disaster Management GIS units.

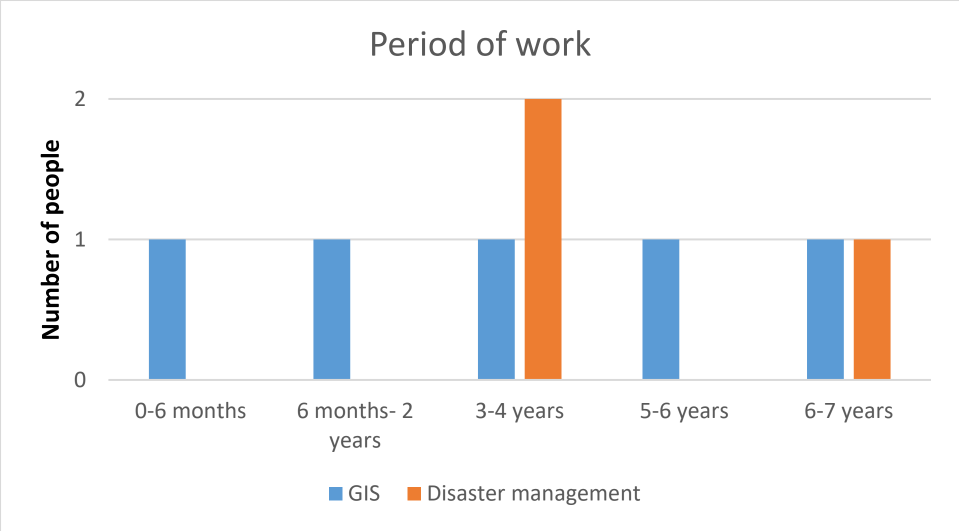

Figure 13: Period of work: Source: Research results in 2020

4.3.2 Qualifications

Staff members were asked to state their qualifications to establish the relevance to current jobs. Significantly, 80% of the staff members in the GIS unit have degrees in Geography and Environment Management, which is most common in the GIS fraternity. One member has a Diploma in GIS, and the other one possesses a B-tech in Surveying. In the Disaster Management Unit, the participants have qualifications in Construction Management, Town Planning and Social Housing.

The respondents within the GIS unit have relevant qualifications to their field of work which places them in a better position to understand the impact that could be made by their involvement in the disaster response and recovery. Within the Disaster Management unit, none of the respondents has a Diploma or post-graduate diploma in Disaster Management, which might limit the full integration. The mere fact that the country is experiencing multiple disasters calls for qualified employees to maximise the impact of disaster response.

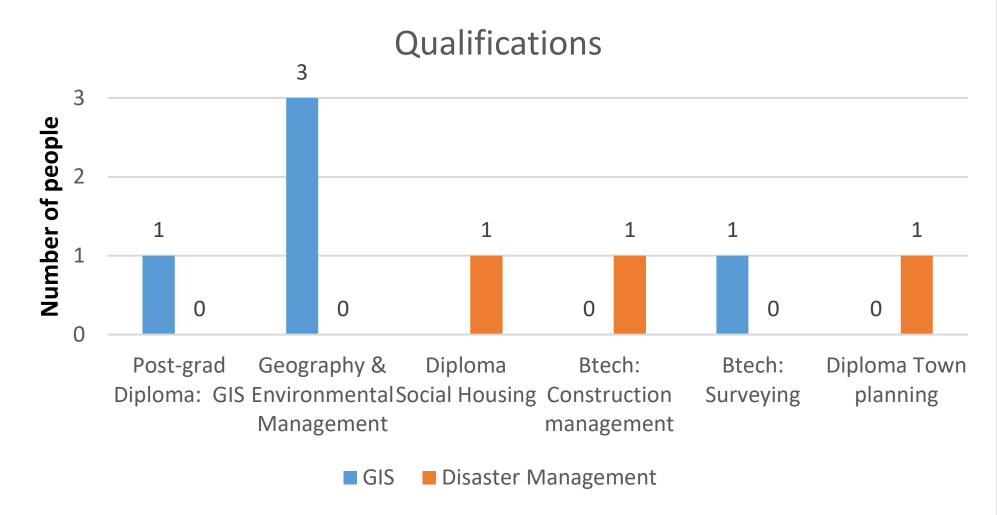

Figure 14: Qualifications. Source: Research results in 2020

4.3.3. Position held in the unit

Three respondents were asked to indicate the positions they hold within the unit to determine whether they are in the implementation level or decision-making level. In the government sphere, most often than not a GIS professional heads the unit which automatically makes him/her a decision-maker of the unit. Directors are at senior management level, also making decisions. In the middle management level, there are Deputy Directors and Assistant Directors who also influence decision-making. Out of five respondents from the GIS Unit, one is a GIS professional, and the other one is an Assistant Director of GIS. The other two perform administrative duties, including a relatively new participant doing an internship programme, and the last one is a survey technician. On the other hand, within the Disaster Management Unit, two participants hold decision-making positions: one being Director and the other one a Deputy Director, with one member being a technical support officer.

Figure 15 shows that the participants held positions in different levels of management which means that they can influence decision-making and even assist the management on how to effectively utilise GIS services when it comes to disaster response and disaster management in general. The researcher found that both units were represented in all management levels from Assistant Director to Director.

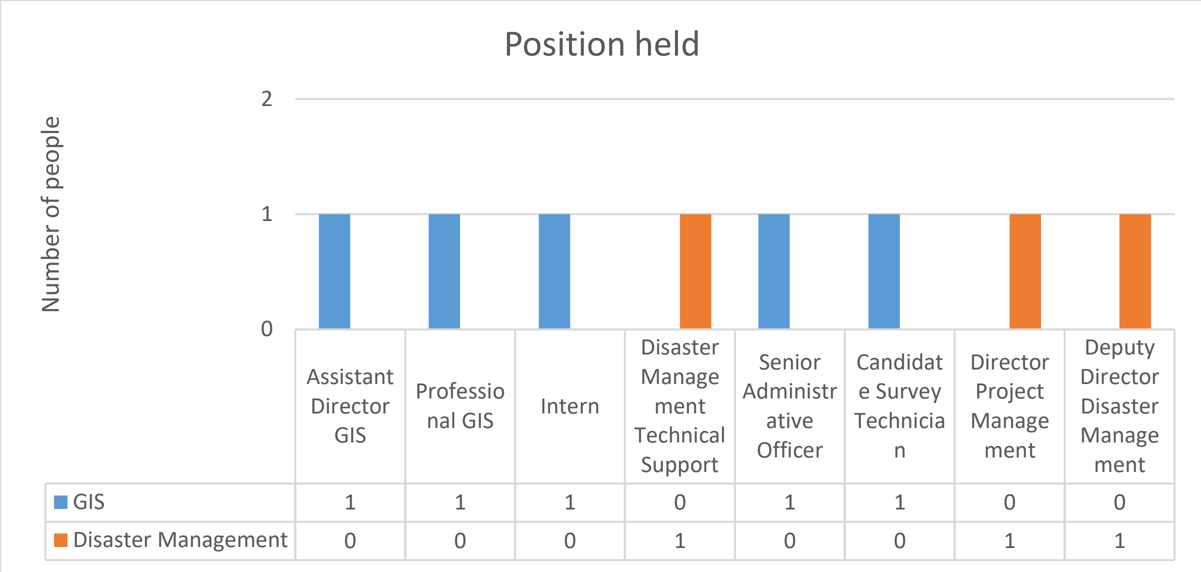

Figure 15: Position held. Source: Research results in 2020

4.3.4. Awareness about the Disaster management unit

Participants were asked if they are aware of the existence of the Disaster Management Unit within the department to determine further the nature of activities, they are involved in the implementation of disaster management. Four out of five respondents indicated that they were aware of its existence. A similar question was asked to the participants in the Disaster Management Unit, whether they were aware of the existence of the GIS Unit. All of them indicated that they were aware of the unit.

The researcher found it important to establish whether the participants were aware of the existence of these units in their department. In some instances, it would appear that some units within the same department were not aware which units existed and therefore, to benefit from such department which could have improved their performance or the impact they would have in the process of service delivery. In this instance, it was not the case, as all the respondents, which translates to 100%, indicating that they were aware of the existence. The question then would be to what extent they took advantage of the available services.

4.3.5. How often do you work with the Disaster Management or GIS units?

Participants were asked to indicate the frequency of the engagement with each unit as illustrated below: 80% of the respondents stated that there was no constant engagement with others as they engage only as and when required.

Figure 16 shows that even though both units were aware of the existence of each other, it was surprisingly evident that there was no element of collaboration in executing the tasks that are related to disaster management, let alone disaster response. The respondents were provided with various options to choose from, six participants out of eight which translates to 75 %, indicated that they only interact with either unit as and when required. This shows an element of silo mentality as the units seem not to take advantage of existing resources to respond to disasters efficiently; moreover, to make informed decisions about the lives which are being threatened at the time of the incident. The remaining 25% indicated that there was no interaction at all as they said this did not apply to them.

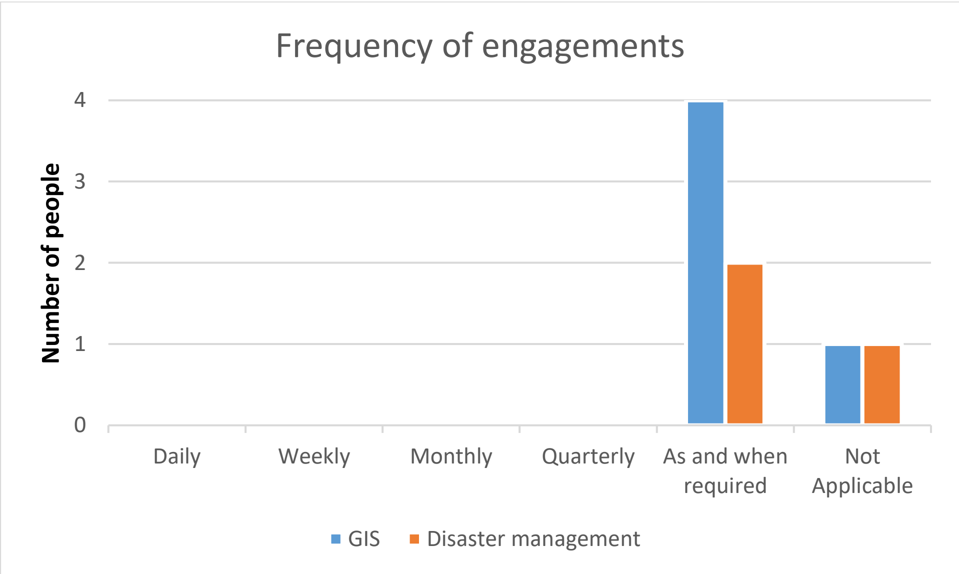

Figure 16: Frequency of engagements. Source: Research results in 2020

4.3.6. Collaborative activities

In question six, members of each unit were asked if they have any collaborative activities that they perform, with the following responses. From both GIS and Disaster Management Unit, three respondents indicated that they work together when the mapping of disaster-affected areas is required. Three respondents indicated that they work with the Disaster Management Unit to capture GPS data for beneficiaries entitled for services. Two respondents mentioned the land audit activity as well as the population of housing settlements. The other two indicated that the question did not apply to them.

In table 4 it shows that 60% of the respondents indicated that the collaborative activities were for mapping the areas affected by disasters as well as recording GPS data for housing beneficiaries. The other 40% stated the areas of collaboration as land audit meant for the relocation of affected families. This means that to a certain extent GIS services were utilised for disaster response and recovery but not for immediate relief/response.

Table 4: Collaborative Activities

Activity	**N=6**
Mapping of areas affected by disaster	3
GPS data capturing for beneficiaries	3
Land audit	2
The population of housing settlements	1
Not Applicable	2

4.3.7 Understanding of GIS by Disaster Management Unit

The respondents from the Disaster Management Unit were asked to explain in their own words what they understand about GIS. The answers were:

"*The utilisation of geographic information to assist with planning of settlements. Enables the department to know where interventions are required and contractors to find beneficiaries easily".*

"Is a tool that is used by the department to use GPS to locate housing beneficiaries".

"Utilisation of GPS to locate housing beneficiaries".

The responses towards the understanding of GIS were not close to the definitions of GIS defined in chapter one of the study. The fact that the respondents do not fully understand GIS may limit the potential of integrating GIS into Disaster Management activities.

4.3.7.1 Understanding Disaster Management by GIS Unit

Similarly, the respondents from the GIS unit were asked to express in their own words their understanding of Disaster Management. The following responses were received:

"*Deals with processes of prevention and mitigation to risk management"*

"In the context of human settlements it relates to natural or unnatural risks that may affect the built environment and thereof plans to manage such event should it occur this may include mitigations such as shifting, avoiding the risk".

"The sorting and delegation of resources and specific duties for the handling of all humanitarians' aspects of emergencies such as reaction in order to minimise the effect of disasters".

"It is the instrument that is used for the distribution of resources and the effective response towards disasters to reduce detrimental effects".

"*It is a programme that deals with emergencies and disasters i.e. identifying locations that need interventions".*

The researcher needed to establish whether the respondents understand either of the concepts and their perception on the advantages of collaborative efforts. For the researcher to make conclusion whether the participants understand disaster management concept, a reference was made to definitions provided in the first chapter of the research. The assumption would be that people may have different perceptions from the norm on the same aspects. However, the participants' perceptions were in line with the norm. It can be concluded that the understanding of the participant of the concept makes them better suited to collaborate in order effectively and efficiently respond to disasters.

4.3.9 Response team for 2017 storm disaster

The respondents were asked if they part of the disaster response team during 2017 storm disaster. Staff members from the GIS unit were not part of the response team, and all the respondents from the Disaster Management unit indicated that were involved in the response process.

Figure 17 shows that the GIS unit was not part of the response team. According to the previous responses about the awareness, one could have concluded that the GIS unit should be part of the response team, which was not the case. In question 10, which was also a follow-up question, the GIS unit could not respond to the question as they were not part of the team. The researcher noted that the disaster management unit requested services from the GIS unit not as part of the response team, but after the incident has passed, which resulted in delays. The delays were caused because the GIS unit went to the site a week or more after the incident. The services that were requested were for recovery purpose as the range between mapping the affected areas, development of settlement plans and land identification.

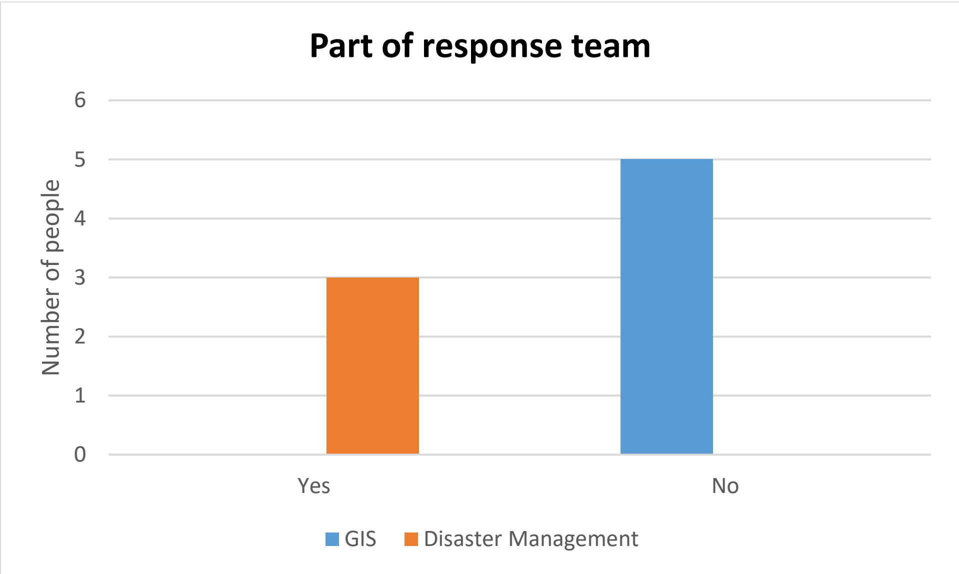

Figure 17: Part of the response team. Source: Research results in 2020

Follow did not apply to the staff members from the GIS unit since they were not part of the response team. However, the researcher asked the questions to know if the GIS unit was part of the response team and what were the activities or services, they offered in the implementation of recovery interventions.

The Disaster Management unit responded to question nine in which they have indicated that they required GIS services. Three respondents stated that they needed GIS services to map disaster-affected areas. Three also required services to locate the affected beneficiaries. Two respondents indicated that they needed services for the development of a settlement plan. The last service that was needed by one respondent was the identification of land to relocate the affected families.

Figure 18 shows the GIS services that were provided to the officials from the Disaster Management Unit. The respondents from the disaster management were asked if their expectations were met in terms of the GIS services that were required. All three respondents from the disaster management unit replied positively.

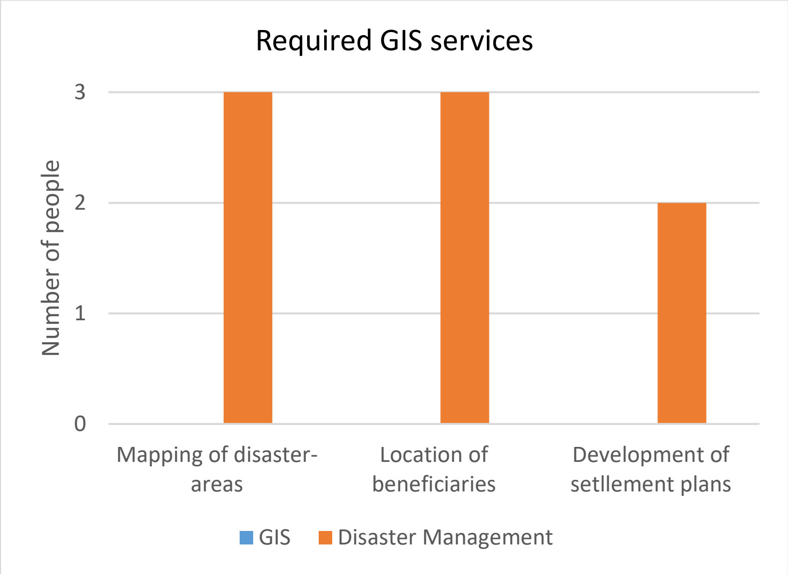

Figure 18: Required GIS services. Source: Research results 2020

The follow-up was only applicable to the respondents who indicated that indeed their expectations were met in terms of the services that were requested from the GIS unit and they were asked to state reasons for their answers. The following were the reasons for their answers:

Figure 19 shows that the participants from the Disaster Management Unit were pleased with the services offered by the GIS unit since they indicated that their expectations were met. The resources that were required and the plans that were requested on settlement, were provided. This enabled the unit to make decisions but it was not applicable to the GIS unit. The participants from the GIS unit indicated that the question did not apply to them

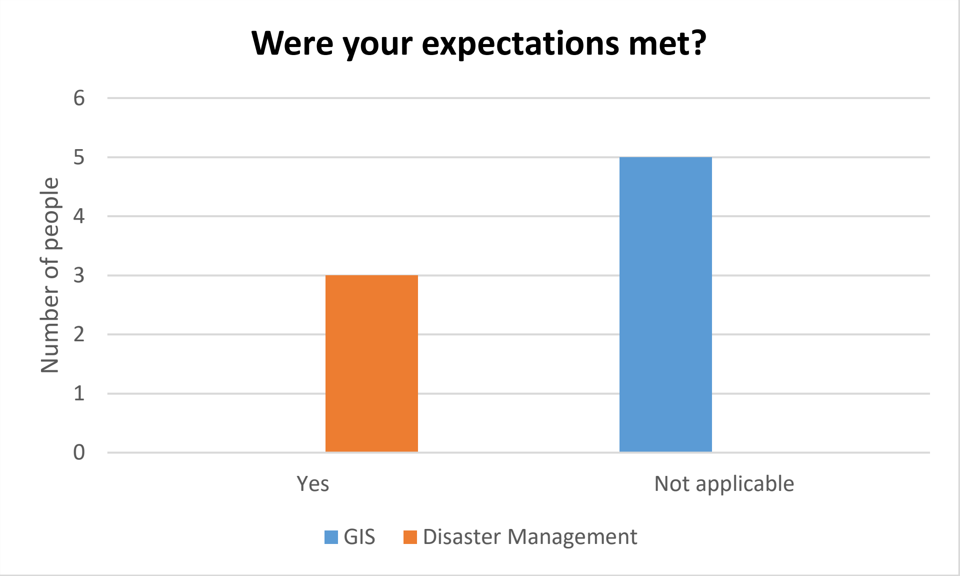

Figure 19. Were your expectations met? Source: Research results in 2020

4.3.10 Possible role of the GIS services during response

In terms of GIS roles, the intention was to find the opinions of the respondents from the GIS unit about the role that could have been played by the GIS unit during the response phase of disaster. Two respondents indicated that the GIS services would have been vital in the effective allocation of the resources and identification of nearest shelters. One respondent felt that the service could have served as a decision support system and also helping in the identification of alternative routes. Two respondents indicated that progress would have been easily monitored. One respondent felt that the impact assessment would have been conducted.

Figure 20 shows that the respondents from the Disaster Management Unit have some ideas of what roles GIS could have played in response to the disaster incident. On the other hand, one would assume that GIS practitioners should understand the nature of disasters and the roles that they ought to play when disaster strikes. Various opinions were expressed which were around efficiency in responding to disasters, identification of nearest shelters, as well as the provision of support to the decision-making of the executives. The research found that the GIS unit is aware that they can play a significant role in responding to disasters.

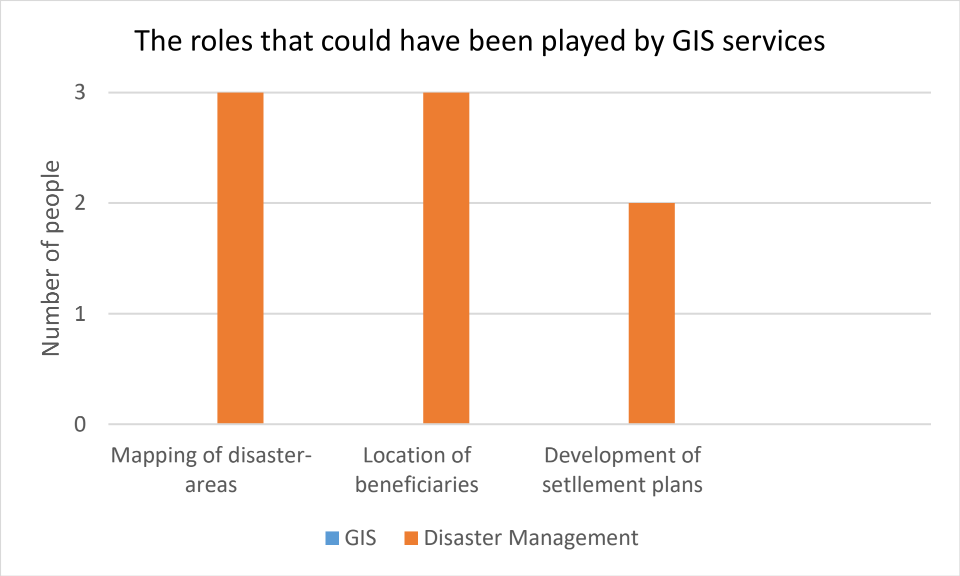

Figure 20. The role that could have been played by GIS unit: Source Research results (2020)

4.3.11 Recommendations and comments

The respondents were requested to make suggestions and comments about the integration of GIS into disaster management. Three respondents indicated that GIS should be integrated for impact assessment; three respondents felt that integration of GIS would be vital in mapping out areas of intervention. Two respondents indicated that GIS could be used to identify future planning areas. Two respondents commented that GIS could be used to identify disaster-prone areas and GPS coordinates could have been incorporated into the profiling process.

Figure 21 shows in the suggestions and comments made that both units understood how the integration of GIS into disaster response and recovery could improve how the department responds to disasters. It was noted that the respondents felt that areas of interventions could be mapped out, which support the principle of GIS to make informed decisions. In general, respondents suggested the integration of these disciplines to efficiently and effectively respond to disasters.

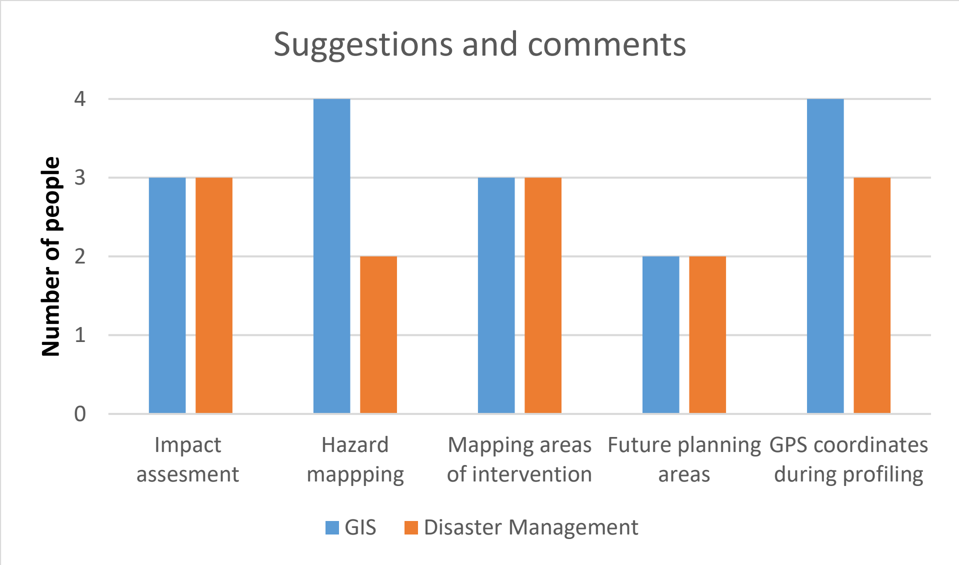

Figure 21: Suggestions and comments. Source Research results (2020)

4.4. Responses from uGu Disaster Management Centre

The researcher sent questionnaires to uGu Disaster Management Centre. However, officials of the centre did not return the questionnaires. Even though the anticipated participants did not respond, the researcher continued since there were eight respondents out of ten respondents that were targeted for the study, which constitutes 80% of the targeted population.

4.6 Summary of the chapter

This chapter presented the responses from the respondents, and the researcher presented the results in the form of tables and graphs for better illustration.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The utilisation and awareness of GIS services in KwaZulu-Natal department of Human Settlement was core to the study in terms of the role played by the GIS Unit during the disaster response process. Another aspect was the manner in which the two units (Disaster Management Unit and GIS unit) are integrated. The objectives of the study were met as the research results showed that the Disaster Management Unit acknowledges the fact that the GIS Unit exists and that it played a role in Disaster Management. However, it was evident that the unit was not optimally utilised. The study revealed that there was a limited extent to which GIS was integrated, nor full collaboration of activities between the units. The real impact that GIS has in disaster response was not evident because the GIS services were not required for during response phase but for medium to long-term solutions during the mitigation phase. The respondents clearly articulated research question regarding the roles played by each unit and the extent of involvement in response to disasters. The respondents were aware of the challenges or disadvantages of not fully utilising GIS services and provided the solutions to better improve the integration of the two disciplines in question.

The conclusions were therefore drawn from the responses and suggestions were made by the targeted audience, which was the officials working for KZN DHS within Disaster Management and GIS Units. The respondents expressed their opinions around disaster management in general as well as disaster response and recovery. The research questions were crafted in a way that can display the understanding in terms of the research objectives.

5.2 Conclusion

According to responses from the participants, the researcher can conclude that the participants have been with the department long enough to understand the processes of disaster response within the concept of disaster management. However, it is a cause for concern that there are no officials with a disaster management qualification within the disaster management unit. The Disaster Management Act highlights the interdisciplinary element in disaster management, which requires an intense background on the disciplines that can play a vital role in the implementation of disaster management. In the light of this backdrop, one can conclude that the qualification has influenced the little collaboration that is evident between the two units.

In terms of positions held by the officials, the researcher concluded that the unit was fairly represented in decision-making platforms. The available platforms have not been used enough to forge intra-relations on how each unit takes advantage of available resources. This has been proven by the fact that even though the participants were aware of the existence, they do not interact at least every week to enhance the implementation of disaster management, which can ultimately result in inefficient disaster response processes.

From the responses on the collaborated activities, it can be concluded that there is limited collaboration and GIS services were regarded as an afterthought. GIS practitioners get involved in the disaster response once the technical assessments have been made, which is not supposed to be the case as GIS services are also vital even during the incidents. Therefore, the researcher concluded that there is a weak link in intra-departmental relations. The involvement of GIS in all the disaster phases reduces the number of fatalities. Ideally, the GIS unit should be part of the Joint Operations Committee (JOC); however, in this case, they were not.

Further conclusions about the roles of GIS in disaster management and its integration thereof. The officials do not fully understand the part of each unit. However, the services are not fully utilised to make an impact when responding to disasters. From the suggestions of the respondents, it is clear that the respondents support the integration of GIS into disaster management. They were fully aware of the benefits that the disaster management unit can use to make better decisions and respond to disaster and for the implementation of disaster management in general.

Both response and recovery require close coordination and information exchange between the field and Emergency Operations Centre (EOC). These requirements are often needed under stressful, chaotic conditions when useful information is needed to support critical operations. GIS provides the capability for rapid data exchange that is easy to assimilate, understand and act on. This capability allows EOC to provide elected officials, department heads, and other stakeholders with accurate situation status and data about actual and potential impacts. Current and timely information is also essential to provide the public with information such as shelter locations, evacuation routes, road closures and hazard areas.

5.3. Recommendations

Culminated from the findings, the researcher provides recommendations of integrating GIS into Disaster Management which can be implemented to enhance disaster response processes as well as disaster management in general. The areas where the gaps have been identified and which required consideration of the recommendations are frequency of interaction, intensification of collaborated activities and integration of GIS in disaster management.

5.3.1 Frequency of interaction

The as and when required approach puts the disaster management unit at a disadvantage because they cannot explore other avenues that can benefit them from frequently utilising GIS services. It is against this backdrop that the researcher recommends an establishment of a platform that will advocate for frequent interaction amongst the unit. The frequency should be at least once a month and this kind of interaction will provide the GIS unit with a platform to share new GIS developments that can enhance the implementation of disaster alleviation. One can rule out the fact that GIS is Information Technology (IT) oriented and IT evolves all the time; therefore, being on par with the latest developments it can result in efficient and effective service delivery. More so, the country is in the phase of embracing the Fourth Industrial Revolution, which is equally important to take into cognisance when implementing disaster management.

5.3.2 Strengthening the areas of collaboration

It is also recommended that collaborative efforts or activities should be regarded as necessary not only for disaster recovery but other Disaster Management Phases as well. Other areas that need to be considered in the areas of collaboration are:

- During the prevention phase, the tasks that can be executed can involve but not limited to susceptibility, vulnerability, hazard and risk mapping, zoning and land use planning or management.

- During the preparedness stage especially, if there has been early warning by developing evacuation plans and resource inventories.

5.3.3. Integration of GIS into disaster management

Integration of GIS and disaster management is recommended to improve service delivery and to shorten the response period, which is caused by different activities that are executed by different units. Integration of the two disciplines is possible due to the GIS capabilities to manipulate and analyse data into structured spatial data. The integrated approach allows for efficient spatial data handling and analysis and creation of integrated geodatabase that can include agricultural, hydrological, and biological and socio-economic information.

5.4 Future research recommendation

The research was done for one District. More evidence is needed to establish if Disaster Management institutions in South Africa have adopted GIS. Therefore, future research is required to determine how these institutions and government spheres have integrated GIS into Disaster Management.

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APPENDICES

Appendix I: Research questionnaire for Disaster Management unit

Interview questions for KwaZulu-Natal Department of Human Settlements Disaster Management Unit

1. How long have you been working for your organisation?

Years	
Months	

2. What is your qualification?

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3. What position do you hold in the department?

…………………………………………………………………………………………………

4. Is there a Geographic Information System (GIS) in your department?

Yes	
No	

5. If yes, how often do you work with the GIS unit

Please tick the relevant box

Daily	
Weekly	
Monthly	
Quarterly	
As and when required	

6. What activities do you perform in collaboration with GIS unit?

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7. What is your understanding of GIS?

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8. Were you part of the response task team during 2017 storm disaster?

Yes	
No	

9. If yes, did you require GIS services to implement aftermath interventions?

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10. If yes, were your expectations met?

Yes	
No	

Please give reasons for your answer.

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11. If you did not require GIS services in response to October 2017 Storm disaster what role do you think GIS could have played?

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12. Please make any other suggestions or comments about integration of GIS into Disaster Management.

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Thank you for completing this questionnaire

Please email the completed questionnaire to: ncumisa.mnguni@kzndhs.gov.za

Appendix II: Research Questionnaire for GIS unit

Interview questions for KwaZulu-Natal Department of Human Settlements GIS section.

1. How long have you been working in the department?

Years	
Months	

2. What is your qualification?

……………………………………………………………………………………………..

………………………………………………………………………………………………

3. What position do you hold in your department?

…………………………………………………………………………………………….

4. Are you aware of the Disaster Management unit in your department?

Yes	
No	

5. If yes, how often do you work with the Disaster Management unit?

Please tick the relevant box

Daily	
Weekly	
Monthly	
Quarterly	
As and when required	

6. What activities do you perform in collaboration with Disaster Management unit?

………………………………………………………………………………………………

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7. What is your understanding of disaster Management?

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8. Were you part of the response task team during 2017 storm disaster?

Yes	
No	

9. If yes, what GIS services were utilised to implement aftermath interventions?

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10. If yes, what impact did they make?

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11. If GIS services were not required in response to October 2017 Storm disaster what role do you think GIS could have played?

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12. Please make any other suggestions or comments about integration of GIS into Disaster Management.

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Thank you for completing this questionnaire

Please email the completed questionnaire to: ncumisa.mnguni@kzndhs.gov.za

Appendix III: Research Questionnaire for uGu Disaster Management Letter

Interview questionnaire for UGu Disaster Management Centre.

1. How long have you been work at uGu Disaster Management Centre?

Years	
Months	

2. What position do you hold in the Disaster Management Centre?

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3. What is your qualification?

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4. Which section of the Disaster Management Centre do you work in?

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5. Were you part of the response task team during October 2017 storm disaster?

Yes	
No	

6. If yes, did you require GIS services to implement aftermath interventions?

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7. If yes, were your expectations met?

Yes	
No	

Please give reasons for your answer.

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8. What is your understanding of Geographic Information System (GIS)?

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9. What is your understanding of Disaster Management?

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10. What activities does your organisation perform in collaboration with GIS unit?

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11. If you did no require GIS services in response to October 2017 Storm disaster, what role do you think GIS could have played?

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12. Please make any other suggestions or comments about integration of GIS into Disaster Management.

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Thank you for completing this questionnaire

Please email the completed questionnaire to: ncumisa.mnguni@kzndhs.gov.za

Appendix IV: Gatekeeper letter

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Acting Head: Department of Human Settlements Acting Head: Department of Human Settlements

I am doing research and would like to request permission to conduct my research at *KwaZulu-Natal Department of Human Settlements.*

22 August 2018

TITLE OF THE RESEARCH PROJECT

Integration of Geographic Information Systems (GIS) into Disaster Management. A case of Kwazulu-Natal Human Settlements in response to October 2017 storm damage.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Mabel Ncumisa Mabengu *Student number: 2014151720* *072 604 0840*

FACULTY AND DEPARTMENT:
*Natural and Agricultural: Disaster Management Training and Education Centre for Africa (*DiMTEC*).*

STUDYLEADER(S) DR HERMAN BOOYSEN: **CONTACT NUMBER:**

The aim of the study is to establish the role of GIS in disaster management response in relation the Department of Human Settlements.

I am working for the department of Human Settlement coordinating the implementation of Emergency Housing.

This study is awaiting approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

The participants are directly involved in responding to disasters and their participation to the study will make an immense contribution identifying areas of integration as they understand the processes and procedure to be followed.

The participants will complete g questionnaires that will be provided by the researcher, it will take approximately 30 minutes to complete the questionnaires.

There will be no personal benefits for participating in the study, if the recommendations of the will be considered they will contribute towards future planning for disasters. The names of the participant will be kept confidential and they will be requested to sign consent forms. The study will by no means cause discomfort and inconvenience to the participants and there are no risks involved as the study will focus on strategic elements of disaster management. The questionnaires will not carry any names of the participants as the information will be used for report purposes and the names of the participants will not be mentioned in the report. The report will be published in relevant information domains but the privacy of the participants will be protected as the participants will remain anonymous.

As a research protocol the questionnaires will safely kept for a period of five years in case they are needed for other verification and other research purposes.

There are no incentives provided for participating in the study.

The researcher will present the findings upon request and can be contacted on; Cellular phone number: 072 649 8545.

Yours sincerely

Ncumisa Mabengu

Appendix V: Letter of consent

<u>Research study information leaflet and consent form</u>

I am doing research and would like to request permission to conduct my research at *KwaZulu-Natal Department of Human Settlements.*

22 August 2018

TITLE OF THE RESEARCH PROJECT

Geographic Information Systems (GIS) and disaster response and recovery: Integrating spatial thinking into disaster management: A case of Kwazulu-Natal Human Settlements in response to October 2017 storm damage.

PRINCIPLE INVESTIGATOR / RESEARCHER(S) NAME(S) AND CONTACT NUMBER(S):

Ncumisa Mabengu *2014151720* *072 604 0840*

FACULTY AND DEPARTMENT:
Natural and Agricultural Science: Disaster Management Training and Education Centre for Africa (DiMTEC).

STUDYLEADER(S) DR HERMAN BOOYSEN: **CONTACT NUMBER:**

The aim of the study is to establish the role of GIS in disaster management response in relation the Department of Human Settlements.

I am working for the department of Human Settlement coordinating the implementation of Emergency Housing.

This study is awaiting approval from the Research Ethics Committee of UFS. A copy of the approval letter can be obtained from the researcher.

The participants are directly involved in responding to disasters and their participation to the study will make an immense contribution identifying areas of integration as they understand the processes and procedure to be followed.

The participants will complete g questionnaires that will be provided by the researcher, it will take approximately 30 minutes to complete the questionnaires.

There will be no personal benefits for participating in the study, if the recommendations of the will be considered they will contribute towards future planning for disasters. The names of the participant will be kept confidential and they will be requested to sign consent forms.

The study will by no means cause discomfort and inconvenience to the participants and there are no risks involved as the study will focus on strategic elements of disaster management.

The questionnaires will not carry any names of the participants as the information will be used for report purposes and the names of the participants will not be mentioned in the report. The report will be published in relevant information domains but the privacy of the participants will be protected as the participants will remain anonymous.

As a research protocol the questionnaires will safely kept for a period of five years in case they are needed for other verification and other research purposes.

There are no incentives provided for participating in the study.

The researcher will present the findings upon request and can be contacted on; Cellular phone number: 072 649 8545.

Yours sincerely

Ncumisa Mabengu

Thank you for taking time to read this information sheet and for participating in this study.

Appendix VI: Consent form for participants

Consent to participate in this study

I, ______________________________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable). I am aware that the findings of this study will be anonymously processed into a research report, journal publications and/or conference proceedings.

I agree to the completion of the questionnaire.

I have received a signed copy of the informed consent agreement.

Full Name of Participant: ______________________________________

Signature of Participant: _____________________________________

Date: _______

Full Name(s) of Researcher(s): _____________________________

Signature of Researcher: _________________________________ Date: ________

Appendix VII: Editor's letter

Marie Engelbrecht

Tel: 27 51 – 4440884 (H)
Freefax: 0866373773 (H)
Mobile: 083 2981685
E-pos/Email: babengel@telkomsa.net

W/Bloem 310
P O Box 12007
BRANDHOF
9324

25 November 2020

TO WHOM IT MAY CONCERN

I, **Marie Engelbrecht** of Bloemfontein, hereby confirm that I have done the editing on the dissertation **"Integration of Geographic Information Systems (GIS) into disaster management. A case of Kwazulu-Natal Human Settlements in response to October 2017 storm damage"** by **Ncumisa Mabengu, student number 2014151720**, submitted in partial fulfilment of the requirements for the degree **Masters in Disaster Management** at the UFS recently, and that I have been paid in full for the work.

I trust you will find this in order.

M. J. Engelbrecht

Signed: **M J ENGELBRECHT**

Appendix VIII: Notice of submission form

NOTICE: SUBMISSION OF RESEARCH MASTERS DEGREE /THESIS OR INTERRELATED, PUBLISHABLE MANUSCRIPTS/ PUBLISHED ARTICLES

Student:

Please complete, sign and return the form to your supervisor/promoter.

STUDENT NUMBER	2014151720	TITLE (Prof/Dr/Mr/Mrs/Miss/ Ms)	Mrs
SURNAME	Mabel Ncamisa		
FIRST NAMES	Mabongu		
DEGREE	Masters Disaster Management		
DEPARTMENT	DIMTEC	FACULTY	Natural Science
POSTAL ADDRESS ON DATE OF SUBMISSION	47 Monzali Drive, Hilton Gardens Hilton, Pietermaritzburg		
TELEPHONE (W)	033 3434765	CELL	072 6498545
EMAIL	zimncu@icloud.com		
Title of dissertation/thesis or publishable article (as served at faculty board)	Intergration of geographic information systems into disaster management. A case of KwaZulu-Natal Human Settlements in response to October 2017 storm damage.		

I, hereby declare that:

1. I, in consultation and with the approval of my supervisor/promoter, give notice of my intention to submit a dissertation/ thesis or publishable article for examination in view of the degree concerned being conferred at a graduation ceremony.
2. **I also accept that all final, properly bound copies and cd must reach the University two weeks before the graduation ceremony. If this is not the case, no statement or degree certificate will be issued during the graduation ceremony.**
3. **Submission can take place throughout the academic year:**
   Up to **May** for the **December** graduation ceremony;
   Up to **November** for the **June/July** graduation ceremony

SIGNATURE OF CANDIDATE	[signature]	DATE	16 December 2020

Supervisor/Promoter:

Please forward the approved notice to the relevant officer as indicated in the abovementioned table.

SURNAME		TITLE (Prof/Dr/Mr/Mrs/Miss/ Ms)	
FIRST NAMES			
EMAIL		CELL	
Title registration date (NB latest board minutes date)			
SIGNATURE OF SUPERVISOR / PROMOTER		DATE	

Appendix IX: Turnitin report

Turnitin Originality Report

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